# ATTACHMENT VII – CQA PLAN AND TECHNICAL SPECIFICATIONS


Schnabel Engineering, LLC
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# Construction Quality Assurance Plan

# CONSTRUCTION QUALITY ASSURANCE PLAN

## Bremo Bluff FFCP Management Facility
## Solid Waste Permit 627
## Fluvanna County, Virginia

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# 1.0 INTRODUCTION

This Construction Quality Assurance (CQA) Plan (CQA Plan) has been prepared for the Bremo Bluff Fossil Fuel Combustion Products (FFCP) Management Facility (Facility) located in Bremo Bluff, Virginia. The Facility will accept coal combustion residuals (CCR) and operate as a captive industrial landfill (CCR Unit) under the Virginia Department of Environmental Quality (DEQ) Solid Waste Permit (SWP) 627. This CQA Plan describes the practices and testing associated with constructing the soil and geosynthetic components of the bottom liner and final cover systems to be used at the Facility, including piping and drainage components. The Facility is subject to the construction and testing requirements of the Virginia Solid Waste Management Regulations (VSWMR, 9VAC20-81). Schnabel Engineering (Schnabel) has prepared this CQA Plan on behalf of the Virginia Electric and Power Company d/b/a Dominion Energy Virginia (Dominion Energy).

A CONTRACTOR familiar with earthwork and geosynthetics installation will provide construction services, and an Owner's Representative will ensure the conformance of construction activities to established CQA standards. In most instances, the CONTRACTOR will perform all earthwork activities, and will retain a qualified geosynthetics installer for installation of geosynthetic materials. The OWNER may also contract directly with the Geomembrane Installer. The CQA Plan provides guidance information and procedures that should be undertaken by all parties to ensure the necessary quality of work.

This CQA Plan is a supplemental document to the Construction Drawings and Technical Specifications. Where a conflict arises, the more stringent criteria will govern.

## 1.1 Project Description

The activities addressed under this CQA Plan include the following activities:

1. Earthworks;
2. Geosynthetic Clay Liner (GCL)
3. Geomembrane (for base liner and final cover systems);
4. Geonet, geocomposite, and geotextile;
5. Leachate Collection Layer; and,
6. Protective Cover Layer and Vegetative Support Layer soils.

## 1.2 Definitions

### *1.2.1 Quality Control*

A planned system of activities, or the use of such a system, whose purpose is to provide a level of quality that meets the needs of users. The objective of quality control is to provide quality that is safe, adequate, dependable, and economical. The overall system involves integrating the quality factors of several related steps including: the proper specification of what is wanted, production to meet the full intent of the specification, inspection to determine whether the resulting material, product, service, etc. is in accordance with the Technical Specifications, and review of usage to determine necessary revisions of Technical Specifications.

In practice, Quality Control refers to those procedures, criteria, and tests employed and paid for by the CONTRACTOR(s) to confirm that the work satisfies the CONTRACTOR's standards and complies with the Construction Drawings and Technical Specifications. This plan does not address quality control procedures, criteria, and/or tests employed by the CONTRACTOR.


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### *1.2.2 Quality Assurance*

A planned system of activities whose purpose is to provide assurance that the overall quality control program is in fact being effectively implemented. The system involves a continuing evaluation of the adequacy and effectiveness of the overall quality control program with the ability to have corrective measures initiated where necessary. For a specific material, product, service, etc., this involves verifications, audits, and the evaluation of the quality factors that affect the specification, production, inspection, and use of the product, service, system, or environment.

In practice, Quality Assurance refers to those procedures, criteria, and tests required and paid for by the OWNER to confirm that the work performed by the CONTRACTOR(s) complies with the approved Construction Drawings and Technical Specifications and any additional requirements of this plan.

### *1.2.3 Lot*

A quantity of resin (usually the capacity of one rail car) used in the manufacture of polyethylene geomembrane rolls. The finished roll will be identified by a roll number traceable to the resin lot used.

### *1.2.4 Panel*

The unit area of geomembrane that will be seamed in the field. A panel is identified as a roll or portion of a roll that is larger than 100 square feet.

### *1.2.5 Subgrade Surface*

The surface which immediately underlies the geosynthetic material(s).

## 1.3 Parties

### *1.3.1 Owner*

The OWNER is the individual, corporation, entity, public body, or authority with whom the CONTRACTOR has entered into the Agreement and for whom the work is performed. For this project, the OWNER is Dominion Energy.

### *1.3.2 Engineer*

The ENGINEER is an official representative of the OWNER. The ENGINEER is responsible for the preparation of the Construction Drawings and Technical Specifications of the project and for preparation of the CQA Plan. The ENGINEER is also responsible for the interpretation of those documents and for resolution of technical matters that arise during construction.

### *1.3.3 Contractor*

The CONTRACTOR has the primary responsibility for ensuring that the project is constructed in accordance with the Construction Drawings and Technical Specifications developed by the ENGINEER and approved by the permitting agency. Other responsibilities include the performance of all construction activities at the site including site facilities, administration, material purchasing, safety, supervision, construction quality control, installation, and subcontracting. The CONTRACTOR is responsible for the protection of completed work until it is accepted by the OWNER. The CONTRACTOR is also responsible for informing the OWNER and Owner's Representative of the scheduling and occurrence of all construction activities.


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### *1.3.4 Owner's Representative*

The Owner's Representative is an entity, independent from the OWNER, CONTRACTOR(s), Manufacturer, and Installer, that is responsible for observing, testing, and documenting activities related to the quality assurance at the site. This party will perform laboratory testing of soils and other earth materials for material evaluation and verification purposes. This party will also observe installation of the geosynthetic cap and coordinate sampling and testing of the geosynthetics with the Geosynthetic CQA Laboratory. The Owner's Representative is also responsible for issuing a certification report, sealed by a Commonwealth of Virginia licensed Professional Engineer.

### *1.3.5 Geosynthetic CQA Laboratory*

The Geosynthetic CQA Laboratory shall be independent from the OWNER, CONTRACTOR, Manufacturer, or Installer, responsible for completing laboratory tests on samples of geosynthetics obtained at the site or during manufacturing.

### *1.3.6 Geotechnical CQA Laboratory*

The Geotechnical CQA Laboratory shall be independent from the OWNER or CONTRACTOR, responsible for completing laboratory tests on soil samples obtained at the site or source.

## 2.0 CQA PARTIES

### 2.1 Owner's Representative

The OWNER will retain an Owner's Representative to assure that proper construction techniques and procedures are used and to verify that the materials used meet the Technical Specifications. The Owner's Representative must employ engineers experienced in the field of landfill construction and licensed to practice in the Commonwealth of Virginia. At the completion of the work, the program requires certification reports indicating that the Facility has been constructed in accordance with the Technical Specifications and approved permit. It is the responsibility of the certifying engineer to prepare these reports.

### 2.2 Geotechnical CQA Laboratory

The Geotechnical CQA Laboratory must have experience in testing soil and aggregate materials and be familiar with ASTM International (ASTM) test standards and other applicable test standards as required in the Technical Specifications. The Geotechnical CQA Laboratory must have proven their abilities on previous work with the ENGINEER and shall provide the ENGINEER with their Qualifications and Experience (Q&E) package demonstrating their experience as it relates to the Technical Specifications. The Q&E package shall include a project list showing the name, address, and telephone number of the appropriate party to contact. The Geotechnical CQA Laboratory must be capable of providing test results within five days of receipt of samples.

The Geotechnical CQA Laboratory shall provide a contract administrator/project manager for the project as the responsible person to contact. This person shall oversee the analytical procedures and testing as well as review and reporting of the results. The Geotechnical CQA Laboratory is responsible for performing all geotechnical laboratory tests and formally submitting results to the ENGINEER as required in the Technical Specifications.


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### 2.3 Geosynthetic CQA Laboratory

The Geosynthetic CQA Laboratory must have experience in testing geosynthetics, and must conform to ASTM, National Sanitation Foundation (NSF), Geosynthetic Research Institute (GRI), and other applicable test standards, as required in the Technical Specifications. The Geosynthetic CQA Laboratory must have proven their abilities on previous work with the ENGINEER or shall provide the ENGINEER with their Q&E package demonstrating their experience as it relates to the Technical Specifications. The Q&E package shall include a project list showing the name, address, and telephone number of the appropriate party to contact. The Geosynthetic CQA Laboratory must be capable of providing test results within 48 hours from receipt of samples.

The Geosynthetic CQA Laboratory shall provide a contract administrator/project manager for the project as the responsible person to contact. This person shall oversee the analytical procedures and testing as well as review and reporting of the results. The Geosynthetic CQA Laboratory is responsible for performing all geosynthetic laboratory tests and formally submitting results to the ENGINEER as required in the Technical Specifications.

## 3.0 CQA TESTING AND INSPECTION CRITERIA

This section of the CQA Plan describes the inspection activities (observations and tests) that will be performed during construction to ensure that the Facility is constructed to meet or exceed all design criteria, plans, and specifications.

The Owner's Representative shall issue a written daily report of activities. These reports shall include, at a minimum: observations, test results, problems encountered, and solutions achieved. Construction reports summarizing significant events, as well as addressing all problems encountered and their solutions shall be issued to the ENGINEER. The format of these reports and frequency shall be established at the pre-construction meeting.

### 3.1 General Preconstruction Activities

Prior to the start of construction, a pre-construction meeting shall be held among the OWNER, the ENGINEER, Owner's Representative, Geomembrane Installer, and the CONTRACTOR responsible for completing the work. The topics covered at this meeting shall include, but not be limited to:

1. Providing each party with all relevant CQA documents and supporting information.
2. Familiarizing each organization with the site-specific CQA plan, its role relative to accomplishing the intent of the design, as well as review of the Construction Drawings and Technical Specifications.
3. Reviewing the responsibilities of each party.
4. Reviewing lines of authority and communication for each organization.
5. Discussing the established procedures or protocol for construction, change orders, deficiencies, repairs, and retesting.
6. Reviewing methods of documenting and reporting inspection data.
7. Reviewing work area security and safety protocol.
8. Discussing procedures for the location and protection of construction materials, and for the prevention of damage of the materials from inclement weather or other adverse events.
9. Conducting a site walk to review site conditions as well as material staging and storage locations.


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10. Discussing the proposed construction plan, schedule, and procedures.
11. Clarifying installation, testing, and acceptance criteria and procedures.

## 3.2 Earthworks

### *3.2.1 Pre-Construction Testing*

The CONTRACTOR shall provide the OWNER or ENGINEER samples from each borrow source to be used as structural fill. From each borrow source, representative composite sample(s) shall be tested for the following:

1. Soil Classification (ASTM D2487, which includes Grain Size Analysis - ASTM D422 (or D6913) and Atterberg Limits - ASTM D4318); two per source or material type.
2. Compaction Testing (Proctor) (ASTM D698); two per source or material type.
3. Environmental testing, such as TPH and TCLP, may be required for questionable borrow sources at the OWNER's discretion.

### *3.2.2 Soil Excavation and Fill*

Excavation and fill placement shall take place under observation of the Owner's Representative. Fill shall be placed in lifts of no greater than nine inches (compacted thickness) to the lines and grades shown on the Construction Drawings. The Owner's Representative shall collect samples for laboratory testing and provide in-situ moisture and density testing in compliance with the Technical Specifications.

Fill material shall be tested at the frequencies shown below. Testing of trench backfill material will involve in-place moisture content and density tests in accordance with ASTM D6938 at one test per 100 linear feet of trench in lieu of the moisture and density frequencies listed above.

**Table 1: Fill Material Testing**

| Property [(1)] | Test Method | QA Testing Frequency |
|---|---|---|
| USCS Soil Classification [(2)] | ASTM D2487 | 1 per 5,000 cy |
| Moisture Content[(3)] | ASTM D2216 | 1 per 10,000 cy |
| Moisture-Density Relationship (Standard Proctor) [(3)] | ASTM D698 | 1 per 10,000 cy |
| In-place density | ASTM D6938 | 1 per 10,000 sf/lift |
| In-place moisture content | ASTM D6938 | 1 per 10,000 sf/lift |

Notes:
1. The Owner's Representative shall prepare a drawing showing the horizontal and vertical locations of all test locations.
2. Includes grain size (ASTM D422 or D6913) and Atterberg Limits (D4318) as appropriate.
3. Additional tests may be required when soil gradation tests indicate that there has been a change in the material being supplied.

Compact fill material to a minimum percentage of the maximum dry density as determined by a standard Proctor (ASTM D698) as shown in the table below:

**Table 2: Fill Material Compaction**

| Material Type / Use | Compaction Requirement | Moisture Content |
|---|---|---|
| Structural Fill (General) | 95% | -2% to +4% |
| Structural Fill (Road Subgrade) | 98% | -2% to +2% |
| Structural Fill (Embankments) | 95% | -2% to +4% |


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| | | |
|---|---|---|
| Structural Fill (Foundations) | 95% | -2% to +4% |
| Trench Backfill | 95% | -2% to +4% |
| Stockpile | 90% | -2% to +4% |
| Liner Subgrade (Soil) | 95% | -2% to +4% |
| Liner Subgrade (CCR) | 95% | -8% to +8% |
| Protective Cover Soil | 90% | -2% to +4% |
| Vegetative Soil | Do Not Compact | N/A |

### *3.2.3 Subgrade Preparation*

Any earthen surface upon which geomembrane or geosynthetic clay liner is to be installed, including CCR, shall be prepared and compacted in accordance with the Technical Specifications (Section 02200). The surface shall be smooth, firm, unyielding, and free of vegetation, construction debris, sticks or roots, sharp rocks, void spaces, ice, abrupt elevation changes, standing water, desiccation cracks, or puncture hazards.

Immediately before geosynthetic deployment, grade the subgrade to fill in all voids and cracks, and then smooth-roll to provide the best practicable surface for the geosynthetic liner. All protrusions extending more than one-half inch from the surface shall be removed, crushed, or pushed into the surface with a smooth-drum compactor.

### *3.2.4 Final Protective Cover and Vegetative Support Layer Soils*

Final Protective Cover and Vegetative Support Layer soils generally consist of medium-textured soils capable of supporting vegetative growth. No cover soils shall be placed in an area until the underlying geosynthetics in that area are complete and approved by the Owner's Representative. Cover soils shall be placed in maximum 12-inch-thick loose lifts using low ground pressure earthmoving equipment to prevent damage to the underlying geosynthetics. The Owner's Representative shall continuously monitor the placement of cover soils to verify the following:

1. Placement of cover soils does not produce large wrinkles or other deformation of the underlying geosynthetics.
2. The Protective Cover Soil is compacted to the requirements of the Technical Specifications.
3. Vehicles not designated as Low Ground Pressure are restricted to travelling on temporary haul roads at least 36 inches thick.

The thickness of the Final Cover Layer will be verified by survey comparing the top of liner subgrade to the top of Final Cover.

## 3.3 HDPE Geomembrane

Stringent quality assurance and careful documentation are required in the production and installation of all geosynthetic materials. The work addressed under this section shall facilitate proper construction of all high-density polyethylene (HDPE) geosynthetic components of the bottom liner and final cover system. All work shall be constructed to the lines, grades, and dimensions indicated on the Construction Drawings, in accordance with the Technical Specifications, or as required by the OWNER or ENGINEER.


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### *3.3.1 Manufacture of Geomembrane*

The Manufacturer shall perform quality conformance testing on the HDPE geomembrane at the frequencies and for the required physical properties indicated below prior to shipping material to the site.

**Table 3: HDPE Geomembrane Quality Conformance Testing**

| Testing Properties | Testing Method | 40-mil HDPE | 60-mil HDPE | Manufacturer QC Testing Frequency (13) |
|---|---|---|---|---|
| Thickness (min avg)<br>• Lowest individual (8 of 10)<br>• Lowest individual (any) | ASTM D5994 | 38 mil<br>36 mil<br>34 mil | 57 mil<br>54 mil<br>51 mil | 1 per roll |
| Asperity Height (min avg) (1) (2) | ASTM D7466 | 16 mil | 16 mil | 1 per 50,000 sf |
| Density | ASTM D1505 or ASTM D792 | 0.940 g/cc | 0.940 g/cc | 1 per 50,000 sf |
| Tensile Properties (min. avg) (3)<br>• Yield strength<br>• Break strength<br>• Yield elongation<br>• Break elongation | ASTM D6693 Type IV | 84 lb/in<br>60 lb/in<br>12%<br>100% | 126 lb/in<br>90 lb/in<br>12%<br>100% | 1 per 50,000 sf |
| Tear Resistance (min. avg) | ASTM D1004 | 28 lb | 42 lb | 1 per 50,000 sf |
| Puncture Resistance (min. avg) | ASTM D4833 | 60 lb | 90 | 1 per 50,000 sf |
| Stress Crack Resistance (4) | ASTM D5397 (App) | 500 hr | 500 hr | (12) |
| Carbon Black Content (range) (5) | ASTM D4218 | 2.0% - 3.0% | 2.0% - 3.0% | 1 per 50,000 sf |
| Carbon Black Dispersion | ASTM D 5596 | (6) | (6) | 1 per 100,000 sf |
| Oxidative Induction Time (OIT) (min avg) (7)<br>• Standard OIT<br>• High Pressure OIT | ASTM D3895<br>ASTM D5885 | 100<br>400 | 100<br>400 | (12) |
| Oven Aging at 85°C (7) (8)<br>• Standard OIT, % retained after 90 days<br>• High Pressure OIT, % retained after 90 days | ASTM D5721<br>ASTM D3895<br>ASTM D5885 | 55%<br>80% | 55%<br>80% | (12) |
| UV Resistance (9)<br>• Standard OIT (min avg)<br>• High Pressure OIT - % retained after 1600 hours (11) | ASTM D7238<br>ASTM D3895<br>ASTM D5885 | N.R. (10)<br>50% | N.R. (10)<br>50% | (12) |

Notes:
1. The lowest individual reading must be ≥ 12 mils.
2. Test each side of the textured geomembrane recording a measurement every lineal foot of textured roll width.
3. Machine direction (MD) and cross machine direction (XMD) average values should be based on 5 test specimens each direction.
   a. Yield elongation is calculated using a gage length of 1.3 inches.
   b. Break elongation is calculated using a gage length of 2.0 inches.
4. The SP-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 of the same sample.
5. Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
6. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   a. 9 in Categories 1 or 2, and


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b. 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.
12. Manufacturer may provide certification letter.
13. Testing frequencies listed are the minimum.

Prior to the installation, the Manufacturer will provide the Owner's Representative with the following:

1. A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the Technical Specifications or equivalent methods approved by the ENGINEER and Owner's Representative.
2. A list of quantities and descriptions of materials other than the base polymer that comprise the geomembrane.
3. The sampling procedure and results of testing.
4. A certification that property values given in the properties sheet are minimum or maximum values and are guaranteed by the Manufacturer.

The Owner's Representative will verify that:

1. The property values certified by the Manufacturer meet all Specifications.
2. The measurements of properties by the Manufacturer are properly documented, the test methods used are acceptable, and the geomembrane meets the Manufacturer specifications and the Technical Specifications.

### *3.3.2 Transportation and Delivery*

All handling on-site is the responsibility of the CONTRACTOR or Installer. The CONTRACTOR or Installer is responsible for the submittal of shipping manifests and all other relevant documents to the Owner's Representative.

Upon delivery at the site, the Owner's Representative shall inventory all rolls and conduct a surface observation of each roll for defects or damage. The inspection will be performed without unrolling rolls unless defects or damages are found or suspected. The Owner's Representative will indicate those rolls with severe flaws that should be removed from the site and those rolls with minor flaws. The Installer will be responsible for the storage of the geomembrane on-site upon arriving at the site. The OWNER will provide storage space such that on-site transportation and handling are minimized. Storage space should be protected from theft, vandalism, passage of vehicles, etc.

The Owner's Representative will verify that storage space selected is in a well-drained area and that adequate cribbing techniques have been used as needed to ensure that the materials will not be sitting in ponded water in the event of rainfall.

### *3.3.3 Conformance Testing*

The Owner's Representative and a designated independent geosynthetics CQA laboratory will perform quality assurance (QA) testing to verify that the HDPE geomembrane sheet meets the requirements of the Technical Specifications. These tests and frequencies are also indicated below. Samples of the HDPE geomembrane material shall be taken from the leading edge of the roll and shall be three feet wide


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by the length of the roll. Samples shall be taken at the factory prior to shipment or upon delivery at the site.

**Table 4: HDPE Geomembrane Quality Assurance Testing**

| Testing Properties | Testing Method | Conformance QA Testing Frequency (4) |
|---|---|---|
| Thickness (min avg)<br>• Lowest individual (8 of 10)<br>• Lowest individual (any) | ASTM D5994 | 1 per 250,000 sf |
| Asperity Height (min avg) (1) (2) | ASTM D7466 | 1 per 250,000 sf |
| Density | ASTM D1505 or ASTM D792 | 1 per 250,000 sf |
| Tensile Properties (min. avg) (3)<br>• Yield strength<br>• Break strength<br>• Yield elongation<br>• Break elongation | ASTM D6693 Type IV | 1 per 250,000 sf |
| Tear Resistance (min. avg) | ASTM D1004 | 1 per 250,000 sf |
| Puncture Resistance (min. avg) | ASTM D4833 | 1 per 250,000 sf |
| Carbon Black Content (range) (5) | ASTM D4218 | 1 per 250,000 sf |
| Carbon Black Dispersion (6) | ASTM D5596 | 1 per 250,000 sf |

Notes:
1. The lowest individual reading must be ≥ 12 mils.
2. Test each side of the textured geomembrane recording a measurement every lineal foot of textured roll width.
3. Machine direction (MD) and cross machine direction (XMD) average values should be based on 5 test specimens each direction.
   a. Yield elongation is calculated using a gage length of 1.3 inches.
   b. Break elongation is calculated using a gage length of 2.0 inches.
4. Testing frequencies listed are the minimum.
5. Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
6. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   a. 9 in Categories 1 or 2, and
   b. 1 in Category 3.

### *3.3.4 Construction*

The Installer shall submit proposed panel layouts to the Owner's Representative at least two weeks prior to mobilization of installation crews. In general, seams should be oriented parallel to the line of maximum slope, i.e. oriented with, not across, the slope. In corners and other geometrically complex locations, the number of seams should be minimized. No base seam or tee seam will be less than five feet from the toe of slope or areas of potential stress concentrations, unless otherwise authorized by the ENGINEER.

Once the panel layout is approved, the Installer may not substantially change the layout without permission of the Owner's Representative, ENGINEER, or OWNER. The Installer shall submit a drawing of proposed seam completion details at panel corners of three or more sheets to the ENGINEER and the Owner's Representative prior to shipment of the geomembrane.

Subgrade surfaces to receive geomembrane installation shall be relatively smooth and even and free of ruts, voids, protrusions, and deleterious material. The Installer shall provide written certification that the subgrade surface on which the geomembrane will be installed is acceptable. During placement, the Owner's Representative will verify the following:

1. Any equipment used does not damage the geomembrane by handling, trafficking, excessive


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heat, leakage of hydrocarbons, or other means.

2. The prepared surface underlying the geomembrane has not deteriorated since previous acceptance and is still acceptable immediately prior to geomembrane placement.
3. Any geosynthetic elements immediately underlying the geomembrane are of acceptable cleanliness and are free of debris.
4. All personnel working on the geomembrane refrain from smoking, wearing damaging shoes, or other activities that could damage the geomembrane.
5. The method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil.
6. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels).
7. Adequate temporary loading and/or anchoring (e.g., sandbags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, the loading should be continuous along the edges of panels to minimize the risk of wind flow under the panels).
8. Direct contact of equipment with the geomembrane is minimized, i.e., the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected. Portable generators may not be placed directly on the geomembrane but shall be placed on a rub sheet.

After placement and prior to seaming, the Owner's Representative will visually examine each panel for damage. The Owner's Representative will advise the Geomembrane Installer which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels that have been rejected will be marked, and their removal from the work area recorded by the Owner's Representative.

Prior to seaming, the Owner's Representative shall verify that the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material. The Owner's Representative shall verify that the bonding surfaces are thoroughly cleaned by mechanical abrasion for extrusion welds. Testing of the seams shall be conducted by the Installer under the observation of the Owner's Representative. The Installer shall supply qualified personnel and testing equipment. The Owner's Representative or Geosynthetic Laboratory may perform additional testing to verify that the seams meet the requirements of the specifications.

#### 3.3.4.1 HDPE Geomembrane Trial Seams

Trial seams shall be made each day prior to commencing field seaming. The seams shall be made on fragment pieces of geomembrane under the same surface and environmental conditions as the production seams to verify that seaming conditions are adequate. The trial seams shall be made at the beginning of each seaming period; at changes of equipment, equipment settings, operator, weather, or sheet temperature; at the ENGINEER's or Owner's Representative's discretion; and at least once every four to six hours during continuous operation of each welding machine; or at change in material type (i.e., smooth-to-smooth seam versus smooth-to-textured seam). Each seamer shall make at least two test seams each day.

The trial seam sample shall be at least five feet long by one foot wide with the seam centered lengthwise. For dual track fusion welds, nine one-inch wide by six-inch long test strips shall be cut from the trial seam. Quantitatively test three specimens for inside peel adhesion, three specimens for outside peel adhesion,


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and three specimens for bonded seam strength (shear). For extrusion welds, six one-inch wide by six-inch long test strips shall be cut from the trial seam. Quantitatively test three specimens for peel and three specimens for bonded seam strength (shear).

A trial seam sample shall pass when the results shown in the table below are achieved.

**Table 5: HDPE Geomembrane Trial Seam Testing**

| Property | Method | 40-mil HDPE | 60-mil HDPE |
|---|---|---|---|
| Hot Wedge (Fusion) Seams (1)<br>• Shear strength (2)<br>• Peel strength (2)<br>• Peel separation | ASTM D6392 | <br>80 lb/in<br>60 lb/in<br>25% | <br>120 lb/in<br>91 lb/in<br>25% |
| Extrusion Fillet Seams<br>• Shear strength (2)<br>• Peel strength (2)<br>• Peel separation | ASTM D6392 | <br>80 lb/in<br>52 lb/in<br>25% | <br>120 lb/in<br>78 lb/in<br>25% |

Notes:
1. Maximum of one-non FTB (Film Tearing Bond) per five specimens tested is acceptable provided that strength requirements are met on that sample. Film Tearing Bond (FTB) definition: A failure in the ductile mode of one of the bonded sheets by tearing prior to complete separation to the bonded area. Examples of FTB and the associated locus of break codes are provided in ASTM D6392.
2. For double fusion welded seams, both tracks shall be tested for compliance with the minimum property values listed above.

Trial seams shall be repeated, in their entirety, when any of the trial seam samples fail in either peel or shear. If additional trial seams fail, the seaming apparatus or seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved. No welding equipment or welder shall be allowed to begin production welds until equipment and welders have a successfully completed trial seam. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. The Installer shall demonstrate that acceptable seaming can be achieved by completing passing trial seams.

The remainder of the successful trial seam shall be assigned a number and marked accordingly by the Owner's Representative, who shall log the date, hour, ambient temperature, number of seaming apparatus, name of seamer, and pass or fail description. The samples should be archived until project completion.

#### 3.3.4.2 HDPE Geomembrane Non-Destructive Testing

Production seams shall be tested by the Installer continuously using non-destructive techniques. The Installer shall perform all air pressure (fusion welded seams) and vacuum testing (extrusion welded seams) under the observation of the Owner's Representative as follows:

1. Extrusion Weld Testing – Non-destructive testing of the extrusion weld shall be conducted with a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft gasket attached to the bottom, valve assembly and a vacuum gauge. The assembly shall be capable of maintaining at least a 4-psi vacuum. A passing extrusion seam shall exhibit at least a 4-psi vacuum for at least 10 seconds when using a soapy solution to seal the gasket to the seam. The presence of soap bubbles in rapid succession is indicative of a leak. The viewing window should be regularly cleaned to ensure a clear view of the seam section being tested. All areas where soap bubbles appear in rapid succession shall be marked, repaired, and retested.


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2. Fusion Weld Testing – Non-destructive testing of the fusion weld shall be conducted with an air pump or tank capable of generating and sustaining pressure over 30 psi; a sharp, hollow needle, or other approved pressure feed device equipped with a pressure gauge; a utility knife with hook blade; hot air gun or other device and clamp to seal the ends of the air channel. After sealing both ends, the fusion seam shall be pressurized to 30 psi and the pressure allowed to stabilize. A passing fusion seam shall have a maximum 4 psi pressure loss over a five-minute time period.
3. Once the seam passes, the opposite end of the seam shall be punctured to release the air, confirming that the entire seam length had been tested. If air is not released once channel has been punctured, a blockage is present. Locate faulty area where the blockage is and retest seam on both sides of blockage. A pressure gauge at both ends of the seam will also be acceptable.

3.3.4.3 HDPE Geomembrane Destructive Testing

Extrusion and fusion welded field seams shall be destructively tested at a minimum frequency of one test per 500 linear feet of seamed length per welding machine. Destructive test samples shall be located by the Owner's Representative as seaming progresses and shall be removed by the Installer to obtain laboratory test results before the geomembrane is covered. Samples shall be 12-inches wide by minimal length (typically 42 inches) with the seam centered lengthwise (minimum of six inches on either side of the seam). The sample shall be cut into three parts for distribution to the Installer for field testing (12-inches), to the Testing Laboratory for conformance testing (18 inches), and to the OWNER for archive (remainder).

Each sample shall be tested five times each for outer peel, inner peel, and shear. A seam sample shall pass when the results shown in the table below are achieved.

**Table 6: HDPE Geomembrane Destructive Testing**

| Property | Method | 40-mil HDPE | 60-mil HDPE |
|---|---|---|---|
| Hot Wedge (Fusion) Seams (1)(2)<br>• Shear strength (3)<br>• Shear elongation at break (4)<br>• Peel strength (3)<br>• Peel separation | ASTM D6392 | <br>80 lb/in<br>50%<br>60 lb/in<br>25% | <br>120 lb/in<br>50%<br>91 lb/in<br>25% |
| Extrusion Fillet Seams (2)<br>• Shear strength (3)<br>• Shear elongation at break (4)<br>• Peel strength (3)<br>• Peel separation | ASTM D6392 | <br>80 lb/in<br>50%<br>52 lb/in<br>25% | <br>120 lb/in<br>50%<br>78 lb/in<br>25% |

Notes:
1. Maximum of one non-FTB (Film Tearing Bond) per five specimens tested is acceptable provided that strength requirements are met on that sample. Film Tearing Bond (FTB) definition: A failure in the ductile mode of one of the bonded sheets by tearing prior to complete separation to the bonded area. Examples of FTB and the associated locus of break codes are provided in ASTM D6392.
2. Destructive seams will be evaluated for strength parameters according to ASTM D6392 (excluding Section 6.3 "Conditioning").
3. For double fusion welded seams, both tracks shall be tested for compliance with the minimum property values listed above.
4. Elongation measurements should be omitted for field testing.

Samples that do not pass the shear and peel tests shall be resampled from locations at least ten feet on each side of the original location. These two retest samples must pass both shear and peel testing. If these two samples do not pass, then additional samples shall continue to be obtained until the


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questionable seam area is defined.

#### 3.3.4.4 HDPE Geomembrane Repairs

Any portion of unsatisfactory geomembrane or seam area failing a destructive or non-destructive test shall be repaired. Damaged geomembrane shall be removed and replaced with acceptable geomembrane materials if damage cannot be satisfactorily repaired. Installer shall be responsible for repair of damaged or defective areas. Agreement upon the appropriate repair method shall be decided between the OWNER, ENGINEER or Owner's Representative, and the Installer. Procedures available include the following:

1. Patching - Used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.
2. Spot Welding - Used to repair pinholes, other localized flaws (minor), or where geomembrane thickness has been reduced.
3. Capping - Used to repair large lengths of failed seams.
4. Removing the unacceptable seam and replace with new material.

In addition, surfaces of the geomembrane that are to be repaired by extrusion welds shall be lightly abraded with disc grinder or equivalent to assure cleanliness. All geomembrane surfaces shall be clean and dry at the time of repair. Patches or caps shall be extended at least six inches beyond the edge of the defect. All corners of patch material shall be rounded.

The Owner's Representative shall number and log each patch repair, and the Installer shall non-destructively test each repair using methods specified in this plan.

#### 3.3.4.5 Final Inspection

A final inspection shall be completed by the Installer, ENGINEER, Owner's Representative, and OWNER prior to the Installer demobilizing from the site. All identified problem areas shall be repaired by the Installer and accepted by the Owner's Representative prior to the Installer demobilizing from the site.

## 3.4 LLDPE Geomembrane

Stringent quality assurance and careful documentation are required in the production and installation of all geosynthetic materials. The work addressed under this section shall facilitate proper construction of all linear low-density polyethylene (LLDPE) geosynthetic components of the final cover system. All work shall be constructed to the lines, grades, and dimensions indicated on the Construction Drawings, in accordance with the Technical Specifications, or as required by the OWNER or ENGINEER.

### *3.4.1 Manufacture of Geomembrane*

The Manufacturer shall perform quality conformance testing on the LLDPE geomembrane at the frequencies and for the required physical properties indicated below prior to shipping material to the site.


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## Table 7: LLDPE Geomembrane Quality Conformance Testing

| Testing Properties | Test Method | 40-mil LLDPE | 50-mil LLDPE Super Gripnet® | 50-mil LLDPE MicroDrain® | Manufacturer QC Testing Frequency (12) |
|---|---|---|---|---|---|
| Thickness (min avg)<br>• Lowest individual (8 out of 10 values)<br>• Lowest individual (any) | ASTM D5994 | 38 mil<br>36 mil<br><br>34 mil | Nom. (-5%)<br>-10%<br><br>-15% | Nom. (-5%)<br>-10%<br><br>-15% | 1 per roll |
| Asperity Height (min. avg) (1) (2)<br>• Asperity Height<br>• Drainage Stud Height<br>• Friction Stud Height | ASTM D7466 | 16 mil<br>N/A<br>N/A | N/A<br>130 mil<br>175 mil | 20 mil<br>130 mil<br>N/A | 1 per 50,000 sf |
| Density (max) | ASTM D1505/ D792 | 0.939 g/mL | 0.939 g/mL | 0.939 g/mL | 1 per 50,000 sf |
| Tensile Properties (min avg) (3)<br>• Break strength<br>• Break elongation | ASTM D 6693, Type IV | 60 lb/in<br>250% | 75 lb/in<br>250% | 75 lb/in<br>250% | 1 per 50,000 sf |
| 2% Modulus (max) | ASTM D5323 | 2400 lb/in | 3000 lb/in | 3000 lb/in | (11) |
| Tear Resistance (min avg) | ASTM D 1004 | 22 lb | 27 lb | 27 lb | 1 per 50,000 sf |
| Puncture Resistance (min. avg) | ASTM D 4833 | 44 lb | 55 lb | 55 lb | 1 per 50,000 sf |
| Axi-Symmetric Break Resistance Strain (min) | ASTM D5617 | 30% | 30% | 30% | (11) |
| Carbon Black Content | ASTM D 1603 (4) | 2%– 3% | 2%– 3% | 2%– 3% | 1 per 50,000 sf |
| Carbon Black Dispersion (5) | ASTM D 5596 | (5) | (5) | (5) | 1 per 50,000 sf |
| Oxidative Induction Time (OIT) (min avg) (6)<br>• Standard OIT<br>• High Pressure OIT | <br>ASTM D3895<br>ASTM D5885 | <br>100<br>400 | <br>100<br>400 | <br>100<br>400 | (11) |
| Oven Aging at 85°C (6)(7)<br>• Standard OIT, % retained after 90 days<br>• High Pressure OIT, % retained after 90 days | ASTM D5721<br>ASTM D3895<br><br>ASTM D5885 | <br>35%<br><br>60% | <br>35%<br><br>60% | <br>35%<br><br>60% | (11) |
| UV Resistance (8)<br>• Standard OIT (min avg)<br>• High Pressure OIT - % retained after 1600 hours (10) | ASTM D7238<br>ASTM D3895<br>ASTM D5885 | <br>N. R.(9)<br>35% | <br>N. R.(9)<br>35% | <br>N. R.(9)<br>35% | (11) |

Notes:
1. The lowest individual reading must be ≥ 12 mils for 40-mil LLDPE and 16 mils for 50-mil LLDPE.
2. Test each side of the 40-mil textured geomembrane recording a measurement every lineal foot of textured roll width. Test the underside of the 50-mil Super Gripnet® and MicroDrain® Liner recording a measurement every lineal foot of textured roll width.
3. Machine direction (MD) and cross machine direction (XMD) average values should be based on 5 test specimens each direction.
   a. Break elongation is calculated using a gage length of 2.0 inches at 2.0 in/min.
4. Other methods such as D4218 (muffle furnace) or microwave method are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   a. 9 in Categories 1 or 2, and
   b. 1 in Category 3.
6. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
7. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90-day response.
8. The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
9. 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.


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10. UV resistance is based on percent retained value regardless of the original HP-OIT value.
11. Manufacturer may provide certification letter.
12. Testing frequencies listed are the minimum.

Prior to the installation, the Manufacturer will provide the Owner's Representative with the following:

1. A properties sheet including, at a minimum, all specified properties, measured using test methods indicated in the Technical Specifications or equivalent methods approved by the ENGINEER and Owner's Representative.
2. A list of quantities and descriptions of materials other than the base polymer that comprise the geomembrane.
3. The sampling procedure and results of testing.
4. A certification that property values given in the properties sheet are minimum or maximum values and are guaranteed by the Manufacturer.

The Owner's Representative will verify that:

1. The property values certified by the Manufacturer meet all of the Specifications.
2. The measurements of properties by the Manufacturer are properly documented, the test methods used are acceptable, and the geomembrane meets the Manufacturer specifications and the Technical Specifications.

### *3.4.2 Transportation and Delivery*

All handling on-site is the responsibility of the CONTRACTOR or Installer. The CONTRACTOR or Installer is responsible for the submittal of shipping manifests and all other relevant documents to the Owner's Representative.

Upon delivery at the site, the Owner's Representative shall inventory all rolls and conduct a surface observation of each roll for defects or damage. The inspection will be performed without unrolling rolls unless defects or damages are found or suspected. The Owner's Representative will indicate those rolls with severe flaws that should be removed from the site and those rolls with minor flaws. The Installer will be responsible for the storage of the geomembrane on-site upon arriving at the site. The OWNER will provide storage space such that on-site transportation and handling are minimized. Storage space should be protected from theft, vandalism, passage of vehicles, etc.

The Owner's Representative will verify that storage space selected is in a well-drained area and that adequate cribbing techniques have been used as needed to ensure that the materials will not be sitting in ponded water in the event of rainfall.

### *3.4.3 Conformance Testing*

The Owner's Representative and the designated independent Geosynthetics CQA Laboratory will perform QA testing to verify that the LLDPE geomembrane sheet meets the requirements of the Technical Specifications. These tests and frequencies are also indicated below. Samples of the LLDPE geomembrane material shall be taken from the leading edge of the roll and shall be three feet wide by the length of the roll. Samples shall be taken at the factory prior to shipment or upon delivery at the site.


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**Table 8: LLDPE Geomembrane Quality Assurance Testing**

| Testing Properties | Test Method | Conformance QA Testing Frequency |
|---|---|---|
| Thickness (min avg)<br>• Lowest individual (8 out of 10 values)<br>• Lowest individual (any) | ASTM D5994 | 1 per 250,000 sf |
| Asperity Height (min. avg) (1) (2) | ASTM D7466 | 1 per 250,000 sf |
| Density (max) | ASTM D1505/ D792 | 1 per 250,000 sf |
| Tensile Properties (min avg) (3)<br>• Break strength<br>• Break elongation | ASTM D 6693, Type IV | 1 per 250,000 sf |
| Tear Resistance (min avg) | ASTM D 1004 | 1 per 250,000 sf |
| Puncture Resistance (min. avg) | ASTM D 4833 | 1 per 250,000 sf |
| Carbon Black Content | ASTM D 1603 (4) | 1 per 250,000 sf |
| Carbon Black Dispersion (5) | ASTM D 5596 | 1 per 250,000 sf |

Notes:
1. The lowest individual reading must be ≥ 12 mils for 40-mil LLDPE and 16 mils for 50-mil LLDPE.
2. Test each side of the textured geomembrane recording a measurement every lineal foot of textured roll width.
3. Machine direction (MD) and cross machine direction (XMD) average values should be based on 5 test specimens each direction.
   a. Break elongation is calculated using a gage length of 2.0 inches at 2.0 in/min.
4. Other methods such as D4218 (muffle furnace) or microwave method are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   a. 9 in Categories 1 or 2, and
   b. 1 in Category 3.

### *3.4.4 Construction*

The Installer shall submit proposed panel layouts to the Owner's Representative at least two weeks prior to mobilization of installation crews. In general, seams should be oriented parallel to the line of maximum slope, i.e. oriented with, not across, the slope. In corners and other geometrically complex locations, the number of seams should be minimized. No base seam or tee seam will be less than five feet from the toe of slope or areas of potential stress concentrations, unless otherwise authorized by the ENGINEER.

Once the panel layout is approved, the Installer may not substantially change the layout without permission of the Owner's Representative, ENGINEER, or OWNER. The Installer shall submit a drawing of proposed seam completion details at panel corners of three or more sheets to the ENGINEER and the Owner's Representative prior to shipment of the geomembrane.

Subgrade surfaces to receive geomembrane installation shall be relatively smooth and even and free of ruts, voids, protrusions, and deleterious material. The Installer shall provide written certification that the subgrade surface on which the geomembrane will be installed is acceptable. During placement, the Owner's Representative will verify the following:

1. Any equipment used does not damage the geomembrane by handling, trafficking, excessive heat, leakage of hydrocarbons, or other means.
2. The prepared surface underlying the geomembrane has not deteriorated since previous acceptance and is still acceptable immediately prior to geomembrane placement.
3. Any geosynthetic elements immediately underlying the geomembrane are of acceptable cleanliness and are free of debris.


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4. All personnel working on the geomembrane refrain from smoking, wearing damaging shoes, or other activities that could damage the geomembrane.
5. The method used to unroll the panels does not cause scratches or crimps in the geomembrane and does not damage the supporting soil.
6. The method used to place the panels minimizes wrinkles (especially differential wrinkles between adjacent panels).
7. Adequate temporary loading and/or anchoring (e.g., sandbags, tires), not likely to damage the geomembrane, has been placed to prevent uplift by wind (in case of high winds, the loading should be continuous along the edges of panels to minimize the risk of wind flow under the panels).
8. Direct contact of equipment with the geomembrane is minimized, i.e., the geomembrane is protected by geotextiles, extra geomembrane, or other suitable materials, in areas where excessive traffic may be expected. Portable generators may not be placed directly on the geomembrane but shall be placed on a rub sheet.

After placement and prior to seaming, the Owner's Representative will visually examine each panel for damage. The Owner's Representative will advise the Geomembrane Installer which panels, or portions of panels, should be rejected, repaired, or accepted. Damaged panels or portions of damaged panels that have been rejected will be marked, and their removal from the work area recorded by the Owner's Representative.

Prior to seaming, the Owner's Representative shall verify that the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material. The Owner's Representative shall verify that the bonding surfaces are thoroughly cleaned by mechanical abrasion for extrusion welds. Testing of the seams shall be conducted by the Installer under the observation of the Owner's Representative. The Installer shall supply qualified personnel and testing equipment. The Owner's Representative or Geosynthetic Laboratory may perform additional testing to verify that the seams meet the requirements of the specifications.

#### 3.4.4.1 LLDPE Geomembrane Trial Seams

Trial seams shall be made each day prior to commencing field seaming. The seams shall be made on fragment pieces of geomembrane under the same surface and environmental conditions as the production seams to verify that seaming conditions are adequate. The trial seams shall be made at the beginning of each seaming period; at changes of equipment, equipment settings, operator, weather, or sheet temperature; at the ENGINEER's or Owner's Representative's discretion; and at least once every four to six hours during continuous operation of each welding machine; or at change in material type (i.e., smooth-to-smooth seam versus smooth-to-textured seam). Each seamer shall make at least two test seams each day.

The trial seam sample shall be at least five feet long by one foot wide with the seam centered lengthwise. For dual track fusion welds, nine one-inch wide by six-inch long test strips shall be cut from the trial seam. Quantitatively test three specimens for inside peel adhesion, three specimens for outside peel adhesion, and three specimens for bonded seam strength (shear). For extrusion welds, six one-inch wide by six-inch long test strips shall be cut from the trial seam. Quantitatively test three specimens for peel and three specimens for bonded seam strength (shear).

A trial seam sample shall pass when the results shown in the table below are achieved.


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**Table 9: LLDPE Geomembrane Trial Seam Testing**

| Property | Method | 40-mil LLDPE | 50-mil LLDPE |
|---|---|---|---|
| Hot Wedge (Fusion) Seams [1]<br>• Shear strength [2]<br>• Peel strength [2]<br>• Peel separation | ASTM D6392 | <br>60 lb/in<br>50 lb/in<br>25% | <br>75 lb/in<br>63 lb/in<br>25% |
| Extrusion Fillet Seams<br>• Shear strength [2]<br>• Peel strength [2]<br>• Peel separation | ASTM D6392 | <br>60 lb/in<br>44 lb/in<br>25% | <br>75 lb/in<br>57 lb/in<br>25% |

Notes:
1. Maximum of one-non FTB (Film Tear Bond) per five specimens tested is acceptable provided that strength requirements are met on that sample. Film Tearing Bond (FTB) definition: A failure in the ductile mode of one of the bonded sheets by tearing prior to complete separation to the bonded area. Examples of FTB and the associated locus of break codes are provided in ASTM D6392.
2. For double fusion welded seams, both tracks shall be tested for compliance with the minimum property values listed above.

Trial seams shall be repeated, in their entirety, when any of the trial seam samples fail in either peel or shear. If additional trial seams fail, the seaming apparatus or seamer shall not be accepted and shall not be used for seaming until the deficiencies are corrected and two consecutive successful full trial seams are achieved. No welding equipment or welder shall be allowed to begin production welds until equipment and welders have a successfully completed trial seam. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. Installer shall demonstrate that acceptable seaming can be achieved by completing passing trial seams.

The remainder of the successful trial seam shall be assigned a number and marked accordingly by the Owner's Representative, who shall log the date, hour, ambient temperature, seaming apparatus number, name of seamer, and pass or fail description. The samples should be archived until project completion.

3.4.4.2 LLDPE Geomembrane Non-Destructive Testing

Production seams shall be tested by the Installer continuously using non-destructive techniques. The Installer shall perform all air pressure (fusion welded seams) and vacuum testing (extrusion welded seams) under the observation of the Owner's Representative as follows:

1. Extrusion Weld Testing – Non-destructive testing of the extrusion weld shall be conducted with a vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft gasket attached to the bottom, valve assembly and a vacuum gauge. The assembly shall be capable of maintaining at least a 4-psi vacuum. A passing extrusion seam shall exhibit at least a 4-psi vacuum for at least 10 seconds when using a soapy solution to seal the gasket to the seam. The presence of soap bubbles in rapid succession is indicative of a leak. The viewing window should be regularly cleaned to ensure a clear view of the seam section being tested. All areas where soap bubbles appear in rapid succession shall be marked, repaired, and retested.
2. Fusion Weld Testing – Non-destructive testing of the fusion weld shall be conducted with an air pump or tank capable of generating and sustaining pressure over 30 psi; a sharp, hollow needle, or other approved pressure feed device equipped with a pressure gauge; a utility knife with hook blade; hot air gun or other device and clamp to seal the ends of the air channel. After sealing both ends, the fusion seam shall be pressurized to 30 psi and the pressure allowed to stabilize. A passing fusion seam shall have a maximum 4 psi pressure loss over a five-minute time period.


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3. Once the seam passes, the opposite end of the seam shall be punctured to release the air, confirming that the entire seam length had been tested. If air is not released once channel has been punctured, a blockage is present. Locate faulty area where the blockage is and retest seam on both sides of blockage. A pressure gauge at both ends of the seam will also be acceptable.

#### 3.4.4.3 LLDPE Geomembrane Destructive Testing

Extrusion and fusion welded field seams shall be destructively tested at a minimum frequency of one test per 500 linear feet of seamed length per welding machine. Destructive test samples shall be located by the Owner's Representative as seaming progresses and shall be removed by the Installer to obtain laboratory test results before the geomembrane is covered. Samples shall be 12-inches wide by minimal length (typically 42 inches) with the seam centered lengthwise (minimum of six inches on either side of the seam). The sample shall be cut into three parts for distribution to the Installer for field testing (12-inches), to the Testing Laboratory for conformance testing (18 inches), and to the OWNER for archive (remainder).

Each sample shall be tested five times each for outer peel, inner peel, and shear. A seam sample shall pass when the results shown in the table below are achieved.

**Table 10: LLDPE Geomembrane Destructive Testing**

| Property | Method | 40-mil LLDPE | 50-mil LLDPE |
|---|---|---|---|
| Hot Wedge (Fusion) Seams [1][2] | | | |
| • Shear strength [3] | ASTM D6392 | 60 lb/in | 75 lb/in |
| • Shear elongation at break [4] | | 50% | 50% |
| • Peel strength [3] | | 50 lb/in | 63 lb/in |
| • Peel separation | | 25% | 25% |
| Extrusion Fillet Seams [2] | | | |
| • Shear strength [3] | ASTM D6392 | 60 lb/in | 75 lb/in |
| • Shear elongation at break [4] | | 50% | 50% |
| • Peel strength [3] | | 44 lb/in | 57 lb/in |
| • Peel separation | | 25% | 25% |

Notes:
1. Maximum of one-non FTB (Film Tear Bond) per five specimens tested is acceptable provided that strength requirements are met on that sample. Film Tearing Bond (FTB) definition: A failure in the ductile mode of one of the bonded sheets by tearing prior to complete separation to the bonded area. Examples of FTB and the associated locus of break codes are provided in ASTM D6392.
2. Destructive seams will be evaluated for strength parameters according to ASTM D6392 (excluding Section 6.3 "Conditioning").
3. For double fusion welded seams, both tracks shall be tested for compliance with the minimum property values listed above.
4. Elongation measurements should be omitted for field-testing.

Samples that do not pass the shear and peel tests shall be resampled from locations at least ten feet on each side of the original location. These two retest samples must pass both shear and peel testing. If these two samples do not pass, then additional samples shall continue to be obtained until the questionable seam area is defined.

#### 3.4.4.4 LLDPE Geomembrane Repairs

Any portion of unsatisfactory geomembrane or seam area failing a destructive or non-destructive test shall be repaired. Damaged geomembrane shall be removed and replaced with acceptable geomembrane materials if damage cannot be satisfactorily repaired. Installer shall be responsible for repair of damaged or defective areas. Agreement upon the appropriate repair method shall be decided


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between the OWNER, ENGINEER or Owner's Representative, and the Installer. Procedures available include the following:

1. Patching - Used to repair large holes, tears, undispersed raw materials, and contamination by foreign matter.
2. Spot Welding - Used to repair pinholes, other localized flaws (minor), or where geomembrane thickness has been reduced.
3. Capping - Used to repair large lengths of failed seams.
4. Removing the unacceptable seam and replace with new material.

In addition, surfaces of the geomembrane that are to be repaired by extrusion welds shall be lightly abraded with disc grinder or equivalent to assure cleanliness. All geomembrane surfaces shall be clean and dry at the time of repair. Patches or caps shall be extended at least six inches beyond the edge of the defect. All corners of patch material shall be rounded.

The Owner's Representative shall number and log each patch repair, and the Installer shall non-destructively test each repair using methods specified in this plan.

3.4.4.5 Final Inspection

A final inspection shall be completed by the Installer, ENGINEER, Owner's Representative, and OWNER prior to the Installer demobilizing from the site. All identified problem areas shall be repaired by the Installer and accepted by the Owner's Representative prior to the Installer demobilizing from the site.

## 3.5 Geosynthetic Clay Liner

This section presents general procedures, quality control testing requirements, and installation procedures for geosynthetic clay liner (GCL) construction. The GCL approved for use at the site consists of sodium montmorillonite clay (bentonite) encapsulated between two needle-punched geotextile layers. All work shall be constructed to the lines, grades, and dimensions indicated on the Construction Drawings, in accordance with the Technical Specifications, or as required by the OWNER or ENGINEER.

### *3.5.1 Manufacture of GCL*

The Manufacturer shall perform MQC testing on the GCL at the frequencies and for the required physical properties indicated below prior to shipping material to the site.

**Table 11: Bentonite Clay Properties**

| Property | Test Method | Value | Manufacturing QC Testing Frequency |
|---|---|---|---|
| Swell Index (min avg) | ASTM D5890 | 24 ml/2g | 1 per 100,000 lbs |
| Fluid loss (max) | ASTM D5891 | 18 ml | 1 per 100,000 lbs |

**Table 12: Geotextile Properties**

| Property | Test Method | Value | Manufacturing QC Testing Frequency |
|---|---|---|---|
| Mass/Unit Area (min avg) | ASTM D5261 | 5.9 oz/yd$^2$ | 1 per 200,000 sf |


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**Table 13: GCL (as Manufactured) Properties**

| Property | Test Method | Value | Manufacturing QC Testing Frequency |
|---|---|---|---|
| Mass/Unit Area (GCL) (1) | D5993 | 0.81 lb/sf | 1 per 45,000 sf |
| Mass/Unit Area (bentonite) (1) | D5993 | 0.75 lb/sf | 1 per 45,000 sf |
| Moisture Content (max) | D5993 | 35% | 1 per 45,000 sf |
| Tensile Strength (M.D.) | D6768 | 23 lb/in | 1 per 225,000 sf |
| Peel Strength | D6496 | 3.5 lb/in | 1 per 45,000 sf |
| Permeability (max)<br>• Final Cover<br>• Bottom Liner | D5887 | $5x10^{-9}$ cm/s<br>$3.4x10^{-9}$ cm/s | 1 per 250,000 sf |

Notes:
1. Mass of the GCL and bentonite is measured after oven drying per ASTM D5993.

Prior to the installation, the Manufacturer will provide the Owner's Representative with the following:

1. Manufacturer's certified raw and roll material data sheets. The certified data sheets shall be attested to by a person having legal authority to bind the GCL manufacturing company. Certified test results shall be submitted at the frequencies specified in Specification 02240 at least 7 days prior to shipment of the GCL.
2. Manufacturer's warranty statement.
3. Qualification statements for the manufacturer, QC inspector, and QC laboratory, including resumes of key personnel involved in this project.
4. Manufacturer's QC laboratory test results including description of equipment and test methods. Results shall include internal shear strength test results at least 25 days prior to deployment.

The Owner's Representative will verify that:

1. The property values certified by the Manufacturer meet all of the Specifications.
2. The measurements of properties by the Manufacturer are properly documented, the test methods used are acceptable, and the geomembrane meets the Manufacturer specifications and the Technical Specifications.

### *3.5.2 Quality Assurance Testing*

QA testing shall be performed by an independent testing laboratory in accordance with the table below.

**Table 14: GCL Quality Assurance Testing**

| Property | Test Method | Value | QA Testing Frequency |
|---|---|---|---|
| Moisture Content (max) | D5993 | 35% | 1 per 250,000 sf |
| Tensile strength (M.D.) | D6768 | 23 lb/in | 1 per 250,000 sf |
| Peel strength | D6496 | 3.5 lb/in | 1 per 250,000 sf |
| Permeability (max)<br>• Final Cover<br>• Bottom Liner | D5887 | $5x10^{-9}$ cm/s<br>$3.4x10^{-9}$ cm/s | 1 per 250,000 sf |


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### *3.5.3 Transportation and Delivery*

All handling on-site is the responsibility of the CONTRACTOR or Installer. The CONTRACTOR or Installer is responsible for the submittal of shipping manifests and all other relevant documents to the Owner's Representative.

Upon delivery at the site, the Owner's Representative shall inventory all rolls and conduct a surface observation of each roll for defects or damage. The inspection will be performed without unrolling rolls unless defects or damages are found or suspected. The Owner's Representative will indicate those rolls with severe flaws that should be removed from the site and those rolls with minor flaws. In order to prevent premature hydration, the GCL rolls shall be shipped in plastic wrapping that shall remain intact until material installation. The rolls will be stacked, stored, and handled in accordance with ASTM D5888, the Technical Specifications, and manufacturer's recommendations.

The Owner's Representative will verify that storage space selected is in a well-drained area and that adequate cribbing techniques have been used to ensure that the materials will not be sitting in ponded water in the event of rainfall.

### *3.5.4 Construction*

#### 3.5.4.1 GCL Subgrade

A controlled subgrade with a minimum thickness of 12 inches shall be provided immediately beneath the GCL. The controlled subgrade shall conform to the requirements of Section 3.2 of this CQA Plan and Sections 02200 and 02240 of the Technical Specifications.

The subgrade surface shall be smooth and free of vegetation, standing water, and angular stones or other foreign matter that could damage the GCL. At a minimum, the subgrade surface shall be rolled with a smooth-drum compactor of sufficient weight to remove most wheel ruts, footprints, or other abrupt grade changes. Minor irregularities on the surface area are acceptable so long as protrusions, rocks, etc. extending more than 3/8-inch from the subgrade are removed, crushed, or pushed into the surface with the smooth-drum compactor.

#### 3.5.4.2 Anchor Trench Construction

The anchor trench shall be constructed according to the project plans and specifications, and the excavation and backfilling operations shall be documented. If the anchor trench is excavated in a clay material susceptible to desiccation, the amount of anchor trench open at any time should be minimized. The inside edge of the trench shall be rounded so as to avoid stresses from sharp bends in the GCL. The GCL shall not be placed into the anchor trench on top of any rocks greater than ½-inch diameter, sharp/angular objects, sticks, roots, or debris of any kind. The anchor trench shall be adequately drained to prevent ponding or hydration of the GCL while the trench is open. The anchor trench shall be backfilled and compacted according to the Contract Drawings and Technical Specifications.

#### 3.5.4.3 GCL Deployment

Equipment used to deploy GCL must not cause excessive rutting of the subgrade. Deployed GCL panels should contain no folds or excessive slack. Installation personnel must not smoke or wear damaging shoes on GCL; and GCL should not be placed during excessive winds. Vehicle traffic other than low contact pressure vehicles such as smooth-tired ATVs or golf carts must not be allowed on the deployed


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GCL. Generators, gasoline or solvent cans, tools, or supplies must not be stored directly on the GCL.

On sideslopes, the GCL should be suspended or anchored at the top of the slope and then unrolled working down to keep the material free of wrinkles and folds.

Panels should be overlapped and seamed as described in the Technical Specifications and as recommended by the manufacturer. End-to-end seams on sideslopes should be kept to a minimum. If end-to-end seams are necessary on sideslopes (i.e., if the GCL roll lengths are insufficient to cover the entire slope length), a minimum overlap of 3 feet will be required. Seams may be glued as recommended by the manufacturer. In addition, end-to-end seams may be placed only in the lower half of the slope and must be staggered.

GCL deployment shall be limited to the amount that can be covered with the overlying geomembrane liner the same day. GCL deployment shall not be undertaken during precipitation or when there is an impending threat of precipitation.

Following deployment, the Owner's Representative shall visually examine the entire surface of the GCL for even bentonite distribution, thin spots, or other panel defects. All defects will be recorded and repaired in accordance with the project specifications. The Owner's Representative shall also verify the following:

1. Proper overlap during deployment.
2. Seams between GCL panels are constructed per manufacturer's recommendations.
3. Defects are patched and overlapped properly.
4. The bentonite has not become excessively hydrated.

#### 3.5.4.4 Repairs

Torn or otherwise damaged GCL must be patched with the same type of GCL. The GCL patch must extend at least 12 inches beyond the edge of the damaged area and must be adhesive or heat bonded or otherwise attached to the main GCL to avoid shifting during backfilling or placement of overlying geosynthetics. Lapping procedures must be the same as specified for original laps of GCL panels.

#### 3.5.4.5 GCL Protection

The overlying geosynthetics and soil layers shall be deployed in such a manner as to ensure that the GCL is not damaged. Textured geomembranes shall not be dragged across previously installed GCL. A smooth rub sheet shall be placed between the GCL and textured geomembrane during handling to prevent damage. The rub sheet will be removed when the geomembrane is in position. Other methods may be employed at the discretion of the Owner's Representative.

#### 3.5.4.6 Final Inspection

A final inspection shall be completed by the installer, ENGINEER, Owner's Representative, and OWNER prior to the Installer demobilizing from the site. All identified problem areas shall be repaired by the Installer and accepted by the Owner's Representative prior to the Installer demobilizing from the site.

## 3.6 Geonet and Geonet Composite

### *3.6.1 Manufacture of Geonet Composite*

The geonet composite manufacturer shall provide the ENGINEER and the Owner's Representative with a


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list of guaranteed properties as well as a Manufacturer's installation guide and a written certification signed by an officer or the Manufacturer's Quality Control Manager indicating that the delivered geonet composite has properties which meet or exceed the guaranteed properties for the type of geonet composite specified. The certification shall include the following:

1. Product identification.
2. Lot number.
3. Geonet composite roll numbers affected by shipment.
4. Manufacturer's quality control test results.

At a minimum, the Manufacturer's quality control (QC) testing frequency should meet the requirements shown below. The geotextile component of the geonet composite shall conform to the requirements of the 8-oz/yd$^2$ nonwoven geotextile shown in Section 3.7.1.

**Table 15: Geonet Component**

| Property | Test Method | 250-mil GC | 275-mil GC | Manufacturing QC Testing Frequency | QA Testing Frequency |
|---|---|---|---|---|---|
| Thickness (min avg) | ASTM D5199 | 250 mil | 275 mil | 1 per 100,000 sf | 1 per 250,000 sf |
| Density (min avg) | ASTM D792 or ASTM D1505 | 0.940 g/cm$^3$ | 0.940 g/cm$^3$ | 1 per 100,000 sf | 1 per 250,000 sf |
| Tensile Strength (min avg) | ASTM D5035/D7179 | 55 lb | 65 lb | 1 per 100,000 sf | 1 per 250,000 sf |
| Carbon Black Content (range) | ASTM D1603 | 2%-3% | 2%-3% | 1 per 100,000 sf | 1 per 250,000 sf |

**Table 16: Finished Geocomposite**

| Property | Test Method | Test Value | Manufacturing QC Testing Frequency | QA Testing Frequency |
|---|---|---|---|---|
| Ply Adhesion (min avg) | ASTM D7005 | 1.0 lb/in | 1 per 100,000 sf | 1 per 250,000 sf |
| Transmissivity, 250 mil and 275 mil (min avg) (1) | ASTM D4716 | (2) | 1 per project | 1 per 500,000 sf |
| Transmissivity, 250 mil only (min avg) (3a) (5) | ASTM D4716 | $9.0 \times 10^{-4}$ m$^2$/s (4a)<br>$2.2 \times 10^{-4}$ m$^2$/s (4b) | N/A | 1 per 500,000 sf |
| Transmissivity, 250 mil only (3b) (4) (5) | ASTM D4716 | (6) | N/A | 1 per project |
| Transmissivity, 275 mil only (3c) (4a) (5) | ASTM D4716 | $1.13 \times 10^{-3}$ m$^2$/s | N/A | 1 per 500,000 sf |

Notes:
1. Transmissivity shall be measured in a 12-inch x 12-inch box using the same boundary conditions, load, duration, and gradient as those used by the manufacturer to establish the min. avg for the required test value.
2. Required value shall be taken from manufacturer's standard material specification sheet for the selected geocomposite material.
3. Transmissivity shall be measured in a 12-inch x 12-inch box using a 100-hour duration and the following gradient and boundary conditions:
    a. 0.05 and Soil/Geocomposite/Geomembrane
    b. 0.05 and Aggregate/Geocomposite/Geomembrane
    c. 0.33 and Soil/Geocomposite/Geomembrane
4. Load conditions for transmissivity testing shall be as follows:
    a. 1,000 psf
    b. 10,000 psf
5. Engineer may approve lower transmissivity values based on analysis of design calculations.
6. Value shall be reviewed and approved by Engineer.


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### *3.6.2 Conformance Testing*

The Owner's Representative or a designated independent geosynthetics laboratory will perform additional QA testing to verify that the geonet composite meets the requirements of the specifications. These tests and frequencies are indicated in Section 3.6.1 above. Samples of the geonet composite drainage fabric shall be taken from the leading edge of the roll and shall be three feet wide by the length of the roll. Samples shall be taken at the factory prior to shipment or upon delivery at the site.

Upon delivery at the site, the Owner's Representative shall inventory all rolls and conduct a surface observation of each roll for defects or damage. The inspection will be performed without unrolling rolls unless defects or damages are found or suspected. The Owner's Representative will indicate those rolls with severe flaws that should be removed from the site and those rolls with minor flaws.

### *3.6.3 Transportation and Delivery*

All handling on-site is the responsibility of the CONTRACTOR or Installer. The CONTRACTOR or Installer is responsible for the submittal of shipping manifests and all other relevant documents to the Owner's Representative. The Installer will be responsible for the storage of the geonet composite on-site. The OWNER will provide storage space such that on-site transportation and handling are minimized. Storage space should be protected from theft, vandalism, passage of vehicles, etc.

The Owner's Representative will verify that storage space selected is in a well-drained area and that cribbing techniques have been used as needed to ensure that the materials will not be sitting in ponded water in the event of rainfall.

### *3.6.4 Construction*

During deployment, the Owner's Representative shall inspect the geonet composite for damage due to equipment, deployment across the geomembrane, or other potentially damaging activities. The Installer shall handle all geonet composites in such a manner as to ensure they are not damaged in any way.

On slopes, the geonet composites shall be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geonet composite sheet in tension. If necessary, the geonet composites shall be positioned by hand after being unrolled to minimize wrinkles. Geonet composites shall not be placed in the horizontal direction, i.e., across the slope.

In the presence of excessive wind, geonet composites shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during placement and shall remain until replaced with cover material.

Adjacent and end-to-end geonet composites shall be joined according to the Manufacturer's recommendations, the Manufacturer's Installation Guide, Construction Drawings, and Technical Specifications. At a minimum, the following requirements shall be met:

1. Adjacent rolls shall overlap the geonet component by at least four inches and end-to-end rolls shall overlap the geonet component by at least six inches.
2. Roll overlaps shall be secured by tying.
3. Tying can be achieved by plastic fasteners or polymer braid. Tying devices shall be white or yellow for easy inspection. Metallic devices are not allowed.
4. Fasteners shall be spaced a maximum of five feet along downslope roll overlaps, a maximum of one foot along cross-slope roll overlaps, and a maximum of six inches in an anchor trench.


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5. The edges of the geotextile component shall be continuously sewn or heat bonded together using a method approved by the ENGINEER.

Holes or tears in the geonet composite shall be repaired by placing a patch of geonet composite extending a minimum of two feet beyond the edges of the hole or tear. The patch shall be fastened to the original roll with approved fasteners spaced every six inches around the patch. If the hole or tear width across the roll is more than 50 percent the width of the roll, the damaged area shall be cut out and the two portions of the geonet shall be tied together every six inches.

## 3.7 Geotextile

### *3.7.1 Manufacture of Geotextile*

The geotextile manufacturer shall provide the ENGINEER and the Owner's Representative with a list of guaranteed properties for the type of geotextile to be supplied for the final cover system. The geotextile manufacturer shall provide the ENGINEER and the Owner's Representative with a Manufacturer's installation guide and a written certification signed by an officer or the Manufacturer's Quality Control Manager indicating that the geotextile actually delivered has properties which meet or exceed the guaranteed properties for the type of geotextile specified. The certification shall include the following:

1. Product identification.
2. Lot number.
3. Geotextile roll numbers included in the shipment.
4. Manufacturer's quality control test results.

For geotextile material requiring heat burnishing, the required testing will be performed prior to heat burnishing of the material. The minimum testing requirements are shown in the table below.

**Table 17: Geotextile Quality Conformance Testing**

| Property [(1)] | Test Method | 8-oz Filter GT | 10-oz Cushion GT | Manufacturer's QC Testing Frequency |
|---|---|---|---|---|
| Mass/Unit Area (min avg) | ASTM D5261 | 8 oz/yd$^2$ | 10 oz/yd$^2$ | 1 per 100,000 sf |
| Grab Tensile Strength | ASTM D4632 | 158 lb | 230 lb | 1 per 100,000 sf |
| Grab Tensile Elongation | ASTM D4632 | 50% | 50% | 1 per 100,000 sf |
| Trapezoidal Tear Strength | ASTM D4533 | 56 lb | 95 lb | 1 per 100,000 sf |
| Puncture Strength | ASTM D6241 | 320 lbs | 700 lb | 1 per 100,000 sf |
| Apparent Opening Size (AOS) | ASTM D4751 | 0.0084 in | 0.0058 in | 1 per 500,000 sf |
| Permittivity | ASTM D4491 | 1.1 sec$^{-1}$ | N/A | 1 per 500,000 sf |
| UV Stability (min) [(2)] | ASTM D7238 | 70% | 70% | Certified by Manufacturer |

Notes:
1. All values are minimum average roll values (MARV) except AOS, which is a maximum average roll value.
2. Evaluation to be on 2.0-inch strip tensile specimens per ASTM D5035 after 500 lt. hrs. exposure.

Upon delivery of non-woven geotextile to the site, the Owner's Representative shall obtain representative samples of the furnished product for conformance testing. The required material properties, test methods, values, and units are presented below. CQA conformance testing is not required for woven geotextiles.


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**Table 18: Geotextile Quality Assurance Testing**

| Property [(1)] | Test Method | QA Testing Frequency |
|---|---|---|
| Mass/Unit Area (min avg) | ASTM D5261 | 1 per 250,000 sf |
| Grab Tensile Strength | ASTM D4632 | 1 per 250,000 sf |
| Grab Tensile Elongation | ASTM D4632 | 1 per 250,000 sf |
| Trapezoidal Tear Strength | ASTM D4533 | 1 per 250,000 sf |
| Puncture Strength | ASTM D6241 | 1 per 250,000 sf |
| Apparent Opening Size (AOS) | ASTM D4751 | 1 per 500,000 sf |
| Permittivity | ASTM D4491 | 1 per 500,000 sf |

Notes:
1. All values are minimum average roll values (MARV) except AOS, which is a maximum average roll value.

### *3.7.2 Transportation and Delivery*

All handling on-site is the responsibility of the CONTRACTOR or Installer. The CONTRACTOR or Installer is responsible for the submittal of shipping manifests and all other relevant documents to the Owner's Representative. The Installer will be responsible for the storage of the geotextile on-site. The OWNER will provide storage space such that on-site transportation and handling are minimized. Storage space should be protected from theft, vandalism, passage of vehicles, etc.

The Owner's Representative will verify that storage space selected is in a well-drained area and that cribbing techniques have been used as needed to ensure that the materials will not be sitting in ponded water in the event of rainfall.

### *3.7.3 Construction*

During deployment, the Owner's Representative shall inspect the geotextile for damage due to equipment, deployment across the geomembrane, or other potentially damaging activities. The Installer shall handle all geotextile in such a manner as to ensure they are not damaged in any way.

On slopes, the geotextile shall be secured in the anchor trench and then rolled down the slope in such a manner as to continually keep the geonet composite sheet in tension. If necessary, the geotextile shall be positioned by hand after being unrolled to minimize wrinkles. Geotextile shall not be placed in the horizontal direction, i.e., across the slope. In the case of heat-burnished geotextile, the heat burnished side shall be installed facing down (against the MicroDrain® or Super Gripnet® geomembrane).

In the presence of excessive wind, geotextile shall be weighted with sandbags or equivalent. Sandbags shall be installed during placement and shall remain until removed and replaced with soil cover material.

Adjacent geotextile shall be joined according to the Manufacturer's recommendations, the Manufacturer's Installation Guide, Construction Drawings, and Specifications. As a minimum, the following requirements shall be met:

1. Adjacent rolls shall overlap the geotextile by at least six inches.
2. The edges of the geotextile shall be continuously sewn or heat bonded together using a method approved by the ENGINEER.

Holes or tears in the geotextile shall be repaired by sewing or heat-bonding a patch of geotextile


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extending a minimum of two feet beyond the edges of the hole or tear.

## 3.8 Leachate Collection Drainage Layer

The leachate collection layer shall consist of a 12-inch coarse aggregate drainage layer overlain by a 6-inch fine aggregate protective layer or shall be 18 inches of fine or coarse aggregate. Where CCR or fine aggregate is placed atop coarse aggregate, a 10-oz filter/separation geotextile shall be placed in between. Coarse aggregate shall be VDOT No. 57, 78, or 8 stone. Fine aggregate shall be VDOT A, B or No. 10 sand. The leachate Collection Sump stone shall be VDOT No. 3. Coarse and Fine aggregates must meet a minimum hydraulic conductivity of $1x10^{-3}$ cm/sec. The leachate collection layer shall be placed according to the Technical Specifications and Construction Drawings. The leachate collection layer shall be free of rubble, wood, stumps, brush, metal, cinders, trash, demolition debris, garbage, topsoil, organic soil, loam, sludge, and other deleterious materials.

Leachate collection pipes shall be bedded in VDOT No. 57 stone. In the event that fine aggregate is used for the leachate drainage layer, 57 stone shall be wrapped in an 8 oz, non-woven geotextile to prevent fine aggregate from infiltrating 57 stone and leachate collection pipes.

### *3.8.1 Material Evaluation*

Preconstruction material evaluations shall be performed on samples from potential sources to ascertain their acceptability as construction materials. Testing shall be performed to verify material compliance with Section 02232 (Leachate Collection Layer) of the Technical Specifications.

Criteria to be used for determination of acceptable materials for construction shall be as defined in the Technical Specifications and as detailed in this CQA Plan. All evaluation tests are to be performed in the Geotechnical CQA Laboratory approved for use by the Owner's Representative. Test reports will state compliance with or deviation from applicable ASTM standards.

#### 3.8.1.1 Preconstruction Material Evaluation

Material proposed for use in construction of the leachate collection layer shall be tested in accordance with Section 02232 of the Technical Specifications to ascertain their acceptability as construction materials. Where material types vary substantially and are not segregated, representative blends anticipated for leachate collection layer construction should also be sampled and tested.

As a general rule, a minimum of two series of preconstruction tests should be performed for every source of material to be used as leachate drainage material. Additional preconstruction samples should be taken when the material varies or as soon as the initial preconstruction test results appear inappropriate or questionable. When the same borrow source is utilized for more than one base liner area, results from previous tests may be used to supplement the preconstruction data.

Prior to delivery of the proposed leachate collection material to the site, at least two samples from each proposed source shall be tested as follows:

1. Grain Size – ASTM C136
2. Permeability – ASTM D2434
3. Carbonate Content – ASTM D3042
4. Interface Friction Angle – ASTM D 5321 (one test per project)


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### *3.8.2 Construction Observation and Testing*

Observation of the drainage layer placement shall be coordinated with construction testing. Acceptance criteria for construction work shall be as identified in the Technical Specifications. At a minimum, the Owner's Representative shall observe and record the following during the placement of the leachate collection layer:

1. Consistency of the materials during processing and placement.
2. Lift thickness.
3. Deleterious material that may damage underlying geosynthetic components.
4. Equipment used for placing leachate collection layer materials is not driven directly onto the geomembrane.
5. A minimum thickness of 12 inches of leachate collection material is maintained between a light dozer (ground pressure of 5 psi or lighter) and the geosynthetics (or as required by the Technical Specifications).

When placing overlying material on the geomembrane, every effort must be made to minimize wrinkle development. Small wrinkles should be isolated and covered as quickly as possible to prevent their growth. The placement of cover materials shall be observed by the Owner's Representative to ensure that wrinkle formation is minimized and in all cases that the geomembrane is not folded over on itself. The leachate collection layer thickness shall be determined by survey.

The leachate collection layer material shall be tested during construction by CQA Personnel in accordance with Section 02232 of the Technical Specifications to verify material compliance. During construction, the leachate collection material shall be tested as follows:

| | |
|---|---|
| 1. Grain Size – ASTM C136 | 1 test per 5,000 CY of in-place material |
| 2. Permeability – ASTM D2434 | 1 test per 5,000 CY of in-place material |

### *3.8.3 Defects and Repairs*

If a defect is identified in the leachate collection layer, the Owner's Representative shall determine the extent and the nature of the defect. If the defect is indicated by an unsatisfactory test result, the Owner's Representative shall determine the extent of the deficient area by additional tests, observations, a review of records, or other means that the Owner's Representative deems appropriate.

After determining the extent and nature of the defect, the Owner's Representative shall promptly notify the CONTRACTOR and the ENGINEER.

The CONTRACTOR shall correct all deficiencies to meet the Technical Specifications. The Owner's Representative shall schedule appropriate retests when the defect has been corrected. Retests by the Owner's Representative must verify that the defect has been corrected before any additional work is performed by the CONTRACTOR in the area of the deficiency. The Owner's Representative shall observe the repair and report any noncompliance with the above requirements in writing to the ENGINEER.

## 3.9 HDPE Piping

The work addressed under this section shall facilitate proper construction of all HDPE piping for the collection and removal of leachate from the CCR Unit. All work shall be constructed to the lines, grades,


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and dimensions indicated on the Construction Drawings, in accordance with the Technical Specifications, or as required by the OWNER or ENGINEER.

### *3.9.1 Manufacture of HDPE Pipe*

The CONTRACTOR shall submit manufacturer's data sheets, certification of compliance with specifications for all pipes, fittings, and appurtenances. Prior to the installation, the CONTRACTOR shall provide the Owner's Representative with the following:

1. A properties sheet including all specified properties measured using test methods indicated in the Technical Specifications or equivalent methods approved by the ENGINEER and Owner's Representative.
2. A certification that property values given in the properties sheet are minimum or maximum values and are guaranteed by the Manufacturer.

The Owner's Representative will verify that:

1. The property values certified by the Manufacturer meet all of the Technical Specifications; and
2. The measurements of properties by the Manufacturer are properly documented, the test methods used are acceptable, and the HDPE pipe meets the Manufacturer's specifications and the Technical Specifications.

### *3.9.2 Transportation and Delivery*

All storage and handling on-site is the responsibility of the CONTRACTOR. The CONTRACTOR is responsible for the submittal of all other relevant documents to the Owner's Representative.

Upon delivery at the site, the Owner's Representative shall conduct a surface observation of the pipe as is feasible for defects or damage. The inspection will be performed without unstacking pipe unless defects or damage are found or suspected. The Owner's Representative will indicate those pipes with severe flaws that should be removed from the site.

Once on site, the CONTRACTOR will be responsible for the storage of the pipe. The OWNER will provide storage space in a location (or several locations) such that transportation and handling are minimized. The storage space should be protected from theft, vandalism, passage of vehicles, etc.

### *3.9.3 Construction*

3.9.3.1 Pipe Placement

Piping shall be field fit and not cut based on measurements made from the Construction Drawings. Pipe shall be carried manually by using mechanical equipment with flat forks or fabric slings. Pipe shall not be dragged on the ground. The CONTRACTOR shall join pipes using the Manufacturer-recommended fusion methods. The pipe bedding and backfill shall be prepared and the pipe placed and buried as required in the Technical Specifications. During placement, the Owner's Representative will verify that:

1. Equipment used does not damage the HDPE pipe by handling, excessive heat, or other means;
2. The prepared surface and trench underlying the HDPE pipe has not deteriorated since previous preparation and is still acceptable immediately prior to pipe placement;
3. Personnel do not engage in activities that could damage the pipe;


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4. Methods used to place the pipe do not damage the pipe or supporting soil;
5. The pipe is backfilled in a method to completely support the pipe with bedding; and
6. Methods used to backfill the pipe do not displace the pipe.

3.9.3.2 Non-Destructive Testing

Non-perforated HDPE pipe shall be tested by the CONTRACTOR using non-destructive techniques prior to backfilling the pipe. The Contractor shall perform hydrostatic testing under the observation of the Owner's Representative according to Section 02651 of the Technical Specifications. Test the electrical integrity of the installed tracer wire prior to backfilling the pipe.

Any portion of piping failing the pressure test shall be repaired. Damaged pipe shall be removed and replaced when pipe damage cannot be satisfactorily repaired. If the pressure test fails, the failing section shall be located, removed, and rejoined.

3.9.3.3 Final Inspection

A final inspection shall be completed by the CONTRACTOR and Owner's Representative prior to backfilling the pipe. All identified problem areas shall be repaired by the CONTRACTOR and accepted by the Owner's Representative prior to backfilling.

## 4.0 CONSTRUCTION QUALITY ASSURANCE DOCUMENTATION

Upon completion of the cell construction project or closure construction project, the Owner's Representative will prepare a Construction Quality Assurance Record Report. This Report will be sealed by a Professional Engineer licensed in the Commonwealth of Virginia certifying that the construction has been completed in accordance with the DEQ-approved solid waste permit.

### 4.1 CQA Report Contents

The CQA Report will contain information relating to the materials, methods, testing, and other documentation to support the Engineer's certification. The Report shall contain a narrative describing the construction and CQA activities in each phase of the construction project. Supporting documentation in the form of manufacturer submittals and test results (lab and field) will be submitted as appropriate for each activity. At a minimum, the Report shall contain the following sections:

1. Project description, description of stakeholder parties;
2. Earthwork activities to prepare the liner subgrade;
3. Geosynthetics;
4. Protective Cover and Vegetative Support Layer installation;
5. Stormwater controls;
6. Construction field reports and photos;
7. Other construction as pertinent to the project;
8. As-built drawings, in accordance with Section 01564, on a grid system the same as provided in Attachment III (Design Plans), and sealed by a Land Surveyor licensed in the Commonwealth of Virginia, showing:
    a. Existing (pre-construction conditions);
    b. Geomembrane subgrade;
    c. Geomembrane panel layout and repair locations;
    d. Geomembrane panel layout and destructive sample locations;


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e. Top of Final Cover layer with thickness verification
f. Grades/details deviated from.

One copy of the CQA Report and two sets of as-built drawings will be provided to DEQ within 90 days of completion of construction.


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# Technical Specifications

# TECHNICAL SPECIFICATIONS

## Bremo Bluff FFCP Management Facility
## Solid Waste Permit 627
## Fluvanna County, Virginia

Prepared for:

Dominion Energy®

Dominion Energy Virginia
120 Tredegar Street
Richmond, Virginia 23219

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Schnabel Reference No. 22130437.031

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*** * * * * END OF SECTION * * * * ***


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# SECTION 01020

# CONTRACTOR WORK PLAN

## PART 1 – GENERAL

1.1 SUMMARY

A. This section covers Contractor Work Plan (Project Execution Plan), Health and Safety Plans, proposed means and methods, and proposed construction sequence requirements.

1.2 SUBMITTALS

A. Submit in accordance with 01300 - Submittals.

B. Prepare and submit a project-specific CONTRACTOR Work Plan (Project Execution Plan) to the OWNER for approval before Work shall commence. The Work Plan shall be submitted fifteen (15) business days prior to mobilization. The Work Plan, at a minimum, shall include the following:

1. Construction Sequence Schedule
2. Weather Contingency Plan
3. Construction Facilities Site Plan
4. Construction Quality Control (CQC) Plan
5. Health and Safety Plan
6. Environmental Protection Plan (Section 01300 – Submittals)
7. FFCP Management Facility Construction Phasing Plan
8. FFCP Management Facility Fill Sequencing Plan
9. FFCP Management Facility Contact and Non-Contact Water Management Plan
10. CCR Excavation Plan
11. CCR Excavation Dewatering Plan
12. CCR Excavation Contact and Non-Contact Water Management Plan
13. CCR Excavation Instrumentation Installation and Monitoring Plan

C. Prepare and submit additional project-specific CONTRACTOR Work Plans to the OWNER and/or ENGINEER for approval, as specified in the appropriate Specification section. The additional project-specific CONTRACTOR Work Plans include:

1. Site Reclamation Plan

1.3 WORK PLAN REQUIREMENTS

A. Work Plans shall be prepared in accordance with all applicable Federal, state, and local laws and regulations, the Contract Documents, and good engineering and construction practices.

B. Work Plans shall be developed in accordance with the requirements of the Technical Specifications.

*** * * * * END OF SECTION * * * * ***


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# SECTION 01050

# FIELD ENGINEERING/SURVEYING

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. Work under this Section includes all surveying services for accurate location of all features of construction and establishing proposed grades.

1.2 RELATED SECTIONS

A. Section 01564 - Project Record Documents

1.3 QUALITY CONTROL

A. CONTRACTOR is responsible for all surveying necessary for control of its work at the site. The Surveyor shall be a qualified Registered Land Surveyor in the Commonwealth of Virginia. The Surveyor shall also have a minimum of two years' experience in Construction Surveying layout and maintenance of as-built construction drawings with a record of performing horizontal and vertical control requirements as stated in the Contract Documents.

1.4 SUBMITTALS

A. Name, address, telephone number, and resume detailing the experience level of Surveyor shall be submitted to OWNER before starting survey work by CONTRACTOR.

B. On request, calibration certificates for all survey equipment shall be submitted to the OWNER by CONTRACTOR.

1. Electronic distance measuring (EDM) instruments used by CONTRACTOR on the Site shall be checked for calibration a minimum of once per month on an established baseline accepted by OWNER. Calibration results shall be kept in a logbook, available for OWNER's review, showing the date and distances measured on the baseline. An EDM shall not be used if it does not meet the minimum advertised accuracy published by the manufacturer of the EDM.
2. Defective instruments shall be promptly replaced, repaired, or adjusted to operate within the tolerances of the instrument manufacturer.

C. On request, documentation verifying accuracy of survey work shall be submitted to OWNER by CONTRACTOR.

D. Complete As-Built surveys in paper and AutoCAD format:

1. Landfill As-Builts:

a. As-Built 1. Subgrades / Bottom of Control Subgrade including alignment and inverts of underdrain piping.
b. As-Built 2. Top of Control Subgrade.
c. As-Built 3. Geomembrane Panel Placement including anchor trench location, limits of geosynthetic components, and destruct sample locations.
d. As-Built 4. Leachate Collection System including alignment and inverts of leachate collection piping and detailed dimensions of all sumps.
e. As-Built 5. Top of Protective Layer including limits of geosynthetic rain cover.
f. As-Built 6. Top of placed CCR in Landfill (top of waste).


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g. As-Built 7. Top of Intermediate Cover.
h. As-Built 8. Cover System Geomembrane Panel Survey including geocomposite.
i. As-Built 9. Top of Protective Cover and Vegetative Support Layer.
j. As-Built 10. Final Site Conditions including final topography of areas outside of the cell limits, the alignment and elevations of underground utility relocation, alignment and inverts of side slope riser and associated connection to valve boxes, electrical lines and components, and the alignment and inverts of stormwater structures including ditches and letdowns.

2. North Ash Pond (NAP) Closure As-builts:

a. As-Built 1. Bottom of CCR excavation and bottom of six (6) inch over excavation below CCR excavation.
b. As-Built 2. Top of Compacted Fill.
c. As-Built 3. Final Site Conditions including final topography of areas outside of the NAP limits, the alignment and elevations of permanent drainage features.
d. As-Built 4. Final Site Conditions including final topography, the alignment and elevations of underground utility relocation, alignment and inverts of side slope riser and associated connection to valve boxes, electrical lines and components, and the alignment and inverts of stormwater structures including ditches and letdowns.

E. The CONTRACTOR shall provide OWNER with an AutoCAD Civil 3D 2018 format (or more recent) file showing the survey points with the point number and elevation specified. The surveyors' point file, in an excel format (csv), shall also be provided to OWNER.

1.5 FIELD CONTROL

A. Field Layout

The OWNER will provide a benchmark adjacent to the Work for job reference and control. The benchmark’s northing, easting and elevation will be provided for the CONTRACTOR'S use. The CONTRACTOR'S Professional Surveyor shall tie into the benchmark and layout the limits of Work for the CONTRACTOR, over the entire project site in accordance with the grid system shown in the Contract Documents. Each benchmark shall be located in the field. In the event the benchmarks are physically lost during construction, the CONTRACTOR'S surveyor shall be responsible for replacing benchmarks at no additional cost to the OWNER.

B. Measurements

The CONTRACTOR’S surveyor shall take measurements to calculate pay quantities for verification by the ENGINEER.

The Professional Surveyor shall make their equipment available to the OWNER and the ENGINEER to perform independent measurements and to confirm readings. All survey information is to be made available to the OWNER to measure cut and fills elevations to calculate pay quantities.

C. Calculations

The pay quantities shall be calculated from CONTRACTOR’s certified surveyor measurements and the ENGINEER'S field notes. The CONTRACTOR may retain an independent Professional Engineer to review the pay quantity calculations.


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1.6 SURVEY REQUIREMENTS

A. CONTRACTOR shall utilize existing control points and establish new control points as needed to complete work under this section.

B. CONTRACTOR shall provide field engineering services and use recognized engineering survey practices.

C. Establish elevations, lines and levels. Locate and layout by instrumentation and similar appropriate means site improvements including roadways, stakes for grading and fill placement, utility locations, slopes, and invert elevations.

D. Periodically verify layouts by same means.

1.7 SURVEY TOLERANCES

A. Grading Tolerances shall be as defined in Division 2 of these specifications.

## PART 2 – PRODUCTS

2.1 PROJECT RECORD DOCUMENTS

A. Maintain a complete and accurate log of control and survey work as it progresses.

B. Maintain Record Drawings.

C. Maintain complete and updated As-Built drawings on-site.

## PART 3 – EXECUTION

3.1 AS-BUILT SURVEYS FOR RECORD DOCUMENTATION

A. Perform surveys to record as-built lines and grades of the work for Record Documentation. The following surfaces shall be surveyed to determine the lines and grades achieved during construction:

1. FFCP As-Builts:

a. As-Built 1. Subgrades / Bottom of Control Subgrade including alignment and inverts of underdrain piping.
b. As-Built 2. Top of Control Subgrade.
c. As-Built 3. Geomembrane Panel Placement including anchor trench location, limits of geosynthetic components, and destruct sample locations.
d. As-Built 4. Leachate Collection System including alignment and inverts of leachate collection piping and detailed dimensions of all sumps.
e. As-Built 5. Top of Protective Layer including limits of geosynthetic rain cover.
f. As-Built 6. Top of placed CCR in Landfill (top of waste).
g. As-Built 7. Top of Intermediate Cover.
h. As-Built 8. Cover System Geomembrane Panel Survey including geocomposite.
i. As-Built 9. Top of Final Cover Soil and Vegetative Support Layer.
j. As-Built 10. Final Site Conditions including final topography of areas outside of the cell limits, the alignment and elevations of underground utility relocation, alignment and inverts of side slope riser and associated connection to valve boxes, electrical lines and components, and the


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alignment and inverts of stormwater structures including ditches and letdowns.

2. North Ash Pond (NAP) Closure As-Builts:

   a. As-Built 1. Bottom of CCR excavation and bottom of six (6) inch over excavation below CCR excavation.
   b. As-Built 2. Top of Compacted Fill.
   c. As-Built 3. Final Site Conditions including final topography of areas outside of the NAP limits, the alignment and elevations of permanent drainage features.
   d. As-Built 4. Final Site Conditions including final topography, the alignment and elevations of underground utility relocation, alignment and inverts of side slope riser and associated connection to valve boxes, electrical lines and components, and the alignment and inverts of stormwater structures including ditches and letdowns.

B. As-Built Surveys must be completed as outlined in this Section and submitted to the ENGINEER for review and approval prior to construction installation or placement of the subsequent fill layers.

C. Provide surveys for project boundaries, including easements, right of ways, and disturbance limits.

D. After submittal of the grid table survey results for each As-Built or portion of As-Built, any work conducted by the CONTRACTOR towards the subsequent As-Built prior to receiving written approval from the ENGINEER, is done at the CONTRACTOR's own risk.

E. Upon completion of each As-Built, the CONTRACTOR shall provide the above as-built surveys to the ENGINEER as both a paper copy and in AutoCAD Civil 3D 2018 format (or more recent) for final approval. Paper copies shall be signed and sealed by a Professional Land Surveyor who is licensed in Virginia.

F. The As-Built Surveys will serve as CQA Hold Points for the project, to verify that the elevations, horizontal locations, alignments, material thicknesses, etc. have been met for each component of the construction, and also to confirm that Quality Control and Quality Assurance documentation has been completed in accordance with the project CQA Plan on the engineered components associated with each As-Built survey prior to constructing the engineered component associated with next As-Built survey.

G. Following the completion of all the clearing and grubbing operations in an area, and before commencing stripping or excavation, CONTRACTOR shall prepare a baseline survey consisting of, at a minimum, cross-sections at 50-foot intervals in all areas of disturbance to be used as a basis for measuring excavation, and placement of earthwork materials. Excavation and fill quantities shall be calculated by either the average end area method or by using digital terrain models.

H. Each month, CONTRACTOR will determine the volume of excavation and earthwork accomplished and the amount of payment requested for that month. The quantities shall be determined using the same cross-sections established during the baseline survey.

I. At the point where the Work performed under each bid item is completed, CONTRACTOR shall perform a final survey using the same cross-sections established during the baseline survey. This survey shall be used by the CONTRACTOR to calculate quantities (as described above) which will be used as the basis of measurement for the completed item.

J. The difference in calculated quantities between the initial and final cross-sections or digital terrain models for each item will be the basis for the measurement for that item unless


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otherwise defined in the Specifications. CONTRACTOR shall submit a copy of cross-section survey data and quantity calculations to OWNER for each monthly payment request.

3.2 INSPECTION

CONTRACTOR shall verify locations of site reference and survey control points prior to starting work. OWNER must be promptly notified of any discrepancies discovered.

3.3 SURVEY REFERENCES POINT

A. CONTRACTOR shall take measures to protect site reference and survey control points prior to starting site work and must preserve permanent reference points during construction. Site reference points may not be relocated without prior written notice to OWNER.

B. The OWNER shall be immediately notified of loss, damage or destruction of any reference point, or relocation required because of changes in grades or other reasons. CONTRACTOR shall replace disturbed survey control points based on original survey control at no extra cost to OWNER.

1. Primary or secondary control monuments removed shall be reset by CONTRACTOR as soon as the Work requiring the removal is complete. Alternatively, other control points may be set so as to reestablish the control network.
2. The position of monuments, control points, or other marks that are subject to movement due to the passage of equipment or other forces shall be rechecked at regular intervals, but not less than monthly.

C. X, Y and Z coordinates of benchmarks and survey control points shall be determined (and recorded) with a maximum permissible error of 0.10 feet (±) in any coordinate direction.

D. All X and Y coordinates are to be referred to the Virginia State Plane coordinate system with an accuracy of 0.10 feet (±).

E. All Z coordinates are to be referred to nearest NGVD benchmark with an accuracy of 0.10 feet (±).

3.4 SURVEY REQUIREMENTS

A. CONTRACTOR shall reference survey and data reference points to permanent benchmarks and record locations of survey control points, with horizontal and vertical data.

B. CONTRACTOR shall reverify layouts periodically during construction by same means.

*** * * * * END OF SECTION * * * * ***


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# SECTION 01300

# SUBMITTALS

## PART 1 – GENERAL

### 1.1 DESCRIPTION OF WORK

A. Wherever submittals are required hereunder, all such submittals by the CONTRACTOR shall be submitted to the OWNER or ENGINEER.

B. Prior to mobilization onto the Site:

1. A preliminary schedule of Shop Drawing, sample, and proposed substitutes or "or equal" submittals.
2. CONTRACTOR shall submit a project specific Contractor Work Plan in accordance with Specification Section 01020 – Contractor Work Plan.

C. Any details deemed by the CONTRACTOR as required for construction but not indicated on the Contract Documents shall be submitted for review by the ENGINEER at least 10 calendar days prior to construction. Responsibility for identifying such details is the responsibility of the CONTRACTOR.

D. Submittals that include engineering design by the CONTRACTOR shall include all drawings and calculations stamped by a Professional Engineer licensed in the Commonwealth of Virginia.

### 1.2 SHOP DRAWING AND PRODUCT DATA SUBMITTALS

A. Whenever called for in the Contract Documents, or where required by the OWNER, CONTRACTOR shall furnish an electronic copy of the shop drawing to the OWNER and ENGINEER. The term "Shop Drawings" as used herein shall be understood to include detailed design calculations, shop drawings, fabrication and installation drawings, erection drawings, lists, graphs, operating instructions, catalog sheets, data sheets, and similar items.

B. All Shop Drawing submittals shall be accompanied by a submittal transmittal form.

C. CONTRACTOR shall furnish submittals including shop drawings in legible electronic format. Submittals shall be consecutively numbered in direct sequence of submittal and without division by subcontracts or trades. For electronic submittals, drawings and the necessary data shall be submitted electronically to OWNER as specified below.

D. All CONTRACTOR shop drawing submittals shall be carefully reviewed by an authorized representative of the CONTRACTOR, prior to submission to the ENGINEER. Each submittal shall be dated and signed by the CONTRACTOR, as being correct and in strict conformance with the Contract Documents. In the case of shop drawings, each sheet shall be so dated and signed. No consideration for review by the ENGINEER of any CONTRACTOR submittals will be made for any items which have not been so certified by the CONTRACTOR. All noncertified submittals will be returned to the CONTRACTOR without action taken by the ENGINEER, and any delays caused thereby shall be the total responsibility of the CONTRACTOR.

E. Product data should be collected into one submittal for each unit of work or system; and mark each copy to show which choices and options are applicable to the Work. Include manufacturer's standard printed recommendations for application of labels and seals, notation of field measurements which have been checked, and special coordination requirements.


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F. The CONTRACTOR shall present Shop Drawings at least one month before work is due to start on that item.

G. CONTRACTOR shall make all submittals far enough in advance of scheduled installation dates to provide all time required for reviews, for possible revisions and resubmittals, and for placing orders and securing delivery.

H. CONTRACTOR shall coordinate and sequence different categories of submittals for the same work, and for interfacing units of work, so that one will not be delayed for coordination with another.

I. Except as may otherwise be provided herein, the ENGINEER will return each submittal to the OWNER for distribution to the CONTRACTOR with its comments noted thereon, within 10 business days following their receipt by the OWNER.

1. Submittals returned to CONTRACTOR by OWNER will be marked with one of the following designations:

    a. No Exceptions Taken
    b. Exceptions Taken
    c. Revise and Resubmit
    d. Rejected

2. Processing of No Exceptions Taken Submittals:

    a. Construction shall be carried out in accordance with the submitted documents and no further changes made except upon written instructions from OWNER or ENGINEER. Final drawings (paper, or electronic) shall be submitted to OWNER as specified in these Contract Documents.

3. Processing of Revise and Resubmit Submittals

    a. When the submittal and data are returned marked “Revise and Resubmit” CONTRACTOR shall not proceed with manufacture and the corrections shall be made as noted thereon and as instructed by OWNER or ENGINEER and corrected copies resubmitted.
    b. Resubmissions will be handled in the same manner as first submissions. Direct specific attention, in writing or on the resubmittal, to revisions other than the corrections requested by OWNER or ENGINEER on previous submittals.

4. Processing of Exceptions Taken Submittals

    a. When the submittal and data are returned marked "Exceptions Noted”, CONTRACTOR may proceed with manufacture at its own risk on the basis of incorporating all comments noted on the returned submittal and data.

5. Processing of Rejected Submittals

    a. When the submittal and data are returned marked “Rejected”, CONTRACTOR shall not proceed with manufacture and shall repeat the initial approval procedure utilizing acceptable material or equipment.

J. The CONTRACTOR shall keep a submittal log documenting all submittals. The submittal log should include the following: submittal number, description, date submitted, response (approved, rejected, etc.), and response date.


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1.3 REQUESTS FOR INFORMATION

A. Whenever additional design information or clarification is required, CONTRACTOR shall submit a Request for Information (RFI) to the OWNER for distribution to the responsible project ENGINEER, if needed.

B. RFI submittals shall be submitted with an RFI tracking form cover. The tracking form shall include the RFI number, description, submittal date, response date, and comments.

C. Except as may otherwise be provided herein, The ENGINEER will return each RFI response to the OWNER for distribution to the CONTRACTOR within 15 business days following their receipt by the OWNER.

1.4 PROPOSED SUBSTITUTES OF "OR APPROVED EQUAL" ITEMS.

A. The requirements of this Section apply to any CONTRACTOR-proposed substitution or alternatives.

B. Whenever materials or equipment are specified or described in the Contract Documents by using the name of a proprietary item or the name of a supplier, the naming of the item is intended to establish the type, function, and quality required. If the name is followed by the words "or approved equal" indicating that a substitution may be permitted, materials or equipment of other suppliers may be accepted by the OWNER if sufficient information is submitted by the CONTRACTOR to allow the ENGINEER to determine that the material or equipment proposed is equivalent or equal to that named, subject to the following requirements:

1. The burden of proof as to the type, function, and quality of any such substitute material or equipment shall be upon the CONTRACTOR.
2. The ENGINEER will determine as to the type, function, and quality of any such substitute material or equipment.
3. The ENGINEER may require the CONTRACTOR to furnish at the CONTRACTOR's expense additional data about the proposed substitute.
4. The OWNER may require the CONTRACTOR to furnish at the CONTRACTOR's expense a special performance guarantee or other surety with respect to any substitution.
5. Acceptance by the ENGINEER of a substitute item proposed by the CONTRACTOR shall not relieve the CONTRACTOR of the responsibility for full compliance with the Contract Documents and for adequacy of the substitute item.
6. The CONTRACTOR shall be responsible for resultant changes and all additional costs which the accepted substitution requires in the CONTRACTOR's work, the work of its subcontractors and of Others, and shall effect such changes without cost to the OWNER.

C. The procedure for review by the ENGINEER will include the following:

1. If the CONTRACTOR wishes to furnish or use a substitute item of material or equipment, the CONTRACTOR shall make written application to the OWNER.
2. The CONTRACTOR shall certify that the proposed substitute will perform adequately the functions and achieve the results called for by the general design, be similar and of equal substance to that specified, and be suited to the same use as that specified.
3. The ENGINEER will be allowed a reasonable time within which to evaluate each proposed substitute.
4. As applicable, no Shop Drawing submittals will be made for a substitute item nor will any substitute item be ordered, installed, or utilized without the ENGINEER's prior written acceptance of the CONTRACTOR's substitution request.


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D. The CONTRACTOR's application shall contain the following statements and/or information which shall be considered by the ENGINEER in evaluating the proposed substitution:

1. The evaluation and acceptance of the proposed substitute will not prejudice the CONTRACTOR's achievement of substantial completion on time.
2. Whether or not the acceptance of the substitution for use in the Work will require a change in any of the Contract Documents to adapt the design to the proposed substitute.
3. Whether or not the incorporation or use of the substitute in connection with the Work is subject to payment of any license fee or royalty.
4. All variations of the proposed substitute for that specified shall be identified.
5. Available maintenance, repair, and replacement service shall be indicated.
6. Estimate of all costs that will result directly or indirectly from acceptance of such substitute, including cost of redesign and claims of other contractors affected by the resulting change.

1.5 MANUFACTURER'S INSTRUCTIONS

A. When specified in individual specification sections, submit manufacturer's printed instructions for delivery, storage, assembly, installation, start-up, adjusting, and finishing, in quantities specified for Product Data.

B. Identify conflicts between manufacturer's instructions and Contract Documents.

1.6 MANUFACTURER'S CERTIFICATES

A. When specified in individual specification sections, submit manufacturer's certificate to ENGINEER for review, in quantities specified for Product Data.

B. Indicate if the material or product conforms to or exceeds specified requirements. Submit supporting reference date, affidavits, and certifications as appropriate.

C. Certificates may be recent or previous test results on material or product but must be acceptable to the ENGINEER.

1.7 LAYOUT DATA

A. General - The CONTRACTOR is responsible for coordinating work of all trades on the job. The CONTRACTOR shall confer with OWNER and provide guidance and information to all trades as required for proper progress of the work.

B. Conflicts - Where the work of two trades will be installed in close proximity to each other, or where there is evidence that work of one trade will interfere with another trade, CONTRACTOR shall prepare composite working drawings if directed by OWNER. Composite drawings shall depict how all work is to be installed. The CONTRATOR shall coordinate with other trades prior to causing interference with work of other trades. The CONTRACTOR shall make necessary changes in the work to correct conditions to the satisfaction of the OWNER without extra charge.

C. Procedures - If requested, by OWNER, CONTRACTOR shall provide detailed drawings as required to indicate construction procedures.

1.8 ENVIRONMENTAL PROTECTION PLAN

A. General – The CONTRACTOR shall prepare an Environmental Protection Plan (EPP) per the requirements of this specification. The Plan shall be submitted to the OWNER 10 business days prior to mobilization and must be approved by the OWNER prior to commencement of the Work.


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B. The OWNER's Environmental Compliance Coordinator (ECC) will conduct daily monitoring of the CONTRACTOR's compliance with the EPP and has the authority to stop WORK when non-compliance is observed. CONTRACTOR shall correct non-compliance at no cost to the OWNER prior to commencing the non-compliant portion of the Work.

C. Required Plan Components – Along with the requirements in the Supplemental Terms and Conditions for the EPP components, the following documents shall be included as stand-alone attachments to the EPP:

1. Spill Prevention, Control, and Countermeasure (SPCC) Plan – CONTRACTOR shall prepare an SPCC Plan that meets the federal regulations in 40 CFR 112 if the quantity of petroleum products exceeds 1,320 gallons at the Work site. The Plan shall address project specific items including, but not limited to, protection against hydraulic hose failure, fueling station containment, work along sensitive areas such as wetlands or water bodies, and protection of outfalls.
2. Fugitive Dust Emissions Plan – CONTRACTOR shall prepare a Fugitive Dust Emissions Plan that addresses the intent of 40 CFR 257.80(b)(1) and (2) for any activities involving the use of ash by the CONTRACTOR. In addition, the CONTRACTOR shall be prepared to assume responsibility for fugitive dust emissions of the entire project during construction.
3. Training Plan – CONTRACTOR shall submit a Training Plan with procedures for training new employees in the requirements of the EPP, providing refresher training for regular employees, and documentation that CONTRACTOR personnel have participated in the training.
4. Weekly Environmental Assessment – CONTRACTOR shall conduct weekly Environmental Assessments in conjunction with the required weekly Safety Assessments as defined in the Supplemental Terms and Conditions.

1.9 MISCELLANEOUS SUBMITTALS

A. Construction Permits

1. Acquire, maintain, and submit copies of all CONTRACTOR-obtained construction permits that are required by agencies to execute the Work.

B. Tests and Test Reports:

1. Classify each as either "project related" or Product Data, depending upon whether report is uniquely prepared for project or a standard publication of workmanship control testing at point of production, and process accordingly.
2. All test equipment used shall be verified to be in calibration at the time of each test and test reports shall so indicate. No test shall be made without such verification.

C. Standards:

1. Where copy submittal is indicated, and except where specified integrally with Product Data submittal, submit a single copy for OWNER's use.
2. Where workmanship at project site and elsewhere is governed by standards, furnish additional copies to fabricators, installers, and others involved in performance of the work.

**PART 2 – PRODUCTS**

NOT USED


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## PART 3 – EXECUTION

A. Repeated failure to present acceptable submittals or excessive services required of ENGINEER due to repeated presentation of unacceptable submittals results in additional engineering expenses. It will be considered excessive if more than one correction of any submittal is required and will result in a charge against the CONTRACTOR for recovery of additional expenses

*** * * * * END OF SECTION * * * * ***


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# SECTION 01320

# SCHEDULE

## PART 1 – GENERAL

1.1 GENERAL REQUIREMENTS

The CONTRACTOR shall submit a Proposal Schedule at the time of bid that will be considered a baseline schedule for the project and the basis for subsequent schedules submitted during the project. The level of detail provided in the Proposal Schedule shall also be used to develop a Schedule of Values and subsequent Earned Value analyses. All schedules shall include complete logic relationships (predecessor and successor for each task) and clearly indicate the critical path for the project.

1.2 SCHEDULE PREPARER

The CONTRACTOR shall designate an authorized representative to be responsible for the preparation of the schedule and all required updating (activity status) and preparation of reports. The authorized representative shall be experienced in scheduling projects similar in nature to this project and shall be experienced in the use of the scheduling software that meets the requirements of this specification.

## PART 2 – MATERIALS AND PRODUCTS

2.1 GENERAL REQUIREMENTS

All schedules must be developed using Primavera P6 or approved equal. Any alternative software proposed must have similar functionality and generate schedules that meet all requirements of this specification.

## PART 3 – EXECUTION

3.1 GENERAL REQUIREMENTS

All schedules shall show the sequence in which the CONTRACTOR proposes to perform the work and dates on which the CONTRACTOR contemplates starting and completing all schedule activities. The scheduling of the entire project, including the permitting, design and construction sequences, is required. The scheduling of construction is the responsibility of the CONTRACTOR.

A. Approved Project Schedule

Use the approved Project Schedule to measure the progress of the work and to aid in evaluating time extensions. The schedule will provide the basis for all progress payments. If the CONTRACTOR fails to submit any schedule within the time prescribed, the OWNER may withhold approval of progress payments until the CONTRACTOR submits the required schedule.

B. Default Terms

Failure of the CONTRACTOR to comply with the requirements of the OWNER shall be grounds for a determination, by the OWNER, that the CONTRACTOR is not prosecuting the work with sufficient diligence to ensure completion within the time specified in the


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contract. Upon making this determination, the OWNER may terminate the CONTRACTOR'S right to proceed with the work, or any separable part of it, in accordance with the default terms of the contract.

## 3.2 PROJECT SCHEDULE DETAILED REQUIREMENTS

The computer software system utilized to produce and update the Project Schedule shall be capable of meeting all requirements of this specification. Failure of the CONTRACTOR to meet the requirements of this specification will result in the disapproval of the schedule.

A. Critical Path Method

Use the Critical Path Method (CPM) of network calculation to generate the Project Schedule.

B. Level of Detail Required

Develop the Project Schedule to an appropriate level of detail. Failure to develop the Project Schedule to an appropriate level of detail, as determined by the OWNER, will result in its disapproval. The OWNER will consider, but is not limited to, the following characteristics and requirements to determine appropriate level of detail:

1. Activity Durations

Reasonable activity durations are those that allow the progress of ongoing activities to be accurately determined between update periods.

2. Mandatory Tasks

The following tasks must be included and properly scheduled. The Project shall include a hammock task that encompasses the following mandatory tasks at a minimum:

a. Design and Permitting – a task for each anticipated permit with duration inclusive of regulatory and OWNER reviews, revisions, and final permit issuance.

b. Mobilization and Site Preparation – a task for all anticipated mobilization activities, including:

i. Temporary Facility Setup.
ii. Utility Connections.
iii. Long-lead Equipment.
iv. Infrastructure Upgrades (list all anticipated).
v. Erosion and Sediment Control Installation.
vi. Any other activities necessary to prepare for Landfill construction and CCR removal activities.

c. Landfill Construction and Operation:

i. Subgrade Preparation.
ii. Liner System Installation (list all components).


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iii. Leachate Collection System Installation (list all components).
iv. CCR Placement (CCR excavation and hauling).
v. Cover System Installation (list all components).

d. CCR Excavation and Handling:

i. Dewatering System Installation.
ii. Contact Water Management System Installation.
iii. CCR excavation and loading.
iv. On-site Ash Handling (i.e. transportation, drying, placement, compaction, etc.).

e. Site Restoration:

i. Grading and Earthwork.
ii. Seeding and Stabilization.
iii. Removal of Temporary Facilities.

f. Construction Permit Closeout (list all permits).

C. Owner Activities

Show OWNER and agency activities that could impact progress. These activities include, but are not limited to: approvals, environmental permit approvals by State regulators, inspections, and Notice to Proceed (NTP) for phasing requirements.

D. Scheduled Project Completion and Activity Calendars

The schedule interval shall extend from NTP date to the required contract completion date. The contract completion activity (End Project) shall finish based on the required contract duration in the accepted contract proposal, as adjusted for any approved contract time extensions. The first scheduled work period shall be the day after NTP is received by the CONTRACTOR. Schedule activities on a calendar to which the activity logically belongs. Activities may be assigned to a seven (7) day calendar when the contract assigns calendar day durations for the activity such as an OWNER Acceptance activity. If the CONTRACTOR intends to perform physical work less than seven (7) days per week, schedule the associated activities on a calendar with non-work periods identified including weekends and holidays.

1. Project Start Date

The schedule shall start no earlier than the date on which the NTP was acknowledged. Include as the first activity in the project schedule an activity called "Start Project" (or NTP). The "Start Project" activity shall have an "ES" constraint date equal to the date that the NTP was acknowledged, and a zero day duration.

2. Start Phase

Include as the first activity for a project phase an activity called "Start Phase X" where "X" refers to the phase of work. The "Start Phase X" activity shall have an


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"ES" constraint date equal to the date on which the NTP was acknowledged, and a zero day duration.

3. End Phase

Include as the last activity for a project phase an activity called "End Phase X" where "X" refers to the phase of work. The "End Phase X" activity shall have an "LF" constraint date equal to the specified completion date for that phase and a zero day duration.

## 3.3 PROJECT SCHEDULE SUBMISSIONS

Provide the submissions as described below. The data CD, reports, and network diagrams required for each submission are contained in Paragraph 3.4, SUBMISSION REQUIREMENTS.

A. Proposal Schedule Submission

Submit with the bid, covering all of the activities described in Paragraph 3.2 at a minimum.

B. Preliminary Project Schedule Submission

Submit the Preliminary Project Schedule, defining the CONTRACTOR's planned operations for the first 90 calendar days for approval within 15 calendar days after the NTP is acknowledged. The approved Preliminary Project Schedule will be used for payment purposes not to exceed 90 calendar days after NTP.

C. Initial Project Schedule Submission

Submit the Initial Project Schedule for approval within the timeframe detailed in the Contract Documents. The schedule shall demonstrate a reasonable and realistic sequence of activities which represent all work through the entire contract performance period.

D. Periodic Schedule Updates

These submissions will enable the OWNER to assess CONTRACTOR'S progress. If the CONTRACTOR fails or refuses to furnish the information and project schedule data, which in the judgment of the OWNER or authorized representative is necessary for verifying the CONTRACTOR'S progress, the CONTRACTOR shall be deemed not to have provided an estimate upon which progress payment may be made.

## 3.4 SUBMISSION REQUIREMENTS

Submit the following items for the Proposal Schedule, Preliminary Schedule, Initial Schedule, and every Periodic Schedule Update throughout the life of the project:

A. Data in electronic format, submitted through an approved file sharing system and/or platform.

Provide native files containing the project schedule in the backup Primavera P6 format. Each submission shall also contain all previous update backup files. File medium shall be


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USB Thumb Drive, or approved File Transfer system, as approved by OWNER. Label each submission indicating the type of schedule (Preliminary, Initial, Update), full contract number, Data Date and file name. Each schedule shall have a unique file name as determined by the CONTRACTOR.

B. Approved Changes Verification

Include only those project schedule changes in the schedule submission that have been previously approved by the OWNER. The Narrative Report shall specifically reference, on an activity by activity basis, all changes made since the previous period and relate each change to documented, approved schedule changes.

C. Schedule Reports

The format, filtering, organizing and sorting for each schedule report shall be as directed by the OWNER.

3.5 REQUESTS FOR TIME EXTENSIONS

In the event the CONTRACTOR believes it is entitled to an extension of the contract performance period, completion date, furnish the following for a determination by the OWNER: justification, project schedule data, and supporting evidence as the OWNER may deem necessary. Submission of proof of excusable delay, based on revised activity logic, duration, and costs (updated to the specific date that the delay occurred) is a condition precedent to any approvals by the OWNER.

A. Justification of Delay

The project schedule shall clearly display that the CONTRACTOR has used, in full, all the float time available for the work involved with this request. The OWNER'S determination as to the number of allowable days of contract extension shall be based upon the project schedule updates in effect for the time period in question, and other factual information. Actual delays that are found to be caused by the CONTRACTOR'S own actions, which result in a calculated schedule delay, will not be a cause for an extension to the performance period, completion date, or any interim milestone date.

*** * * * * END OF SECTION * * * * ***


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# SECTION 01400

# QUALITY ASSURANCE

## PART 1 – GENERAL

1.1 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 01410 - Laboratory Testing Services

1.2 QUALITY ASSURANCE

A. The OWNER shall appoint an Owner's Representative to monitor and report construction activities and the CONTRACTOR shall monitor quality control over products, services, site conditions, and workmanship, for conformance with the Contract Documents by development of a Construction Quality Control (CQC) Plan.

B. CONTRACTOR shall comply fully with manufacturers' instructions, including each step-in sequence.

C. Should manufacturers' instructions conflict with Contract Documents, CONTRACTOR shall request clarification from the ENGINEER or OWNER before proceeding.

D. CONTRACTOR shall comply with specified standards as a minimum quality for the Work except when more stringent tolerances, codes, or specified requirements indicate higher standards or more precise workmanship.

E. CONTRACTOR shall perform Work by persons qualified to produce workmanship of specified quality.

F. Secure products in place with positive anchorage devices designed and sized to withstand stresses, vibration, physical distortion, or disfigurement.

G. For products or workmanship specified by association, trades, or other consensus standards, comply with requirements of the standard, except when more rigid requirements are specified or are required by applicable codes or regulations.

1.3 QUALITY CONTROL

A. OWNER Responsibilities: Where quality-control services are indicated as OWNER's responsibility, OWNER will engage a qualified testing agency to perform these services.

1. OWNER will furnish CONTRACTOR with names, addresses, and telephone numbers of testing agencies engaged and a description of the types of testing and inspecting they are engaged to perform.
2. Costs for retesting and re-inspecting construction that replaces or is necessitated by work that failed to comply with the Documents will be charged to CONTRACTOR.

B. CONTRACTOR shall coordinate sequence of activities to accommodate required quality assurance and quality-control services with a minimum of delay and to avoid necessity of removing and replacing construction to accommodate testing and inspecting.

C. CONTRACTOR shall facilitate Construction Materials Testing necessary to satisfy CONTRACTOR internal quality control procedures and to control the Work.

D. CONTRACTOR shall establish quality control for all work elements. The Owner's Representative shall inspect the CONTRACTOR's quality control means and methods and conduct Construction Quality Assurance (CQA) testing. The CONTRACTOR is responsible


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for correcting any deficiencies identified by the Owner's Representative to the satisfaction of the ENGINEER and the OWNER.

E. CONTRACTOR shall, at all times when the Work is in progress, keep a competent representative or superintendent in charge of the work who shall have full authority to receive and give orders to CONTRACTOR personnel. CONTRACTOR shall give the Work the constant attention necessary to facilitate the progress thereof and shall cooperate with OWNER and ENGINEER, and with other contractors authorized to perform work adjacent to or within the physical limits of the work area. CONTRACTOR shall provide experienced management, supervisory and key personnel as required to complete the Work.

F. Provide a quality control system to perform inspections, tests, and rework in the event of failure of items of work, including that of the CONTRACTOR and all other subcontractors, to ensure compliance with the Contract provisions.

G. Regardless of whether original tests or inspections were CONTRACTOR's responsibility, provide quality-control services, including retesting and re-inspecting, for construction that revised or replaced Work that failed to comply with requirements established by the Documents.

1.4 REFERENCES

A. Conform to the reference standard defined in each Specification section, which is in effect as of the date of Issued For Construction Documents.

B. Obtain copies of standards when required by Contract Documents.

C. Should specified reference standards conflict with Contract Documents, request clarification from ENGINEER or OWNER before proceeding.

D. The contractual relationship of the parties to the Contract shall not be altered from the Contract Documents by either mention or inference in any reference document.

1.5 INSPECTION AND LABORATORY TESTING SERVICES

A. The CONTRACTOR is responsible for performing all Quality Control testing identified in the approved CQC Plan. OWNER will appoint, employ, and pay for services of an Owner's Representative to perform verifying quality assurance inspection and testing described in the site-specific Construction Quality Assurance (CQA) Plan. The CQA Plan contains minimum testing criteria in addition to the testing defined in these Specifications. Where there is a conflict between the CQA Plan and these Specifications, the more stringent requirement will be maintained.

B. The Owner's Representative will perform inspections, tests, and services as required by the CQA Plan and these Specifications.

1. An initial inspection shall be performed as soon as a representative segment of the particular item of work has been accomplished. Initial inspection shall include review of tests, examination of the quality of workmanship, a review for omissions or dimensional errors, and approval or rejection of the initial segment of the Work.
2. Follow-up inspections shall be performed as necessary and shall include continued testing and examinations to ensure continued compliance with the Contract requirements.

C. Reports will be submitted by the Owner's Representative to the OWNER, indicating observations and results of tests and indicating compliance or non-compliance with Contract Documents.


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D. The CONTRACTOR, when required, shall cooperate with Owner's Representative to furnish samples of materials, design mix, equipment, tools, storage and assistance as requested.

1. Notification shall be provided to Owner's Representative 24 hours prior to expected time for operations requiring services.
2. Make arrangements with Owner's Representative and pay for additional samples and tests required for CONTRACTOR's use.

E. Retesting or reinspection required because of non-conformance to specified requirements shall be performed by the Owner's Representative, on instructions by the OWNER, and at the CONTRACTOR's expense.

1.6 SUBMITTALS

A. Reports: Prepare and submit certified written reports that include the following:

1. Date of issue
2. Project title and number.
3. Name, address, and telephone number of testing agency.
4. Dates and locations of samples and tests or inspections.
5. Names of individuals making tests and inspections.
6. Description of the Work and test and inspection method.
7. Identification of product and Specification Section.
8. Complete test or inspection data.
9. Test and inspection results and an interpretation of test results.
10. Ambient conditions at time of sample taking and testing and inspecting.
11. Comments or professional opinion on whether tested or inspected Work complies with the Document requirements.
12. Name and signature of laboratory inspector.
13. Recommendations on retesting and re-inspecting.

B. Permits, Licenses, and Certificates: For OWNER's records, submit copies of permits, licenses, certifications, inspection reports, releases, jurisdictional settlements, notices, receipts for fee payments, judgments, correspondence, records, and similar documents, established for compliance with standards and regulations bearing on performance of the Work.

**PART 2 – PRODUCTS**

NOT USED

**PART 3– EXECUTION**

3.1 TESTING AND INSPECTION LOG

A. Prepare a record of tests and inspections to include the following:

1. Date test or inspection was conducted.
2. Description of the work tested or inspected.
3. Identification of testing agency or special inspector conducting test or inspection.

3.2 REPAIR AND PROTECTION

A. General: On completion of testing, inspecting, sampling, and similar services, repair damaged construction and restore substrates and finishes.


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1. Provide materials and comply with installation requirements specified in other Sections of these Specifications. Restore patched areas and extend restoration into adjoining areas in a manner that eliminates evidence of patching.

B. Protect construction exposed by or for quality-control service activities.

C. Repair and protection are CONTRACTOR's responsibility, regardless of the assignment of responsibility for quality-control services.

*** * * * * END OF SECTION * * * * ***


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# SECTION 01410

# QUALITY ASSURANCE LABORATORY TESTING SERVICES

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The OWNER will select and employ an Independent Testing Laboratory, or Laboratories, to perform services as required by these Technical Specifications.

B. The OWNER shall pay all charges of the Testing Laboratory.

1.2 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 01564 – Project Record Documents

1.3 LABORATORY DUTIES

A. Cooperate with OWNER, ENGINEER and Owner's Representative and provide qualified personnel promptly on notice. Perform specified inspections, sampling and testing of materials and methods of construction; and ascertain compliance with requirements of Contract Documents.

B. Promptly notify OWNER, ENGINEER and Owner's Representative of irregularities or deficiencies of work which are observed during performance of services. Submit two (2) copies of reports of inspections and tests to OWNER, including:

1. Date issued.
2. Project title and number.
3. Testing Laboratory name and address.
4. Name and signature of Inspector.
5. Date of inspection or sampling.
6. Record of temperature and weather.
7. Date of test.
8. Identification of product and specification section.
9. Location in project.
10. Type of inspection or test.
11. Observations regarding compliance with Contract Documents.

C. Laboratory is not authorized to release, revoke, alter or enlarge on requirements of Contract Documents; to approve or accept any portion of work, or perform any duties of the CONTRACTOR.

1.4 LABORATORY REPORTS

A. After each inspection and test, submit two (2) copies of laboratory report to Owner's Representative, ENGINEER and to the OWNER.

B. Include:

1. Date issued.


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2. Project title and number.
3. Name of inspector.
4. Date and time of sampling or inspection.
5. Identification of product and Specifications Section.
6. Location in the Project.
7. Type of inspection or test.
8. Date of test.
9. Results of tests.
10. Conformance with Contract Documents.

C. When requested by OWNER, provide interpretation of test results.

1.5 CONTRACTOR'S RESPONSIBILITY

A. Cooperate with Laboratory personnel and provide access to work.

B. Provide to Laboratory, preliminary representative samples of materials to be tested, in required quantities.

C. Furnish casual labor and facilities to provide access to work to be tested, to obtain and handle samples at the site, and to facilitate inspections and tests.

D. Notify Laboratory sufficiently in advance of operations to allow for their assignment of personnel and schedule of tests.

E. Arrange with Laboratory, and pay for, any additional samples and testing required for CONTRACTOR's convenience.

*** * * * * END OF SECTION * * * * ***


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# SECTION 01500

# CONSTRUCTION FACILITIES

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

The CONTRACTOR shall furnish temporary construction facilities as required for the use of all trades during the construction period.

1.2 SUBMITTALS

A. Location Map: Suggested areas for temporary facilities and parking are shown on the Contract Documents. The Contractor shall provide a location map showing proposed temporary facilities, utility hookups, staging areas, and parking areas for construction personnel.

1.3 ACCESS AND PARKING

OWNER shall provide adequate and safe access to site and work, and CONTRACTOR shall maintain designated parking areas. All construction personnel must park in designated areas.

1.4 TRASH REMOVAL

Clean up and trash removal shall be performed in accordance with Supplemental Terms and Conditions.

1.5 TEMPORARY SANITARY FACILITIES

CONTRACTOR shall provide and maintain chemical type self-contained temporary toilet accommodations on the premises for use of workmen employed during the project. After completion of the project they shall be removed. The temporary toilets shall be enclosed and weather-proof and kept in a sanitary condition at all times. The temporary sanitary facilities shall be anchored to ground to prevent wind uplift.

1.6 TEMPORARY UTILITIES

The CONTRACTOR shall provide all temporary electric, water and lighting utilities necessary for the proper performance of the work, except for the construction trailer power and water only.

1.7 FIELD OFFICES

A. Field offices, General: Prefabricated or mobile units with serviceable finishes, temperature controls, and foundations adequate for normal loading. Items to be provided in accordance with Federal, State, and Local Building codes. CONTRACTOR shall be responsible for providing a minimum 8 ft x 20 ft office trailer equipped with electricity, internet, heat and air conditioning, and sanitary facilities for Owner's Representative and other CQA field staff including a lockable room for storing a nuclear density gauge.

B. Common-Use Field Office: Of sufficient size to accommodate needs of construction personnel. Keep office clean and orderly. Furnish and equip offices as necessary.

1.8 REMOVAL OF UTILITIES, FACILITIES, AND CONTROLS

A. Remove temporary above-grade or buried utilities, equipment, facilities, materials, prior to Final application for Payment inspection.

B. Remove temporary underground installations.


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C. Clean and repair damage caused by installation or use of temporary work.

D. Restore existing facilities used during construction to original condition. Restore permanent facilities used during construction to specified conditions.

1.9 PROTECTION OF EXISTING UTILITIES AND FACILITIES

A. Protect and maintain in-service all existing utilities.

B. Provide temporary services where required to provide uninterrupted utility services for on-going site operations.

C. Prevent damage to existing facilities structures and buildings - repair damage or replace immediately on direction of OWNER.

*** * * * * END OF SECTION * * * * ***


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# SECTION 01540

# DUST CONTROL

## PART 1– GENERAL

1.1 DESCRIPTION OF WORK

The CONTRACTOR shall employ construction methods and means that keep airborne particulates to a minimum and shall provide for the application of water or employ other appropriate preventive means or methods to maintain dust control and to eliminate fugitive dust, subject to the approval of the OWNER.

Dust control measures shall be compatible with existing on-site materials and proposed materials.

CONTRACTOR shall prepare a Fugitive Dust Emissions Plan as part of the Environmental Protection Plan and Health and Safety Plan in compliance with applicable permits and to eliminate the generation of fugitive emissions when working with CCR.

1.2 RELATED SECTIONS

A. Section 01300 - Submittals

B. Section 02100 - Site Preparation

C. Section 02110 - Site Clearing and Grubbing

D. Section 02200 - Earthwork

## PART 2 – PRODUCTS

Materials (e.g. soil tackifiers, polymers) and water sources being used for dust control shall be submitted to the OWNER and ENGINEER for approval prior to use.

## PART 3 – EXECUTION

Watering equipment shall be used to minimize airborne concentrations and shall consist of pipelines, tank trucks, or other devices approved by the OWNER, which are capable of applying a uniform spread of water over the ground surface. A suitable device for a positive shut-off and for regulating the flow rate of water shall be located so as to permit positive operator control. Calcium chloride is not allowed for dust control.

Water for dust control shall not create runoff that leaves the site.

*** * * * * END OF SECTION * * * * ***


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# SECTION 01562
# CONTRACT CLOSEOUT

## PART 1 – GENERAL

1.1 FINAL CLEANING

A. Execute final cleaning prior to final inspection.

B. Clean debris from drainage system, sedimentation ponds, roads and work areas.

C. Clean remainder of the Site of any deleterious material as directed by OWNER.

D. Remove waste and surplus materials, rubbish, and construction facilities from the Site.

1.2 FINAL REVIEW

A. CONTRACTOR shall submit in writing that:

1. Work has been completed in accordance with Contract Documents.
2. Equipment and systems have been tested in presence of OWNER and are operational.
3. All inspections by local or regional agencies have been satisfactorily completed.
4. Project is completed, and ready for final review.
5. The project record documents have been maintained in accordance with Section 01564 and accurately describes the complete work.

B. Upon Virginia Department of Environmental Quality review of the Work, OWNER will request CONTRACTOR to make project closeout submittals.

C. Should OWNER consider that work is not finally complete:

1. OWNER will notify CONTRACTOR, in writing, stating reasons.
2. CONTRACTOR shall take immediate steps to remedy the stated deficiencies and send second written notice to OWNER certifying that work is complete.
3. OWNER will again review the work.

1.3 CLOSEOUT SUBMITTALS

A. Project Record Documents: In accordance with requirements of Section 01564.

B. Deliver evidence of compliance with requirements of governing authorities, e.g. building permit closeout and stormwater inspections.

C. Deliver warranties for Products and Completed Operations.

D. Applicable requirements of federal, state, and local agencies having jurisdiction.

*** * * * * END OF SECTION * * * * ***


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# SECTION 01564

# PROJECT RECORD DOCUMENTS

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The work under this Section includes, but is not necessarily limited to, the maintenance, recording and submittal of Project Record Documents as herein specified.

B. The CONTRACTOR shall maintain in designated locations at the Site for the OWNER one record copy of:

1. Drawings and Addenda.
2. Specifications and Addenda
3. Change orders and other modifications to the Contract.
4. OWNER field orders or written instructions.
5. Reviewed shop drawings, product data and samples.
6. Red-line record drawings.
7. Field test records.
8. Manufacturer’s certificates/warranties.
9. Weekly Reports.
10. Monthly Reports.

C. Other Documents: Manufacturer’s certifications, inspection certifications, field test records required by individual Specifications Sections.

D. The CONTRACTOR shall keep and maintain at the Site, one set of progress drawings for each project. On these, it shall mark all project conditions, locations, configurations, and any other changes or deviations which may vary from the details represented on the Contract Documents, including buried or concealed construction and utility features which are revealed during the course of construction. Special attention shall be given to recording the horizontal and vertical location of all buried utilities that differ from the locations indicated, or which were not indicated on the Contract Documents. The progress drawings shall be supplemented by any detailed sketches as necessary or directed to indicate, fully, the Work as actually constructed. These progress drawings of the CONTRACTOR's representation of As-Built conditions, including all revisions made necessary by addenda, change orders, and the like shall be maintained up to date during the progress of the Work.

E. Progress drawings shall be accessible to the Owner’s Representative at all times during the construction period and shall be delivered to the Owner’s Representative upon completion of the Work.

F. Upon Substantial Completion of the Work and prior to Final Acceptance, the CONTRACTOR shall complete and deliver 6 complete sets of record drawings and electronic versions of the record drawings in, PDF and AutoCAD (DWF or DWG) Format to the OWNER and Owner’s Representative, conforming to the construction records of the CONTRACTOR. This set of drawings shall consist of corrected drawings showing the reported location of the Work. The information submitted by the CONTRACTOR and incorporated by the Owner’s Representative into the Record Drawings will be assumed to be reliable, and the Owner’s Representative will not be responsible for the accuracy of such information, nor for any errors or omissions which may appear on the Record Drawings as a result.

As part of each certification report submitted to the Virginia Department of Environmental Quality (DEQ), As-Built drawings sealed by a Virginia Licensed Land Surveyor will be included. These drawings must be to scale, have a contour interval of two (2) feet or less, and be on a 24”x36” sheet size.


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As a minimum, drawings will include the As-Built Surveys:

1. Existing Conditions
2. Landfill As-Builts:

    a. As-Built 1. Subgrades / Bottom of Control Subgrade.
    b. As-Built 2. Top of Control Subgrade/Liner Subgrades.
    c. As-Built 3. Geomembrane Panel Survey.
    d. As-Built 4. Leachate Collection System.
    e. As-Built 5. Top of Protective Cover.
    f. As-Built 6. Top of placed CCR in Landfill (top of waste).
    g. As-Built 7. Top of Intermediate Cover.
    h. As-Built 8. Cover System Geomembrane Panel Survey.
    i. As-Built 9. Top of Final Cover Soil and Vegetative Support Layer.
    j. As-Built 10. Final Site Conditions.

3. North Ash Pond (NAP) Closure As-Builts:

    a. As-Built 1. Bottom of CCR excavation and bottom of six (6) inch over excavation below CCR excavation.
    b. As-Built 2. Top of Compacted Fill.
    c. As-Built 3. Final Site Conditions.
    d. As-Built 4. Any other permanent or ancillary structures important to the Project, as directed by OWNER.

1.2 MAINTENANCE OF DOCUMENTS AND SAMPLES

A. Storage:

1. Store documents and samples in CONTRACTOR's field office apart from documents used for construction.
2. Provide files and racks for storage of documents.
3. Provide locked cabinet or secure storage space for storage of samples.

B. File documents and samples in accordance with format of these Specifications.

C. Maintenance:

1. Maintain documents in a clean, dry, legible condition and in good order.
2. Do not use record documents for construction purposes.

D. Make documents and samples available at all times for inspection by OWNER.

1.3 RECORDING

A. Label each document "PROJECT RECORD" in neat, large-printed letters.

B. Recording:

1. Record information concurrently with construction progress.
2. Do not conceal any work until required information is recorded.

C. Drawings: Progress drawings shall be reproducible, shall have a title block indicating that the drawings are record drawings, the name of the company preparing the progress drawings and the date the progress drawings were prepared. The CONTRACTOR will be provided paper and/or digital copies of the Contract Documents, at the cost of reproduction, or may elect to provide reproducible drawings via another method. Legibly mark drawings to record actual construction:


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1. Measured horizontal and vertical locations, dimensions, and elevations of underground drain piping and appurtenances, referenced to permanent surface improvements or benchmarks.
2. Field changes of dimension and detail.
3. Changes made by Requests for Information (RFI), field order or by change order.
4. Details not on original Contract Documents.

D. Specifications: Legibly mark and record at each product section description of actual products installed, including the following:

1. Manufacturer, trade name, catalog number, and supplier of each product and item of equipment actually installed.
2. Product substitutions or alternates utilized.
3. Changes made by Requests for Information (RFI), field order or by change order.

1.4 SUBMITTAL

A. At Contract closeout, deliver record documents in the form of a Final Construction Report to the OWNER for each project.

B. Accompany submittal with transmittal letter, in duplicate, containing:

1. Date.
2. Project title and number.
3. CONTRACTOR's name, address, and telephone number.
4. Title and number of each record document.
5. Signature of CONTRACTOR's authorized representative.

*** * * * * END OF SECTION * * * * ***


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# SECTION 01600

# MATERIALS AND EQUIPMENT

## PART 1 – GENERAL

1.1 SUMMARY

A. All equipment, materials, instruments, or devices incorporated in this project shall be new and unused, unless indicated otherwise in the Contract Documents. Equipment and materials to be incorporated into the Work shall be delivered sufficiently in advance of their installation and use to prevent delay in the execution of the Work, and they shall be delivered as nearly as feasible in the order required for executing the Work.

B. CONTRACTOR shall protect all equipment and materials from deterioration and damage, including provision of temporary storage buildings as needed. Storage of equipment and materials shall be in locations completely protected from flooding, standing water, excessive dust, brush fire, etc. and acceptable to OWNER and ENGINEER. Storage areas shall be located sufficiently distant from all construction activities and the movement of construction vehicles to minimize the potential for accidental damage. Any equipment or materials of whatever kind which may have become damaged or deteriorated from any cause shall be removed and replaced by good and satisfactory items at CONTRACTOR's expense for both labor and materials.

C. Equipment and materials shall be installed in accordance with the requirements of the respective specification sections.

1.2 STORAGE OF MATERIALS AND EQUIPMENT

A. All equipment and materials shall be stored in accordance with manufacturer's recommendations and as directed by OWNER or ENGINEER, and in conformity to applicable statutes, ordinances, regulations, and rulings of the public authority having jurisdiction.

B. CONTRACTOR shall enforce the instructions of OWNER and ENGINEER regarding the posting of regulatory signs for loadings on structures, fire safety, and smoking areas.

C. Stockpiles of aggregate materials shall be kept separate from soil stockpiles to prevent fouling or mixing of dissimilar materials.

D. CONTRACTOR shall provide overnight parking and staging for equipment and vehicles at locations designated by the OWNER.

E. CONTRACTOR shall not store materials in such a manner that they are exposed to weather which, in ENGINEER'S or manufacturer's opinion can alter the material properties.

F. CONTRACTOR shall not store unnecessary materials or equipment on the job site and shall take care to prevent any structure from being loaded with a weight which will endanger its security or the safety of persons.

G. Materials or equipment shall not be placed within ten (10) feet of fire hydrants. Gutters, drainage channels, swales, and inlets shall be kept unobstructed at all times.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02100

# SITE PREPARATION

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all materials, labor, equipment, tools and appurtenances required to complete the work.

B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

C. Remove and dispose of all debris, bulky items, waste materials, etc. existing in the area to be constructed and encountered in the work area. All bulky items such as large debris, stumps, cars, old fencing, etc. are to be disposed off-site at the CONTRACTOR's expense and shall be accompanied with a manifest signed by the OWNER. Material containing CCR or coal shall be disposed of in an off-site regulated landfill at the CONTRACTOR's expense, or as approved by the OWNER.

D. Protect and maintain benchmarks, monuments, monitoring wells and other reference points. Re-establish, at no cost to the OWNER, any such reference points if disturbed or destroyed. The CONTRACTOR's surveyor shall conduct a survey of all monuments and property markers within proposed cover areas prior to any disturbance such as they can be re-established after completion of the cover by the CONTRACTOR as part of this Contract.

E. Remove, demolish, excavate, haul and dispose of any on-site structures, pavement, roads, drainage pipes, utilities, etc. per paragraph C above.

1.2 RELATED SECTIONS

A. Section 02110 - Site Clearing and Grubbing

B. Section 02200 - Earthwork

*** * * * * END OF SECTION * * * * ***


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# SECTION 02110

# SITE CLEARING AND GRUBBING

## PART 1 – GENERAL

### 1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all materials, labor, equipment, tools and appurtenances required to complete the work as described below. The CONTRACTOR shall provide a Competent Person to implement and supervise all work. All materials and equipment mobilized to the site from a zone identified by the USDA as a "Fire Ant Quarantine Zone" shall be inspected by a qualified person prior to arrival onsite.

B. The CONTRACTOR is responsible for obtaining and complying with necessary certificates, limited permits, and/or compliance agreements. The CONTRACTOR is responsible for providing such documentation to the OWNER.

C. Site clearing includes, but is not limited to, removing from the limits of work and disposing of trees, stumps, roots, brush, structures (at and below ground), abandoned utilities, trash, asphalt, debris and all other materials found on or near the surface of the ground in the construction area. Precautionary measures that prevent damage to existing features to remain are part of the work. The CONTRACTOR shall get the OWNER's approval prior to disposal of materials.

D. Comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, State or Federal authorities having jurisdiction.

1. Clearing restrictions (due to long eared bat): June 1 – July 31, unless otherwise approved by owner.

E. No clearing and grubbing will be allowed without adequate erosion and sedimentation control measures in place and to the satisfaction of the OWNER or ENGINEER.

### 1.2 RELATED SECTIONS

A. Section 01540 - Dust Control

B. Section 02125 - Temporary and Permanent Erosion and Sediment Control

C. Section 02200 - Earthwork

### 1.3 DEFINITIONS

A. Clearing - Removal from ground surface and disposal within designated areas of trees, brush, shrubs, downed timber, decayed wood, other vegetation, rubbish, and debris as well as removal of fences and incidental structures.

B. Grubbing - Removal and disposal of stumps, buried logs, roots larger than 0.5 inches in diameter, matted roots, and organic materials.

C. Topsoil - Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 0.5 inches in diameter; and free of weeds, roots, toxic materials, or other non-soil materials.


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1.4 JOB CONDITIONS

A. The area to be cleared and grubbed includes all areas designated for excavation, access road construction, stormwater channel/swale construction, contractor laydown areas, required construction access areas, and any other areas required to complete the scope of work.

1.5 SUBMITTALS

A. Prior to the start of any construction activities, the following shall be submitted to the OWNER:

1. Clearing and Grubbing Plan:

a. Describe method for vegetation removal and disposal.
b. Describe temporary barriers and methods to protect existing structures and property, existing plant life and features designated to remain, and areas beyond limits of disturbance as identified on the Contract Documents.

2. Photographs or videotape, sufficiently detailed, of existing conditions of trees and plantings, adjoining construction, and site improvements that might be misconstrued as damage caused by site clearing.

**PART 2 – PRODUCTS**

The CONTRACTOR shall furnish equipment of the type normally used in clearing and grubbing operations including, but not limited to, dozers, shears, skidders, loaders, root rakes, chipping equipment and stump grinders.

**PART 3 – EXECUTION**

3.1 SCHEDULING OF CLEARING

A. CONTRACTOR shall install all temporary Erosion and Sediment Controls per CONTRACTOR's approved Soil Erosion and Sediment Control Plan to the acceptance of the OWNER prior to startup of clearing operations.

B. CONTRACTOR shall coordinate and confirm with the OWNER that the Unexploded Ordinance (UXO) survey and monitoring has been completed and that the area is cleared prior to the CONTRACTOR performing any clearing and grubbing.

C. CONTRACTOR shall maintain all survey controls.

D. Limits of Disturbance (LOD) to be cleared, delineated wetlands, and resource protection areas (RPAs) must be clearly staked out. Locate and clearly flag trees and vegetation to remain or to be relocated. The CONTRACTOR shall maintain and replace staking and flagging as necessary during construction.

3.2 PROTECTION

A. Verify the area to be cleared, and existing plant life and features designated to remain, with OWNER before initiating any clearing operations in that area. Unauthorized clearing will not be measured, and CONTRACTOR is responsible for damage to existing plant life and features designated to remain.

B. Protect any trees, plant growth, and site features not designated for removal or designated for protection per Virginia Erosion and Sediment Control Handbook (VESCH) Section 3.38, Tree Preservation and Protection and approved of by the OWNER. Remove only the plant growth required for the Work.


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C. Do not disturb trees or shrubbery in public right-of-way or on property outside of the limits of disturbance shown on the Contract Documents.

D. CONTRACTOR is responsible for damage to vegetation, that is to remain, caused by CONTRACTOR operations, personnel, or equipment. Remove and replace damaged vegetation with vegetation of same type and size at no additional cost to OWNER.

## 3.3 CONSTRUCTION AREA CLEARING AND GRUBBING

A. Materials to be cleared, grubbed, and removed from the construction areas include, but are not limited to, the following: all trees, stumps, roots, brush, trash, organic matter, miscellaneous structures, debris, and abandoned utilities.

B. Grubbing shall consist of completely removing roots, stumps, trash and other debris from all graded areas so that surface material is free of roots and debris. Surface material is to be left sufficiently clean so that further picking and raking will not be required.

C. All construction areas shall be grubbed by tractors with root rakes.

D. All stumps, roots, foundations and planking embedded in the ground shall be removed and disposed of.

E. All mulch materials shall be hauled and removed from the Site in accordance with applicable Federal, State, and Local regulations. Mulch material stockpiling shall not be allowed.

F. There will be no on-site burning permitted.

G. Surface rocks and boulders shall be grubbed from the soil and removed to the area on-site as directed by the OWNER.

H. Where tree limbs interfere with utility wires, or where the trees to be felled are in close proximity to utility wires, the tree shall be taken down in sections to eliminate the possibility of damage to the utility. The CONTRACTOR shall coordinate with the OWNER for all replacements/repairs to damaged utilities at no cost to OWNER.

I. Any work pertaining to utility poles and guy wires shall comply with the requirements of the appropriate utility and shall be approved by the OWNER.

J. Stumps and roots shall be grubbed and removed to a depth not less than two feet below grade. All holes or cavities which extend below the subgrade elevation of the proposed work shall be filled with suitable material, compacted to a similar density as the surrounding material.

K. The CONTRACTOR shall exercise special precautions for the protection and preservation of identified trees and shrubs within the construction area or those situated adjacent to the limits of the construction area. The CONTRACTOR shall be held liable for any damage the CONTRACTOR's operations have inflicted on such property.

L. The CONTRACTOR shall be responsible for all damages to existing structures and/or improvements resulting from CONTRACTOR's operations.

## 3.4 TOPSOIL STRIPPING

A. Strip topsoil to whatever depths are encountered in a manner to prevent intermingling with underlying subsoil or other waste materials.

B. Remove subsoil and non-soil materials from topsoil, including trash, debris, and other waste materials.


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C. All topsoil stockpiles shall be placed at least 50-feet away from any excavation and shall not intermix with any subsoil. Grade and shape stockpiles to drain surface water. Cover to prevent windblown dust, temporary or permanent seeding may be required to adequately protect stockpiles and shall be in compliance with the SWPPP and VESCH Sections 3.31 and 3.32.

3.5 OVERHEAD UTILITY LINE RIGHT OF WAY CLEARING

A. All tree trimming operations within the right of way of overhead utility lines shall be completed in accordance with Dominion Virginia Power Specifications.

B. Trees at edge of right of way shall be side-walled ground to sky.

C. Stumps shall be cut to within 3" of ground level.

D. Brush shall be chipped and windrowed out of right of way or ground up with a brush hog in the right of way.

E. No wood shall be left in right of way (stack it out of right of way).

3.6 DISPOSAL OF DEBRIS

A. All wood debris (stumps, roots, branches, and leaves) resulting from the clearing and grubbing operation shall be disposed of by chipping, grinding, or by other methods as approved by OWNER, in accordance with the Contract Documents and Specifications.

B. Clearing debris that cannot be mulched or chipped shall be disposed off-site by the CONTRACTOR at a properly permitted disposal facility on the OWNER's approved disposal facilities list, and in accordance with Local and State regulations at no additional cost to the OWNER. CONTRACTOR shall provide OWNER with the location of proposed disposal facilities and the related documentation of regulatory approval and applicable permits.

C. Burning of cleared vegetation and other waste materials is prohibited.

3.7 MAINTENANCE OF CLEARED AREAS

A. Maintain cleared work areas in a condition free from additional weeds and brush that require clearing for the duration of the project. Use of herbicides to discourage plant growth is not allowed. CONTRACTOR shall be compensated for clearing each area only one time. If weeds and brush growth require additional clearing, this shall be performed solely at CONTRACTOR's expense.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02125

# TEMPORARY AND PERMANENT EROSION AND SEDIMENT CONTROL

## PART 1 – GENERAL

### 1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide all materials and promptly take all actions necessary to achieve erosion and sedimentation control in accordance with acceptable federal, state and local enforcing agency guidelines and these Specifications. CONTRACTOR shall provide a "Competent Person" to implement and supervise all work.

B. The work shall include, but not necessarily be limited to, installation and maintenance of temporary erosion and sediment control measures, such as silt fence, diversion devices, sediment traps, basins, temporary and permanent seeding, and best management practices (BMPs) in accordance with State and Federal regulations. Work to also include the removal of temporary erosion and sediment control measures after receiving written approval from the OWNER.

C. The Contract Documents include plan, detail, and notes for installing stormwater and sediment and erosion control devices required for the project. The work shown on the Contract Documents shall be considered a minimum requirement. What is shown shall not relieve the CONTRACTOR of the responsibility to actively take all steps necessary to control soil erosion and sedimentation.

D. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction. All sediment and erosion control devices shall be installed and activities completed in accordance with the Contract Documents, this Section of the Specifications, the General VPDES Permit for Discharges of Stormwater from Construction Activities (VAR10), the approved Erosion and Sediment Control Plan, and any additional State and Federal permit requirements that exist in the vicinity of the Work. If there is a contradiction between the Contract Documents or these Specifications with the VAR10 permit requirements, then the VAR10 permit requirements shall prevail.

E. CONTRACTOR shall maintain erosion and sediment controls and site conditions in accordance with the Virginia Erosion and Sediment Control Handbook (VESCH) and the SWPPP at the CONTRACTOR's expense.

F. Erosion Control Measures shall be provided for all construction activities and other related work throughout the site. CONTRACTOR shall maintain at least 20% overstock of erosion control items stockpiled on-site for ease of use to replace installed items as deemed necessary or provide evidence that necessary amounts of materials are readily available from local suppliers.

G. The temporary erosion control features installed by the CONTRACTOR shall be maintained by the CONTRACTOR until no longer needed as determined by the OWNER, or permanent erosion control methods are installed.

H. In addition to the stormwater and sediment and erosion control measures shown on the Contract Documents, CONTRACTOR shall provide all adequate means to prevent any sediment from entering any storm drains, drop inlets, ditches, streams, or bodies of water downstream of any area disturbed by construction. Excavation materials shall be placed upstream of any trench or other excavation to prevent sedimentation of off-site areas. In areas where a natural buffer area exists between the Work area and the closest stream or water course, this area shall not be disturbed. All paved areas shall be scraped and swept as necessary to prevent the accumulation of dirt and debris.


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I. It shall be the sole responsibility of the CONTRACTOR to properly schedule and coordinate all necessary labor, equipment and materials such that the specified work is performed in accordance with the project schedule and the Contract requirements. At the discretion of the OWNER, the OWNER may reject or direct the CONTRACTOR to repair (at the CONTRACTOR's sole expense) those items which are detrimental to the project or not in compliance with the Contract Documents. Such direction or rejection by the OWNER shall not relieve the CONTRACTOR of his obligation to properly schedule and perform other specified work items in conformance with the Contract Documents.

1.2 RELATED SECTIONS

A. Section 02200 – Earthwork

B. Section 02126 – Hydraulically Applied Flexible Growth Medium

1.3 REFERENCES

A. Virginia Department of Environmental Quality (VDEQ) Erosion & Sediment Control Handbook (VESCH), Third Edition, 1992 (or latest edition).

1.4 SUBMITTALS

A. At the preconstruction conference, the CONTRACTOR shall submit for OWNER's approval, a schedule and construction drawing for temporary and permanent erosion control work, as applicable for clearing and grubbing, grading, structures at watercourses, and general construction. No work shall be started prior to installation of the erosion and sediment controls and methods of operations for each phase of construction have been accepted by the OWNER. This plan will be referred to as the CONTRACTOR's Soil Erosion and Sediment Control Plan.

B. Manufacturer cut sheets, product information, etc. shall be provided by CONTRACTOR to OWNER or Owner's Representative to show evidence that materials received meet and/or exceed Contract Document specifications.

1.5 QUALITY ASSURANCE

CONTRACTOR shall be responsible for the timely installation and maintenance of all stormwater and erosion and sediment control devices necessary to prevent the movement of sediment from the construction site to offsite areas or wetland areas via surface runoff or underground drainage systems. CONTRACTOR shall not remove any stormwater or erosion and sediment control devices without approval of the OWNER, even if those controls are in addition to those shown on the Contract Documents. Control measures installed in addition to those shown on the Contract Documents necessary to prevent the movement of sediment outside the limits of construction shall be installed, maintained, removed, and cleaned up at the expense of CONTRACTOR.

**PART 2 – PRODUCTS**

2.1 SILT FENCE

A. Silt fence shall meet the general requirements of the VESCH Section 3.05.

B. Reinforced silt fence shall meet the general requirements of the VESCH Section 3.05. Belted silt fence such as ACF SMARTfence® or approved equal may be used in place of wire-backed silt fence where approved by the ENGINEER.

2.2 BALES

A. Straw bales shall be clean, seedfree oat or wheat type.


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2.3 SEED

A. Seed type shall meet the requirements of Section 02936 - Seeding.

2.4 HYDRAULICALLY APPLIED PRODUCTS (FLEXIBLE GROWTH MEDIUM)

A. Hydraulically applied Flexible Growth Medium (FGM) products, such as Flexterra and others, shall be meet the requirements of Section 02126 – Hydraulically Applied Flexible Growth Medium and shall be installed per the manufacture's specifications.

2.5 SOIL STABILIZATION BLANKETS AND MATTING

A. Soil stabilization blankets and matting shall meet the general requirements of the VESCH Section 3.36. Contractor shall supply information on proposed material to the ENGINEER for approval.

B. Temporary Erosion Control Mat shall be either a natural or synthetic material that is photo- and bio-degradable matting suitable for seed establishment and capable of offering erosion protection for at least one growing season.

**PART 3 – EXECUTION**

3.1 GENERAL

A. The CONTRACTOR shall designate an individual who will be their primary contact for all issues regarding compliance with the VAR10 general permit and the VSMP approved erosion and sediment control plan.

B. Conduct earthwork and excavation activities in such a manner to fit the topography, soil type and site conditions.

C. Minimize the area being disturbed and the duration of exposure to erosion elements.

D. Stabilize disturbed areas immediately.

E. Prevent silt and sediment from entering any watercourse if soil erosion cannot be prevented.

F. Prevent silt and sediment from migrating downstream in the event it cannot be prevented from entering the watercourse, after receiving approval from the OWNER (additional permits to perform such work may be required).

G. Initially clear only those areas necessary for installation of the perimeter erosion and sediment control measures. The balance of the site shall not be cleared or otherwise disturbed until the perimeter erosion and sediment control measures are installed, functional and approved by ENGINEER and VSMP inspector.

H. Inspect erosion and sediment control measures at least once every four business days, unless otherwise described by the OWNER, and no later than 24 hours following a measurable storm event (rainfall greater than 0.5 inches per 24-hour period). All erosion and sediment control measures shall be cleaned out and repaired by the CONTRACTOR as necessary.

I. The location and extent of erosion control devices shall be revised at each phase of construction that results in a change in either the quantity or direction of surface runoff from construction areas. All deviations from the control provisions shown on the Contract Documents shall have the prior approval of ENGINEER and OWNER.

J. Where provisions of pertinent rules and regulations conflict with these Specifications, the more stringent provisions shall govern.


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K. The OWNER has the authority to limit the surface area of erodible material exposed by clearing and grubbing, and to direct the CONTRACTOR to provide immediate temporary or permanent control measures to prevent sediment impact on adjacent watercourses.

L. Where erosion is likely to be a problem, clearing and grubbing operations should be so scheduled and performed that grading operations and permanent erosion control features can follow immediately thereafter if the Project conditions permit; otherwise, erosion control measures may be required between successive construction stages.

M. The OWNER will limit the area of excavation, and embankment operations in progress commensurate with the CONTRACTOR's capability and progress in keeping the finish grading, mulching, seeding and other such permanent control measures current in accordance with the accepted schedule. Should seasonal limitations make such coordination unrealistic, temporary erosion control measure shall be taken immediately to the extent feasible and justified.

N. In the event that additional temporary erosion and sediment control measures are required due to the CONTRACTOR's negligence, carelessness or failure to install permanent controls as part of the work schedule, and are ordered by the OWNER, such work shall be performed by the CONTRACTOR at the CONTRACTOR's expense, and no time extension shall be given.

## 3.2 TEMPORARY EROSION AND SEDIMENTATION CONTROL

A. Temporary erosion control measures shall be used to correct conditions that develop during construction leading to soil erosion or deposition of waterborne sediments; that are needed prior to converting stormwater features to permanent controls; or that are needed temporarily to control erosion that develops during normal construction practices.

B. Temporary erosion and sedimentation control devices shall be installed and maintained prior to the initial land disturbance activity until the satisfactory completion and establishment of permanent vegetation. At that time, temporary devices shall be removed.

C. The CONTRACTOR shall coordinate the installation of temporary erosion and sedimentation control provisions contained herein with the permanent stormwater control features, to ensure economical, effective, and continuous erosion control throughout the construction and post-construction period.

D. Temporary erosion and sedimentation control procedures should be initially directed toward preventing silt and sediment from moving or discharging off-site and entering the watercourses. The preferred method is that stormwater, while covered under the VAR10 general permit, discharges from the site after being settled, filtered, or similarly treated prior to off-site discharge.

E. Silt fences, barriers, temporary sedimentation basins and other temporary measures and devices shall be installed, and shall be maintained until no longer needed, as determined by the OWNER. At that time, the items shall be removed by the CONTRACTOR. All temporary items and devices must be removed with the OWNER's approval prior to final demobilization from the Site.

F. Where permanent vegetation is not appropriate, and where the CONTRACTOR's temporary erosion and sedimentation control practices are inadequate, the CONTRACTOR shall provide temporary vegetative cover. Such temporary vegetative cover shall be provided by the CONTRACTOR in compliance with Section 02936 - Seeding of these Specifications.

## 3.3 TEMPORARY EROSION AND SEDIMENT CONTROL TECHNIQUES

A. Temporary Diversion Berms (or approved alternates)


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1. A temporary diversion berm is constructed of compacted soil, with or without a shallow ditch, at the top of fill slopes.
2. These diversion berms are used temporarily at the top of newly constructed slopes to prevent excessive erosion until permanent controls are installed or slopes stabilized.
3. A temporary diversion berm shall be constructed of compacted soil, with a minimum width of 24 inches as the top and minimum height of 12 inches with or without a shallow ditch. Side slopes shall be three horizontal to one vertical (3H:1V) or flatter.

B. Temporary Slope Drains

1. All temporary slope drains shall be adequately anchored to the slope to prevent disruption by the force of the water flowing in the drains. The base of temporary slope drains shall be compacted and concavely formed to channel water or hold the slope drain in place.
2. Inlet and Outlet Protection, or other approved energy dissipator devices, shall be constructed at the inlet and outlet ends of the slope drains to reduce erosion.

C. Sediment Control Structures

1. Sediment basins and traps are prepared storage areas constructed to trap and store sediment from erodible areas in order to protect stream channels below the construction areas from excessive siltation.
2. When use of temporary sediment structures is to be discontinued, all sediment accumulation shall be removed, and all excavation backfilled and properly compacted. The existing found shall be restored to its natural or intended condition.

D. Riprap

1. Unless shown otherwise on the Contract Documents, riprap shall be placed where ordered by the OWNER and at all points where banks of streams or drainage ditches are disturbed by excavation. Fill or backfill shall be carefully compacted and riprap placed to prevent subsequent settlement and erosion. This requirement applied equally to construction alongside a stream or drainage ditch as well as crossing a stream or drainage ditch. Reference Section 02271 – Stone Riprap.

E. Straw Bales

1. Straw bales are temporary measures to control erosion and retain the suspended silt particles in the runoff water leaving disturbed areas. Bales shall contain five cubic feet or more of material.
2. Straw bales shall be embedded in the ground 4 to 6 inches to prevent water flowing under them. The bales shall also be anchored securely to the ground by wooden stakes driven through the bales into the ground. Bales shall be removed after they have served their purpose, as determined by the OWNER.
3. The CONTRACTOR shall keep the bales in good condition by replacing broken or damaged bales immediately after damage occurs. Normal debris clean out will be considered routine maintenance.
4. Straw bales shall be used at the toe of fill slopes, in ditches, or other areas where siltation, erosion, or runoff is a problem. Straw bales should not be used in areas where large stormwater flows are expected.

F. Silt Fences

1. Silt fences are temporary measures utilizing geofabrics or other approved materials attached to posts with filter cloth attached to the upstream side of the fence to retain the suspended silt particles in the runoff water.


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2. Temporary silt fences shall be placed on the natural ground, at the toe of fill slopes, in ditches or other areas where siltation is a problem. Materials shall be installed/anchored as indicated on the Contract Documents.
3. The CONTRACTOR shall be required to maintain the silt fence in a satisfactory condition for the duration of the Project or until its removal is requested by the OWNER. The silt accumulation at the control must be removed and placed on Site as directed by the OWNER.

G. Temporary Construction Entrance

1. Furnish and install stone aggregate and filter fabric as shown on Contract Documents and as directed by the ENGINEER.
2. Maintain gravel pad in a condition to prevent mud or sediment from leaving the construction site.
3. Repair as needed. Periodic top-dressing with additional stone may be needed at no additional cost to the owner.
4. Immediately remove all objectionable materials spilled, washed, or tracked onto public roadways.

H. Temporary Vegetation

1. Temporary vegetation are measures consisting of seeding, mulching, fertilizing and FGM utilized to reduce erosion. All cut and fill slopes shall be seeded when and where necessary to eliminate erosion. Disturbed or bare soil areas shall not be left without stabilization for more than 30 days.
2. Seeding, mulching and fertilizing shall be performed in accordance with Section 02936 – Seeding of these Specifications.
3. If late fall completion prevents germination. Disturbed areas shall be protected by mulching without application of seed as a minimum.

## 3.4 PERMANENT SITE STABILIZATION MEASURES

A. The CONTRACTOR shall incorporate all permanent site stabilization measures into the Project at the earliest practicable time as outlined in the CONTRACTOR's Soil Erosion and Sediment Control Plan accepted schedule or as land disturbance for each segment of the Project has been completed.

B. Restore the work site to its original contours, unless shown otherwise on the Contract Documents or directed by the OWNER.

C. All references to permanent vegetation, unless noted otherwise, shall relate to establishing permanent vegetative cover and be in accordance with Section 02936 – Seeding of these Specifications.

D. When final grade has been established, all bare soil, unless otherwise required by the Contract Documents, shall be seeded, fertilized and mulched in an effort to restore to a protected condition. Areas that are not stabilized with seed and mulch shall be sodded as approved or directed by the OWNER.

E. Specified permanent vegetation shall be established at the first appropriate season following establishment of final grading in each section of the Site.

F. Permanent vegetative cover activities shall comply with local soil and water conservation guidelines.

G. Where permanent vegetative cover cannot be immediately established (due to season or other circumstances) the CONTRACTOR shall provide temporary vegetative cover.

H. Riprap


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1. Riprap used for permanent stabilization of channels, slopes and culvert outlets shall be installed in accordance with the Contract Documents and Section 02271 – Stone Riprap of these Specifications.
2. Placement of riprap at locations other than those specified on the Contract Documents shall be done only with approval or by the direction of the OWNER.
3. The ground surface around which the riprap is to be placed shall be brought in reasonably close conformity to the correct lines and grades before placement is commenced.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02126

# HYDRAULICALLY APPLIED FLEXIBLE GROWTH MEDIUM

## PART 1 – GENERAL

### 1.1 SUMMARY

A. This section specifies the hydraulically applied erosion control product category of High Performance-Flexible Growth Medium (FGM). The recommended hydraulically applied erosion control product shall be Flexterra high performance FGM as manufactured by Profile, or an OWNER approved equivalent.

B. The high performance FGM shall be 100% biodegradable, made in the United States and composed of 100% recycled, thermally refined (within a pressurized vessel) virgin wood fibers, crimped interlocking biodegradable fibers, mineral activators, and wetting agents (including high-viscosity colloidal polysaccharides, cross-linked biopolymers and water absorbents). The high performance FGM must be phytosanitized, free from plastic netting, require no curing period and upon application from an intimate bond with the soil surface to create a continuous, porous, absorbent and flexible erosion resistant blanket that allows for rapid germination and accelerated plant growth.

### 1.2 RELATED SECTIONS

A. Section 02125 - Temporary and Permanent Erosion and Sediment Control

B. Section 02936 - Seeding

### 1.3 SUBMITTALS

A. CONTRACTOR shall submit in accordance with Section 01300 - Submittals.

B. At the preconstruction conference, the CONTRACTOR shall submit for OWNER's approval, a schedule and construction drawing for accomplishment of temporary and permanent erosion control work, as are applicable for clearing and grubbing, grading, structures at watercourses, and general construction. No work shall be started prior to installation of the erosion and sediment controls and methods of operations for each phase of construction have been accepted by the OWNER. This plan will be referred to as the CONTRACTOR's Soil Erosion and Sediment Control Plan.

C. Prior to installation, the CONTRACTOR shall submit for OWNER's approval, the name and address of the FGM supplier, manufacturer's product data and installation instructions including required substrate preparation, list of materials, and application rate.

D. Prior to installation, the CONTRACTOR shall submit for OWNER's approval, a letter of certification that the FGM product materials meet or exceed all technical and packaging requirements.

E. Delivery tickets or other approved receipts as evidence for materials received that will be incorporated into construction. Manufacturer cut sheets, product information, etc. shall also be provided by CONTRACTOR to OWNER to show evidence that materials received meet and/or exceed these specifications.

### 1.4 DELIVERY, STORAGE AND HANDLING

A. Materials and products shall be delivered in UV and weather-resistant factory labeled packages. The CONTRACTOR shall store and handle the materials and products in strict compliance with manufacturer's instructions and recommendations and provide protection from damage, weather, and excessive temperatures and construction operations.


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1.5 QUALITY ASSURANCE

A. CONTRACTOR shall be responsible for the timely installation and maintenance of all sediment and erosion control devices necessary to prevent the movement of sediment from the construction site to offsite areas or wetland areas via surface runoff or underground drainage systems. CONTRACTOR shall not remove any stormwater and sediment and erosion control devices without approval of the OWNER even if those controls are in addition to those shown on the Contract Documents. Control measures installed in addition to those shown on the Contract Documents necessary to prevent the movement of sediment outside the limits of construction shall be installed, maintained, removed, and cleaned up at the expense of CONTRACTOR. No additional charges to OWNER will be considered for the Work under this Section.

B. Temporary seeded areas shall be reviewed by OWNER for bare soils caused by surface or wind erosion. Bare areas shall be regraded, seeded, and protected through hydroseeding or by applying a Flexible Growth Medium (FGM).

## PART 2 – PRODUCTS

2.1 HYDRAULICALLY APPLIED PRODUCTS (FLEXIBLE GROWTH MEDIUM)

A. Hydraulically applied High Performance-Flexible Growth Medium (FGM) products such as Flexterra and others, may be used in lieu of temporary erosion control mat (EC-2) or with the approval of the OWNER and ENGINEER. High performance FGM with geofabric backing may be used in lieu of permanent erosion matting with the approval of the OWNER and ENGINEER. If high performance FGM is used in conjunction with seeding, provide the required soil testing to manufacturer for seed and fertilizer mix design (reference Section 02936 – Seeding).

2.2 MATERIALS

A. The FGM shall conform to the following typical property values included in Table 1 when uniformly applied at a rate of 3,500 lb/acre under laboratory conditions.


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**Table 1**

| Property | Test Method | Tested Value |
|---|---|---|
| **Physical** | | |
| Mass Per Unit Area | ASTM D6566 (A) | ≥ 11.6 oz/yd$^2$ |
| Thickness | ASTM D6525 | ≥ 0.22 inch |
| Ground Cover | ASTM D6567 | ≥ 99% |
| Water Holding Capacity | ASTM D7367 | ≥ 1,700% |
| Material Color | Observed | Green |
| **Performance** | | |
| Cover Factor (B) | Large Scale Testing (C) | ≤ 0.01 |
| % Effectiveness (D) | Large Scale Testing | ≥ 99% |
| Cure time | Observed | 0 – 2 hours |
| Vegetation Establishment | ASTM D7322 (A) | ≥ 800% |
| Functional Longevity (E) | ASTM D5338 | ≤ 18 months |
| **Environmental** | | |
| Ecotoxicity | EPA 2021.0 | 48-hr $LC_{50}$ > 100% |
| Effluent Turbidity | Large Scale Testing | ≤ 250 NTU |
| Biodegradability | ASTM D5338 | Yes |

(A) ASTM test methods developed for Rolled Erosion Control Products and have been modified to accommodate Hydraulically applied Erosion Control Products.

(B) Cover Factor is calculated as soil loss ratio of treated surface versus an untreated control surface.

(C) Large scale testing conducted at Utah Water Research Laboratory. For specific testing information please contact a manufacturer representative.

(D) % Effectiveness = One minus Cover Factor multiplied by 100%.

(E) Functional Longevity is the estimated time period, based upon ASTM D5338 testing and field observations, that a material can be anticipated to provide erosion control and agronomic benefits as influenced by composition, as well as site-specific conditions, including; but not limited to – temperature, moisture, light conditions, soils, biological activity, vegetative establishment and other environmental factors.

B. Composition

1. All components of the high performance FGM shall be prepackaged by the Manufacturer to assure both material performance and compliance with the following values. Under no circumstances shall field mixing of components be permitted. No chemical additives with the exception of fertilizer, soil neutralizers and biostimulant materials should be added to this product.
2. Thermally Processed (within a pressurized vessel) Virgin Wood Fibers – 80% (Heated to a temperature greater than 380°F for 5 minutes at a pressure greater than 50 psi).
3. Wetting agents (including high-viscosity colloidal polysaccharides, cross-linked biopolymers, and water absorbents) – 10%.
4. Crimped Biodegradable Interlocking Fibers – 5%.
5. Micro-Pore Granules – 5%.


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C. Packaging

1. Bags: Net Weight – 50 lb, UV and weather-resistant plastic film.
2. Pallets: Weather-proof, stretch-wrapped with UV resistant pallet cover.
3. Pallet Quantity: 40 bags/pallet or 1 ton/pallet.

2.3 VEGETATION SPECIES SELECTION

A. Species selection and establishment shall meet or exceed the requirements of Section 02936 – Seeding, when applicable.

B. Site and project specific information considered for species selection shall include:

1. Project Location and Planning.
   a. Climate
   b. Elevation
   c. Aspect
   d. Slope/Gradient
   e. Permanent or Temporary Planting
   f. Installation Date(s)

2. Soil Conditions.

   a. Soil texture
   b. Soil pH
   c. Aspect
   d. Toxicities/Deficiencies noted in the previous section.

3. Site Maintenance Requirements.

   a. Mowing
   b. Irrigation
   c. Animal grazing preference

4. Preferred Vegetation.

   a. Drought tolerant
   b. Native vegetation
   c. Shrub species
   d. Turf grasses
   e. Cool season
   f. Warm season
   g. Blend of cool and warm season
   h. Legume species
   i. Cover crops

**PART 3 – EXECUTION**

3.1 SOIL TESTING

A. Prior to vegetation, the CONTRACTOR shall adequately test the soils to be vegetated to ensure adequacy of the stabilization and seeding requirements of the approved erosion and sediment control plan and provide results to the OWNER. Any modifications to these requirements deemed necessary after the review of soil test results shall be at the CONTRACTOR's expense. The OWNER will perform observations to determine when successful vegetation is achieved (Refer to Section 02936 – Seeding).


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B. The tests shall include analysis and interpretation of results.

C. Soil Analysis shall include results for:

1. Soil pH
2. Soluble salts
3. Excess carbonate
4. Organic matter
5. Nutrient readings for:
   a. Nitrogen, Phosphorus, Potassium
   b. Magnesium, Calcium, Sodium, Manganese, Sulfur, Zinc, Copper, Iron, and Boron
6. Cation exchange capacity
7. Percent base saturation Sodium

## 3.2 SUBSTRATE AND SEEDBED PREPARATION

A. Any growth, rocks, or other obstructions which might interfere with tilling, seeding, or later maintenance operations shall be removed and disposed of properly. Remove stones over 1/2 inches in diameter in any dimension and sticks, roots, rubbish and other extraneous matter.

B. Finished grade shall be “cat-tracked” or “dozer-walked” so that track/cleat marks from the equipment form an indentation on the slope that is parallel to the contour of the slope (perpendicular to the flow of water moving down the slope).

C. If prepared areas are eroded or otherwise disturbed after preparation and prior to planting, they shall be restored to specified condition prior to planting.

## 3.3 INSTALLATION

A. Strictly comply with equipment manufacturer’s installation instructions and recommendations. Use approved hydroseeding machines with fan-type nozzle (50- degree tip). To achieve optimum soil surface coverage, apply HP-FGM from opposing directions to soil surface. Rough surfaces (rocky terrain, cat tracked and ripped soils) may require higher application rates to achieve 100% cover. Slope interruption devices or water diversion techniques are recommended when slope lengths (on a 3H:1V slope gradient) exceed 100 ft. Slope interruption intervals may need to be decreased based on steeper slopes or other site conditions. HP-FGM is not recommended for channels or areas with concentrated water flow unless used in conjunction with a rolled erosion control product designed to accommodate the anticipated hydraulic conditions. Unless approved by the Manufacturer, no chemical additives with the exception of fertilizer, soil neutralizers and biostimulant materials should be added to this product.

B. For Erosion Control and Revegetation: To ensure proper application rates, measure and stake area. For maximum performance, apply FGM in a two (2)-step process [(A)].

1. Step One: Apply fertilizer with specified prescriptive agronomic formulations and typically 50% of specified seed mix with a small amount of FGM for visual metering. Do not leave seeded surfaces unprotected, especially if precipitation is imminent.
2. Step Two: Mix balance of seed and apply HP-FGM at a rate of 50 lb. of FGM per 125 gallons of water over freshly seeded surfaces. Confirm loading rates with equipment manufacturer.

Best results and more rapid curing are achieved at temperatures exceeding 60° F. Curing times may be accelerated in high temperature, low humidity conditions with product applied on dry soils.


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(A) Depending upon site conditions HP-FGM may be applied in a one (1)-step process where all components may be mixed together in single tank loads. Consult with Manufacturer for further details.

C. Mixing: A mechanically agitated hydroseeding machine is strongly recommended:

1. Fill 1/3 of mechanically agitated hydroseeder with water. Turn pump on for 15 seconds and purge and pre-wet lines. Turn pump off.
2. Turn agitator on and load low density materials first (i.e. seed).
3. Continue slowly filling tank with water while loading fiber matrix into tank.
4. Consult application and loading charts to determine number of bags to be added for desired area and application rate. Mix at a rate of 50 lb. of FGM per 125 gallons.
5. All FGM should be completely loaded before water level reaches 75% of the top of tank.
6. Top off with water and mix until all fiber is fully broken apart and hydrated (minimum of 10 minutes – increase mixing time when applying in cold conditions). This is very important to fully activate the bonding additives and to obtain proper viscosity.
7. Add fertilizer and any other remaining amendments.
8. Shut off recirculation valve to minimize potential for air entrainment within the slurry.
9. Slow down agitator and start applying with a 50-degree fan tip nozzle.
10. Spray in opposing directions for maximum soil coverage.

D. Application Rates: These application rates are for standard conditions. Application rates may need to be increased to accommodate very rough surfaces.

| Slope Gradient / Condition | Rate (lb/acre) |
|---|---|
| ≤ 4H to 1V | 2,500 |
| > 4H to 1V and ≤ 3H to 1V | 3,000 |
| > 3H to 1V and ≤ 2H to 1V | 3,500 |
| > 2H to 1V and ≤ 1H to 1V | 4,000 |
| > 1H to 1V | 4,500 |
| Below ECB or TRM | 1,500 |
| As infill for TRM (A) | 3,500 |

(A) Use only approved and tested Turf Reinforcement Mats (TRMs)

For additional details including mixing ratios/loading rates for specific machine sizes and visual keys for proper application, please consult the Manufacturer's Application Guide for High Performance – Flexible Growth Medium.

3.4 CLEANING AND PROTECTION

A. After application, thoroughly flush the tank, pumps and hoses to remove all material. Wash all material from the exterior of the machine and remove any slurry spills. Once dry, material will be more difficult to remove.

B. Clean spills promptly. Advise OWNER of methods for protection of treated areas. Do not allow treated areas to be trafficked or subjected to grazing.


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3.5 INSPECTION AND MAINTENANCE

A. The CONTRACTOR shall be responsible for maintaining all treated areas through the end of the project. The CONTRACTOR shall provide, at their expense, protection of all treated areas against damage at all times until acceptance of the work.

B. All inspections and maintenance recommendations shall be conducted by qualified professionals consistent with the OWNER, ENGINEER and VDEQ expectations.

C. Initial inspections shall insure installations are in accordance with the Contract Documents and specifications with material quantities and activities fully documented. Refer to Section 02936 – Seeding for any additional requirements.

D. Subsequent inspections shall be conducted at pre-determined time intervals and corrective maintenance activities directed after each significant precipitation or other potentially damaging weather or site event.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02141

# CONSTRUCTION DEWATERING

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. This section specifies the requirements for handling and management of dewatering activities.

B. CONTRACTOR shall be responsible for management of water during construction, regardless of source.

C. CONTRACTOR shall design, construct and maintain all dikes, sumps, and diversion and drainage channels as necessary to complete the construction and to protect the areas to be occupied by permanent work from water damage. CONTRACTOR shall remove temporary works after they have served their purpose.

D. CONTRACTOR shall be responsible for the stability of all temporary and permanent slopes, grades, foundations, materials, and structures during the course of the Contract. Repair and replace all slopes, grades, foundations, materials and structures damaged by water, both surface and subsurface, to the lines, grades and conditions existing prior to the damage, at no additional cost to OWNER.

E. The CONTRACTOR shall submit a description of its methods for accomplishing construction dewatering to OWNER and ENGINEER for approval.

F. CONTRACTOR shall provide measures to minimize accumulation of surface water in the work area.

G. CONTRACTOR will segregate all surface runoff and waters from perched groundwater and seeps encountered by CONTRACTOR during excavation or filling operations. Perched groundwater and seeps encountered by CONTRACTOR will be collected, pumped, transferred and hauled to an on-site discharge point as directed by OWNER.

1.2 RELATED SECTIONS

A. Section 02125 - Temporary and Permanent Erosion and Sediment Control

B. Section 02200 - Earthwork

## PART 2 – PRODUCTS

Piping, pumping equipment, and all other equipment and materials required for dewatering shall be suitable for the intended purpose. Standby pumping units shall be maintained at the Site to be used in case of failure of the normal pumping units.

## PART 3 – EXECUTION

3.1 HANDLING OF NON-CONTACT WATER

A. Non-Contact Water shall be defined as water generated from surface water runoff, groundwater entering or removed from excavations, or any combination. This is water that has not come into contact with CCR and is not considered to be leachate under applicable regulations.

B. Design, furnish, install, maintain, monitor, operate and remove necessary pumping and other equipment for dewatering the various parts of the Work and for maintaining the work areas free from water as required for constructing each part of Work.


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C. Install all drainage ditches, sumps, and pumps to control excessive seepage on excavated slopes, to drain isolated zones with perched water tables and to drain impervious surfaces at final excavation elevation.

D. Non-Contact Water shall be filtered by a dewatering structure to remove sediment prior to discharge by means of a filter box, sediment tank, Dirtbag®, or other means compliant with Std. & Spec 3.26 of the Virginia Erosion and Sediment Control Handbook (VESCH). Water shall be treated for suspected contaminants in accordance with applicable local standards.

E. Dewater by means which will enable completion of the Work and preserve final lines and grades. Do not disturb or displace adjacent soil. If adjacent or downgradient soils are eroded due to dewatering operations, CONTRACTOR is responsible for making repairs at no additional expense to the OWNER.

F. All pumping and drainage shall be done with no damage to property or structures and without interference with the rights of the public, owners of private property, pedestrians, vehicular traffic, or the Work of other contractors, and in accordance with all Federal, State, and local laws, ordinances, and regulations.

G. Do not overload or obstruct existing drainage facilities.

H. After they have served their purpose, remove all temporary protective work at a time and in a manner approved by the OWNER. All temporary diversion channels and other temporary excavations in areas where the compacted fill or other structures will be constructed shall be cleaned out, backfilled, and processed under the same specifications as those governing the compacted fill (Section 02200 - Earthwork).

I. When the temporary works will not adversely affect any item of permanent work on the planned usage of the project, CONTRACTOR may be permitted to leave such temporary works in place. In such instances, breaching of dikes and other temporary works may be required.

3.2 DEWATERING

A. By the use of pumps, siphons, tile drains or other approved methods, CONTRACTOR shall control the flow and accumulation of water in excavated areas to prevent excessive softening and disturbance of exposed soils in excavations and down-gradient of the dewatering structure as necessary for completion of the Work.

B. The system used shall not cause settlement damage to adjacent structures. The CONTRACTOR shall carry out the Work by the use of methods not to endanger adjacent structures, existing contours, or vegetation; all such Work shall be done at the CONTRACTOR’s expense.

3.3 HANDLING OF CONTACT WATER

A. Contact water will be managed in accordance with the CONTRACTOR’s Contact Water Management Plan and the contract documents.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02150

# SHORING AND BRACING

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of shoring, bracing, and sheeting or sheet piling, necessary to complete the construction, protect structures, and prevent the loss of ground or caving of embankments, excavations, or cut slopes, as shown, specified or required, and shall meet all applicable building and safety codes.

B. CONTRACTOR shall be solely responsible for proper excavation procedures including, but not limited to, safe slope angles and the design and use of properly designed and installed shoring and bracing systems in accordance with OSHA and other applicable standards and requirements. As required, shoring and bracing shall be designed by the CONTRACTOR's engineer who is a registered Professional Engineer in the Commonwealth of Virginia. Remove all shoring and bracing without disturbing backfill, bedding, haunching, pipes or structures. The presence of the Owner's Representative, OWNER or the ENGINEER shall not relieve the CONTRACTOR of his responsibility to properly design, install and maintain shoring and bracing.

C. Pressures on sheeting and the stability of the sheeting and bottom of the excavation are dependent not only on soil conditions but upon many procedures and options available to the CONTRACTOR, such as dewatering, staging of excavation and installation of bracing, flexibility of sheeting, construction equipment used, and time of completing the work. All factors shall be considered and investigated as necessary in the design of the sheeting and bracing. Owner-provided Subsurface Data should be utilized by the CONTRACTOR to obtain site specific subsurface data for use in design.

D. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

1.2 RELATED REFERENCES

A. Recommended Technical Provisions for Shoring and Sloping of Trenches and Excavations, U.S. Department of Commerce.

B. Construction Safety and Health Regulations, U.S. Department of Labor, Occupational Safety and Health Administration.

C. Occupational Safety and Health Regulations - Excavations, U.S. Department of Labor, Occupational Safety and Health Administration, 29 CFR Part 1926.

1.3 RELATED SECTIONS

A. Section 02200 – Earthwork

1.4 SUBMITTALS

A. In cases where the excavation cannot be open cut to a safe working angle in accordance with applicable requirements or where excavation may jeopardize adjacent site areas or the stability of nearby structures or facilities, the CONTRACTOR shall submit drawings, computations and substantiating data, prepared, signed, and sealed by a Professional Engineer licensed in the Commonwealth of Virginia, showing the proposed shoring and bracing design and method of construction for the information of the OWNER prior to the start of such construction.


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B. Shoring and bracing systems shall be designed such that removal shall not jeopardize work already performed. Shoring and bracing systems shall not remain permanently in place without the written approval of the OWNER.

C. Any review or comments by the OWNER shall not relieve the CONTRACTOR of his responsibility for sheeting and bracing.

D. In trenches, the sheeting shall be designed so that the lowest brace is no closer than 12 inches above the base of the structure to be installed.

1.5 QUALITY CONTROL

During the installation of the sheeting and bracing and as long as the excavation is open, the CONTRACTOR shall monitor the work to ensure that it is completed in accordance with his design and procedures.

## PART 2 – PRODUCTS

All materials shall meet, or exceed, the minimum requirements of the applicable codes and those assumed in the design submitted by the CONTRACTOR.

## PART 3 – EXECUTION

3.1 VERIFYING EXISTING CONDITIONS

Existing areas where near vertical excavations will be required will require stabilization depending on the depth of the excavation. Before commencing work, the CONTRACTOR shall check and verify all governing dimensions and elevations, including field measurements of existing and adjoining work on which his work is dependent, to assure proper fit and clearance of each part of the work to the new and existing structures.

3.2 COORDINATION WITH OTHER OPERATIONS

The schedule and progress of the shoring, bracing, and sheeting work shall be coordinated with the excavation and backfilling work. If, during the progress of the excavation, lateral movement of the surrounding soils, or any other evidence of instability is discovered, further excavation or backfilling work in the excavation shall cease and corrective measures shall be taken immediately to prevent further movement.

3.3 REMOVAL OF SHORING AND BRACING MATERIALS

A. Where the CONTRACTOR elects and is permitted not to remove shoring and bracing material, all such material shall be removed to the extent that the top of the material shall be a minimum of five (5) feet below the proposed finished grade. No shoring or bracing may remain in place within the limits of the proposed geosynthetics placement.

B. Removal of shoring and bracing shall be completed in a manner such that no structure or existing utilities shall be disturbed or damaged during or after removal. Protection of structures during the removal of shoring and bracing shall be the sole responsibility of the CONTRACTOR, and any disturbance or damage shall be rectified at no expense to the OWNER.

C. The CONTRACTOR shall be responsible for the safe removal of the existing sheet pile.

3.4 SAFETY

A. Installation and removal methods of shoring and bracing shall meet, or exceed, the minimum requirements of the applicable codes and safety precautions as outlined in such codes and shall be enforced by the CONTRACTOR.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02200

# EARTHWORK

## PART 1 – GENERAL

### 1.1 WORK INCLUDED

A. The work under this section includes the furnishing of all labor, equipment and materials, and completing all operations in connection with excavating, backfilling, compacting, grading, and placing soil materials and all other incidental work necessary for construction according to Contract Documents and Technical Specifications.

B. The work shall include, but not be limited to:

1. Excavate soil to the lines and grades shown on the Contract Documents.
2. Backfill using the materials shown on the Contract Documents or specified herein.
3. Maintain all excavations and the surface of all grading and earthwork.
4. Perform all surveys necessary to establish and verify lines and grades for all earthwork, including cuts, fills, general grading, and pipe excavations.

C. It is the intent of this Specification that the CONTRACTOR conducts the construction activities in such a manner that erosion of disturbed areas and off-site sedimentation be absolutely minimized. Stormwater and sediment and erosion control structures shall be constructed prior to commencement of ground disturbance activities to the extent practical (reference Section 02125 –Temporary and Permanent Erosion and Sediment Control).

D. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, state or federal authorities having jurisdiction.

E. The CONTRACTOR shall locate all existing active and abandoned utilities and structures in work areas and shall obtain and provide a Miss Utility ticket to the OWNER prior to commencing any earthwork activities, and shall protect from damage those utilities and structures which are to remain in place.

F. Grading tolerance for all fill and backfill shall be ±0.1 feet. Protective cover soil and vegetative support layer tolerances shall be -0.0 to +0.3 feet.

G.

### 1.2 RELATED WORK

A. Other specification sections containing requirements relating to this section include, but are not limited to, the following:

1. Section 02141 – Construction Dewatering
2. Section 02210 – Excavation by Blasting
3. Section 02235 – Vegetative Support Layer
4. Section 02599 – Protection of Geosynthetics

### 1.3 REFERENCES

A. Virginia Department of Transportation (VDOT) Road and Bridge Specifications (VDOT Standard Specifications), latest edition.

B. American Association of State and Highway Transportation Officials (AASHTO):


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1. AASHTO M43-05 Standard Specification for Sizes of Aggregate for Road and Bridge Construction

C. American Society for Testing and Materials (ASTM) International:

1. ASTM D422 Standard Text Method for Particle-Size Analysis of Soils
2. ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
3. ASTM D2216 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
4. ASTM D2487 Standard Practice for Classification of Soils for Engineering Purposes
5. ASTM D3080 Standard Test Method for Direct Shear Test of Soils Under Consolidated Drained Conditions
6. ASTM D4318 Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils
7. ASTM D5321 Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic or Geosynthetic-Geosynthetic Interfaces by Direct Shear
8. ASTM D6913 Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis

## 1.4 DEFINITIONS

A. Excavation shall mean the removal from place of all materials and shall include soil, facilities, structures above and below ground, rock, pavements, topsoil, boggy waste, rubbish, tree stumps, boulders, logs, ashes, cinders, organic material such as peat, humus or organic silt, softened or disturbed soils or other unsuitable bearing materials determined in the field by the ENGINEER.

B. Mucking or mucking-out shall mean excavation, as defined herein before, without prior dewatering.

## 1.5 PROTECTION OF PEOPLE AND PROPERTY

A. The CONTRACTOR shall plan and conduct operations in accordance with OSHA and local codes and ordinances so as to prevent damage to existing structures, safeguard people and property, minimize traffic inconvenience, protect the structures to be installed, and provide safe working conditions.

B. The CONTRACTOR shall control stormwater such that run-on and run-off do not affect the quality of receiving wetlands, brooks, streams, or rivers. The CONTRACTOR shall be responsible for cleaning (removal of silt) stormwater structures (swales, culverts, basins) as needed during construction, after stabilization of project areas, and at the conclusion of work prior to demobilization.

C. The CONTRACTOR shall be responsible for protecting existing environmental monitoring devices such as groundwater monitoring wells within the limits of work. Any damage to existing environmental monitoring devices resulting from construction activities shall be the responsibility of the CONTRACTOR to correct at no additional cost to the OWNER.

D. Excavations, except as specified, shall be adequately shored and braced. Where the installation of shoring is impractical or might cause damage, as a result of, but not limited to, vibration, settlement or lateral movement, the CONTRACTOR shall utilize other approved methods.

E. CONTRACTOR shall be solely responsible for proper excavation procedures including, but not limited to, safe slope angles and the design and use of properly designed and installed shoring and bracing systems in accordance with OSHA and other applicable standards


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and requirements. As required, shoring and bracing shall be designed by the CONTRACTOR's engineer who is a registered Professional Engineer in the Commonwealth of Virginia. Remove all shoring and bracing without disturbing backfill, bedding, haunching, pipes or structures. The presence of the ENGINEER shall not relieve the CONTRACTOR of his responsibility to properly design, install and maintain shoring and bracing. The OWNER shall not be the competent person on the Site.

F. In cases where excavation without shoring and bracing is not permissible solely because of protection of workers, trench boxes may be used.

G. The CONTRACTOR shall not stockpile any excavated material without OWNER approval. Stockpile location shall be approved by the ENGINEER or OWNER.

1.6 SUBMITTALS

A. Submit the following in accordance with Section 01300 - Submittals

1. Name and location of all material suppliers.
2. List of disposal sites, in accordance with OWNER approved disposal facilities list, for debris, refuse and excess or unsuitable materials and all required permits for use of those sites, if applicable.

B. Shoring and Bracing

1. In cases where the excavation cannot be open cut to a safe working angle in accordance with applicable requirements or where excavation may jeopardize adjacent site areas or the stability of nearby structures or facilities, the CONTRACTOR shall submit drawings, computations and substantiating data, prepared, signed, and sealed by a Professional Engineer licensed in the Commonwealth of Virginia, showing his/her proposed shoring and bracing design and method of construction for the information of the OWNER prior to the start of such construction.
2. Shoring and bracing systems shall be designed such that removal shall not jeopardize work already performed. Shoring and bracing systems shall not remain permanently in place without the written approval of the OWNER.
3. Any review or comments by the OWNER shall not relieve the CONTRACTOR of their responsibility for sheeting and bracing.
4. In trenches, the sheeting shall be designed so that the lowest brace is no closer than 12 inches above the base of the structure to be installed.

C. Borrow Sources

1. All backfill and fill materials, unless otherwise specified, shall consist of suitable, selected, and OWNER approved soil from borrow areas.
2. The CONTRACTOR shall provide the OWNER or ENGINEER samples from each borrow source to be used as structural fill. From each borrow source, representative composite sample(s) shall be tested for the following:

| TEST | METHOD | FREQUENCY |
|---|---|---|
| Standard Proctor Compaction | ASTM D698 | 2 per source/type |
| USCS Classification | ASTM D2487 | 2 per source/type |
| Atterberg Limits | ASTM D4318 | 2 per source/type |
| Sieve Analysis | ASTM D6913 | 2 per source/type |


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3. If the OWNER or ENGINEER determines that the source contains more than one soil type, as determined by the Unified Soil Classification System (USCS), the tests listed shall be completed for each soil type.
4. Soils from borrow sources with potential exposure to contamination (such as petroleum or TCLP metals) may be subject to environmental testing at the discretion of the OWNER.

D. The CONTRACTOR shall submit the technical data sheet for the proposed compaction equipment to the OWNER or ENGINEER for review and approval.

E. Employ a professional land surveyor licensed in Virginia to conduct a topographic survey of the top of structural fill and bottom liner and final cover subgrades, as appropriate, and prepare a survey drawing showing contours at maximum two-foot intervals. Furnish the ENGINEER with three copies of the topographic survey drawing. This drawing shall become part of the record drawings required by this contract.

1.7 SUBSURFACE CONDITIONS

A. Information on subsurface conditions is included in existing regulatory submittals by OWNER.

B. Attention is directed to the fact that there may be electrical lines, water pipes, storm drains and other utilities located in the area of proposed excavation. Perform all repairs to utilities in the event that excavation activities disrupt service.

1.8 USE OF EXPLOSIVES

A. The use of Explosives shall be conducted in areas approved by the OWNER in strict accordance with Section 02210, Blasting of these Specifications.

1.9 TOLERANCES

A. Grading tolerance for all fill and backfill shall be ±0.1 feet vertically and ±0.1 foot horizontally.

1.10 QUALITY ASSURANCE

A. The CONTRACTOR shall be an experienced earthwork CONTRACTOR who has at least five years' experience. The CONTRACTOR shall have completed at least three projects with the same material and of similar scope as that indicated for this project with a successful installation and maintenance record of in-service performance.

B. The CONTRACTOR is required to demonstrate compliance to the above requirements to the satisfaction of the ENGINEER and OWNER.

C. CONTRACTOR shall participate in and conform to the items and requirements of the quality assurance program as outlined in this Specification and the Quality Assurance Plan.

D. The OWNER will engage and pay for the services of an Owner's Representative and testing laboratory to monitor the earthworks operations and complete conformance testing.

## PART 2 – PRODUCTS

2.1 MATERIALS

A. All backfill and fill materials, unless otherwise specified, shall consist of suitable, selected, and approved (by the OWNER and ENGINEER) soil from borrow areas.

B. No frozen earth shall be used for backfill and fill, and no fill or backfill shall be placed over frozen surfaces. All backfill and fill materials shall be free from all perishable and


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objectionable (as described below) materials. All fill shall be protected from frost if the ENGINEER judges frost will prevent the material from performing as required.

C. All required materials shall be free from organic materials, wood, trash, and other objectionable materials which may be compressible, or which cannot be properly compacted. Backfill and fill materials shall not contain rock fragments broken concrete, masonry rubble, or other similar materials. It shall have physical properties such that it can be readily spread and compacted to the specified density. Snow, ice, and frozen soil shall be removed from fill material prior to placement.

D. Soil material from onsite borrow areas should be processed as needed to meet particle size requirements. Processing may include, but is not limited to, rock crushing, screening, or rock picking by hand to meet soil particle size requirements.

E. Compact fill material to a minimum percentage of the maximum dry density as determined by a standard Proctor (ASTM D698) as shown in the table below. Do not compact frozen fill material or onto frozen surfaces. Fill material in place, which does not meet the density requirements, shall be re-compacted or removed and reworked to meet density objectives.

| Material Type (Use) | Compaction Requirement | Moisture Content |
|---|---|---|
| Structural Fill (General) | 95% | -2% to +4% |
| Structural Fill (Road Subgrade) | 98% | -2% to +2% |
| Structural Fill (Embankments) | 95% | -2% to +4% |
| Structural Fill (Foundations) | 95% | -2% to +4% |
| Trench Backfill | 95% | -2% to +4% |
| Stockpile | 90% | -2% to +4% |
| Liner Subgrade | 95% | -2% to +4% |
| CCR Liner Subgrade | 95% | -8% to +8% |
| Protective Cover Soil | 90% | -2% to +4% |
| Vegetative Soil | N/A | N/A |

## 2.2 STRUCTURAL FILL

A. Structural fill materials shall be used general fill, clean backfill, pipe bedding, final cover construction, and as other material as shown on the Contract Documents.

B. Structural fill materials shall be classified according to the USCS as GM, GC, SM, SC, ML, CL, MH or CH (ASTM D2487). Structural fill shall be approved by the OWNER for each application.

C. Structural fill shall be free of rubble, wood, stumps, brush, metal, cinders, trash, demolition debris, garbage, topsoil, organic soil, loam, sludge and other deleterious materials. The maximum stone size shall be two inches in any dimension and shall not comprise more than five percent of the total soil mass.

D. Structural Fill shall be approved by the Owner’s Representative for each application.

## 2.3 BOTTOM LINER SUBGRADE

A. The bottom liner subgrade is defined as the top twelve inches of material underlying the geosynthetic clay liner (GCL) and shall consist of Controlled Subgrade.

B. Controlled Subgrade materials shall consist of soils having a Unified Soil Classification of SC, SM, ML, CL, MH, or CH (ASTM D2487). Controlled Subgrade shall be compacted to a minimum in-place density of 95% of the maximum dry density as determined by ASTM D 698 (Standard Proctor).


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C. Bottom liner subgrade shall be free of rubble, wood, stumps, brush, standing water, metal, cinders, trash, demolition debris, garbage, topsoil, organic soil, loam, sludge, and other deleterious materials. The maximum stone size shall be 1/2 inches in any dimension (unless otherwise approved by ENGINEER).

D. Upon reaching the bottom of excavation the CONTRACTOR shall proof-roll the foundation subgrade with slopes equal to or less than a 5% grade as follows:

1. Use a loaded articulated dump truck or other pneumatic-tired vehicle. Proof rolling equipment shall have a minimum loaded rear axle weight of 8 tons, with a minimum tire pressure of 36 pounds per square inch (psi) unless otherwise approved by the OWNER.
2. Drive the equipment at a slow speed (less than approximately 5 miles per hour) across the area to allow the OWNER and Owner's Representative to evaluate and confirm the firmness of the subgrade.
3. Make a minimum of 3 passes over the entire work area, or more passes if directed by the OWNER based on suspected or identified cover collapse features (i.e., depressions or dropouts), rock pinnacles, or soft areas. Overlap passes such that one set of tires on each pass runs between the two sets of tire tracks from the previous pass.

E. Based on the proof-rolling results, remediation results for cover-collapse depressions and/or dropouts, rock pinnacles, and soft areas identified through proof-rolling or visual means shall be implemented using one or more of the techniques listed below, as recommended by the Owner's Representative for the field conditions observed, and as approved by the OWNER.

1. Cover-Collapse features. Install graded rock filter, soil/geotextile plug, or fill grouting as approved by the OWNER
2. Rock Pinnacles. Remove pinnacles to requisite separation distances below bottom of excavation and use flowable fill for backfilling annular spaces of rock pinnacles left in-place as approved by the OWNER.
3. Soft Soils. Over-excavate soft areas, stabilize the bottom of excavation, and backfill or grout as approved by the OWNER.
4. Excavation Extending Below Water Table. Conduct dewatering or ground improvement techniques to stabilize the bottom of excavation, as approved by the OWNER.

F. The bottom liner subgrade surface shall be rolled with a smooth-drum compactor of sufficient weight to remove most wheel ruts, footprints, or other abrupt grade changes. Minor irregularities on the surface are acceptable so long as protrusions, rocks, etc. extending more than 3/8-inch from the subgrade are removed, crushed, or pushed into the surface with the smooth-drum compactor.

G. The interface friction angle between the controlled subgrade and the overlying geosynthetics, as well as any material interface of the bottom liner system, shall be greater than or equal to 22.7°, or equivalent shear strength as approved by the ENGINEER, as determined by ASTM D5321. Frequency shall be at 1 per project per interface.

1. Each direct shear test shall determine interface strength at normal stresses of 500 pounds per square foot (psf), 1,000 psf, and 2,000 psf. Tests shall be completed under fully saturated conditions (saturation time of 15 minutes), have a seat time of 15 minutes, and have a shear rate of 0.04 inches per minute (in/min).
2. The direct shear test shall be completed using installation procedures used under actual field conditions.
3. Additional samples shall be collected and tested if the material does not meet the minimum requirements of this Technical Specification.


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H. The interface friction angle between the controlled subgrade and the overlying geosynthetics, as well as any material interface of the bottom liner system, shall be greater than or equal to 13.5°, or equivalent shear strength as approved by the ENGINEER, as determined by ASTM D5321. Frequency shall be at 1 per project.

1. Each direct shear test shall determine interface strength at normal stresses of 2,000 pounds per square foot (psf), 5,000 psf, 10,000 psf, and 20,000 psf. Tests shall be completed under fully saturated conditions (saturation time of 15 minutes), have a seat time of 15 minutes, and have a shear rate of 0.04 inches per minute (in/min).
2. The direct shear test shall be completed using installation procedures used under actual field conditions.
3. Additional samples shall be collected and tested if the material does not meet the minimum requirements of this Technical Specification.

## 2.4 FINAL COVER SUBGRADE

A. The final cover subgrade (prepared and compacted subgrade) shall consist of the top twelve inches of material underlying the geomembrane liner or geosynthetic clay liner (GCL), as appropriate. The final cover subgrade may consist of CCR material or intermediate cover soils that meet the requirements for final cover subgrade.

B. Final cover subgrade materials shall consist of CCR material compacted to a minimum of 92% of the maximum dry density as determined by ASTM D698 (Standard Proctor) or shall consist of soils having a USCS classification of SC, SM, ML, CL, MH, or CH compacted to a minimum of 95% of the maximum dry density.

C. Final cover subgrade shall be free of rubble, wood, stumps, brush, standing water, metal, cinders, trash, demolition debris, garbage, topsoil, organic soil, loam, sludge, and other deleterious materials. The maximum stone size shall be 1/2 inches in any dimension (unless otherwise approved by ENGINEER).

D. The final cover subgrade surface shall be rolled with a smooth-drum compactor of sufficient weight to remove most wheel ruts, footprints, or other abrupt grade changes. Minor irregularities on the surface are acceptable so long as protrusions, rocks, etc. extending more than 1/2-inch from the subgrade are removed, crushed, or pushed into the surface with the smooth-drum compactor.

E. The interface friction angle between the final cover subgrade and the overlying geosynthetics, as well as any material interface of the final cover system, shall be greater than or equal to 25.9°, or equivalent shear strength as approved by the ENGINEER, as determined by ASTM D5321. Frequency shall be at 1 per project.

1. Each direct shear test shall determine interface strength at normal stresses of 500 pounds per square foot (psf), 1,000 psf, and 2,000 psf. Tests shall be completed under fully saturated conditions (saturation time of 15 minutes), have a seat time of 15 minutes, and have a shear rate of 0.04 inches per minute (in/min).
2. The direct shear test shall be completed using installation procedures used under actual field conditions.
3. Additional samples shall be collected and tested if the material does not meet the minimum requirements of this Technical Specification.

## 2.5 PROTECTIVE COVER

A. Protective cover soils shall consist of the eighteen inches of material placed over the geosynthetic portion of the final cover system.

B. Protective cover soil shall consist of soil materials having a USCS classification of SC, SM, ML, CL, MH, or CH, and shall be compacted to a minimum of 90% of the maximum dry density as determined by ASTM D698 (Standard Proctor).


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C. Protective cover soil shall be free of rubble, wood, stumps, brush, metal, cinders, trash, demolition debris, garbage, organic soil, loam, sludge, and other deleterious materials. The maximum stone size shall be 2 inches in any dimension (unless otherwise approved by ENGINEER).

D. The interface friction angle between the protective cover soils and the underlying geosynthetics shall be greater than or equal to 25.9°, or equivalent shear strength as approved by the ENGINEER, as determined by ASTM D5321. Frequency shall be at 1 per project per interface.

1. Each direct shear test shall determine interface strength at normal stresses of 500 pounds per square foot (psf), 1,000 psf, and 2,000 psf. Tests shall be completed under fully saturated conditions (saturation time of 15 minutes), have a seat time of 15 minutes, and have a shear rate of 0.04 inches per minute (in/min).
2. The direct shear test shall be completed using installation procedures used under actual field conditions.
3. Additional samples shall be collected and tested if the material does not meet the minimum requirements of this Technical Specification.

A. Remediated contaminated soil shall not be permitted as protective cover material.

2.6 VEGETATIVE SUPPORT LAYER

A. The vegetative support layer materials shall consist of the minimum six inches of vegetation-supporting soil placed directly over the protective cover soils. The vegetative support layer soils shall not be compacted to facilitate plant growth

B. Vegetative Support Layer shall be free of rubble, wood, stumps, brush, metal, cinders, trash, demolition debris, garbage, loam, sludge, and other deleterious materials. The maximum stone size shall be 1 inch in any dimension (unless otherwise approved by ENGINEER).

C. Vegetative support layer soils shall conform to the requirements in Section 002235 – Vegetative Support Layer of these Technical Specifications.

D. Remediated contaminated soil shall not be permitted as vegetative support layer material.

2.7 TOPSOIL

A. Topsoil shall be considered the surface layer of soil and sod, suitable for use in seeding and planting. It shall contain no mixture of refuse or any material toxic to plant growth.

B. Fill for Topsoil shall consist of soil material that is void of deleterious materials, has no particles over 1 inch in any dimension and meets the requirements of Section 02235 – Vegetative Cover of the Technical Specifications.

2.8 ROCK

A. Any material occupying an original volume of at least one cubic yard which cannot be excavated with a single-tooth ripper drawn by a crawler tractor having minimum draw bar pull rated at not less than 60,000 pounds or 305 flywheel horsepower (Caterpillar D8R, or equivalent). Excavation of material with larger equipment will be paid as Earth excavations unless CONTRACTOR demonstrates inability to excavate with above specified equipment. The presence of isolated boulders or rock fragments larger than 1 cubic yard is not in itself sufficient cause to change the classification of the surrounding material.


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## PART 3 – EXECUTION

3.1 GENERAL

A. Construct project features to the lines and grades shown on the Contract Documents.

B. Do not place or compact fill material or construct liner subgrades where ambient temperature is below 32° F for 24 consecutive hours or more. Do not use frozen material for construction. Controlled Subgrade may be placed and compacted during periods of early morning and evening freezing temperatures with warming trends above freezing during the day.

C. Exposed surfaces shall be rolled with a smooth drum roller to seal the surface. Any surface which is smooth shall be scarified prior to placement of a subsequent lift.

3.2 PREPARATION

A. The CONTRACTOR shall establish and identify required lines and levels.

B. The CONTRACTOR shall maintain benchmarks, monuments, and other reference points and reestablish them if disturbed or destroyed, at no cost to OWNER.

C. Before start of grading, the CONTRACTOR shall establish the location and extent of utilities in the work areas. The CONTRACTOR shall obtain the OWNER's approval prior to contacting utilities. The CONTRACTOR shall notify utilities to remove and relocate lines that are in the way of construction and are not to be relocated as a part of the work covered by these specifications.

D. The CONTRACTOR shall maintain, protect, reroute, or extend as required existing utilities to remain in place that pass through the work area.

E. The CONTRACTOR shall develop access to the construction area in accordance with the requirements of the Contract Documents and Section 02110 – Site Clearing and Grubbing.

F. The CONTRACTOR shall install the adequate erosion and sediment controls prior to the beginning of work in an area to prevent erosion in the vicinity of the planned earthworks operations in accordance with Section 02125 – Temporary and Permanent Erosion and Sediment Control. The CONTRACTOR shall maintain the erosion and sediment controls for the duration of construction. Accumulated sediment shall be disposed of by the CONTRACTOR in a manner approved by the OWNER.

G. Diversion ditches, either permanent or temporary, shall be constructed in accordance with the Contract Documents, Section 02125 – Temporary and Permanent Erosion and Sediment Control and as necessary to control surface water. The CONTRACTOR shall be responsible for constructing diversion ditches as required to divert run-on around the construction area and maintain the diversions until approved by the OWNER or ENGINEER.

H. The CONTRACTOR shall install barriers and other devices to protect areas adjacent to construction.

3.3 STOCKPILING

A. Excavated materials classified as suitable for use as structural fill shall be stockpiled in designated areas free of incompatible soil, clearing debris, or other objectionable materials. Stockpile areas shall be approved by the OWNER.

B. Excavated material classified as topsoil shall be segregated from fill and stockpiled in the manner shown on the Contract Documents or as specified by the OWNER.


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C. Stockpiles of fill or topsoil shall be no steeper than 3:1 (horizontal: vertical), graded to drain, sealed by tracking with a dozer perpendicular to the slope so as not to create vertical grooves susceptible to erosion rills or other means approved by the ENGINEER, and dressed daily during periods when fill is taken from the stockpile. Adequate erosion and sediment controls shall be employed to manage potential erosion of the stockpiles.

3.4 EXCAVATION - GENERAL

A. Excavation shall be performed, at a minimum, to the lines and grades indicated on the Contract Documents. Additional excavation shall only be performed to achieve a stable working base or to "bridge" over weak subgrade materials if approved by the ENGINEER. The limits of additional excavation shall be determined by the ENGINEER and approved by the OWNER.

B. Excavated materials shall be transported to stockpile or placement locations, as indicated on the Contract Documents or as directed by the OWNER.

3.5 GRADING - GENERAL

A. Uniformly grade areas to a smooth surface, free of irregular surface changes, to the lines and grades indicated on the Contract Documents. Provide a smooth transition between existing grades and new grades.

B. Prepare areas to receive fill by grading the area to a uniform surface. Scarify the surface as directed by the Owner’s Engineer or ENGINEER. Dry or wet the area to establish acceptable moisture content. Do not place fill until the subgrade has been approved by the Owner’s Engineer.

C. Unless otherwise specified, place borrow fill and trench backfill material in lifts of not more than nine inches in compacted thickness for material compacted by heavy construction equipment, and not more than four inches in loose depth for material compacted by hand-operated tampers. Compact material as specified in Section 2.1 of this specification.

3.6 TRENCH EXCAVATION AND BACKFILL

A. Excavation for all drainage, piping, and other structures shall conform to the lines and grades shown on the Contract Documents. Excess or unsuitable material removed from the excavations shall be replaced with approved material. The CONTRACTOR will be responsible for all shoring, bracing, trench boxes, etc., necessary to complete the excavation and pipe installation in a safe manner.

B. Stability of Excavations: Side slopes of excavations shall comply with OSHA and local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated.

C. Unless directed otherwise by the OWNER excavations shall not be backfilled until the work as installed conforms to all requirements specified in these Technical Specifications. Each lift of trench backfill material shall be moisture conditioned as necessary and compacted in such a manner as to permit the proper and desired compaction of the filled excavation to provide the necessary support and protection for the pipe.

D. Placement of pipe bedding shall be done in accordance with the following procedures.

1. The bottoms of excavations shall be compacted to provide a firm subgrade free of loose or soft soil and in an approved condition prior to placing pipe bedding. Pipe bedding shall be placed in layers not exceeding four inches in loose depth. Each layer shall be compacted by at least two passes of an approved plate-type vibratory compactor. A four-inch mud mat may be installed in the bottom of trench excavation in lieu of pipe bedding.


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2. Pipe bedding shall be graded, compacted, and shaped so that the full length of pipe barrel has complete and uniform bearing for the bottom quadrant of each pipe.
3. The CONTRACTOR shall exercise care in all operations to prevent disturbing joints, displacement of or damage to the pipes already installed, and tearing of the geotextile. As the work progresses, the pipelines will be checked by the OWNER or Owner's Representative to determine whether any disturbance, displacement, or damage has occurred. If inspection shows poor alignment, displaced or damaged pipe, disturbed joints, or any other defects, all defects designated by the OWNER shall be remedied in a satisfactory manner by the CONTRACTOR, at no additional expense to the OWNER.

E. Backfilling

1. Backfill trench with clean backfill material, as shown in the Contract Documents and specified in this section, that meets the requirements for structural fill unless otherwise approved by the OWNER or ENGINEER and as details.
2. Compact soil materials using equipment suitable for materials to be compacted and work area locations. Hand-operated plate type vibratory or other suitable equipment may be used in areas not accessible to larger rollers or compactors, and to avoid damaging pipes or structures. Any pipe that is damaged shall be replaced at the CONTRACTOR's expense.
3. Compact backfill in layers not exceeding six inches compacted thickness. The moisture content of backfill shall be such that proper compaction will be obtained. It is the responsibility of the CONTRACTOR to ensure that the minimum specified densities are obtained. Puddling or jetting of backfill with water will not be permitted.
4. Any backfill that fails to comply with the minimum compaction requirements specified shall be recompacted or, if necessary, removed to the limits directed by the OWNER or ENGINEER. The trench shall then be refilled with approved materials and by approved methods. The backfill shall be compacted by approved methods to the minimum requirements specified. All rework shall be completed by the CONTRACTOR at no additional expense to the OWNER.
5. During filling and backfilling operations, pipelines will be checked by the OWNER or Owner's Representative to determine whether any displacement of the pipe has occurred. If the inspection of the pipelines shows poor alignment, displaced pipe or any other defects, the defects designated by the OWNER shall be remedied in a satisfactory manner by the CONTRACTOR at no additional expense to the OWNER.

F. After backfilling, the CONTRACTOR shall maintain the filled surfaces in good condition with a smooth surface level with adjacent undisturbed surfaces. Any subsequent settling shall be immediately repaired by the CONTRACTOR in a manner satisfactory to the OWNER or Owner's Representative. Such maintenance shall be provided by the CONTRACTOR for the remainder of this contract at no additional expense to the OWNER.

## 3.7 PROTECTION AND ACCEPTANCE

A. Protect the finished surface from erosion, desiccation, or other damage.

B. Develop a contingency plan for responding to construction deficiencies due to inclement weather, defective materials, and construction inconsistent with the Technical Specifications. The plan shall provide a methodology for selecting and implementing corrective action.

C. Portions of the work damaged due to exposure shall be reworked to meet the Technical Specifications or, at the discretion of the Owner's Engineer, removed and replaced with conforming material at no additional cost to the OWNER.


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3.8 REMOVAL OF SHORING AND BRACING MATERIALS

A. Where the CONTRACTOR elects and is permitted not to remove shoring and bracing material, all such material shall be removed to the extent that the top of the material shall be a minimum of five feet below the proposed finished grade. No shoring or bracing may remain in place within the limits of the proposed geomembrane or GCL placement.

B. Removal of shoring and bracing shall be carried out in a manner such that no structure shall be disturbed or damaged during or after removal. Protection of structures during the removal of shoring and bracing shall be the sole responsibility of the CONTRACTOR, and any disturbance or damage shall be rectified at no expense to the OWNER.

3.9 QUALITY ASSURANCE

A. Soil tests shall be performed by the Owner's Representative and an approved geotechnical laboratory to ensure adequate placement and compaction of material. Soil testing shall be performed at the minimum frequencies presented below.

| **Property (1)** | **Test Method** | **QA Testing Frequency** |
|---|---|---|
| USCS Soil Classification (2) | ASTM D2487 | 1 per 5,000 $yd^3$ |
| Moisture Content (3) | ASTM D2216 | 1 per 10,000 $yd^3$ |
| Moisture-Density Relationship (Standard Proctor) (3) | ASTM D698 | 1 per 10,000 $yd^3$ |
| In-place density | ASTM D6938 | 1 per 10,000 $ft^2$/lift |
| In-place moisture content | ASTM D6938 | 1 per 10,000 $ft^2$/lift |

1. The CQA Consultant shall prepare a drawing showing the horizontal and vertical locations of all test locations.
2. Includes grain size (ASTM D422 or D6913) and Atterberg Limits (D4318) as appropriate.
3. Additional tests may be required when soil gradation tests indicate that there has been a change in the material being supplied

1. Testing of trench backfill material will involve in-place moisture content and density tests in accordance with ASTM D6938 at one test per 100 linear feet of trench in lieu of the moisture and density frequencies listed above.

B. The CONTRACTOR shall cooperate with the Owner's Representative in obtaining samples for testing and conducting in-situ tests during the construction period. The CONTRACTOR shall provide all necessary labor, equipment, and material to refill sample locations as directed.

C. If the tests conducted on a particular lift and section do not meet required specifications, the CONTRACTOR shall be responsible for any expenses incurred performing additional tests following re-compaction of the material until passing test results are achieved.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02210

# EXCAVATION BY BLASTING

## PART 1 – GENERAL

1.1 WORK INCLUDED

A. Rock, meeting the definition provided in this Specification, may be removed by blasting when approved by the OWNER. The work shall consist of excavation of rock by systematic drilling and blasting operations. The work shall only be performed within the limits shown on the Drawings or as directed by the ENGINEER and as necessary to perform rock excavation included within the scope of the contract documents.

B. The work under this section includes the furnishing of all labor, equipment and materials, and completing all operations in connection with excavating by blasting, including monitoring during blasting, meeting state and federal requirements for rock excavation by blasting methods.

C. The work outlined in this Section only applies to rock excavation required to attain lines and grades.

1.2 RELATED WORK

A. Carefully examine all Contract Documents for requirements affecting the work of this section.

B. Other specification sections containing requirements relating to this section include, but are not limited to, the following:

1. Section 02200 – Earthwork
2. Section 02141 – Landfill Construction Dewatering

1.3 REFERENCES

A. Virginia Department of Transportation (VDOT) Road and Bridge Specifications (VDOT Standard Specifications), latest edition.

B. American Association of State and Highway Transportation Officials (AASHTO):

1. AASHTO M43-05 Standard Specification for Sizes of Aggregate for Road and Bridge Construction

1.4 DEFINITIONS

A. Rock - Any material occupying an original volume of at least one cubic yard which cannot be excavated with a single-tooth ripper drawn by a crawler tractor having minimum draw bar pull rated at not less than 60,000 pounds or 305 flywheel horsepower (Caterpillar D8R, or equivalent). Excavation of material with larger equipment will be paid as Earth excavations unless CONTRACTOR demonstrates inability to excavate with above specified equipment. The presence of isolated boulders or rock fragments larger than 1 cubic yard is not in itself sufficient cause to change the classification of the surrounding material.

1.5 SUBMITTALS

A. Submit the following submittals in accordance with Section 01300 - Submittals


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B. The CONTRACTOR will be required to submit a Safety Plan / Blasting Control Plan, Shot Plans, Shot Records and Seismograph Reports.

C. SAFETY PLAN / BLASTING CONTROL PLAN. CONTRACTOR shall submit in writing detailed Safety Plan/Blasting Control Plan for the proposed method and sequence of blasting prior to the start of work to be performed under this Section. All such plans shall be subject to the approval of the ENGINEER. The plan shall include an example of a shot-hole drill log to be used. The drill log shall at a minimum indicate a general rock description, drilling penetration rate, and the means to convey the depth of voids and soft seams encountered. Such plans must include pre-splitting and line drilling procedures, together with the pertinent data for each stage of each specific area. Such data shall include the location, depth, and area of each blast; the diameter, spacing, depth, pattern, and inclination of blast holes; the type, strength amount, column load, and distribution of explosives to be used per delay and per blast; the sequence and pattern of delays; and the description and purpose of any special methods to be adopted by CONTRACTOR. Plan view and cross sections through proposed blasting areas might be required to portray the required blast design information.

1. The plan shall also include a complete list of all authorities having jurisdiction over operations involving the transportation, storage, handling and use of explosives; a printed copy of all applicable federal, state and local regulations governing the use and storage of explosives for this work; copies of all required blasting permits regarding explosive use and storage; and copies of necessary blasting licenses or authorization obtained from the Commonwealth of Virginia State Fire Marshall or authorized Local Fire Official. Within two weeks of receipt of the plan, the ENGINEER shall advise CONTRACTOR in writing of approval or rejection of the plan. The ENGINEER reserves the right to reject the proposed plan if, in his opinion, undesirable damage to permanent rock surfaces or existing structures would result from performing the blasting as proposed. If approval is withheld, a new plan, in whole or in part, shall be carried out in areas for which the plan has not been approved by the ENGINEER. The plan shall include format examples of the Shot Plans, Shot Records and Seismograph Reports.
2. If at any time in a specific area, a plan that has been previously approved does not produce results in accordance with the requirements of these specifications, CONTRACTOR shall submit a revised plan to the ENGINEER as specified herein.
3. CONTRACTOR shall submit proposed blasting mat materials and utilization operations during blasting for review and approval as part of the Blasting Control Plan.

D. SHOT PLAN. The CONTRACTOR shall prepare a shot plan for each blast. No less than 1 hour prior to each shot, a paper copy of the shot plan shall be delivered to the ENGINEER and an electronic copy sent via email to a distribution list provided by the ENGINEER. Each shot plan shall be signed by the licensed explosive use-blaster and shall include the following.

1. The date and order number of the shot.
2. The shot-hole drill log that indicates the known voids and soft seams encountered during drilling. The licensed regulated explosive use-operator shall review the drill log and shall acknowledge review by initialing the first page of each drill log.
3. Details, including tables, maps and plan sheets showing the actual shot-hole positions and charge placement.
4. The GPS horizontal location of the outermost shot-holes and the lift elevations.
5. The total weight of explosives placed.
6. The total number of holes to be shot.
7. Whether decking or delays within a single hole will be used.
8. A table of the shot-hole data by the ascending time order of delays for the shot, not by hole number or order down a row of holes, with each hole as a row in the table,


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providing: the number of the hole, the top-of-rock depth, length of rock in the hole, total hole depth, depth of top stemming, whether other stemming intervals were required and their lengths, charge weight within the hole, and total delay time for that hole.

9. Maximum charge weight per delay for the shot.
10. Powder factors, both in charge weight per cubic yard of material shot and in charge weight per foot of total shot-hole depth.
11. A table of monitoring locations, with each location as a row in the table, providing: the monitoring positions or nearest structure's name or number, the closest approach to the blast, scaled distance for monitoring location or structure, the maximum particle velocity and airblast overpressure allowed for that monitoring location or structure, and the estimated particle velocity and airblast overpressure calculated for the monitoring location or nearest structure.
12. The procedure for controlling flyrock.
13. The location of the blast pattern on a plan map of the project.
14. A large-scale plan map depicting the shot pattern, firing order and delays to be employed.
15. A generalized elevation sketch of a typical hole depicting sub-drilling, decking charges, locations of explosives and stemming, and the locations of primers and boosters.
16. A section on methods or procedural changes for this shot to rectify blasting problems for prior shots noted in prior shot records.

E. SHOT RECORD. The CONTRACTOR shall submit a shot record for each blast to the ENGINEER. No more than one business day after each shot and no less than one hour prior to a subsequent shot, whichever occurs first, a paper copy of the shot record shall be delivered to the Engineer and an electronic copy sent via email to a distribution list provided by the ENGINEER. A concluding shot record shall be delivered to the ENGINEER and an electronic copy sent via email to a distribution list provided by the ENGINEER within two business days following the last shot. The concluding shot record shall report on the last shot's damages and/or shot impediments and provide any remaining assessments or reporting for all prior shots that have an unresolved issue concerning damage from such prior shots.

F. Each shot record shall be signed by the persons in responsible charge of both the shot and the monitoring. Each shot record shall include the following.

1. The date and order number of the shot.
2. A narrative description of the shot's performance.
3. A narrative of flyrock observations and measurements, if an observation was made.
4. Details, including tables, maps and plan sheets that compare the blast's actual charge placement in shot holes, timing and pattern, and special reference to any parameters that were determined to be different from the shot plan for any reason.
5. The total weight of explosives shot, reduced by the charge weight of any explosives that did not detonate.
6. The total number of holes shot.
7. The actual maximum charge weight per delay for the shot, recomputed if necessary.
8. The powder factors, both in charge weight per cubic yard of material shot and in charge weight per foot of total shot-hole depth, recomputed if necessary.
9. A narrative description of the shot's monitoring and comparison of the actual monitored parameters to the estimated parameters.
10. A section on the immediately prior shot, and developments (new or revised information or corrections to any data or evaluations of the data) of any earlier shot, that includes, but is not limited to, the following events.

    a. An injury or a complaint of damage due to blasting.


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b. A flyrock projectile thrown a sizable distance or endangering either personnel or property.
c. A shot that either exceeded maximum particle velocity or airblast overpressure limits or recorded maximum particle velocity or airblast overpressure 25% greater than that estimated for the shot.
d. A misfire, including any portion of the pattern not firing or a delay being skipped.

11. The section on prior shots shall reference separately each earlier shot with the following.

a. The date and order number of the earlier shot being noted.
b. Any alleged damage due to an earlier shot.
c. Any impediments or problems with the shot.
d. If the shot was an aborted or delayed shot.
e. Vibration and airblast data that exceeded contract limits or that were 25% greater than the prior shot plan's estimate, including the monitoring location, the estimated and recorded peak values of particle velocity and airblast overpressure, the monitoring equipment's manufacturer, model, serial number, and last calibration date and the closest approach to the blast. A brief narrative shall describe the cause of each difficulty, and the means to avoid its future occurrence.
f. Possible methods or procedural changes to rectify blasting problems in future shots.

12. A table of monitoring locations, with each location as a row in the table, providing: the monitoring position's or nearest structure's name or number, the closest approach to the blast, scaled distance for monitoring location or structure, the maximum particle velocity and airblast overpressure allowed for that monitoring location or structure, and the estimated, peak particle velocity and airblast overpressure, the actual, peak particle velocity and airblast overpressure for the monitoring location, and the actual recorded (total vector) peak particle velocity.
13. The location of the blast pattern on a plan map of the project with the monitoring locations and nearest structures of interest shown.

G. SEISMOGRAPH REPORT. The Monitoring Subcontractor (sub to the general CONTRACTOR) shall submit a seismograph report for each blast to the ENGINEER. No more than two business day after each shot, a paper copy of the seismograph report shall be delivered to the Engineer and an electronic copy sent via email to a distribution list provided by the ENGINEER.

H. Each seismograph report shall be signed by the person in responsible charge of the monitoring and shall include the following.

1. The date and order number of the shot.
2. A narrative description of the shot's monitoring and comparison of the actual monitored parameters to the estimated parameters. The narrative shall include the procedures and references used to assess the monitored parameters of airblast overpressure and particle velocity. The narrative shall include reference to all digital file attachments.
3. The GPS horizontal location and approximate elevation for all the monitoring locations and nearby structures.
4. The monitoring equipment's' manufacturer, model, serial number, and the last calibration date by location.
5. All of the data submitted with that blast's shot record pertinent to the monitoring, revised if necessary. The values of the three vector components and vector sum of particle velocity and airblast overpressure for each of the monitoring locations or structures.


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6. A graph (in log-log scales) of peak, component particle velocity versus scaled distance from all prior shots. The present shot's data symbol shall be clearly distinct from the symbol for all prior shots.
7. A graph (in the format of Figure A. of 3.2.C.2) for each seismograph location depicting the positions component particle velocity peaks versus frequency.
8. The digital monitoring records for each seismograph (not required with the paper copy).

I. Any other monitoring records for the shot, such as digital video recordings required by the contract or ENGINEER. The seismograph monitoring records shall be provided as digital files.

1.6 SUBSURFACE CONDITIONS

A. Owner-provided subsurface data should be utilized by the CONTRACTOR to obtain site specific subsurface data.

B. Attention is directed to the fact that there may be electrical lines, water pipes, storm drains and other utilities located in the area of proposed excavation. Perform all repairs to same in the event that excavation activities disrupt service.

1.7 CONTRACTOR'S RESPONSIBILITY

A. CONTRACTOR shall be held liable for all claims resulting from any personal injury and damage to property and equipment that may result from any blasting operations and he agrees by submission of a bid to indemnify and hold OWNER, its officers, agents, employees, volunteers and project consultants harmless from any and all liability claims, costs, expenses including expenses of investigation and defending against the same in regard thereto. Any and all damage to the work by blasting shall be repaired at no additional cost to OWNER. No approvals of submissions or acceptance of submissions by the ENGINEER shall relieve the CONTRACTOR of responsibility for blasting and its incidental operations. The CONTRACTOR shall provide the ENGINEER with the CONTRACTOR's contact information for public distribution concerning the submission of damage claims.

B. CONTRACTOR shall be solely responsible for damage resulting from, and taking all precautions and developing procedures to avoid, blasting impacts. Damage due to blasting includes, but is not limited to, the effects from airblast overpressure, vibrations (as measured by particle velocity), and flyrock. Other direct or secondary damage due to blasting shall be the sole responsibility of the CONTRACTOR, even though the damage is not named or studied by the contracting documents and references.

C. All equipment and labor furnished under this section shall comply with OSHA, ASTM, AA, NEC, ANSI and other applicable Federal, State and County codes and regulations including revisions to the date of the Contract.

D. CONTRACTOR shall immediately notify the ENGINEER if the geotechnical information or existing or proposed elevations on the plans do not correspond with CONTRACTOR'S understanding of existing conditions.

E. CONTRACTOR shall be responsible for transferring benchmarks, control points, lines and grades as necessary to complete his work.

F. The CONTRACTOR shall provide all necessary supervision, labor, equipment and materials as needed to perform the specified work.

G. Verify that the survey control system is installed and properly protected from construction operations prior to performing earthwork.


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H. Protect previous construction overburden soils to be excavated and used in landfill construction from contamination by rock heave. The uses of blasting mats are acceptable; requires submittal. The CONTRACTOR shall not use overburden soil as cover material.

## PART 2 – PRODUCTS

A. The location and design of powder magazines, the methods of transporting explosives, the use of explosives, and the precautions taken to prevent accidents shall be in accordance with the appropriate laws and regulations of local, state, and federal agencies.

B. Caps, exploders, or fuses shall, in no case, be stored or kept in the same place in which other explosives are stored or kept. All storage facilities shall be subject to approval of the OWNER and ENGINEER.

## PART 3 – EXECUTION

3.1 SAFETY

A. No drilling or blasting work shall be performed until the CONTRACTOR's Safety Plan/Blasting Control Plan for such operations has been submitted and approved by the ENGINEER. Only qualified personnel shall be responsible for the planning and execution of each shot.

B. CONTRACTOR shall comply with all applicable existing federal, state, and local blasting safety laws and regulations. CONTRACTOR shall also comply with the performance and safety requirements as outlined in the Blasting Plan. Fines resulting from noncompliance shall be the sole responsibility of the CONTRACTOR.

C. Five minutes before detonation of each blast, CONTRACTOR shall give an audible signal using a compressed air horn such as the portable units used in boating or an equivalent approved in advance by the ENGINEER. The five-minute signal shall be made by five consecutive soundings of the horn of five seconds each. One minute before detonation of each blast, CONTRACTOR shall give a final audible warning signal using the same air horn. The one-minute signal shall be made by five consecutive soundings of the horn of one second each.

D. After detonation of the blast, CONTRACTOR’s blasting personnel shall inspect the blast area to determine if live explosives or misfires are present. All others shall be kept at a safe distance away from the blast area during this inspection. Once it is determined that no misfires or live explosives are present, an “all clear” signal shall be given with the air horn by sounding it once continuously for ten seconds. When blast signaling with the compressed air horn or other approved device, it shall be rotated around during each sounding so that its sound is directed as much as possible toward all surrounding work areas.

E. The CONTRACTOR is responsible for maintaining traffic control to restrict access to areas where blasting is occurring for the duration of blasting operations. Traffic will be stopped no less than 30 minutes prior to the blast, and will not continue until the All Clear signal has been given. Blasting shall be scheduled so as to minimize traffic impacts or conflicts with OWNER or CONTRACTOR activities on site. Time restrictions, where applicable, will be provided by the OWNER. Blasting on Saturdays or Sundays is prohibited.

F. Prior to the start of blasting operations, CONTRACTOR shall post two signs of at least 4.0’ by 4.0’ size at the sides of each entrance road into the job site. The signs shall be separated from each other along the length of the road by at least 500’ and each shall be clearly visible from the road.


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1. The signs shall be clearly lettered with large letters readable from the road and shall give the following information:

    a. Danger – Blasting Area
    b. Turn Off Two-way Radios
    c. Blasting Signals:

        1) Five minutes before blast – five long tones
        2) One minute before blast – five short tones
        3) All clear – one long tone

3.2 PROTECTION OF ADJOINING PROPERTY

A. Pre-Blast Survey: A pre-blast survey will be conducted by the ENGINEER in coordination with the CONTRACTOR to document the existing condition of the structures, dams, embankments, monitoring wells, appurtenances, cemeteries, electric towers, etc.

B. Areas to be Protected: Blasting shall be permitted only after suitable precautions have been taken for the protection of persons, adjoining property, and completed work. CONTRACTOR shall coordinate with ENGINEER and OWNER to identify monitoring locations for each blast based upon the pre-blast survey. Existing conditions and OWNER requirements. The Blast Plan shall include the following monitoring locations, at a minimum:

1. Closest transmission tower to the blast site,
2. Closest Monitoring Well(s) to the blast site,
3. Closest location along private driveway along east boundary of site,
4. Closest location(s) to sluiced CCR, dams, and embankments of the North Ash Pond

C. Monitoring. A subcontractor independent of the CONTRACTOR (sub to the general CONTRACTOR) shall conduct all site airblast and particle velocity monitoring. Two seismographs shall be used to record each blast and record the airblast and particle velocity. Each seismograph used for airblast and vibration monitoring shall have a calibration certificate within an 11 month period to the date of use on the project. The CONTRACTOR shall accept the monitoring locations selected by the ENGINEER and OWNER or propose in the Blast Plan for acceptance by the ENGINEER to protect the areas described in Paragraph 3.2B of this Specification. Data shall be collected for 3 days prior to blasting to determine background vibrations at the site. The component particle velocities recorded at the required monitoring stations from each blast will be limited both by the maximum value for the recording and by the peak value at varied frequencies.

1. Ground vibration, the maximum component particle velocity, at the required recording stations shall be limited in accordance with **Table 02210-1** below.

**Table 02210-1. Maximum Component, Peak Particle Velocity by Distance to the Seismograph**

| Seismograph Distance to the closest part of a Shot Pattern (feet) | Maximum Allowable Component, Peak Particle Velocity (inch/second) |
|---|---|
| less than 300 | 1.25 |
| 300 to 2,000 | 1.00 |
| greater than 2,000 | 0.75 |


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2. The peak particle velocity based upon the frequency of the blast vibration shall be limited to fall below the allowable lineation provided in **Figure A**.

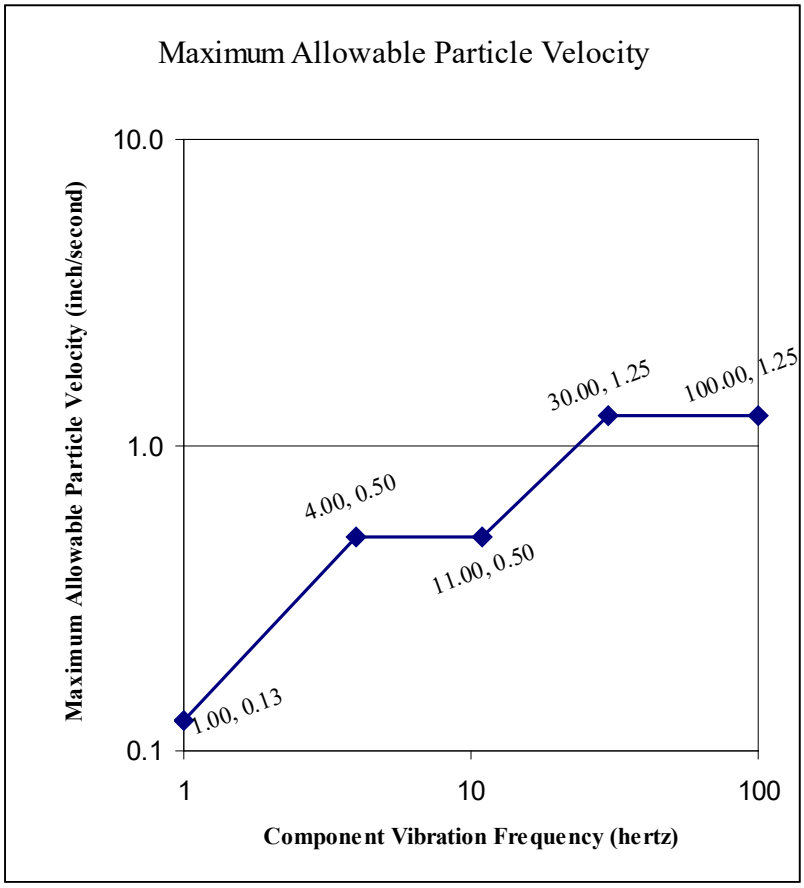


**Figure A. Maximum Allowable Component Particle Velocity versus Frequency**

3. Airblast resulting from blasting activities shall not exceed one hundred forty decibels (140 dB) at the areas to be protected as described in Paragraph 3.2, B of this Specification.
4. Actual peak particle velocity values (total vector sum) shall be provided for each monitoring location in the Shot Record.
5. A seismograph report will be submitted no more than two business days after the blast as a written blast report. A paper copy of the seismograph report shall be delivered to the ENGINEER and an electronic copy sent via email to a distribution list provided by the ENGINEER. The blast report shall include details of the actual blast as conducted, including all pertinent blasting information. The airblast and particle velocity records of the subject blast for each monitoring location shall be included in the report.
6. Variations to the allowable maximum ground vibrations and airblast may be permissible only with the approval of the ENGINEER.

D. The ENGINEER may monitor part or all of CONTRACTOR's blasting operations utilizing seismographic or other equipment to determine the effects or probable effects of such operations on rock formations or structures. CONTRACTOR shall cooperate with the ENGINEER in the placing, operating and recording of monitoring equipment.


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E. Blasting operations shall not be permitted within 100’ of concrete or grouting for a period of 48 hours after placement.

## 3.3 BLASTING TECHNIQUES

A. A Test Blasting Program shall be conducted by the CONTRACTOR prior to any production blasting. Test Blasting refers to the controlled use of explosives and blasting accessories prior to production shooting. The purpose of the Test Blasting is to: develop the production blasting design; conduct airblast and particle velocity monitoring at monitoring locations; note whether any detrimental impacts result as Scaled Distances are reduced; and, build the set of actual records for the site’s Scaled Distance versus Peak Particle Velocity Graph. The burden, drill hole pattern, hole depth, explosive type and quantity, blasting sequence, and delay pattern shall be modified to achieve the requirements specified herein.

1. The first shot of the Test Blast Program shall have only a single row of holes with no more than five shot holes to be fired in the pattern. The first Test Shot shall have a Scaled Distance larger than 75 feet per square root of charge weight in pounds (where the charge weight is the maximum charge weight per delay, if delays are used) to the nearest monitoring location.
2. Subsequent shots of the Test Blast Program shall have a Scaled Distance to the nearest monitoring location that is no smaller than 70% of any preceding Test Shot’s Scaled Distance, which had no detrimental impacts.
3. The second Test Shot shall have no more than seven shot holes in a row and no more than two rows of shot holes. The third and later Test Shots are not limited by the number of shot holes or the number of rows.
4. The CONTRACTOR may note the completion of the Test Blast Program for the Shot Plan that will not require significant reduction in the Scaled Distance to the nearest monitoring location for any subsequent rock-excavation production shots.

B. Limitations will be placed on all of the Test Blasting Program’s and production shots to avoid adverse impacts at the site.

1. Every anticipated shot hole shall be carefully logged using the cuttings, drilling pressure and drilling rate of advance to assess by depth the rock requiring blasting and weathered rock, soil infill or voids that should not be stemmed.
2. No shot hole may be loaded with explosives without the drilling log’s availability. The actual loading of explosives and placement of stemming shall be recorded by depth for every shot hole.
3. Uniform angular stemming, properly sized for the shot hole, shall be placed and tamped a minimum four hole diameters below the top of the logged firm rock depth. Weak zones and voids shall have stemming placed and tamped a minimum four hole diameters beyond logged firm rock above and below the defect. Shot holes within the shot pattern that do not need to be loaded and fired shall be fully stemmed.
4. No delay timing shall be shorter than 9 milliseconds.
5. All shot holes in a row shall be fired before any shot in a subsequent row further from the free face is fired. The minimum delay time between rows shall be 25 milliseconds.

C. CONTRACTOR may be required by ENGINEER to engage blasting specialists to assist in establishing satisfactory techniques.

D. CONTRACTOR may perform additional test borings and conduct other exploratory operations if necessary based on approval by the ENGINEER at no additional cost to the Owner.


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## 3.4 SUBSURFACE CONDITIONS

A. Geotechnical and Borrow Study reports were prepared for the site and are available for information only. The CONTRACTOR must interpret such subsurface data according to his own judgement and acknowledge that he is not relying upon the same as accurately describing the subsurface conditions, which may be found to exist. The Owner will not be responsible for interpretations or conclusions drawn from this data.

## 3.5 SCALING

A. Immediately following blasting and at any time during the contract, all loose material which appear to be unsafe or to endanger persons, work, or property shall be scaled and removed from the excavations. The fact that such scaling and removal may enlarge the excavation beyond the required excavation lines shall not relieve the CONTRACTOR from the necessity of performing these activities.

## 3.6 PRE-SPLITTING AND LINE DRILLING

A. No pre-splitting or line drilling is anticipated for this project. When required by the ENGINEER or as shown on the drawings, vertical excavated faces in competent rock may be pre-split or line drilled as shown on the drawings.

B. Pre-splitting consists of drilling a single row of closely spaced holes, loading all the holes uniformly and lightly, stemming the entire length of the hole, and then firing them simultaneously. Pre-splitting is performed either in advance of drilling and loading the adjacent main excavation areas, or simultaneously with the main blast, using electric blasting caps to initiate the pre-splitting holes fifty or more milliseconds in advance of the main blast. The blasting techniques required to remove the adjoining rock involve a reduction of the explosive charge in the line of holes nearest the pre-split line and a minimum distance from the pre-split line to the closest line of main blast holes. Drill holes for pre-splitting shall not be less than 2” in diameter and at a maximum spacing of 36” on the face of the required rock surface. All production blast holes within 30’ of the pre-split face shall be loaded and detonated in a sequence to ensure that a minimum of damage will result to the pre-split face when the main charge is fired.

C. Line drilling consists of forming excavated rock faces by drilling a single line of closely spaced holes down the required rock slope such that rock will break along the desired lines. Line drilling holes shall generally not be loaded except for the possible use of special explosive to split the rock webs between adjacent holes. Line drilling techniques shall include a substantial reduction in the explosive charge in the line-drilled holes, if needed, and a limit on the distance between the line drilled holes and the nearest line of preliminary blast holes. Drilling holes for line drilling shall be not less than 2” in diameter and shall be spaced two hole diameters or less, center to center, on the face of the required rock surface. The maximum depth of holes for line drilling or pre-splitting shall not exceed the height of the bench of adjacent area being excavated.

D. Pre-splitting and line drilling procedures shall be subject to approval of the ENGINEER and may require modification, as specified herein, to achieve the requirements of these specifications. CONTRACTOR’s techniques of presplitting or line drilling shall be considered acceptable and in accordance with these specifications or controlling the completed rock surfaces when at least 40% of the drill hole traces are visible and are distributed generally uniformly over the rock surface after scaling of all loose shattered rock.

## 3.7 RECORDS

A. Keep accurate records of each blast (i.e. locations, spacing, etc.). Maintain records throughout construction and for a minimum of two-years after completion of construction.


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Provide complete set of records to the ENGINEER and the OWNER at the completion of construction, or upon request by the OWNER.

3.8 DISPOSAL OF SURPLUS AND WASTE MATERIALS

A. Cobles and rock fragments removed during excavation by blasting must be a maximum of 2-ft diameter or less. Rock fragments may be used as rock fill (see Section 02200 – Earthwork) or disposed of by the CONTRACTOR.

B. Shattered material resulting from over break beyond the planned excavation lines or from the opening of seams due to blasting shall be removed by CONTRACTOR at no additional cost to owner.

C. Disposal: Remove waste material, trash, and debris, and dispose of it in a properly permitted disposal facility.

1. Disposal: Transport surplus satisfactory soil to designated storage areas on OWNER'S property. Stockpile or spread soil as directed by the ENGINEER.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02232

# LEACHATE COLLECTION LAYER

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing, placing and compacting the leachate collection layer as shown, specified or required.

B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

1.2 RELATED SECTIONS

A. Section 02200 – Earthwork

B. Section 02233 - Aggregate

C. Section 02597.a – HDPE Geomembrane

D. Section 02650 – Leachate Collection and Conveyance Pipe

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. ASTM C136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
2. ASTM D2434 Standard Test Method for Permeability of Granular Soils
3. ASTM D3042 Standard Test Method for Insoluble Residue in Carbonate Aggregates

1.4 TOLERANCES

A. Tolerance for thickness of leachate collection layer is ≥0.0 to +0.3 ft.

B. Minimum thickness of leachate drainage layer is 12 inches.

C. Minimum thickness of leachate protective layer is 6 inches.

1.5 SUBMITTALS

A. At least 10 business days prior to delivery of the material to the site, the Contractor shall provide to the OWNER the locations of any proposed off-site sources for leachate collection materials. The Contractor shall also provide Material Supplier data from the proposed borrow source to the OWNER for review and approval. The Material Supplier data (cut sheets) should provide testing data results for the proposed material showing that it meets the minimum requirements of this specification and Section 02233 – Aggregate.

## PART 2 – PRODUCTS

2.1 MATERIAL

A. The minimum permeability for material used for the leachate collection layer shall be $1x10^{-3}$ cm/sec, as measured in the laboratory.

B. The material used for the leachate collection layer shall consist of aggregate or fine aggregate in accordance with the requirements of Section 02233 – Aggregate. Coarse


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aggregate shall be VDOT No. 57, 78, or 8 stone and fine aggregate shall be VDOT A, B or No. 10 sand. Stone aggregate for use in the leachate collection sump shall be VDOT No. 3 stone. Fine aggregate for use as filter sand shall meet the requirements below.

| Gradation | Minimum Size (mm) | Maximum Size (mm) |
|---|---|---|
| $D_{90}$ | - | 20 |
| $D_{60}$ | 0.7 | 3.5 |
| $D_{15}$ | 0.14 | 0.7 |
| $D_{10}$ | 0.12 | - |
| $D_5$ | 0.075 | - |

C. Verification of the above specifications shall be supplied to the Owner's Representative and OWNER prior to delivery of the collection layer material. The Owner's Representative or OWNER may request the CONTRACTOR to supply samples of leachate collection layer material being placed, for testing by the Owner's Representative, if necessary, to check that the properties of the delivered materials have not changed an do conform to the specifications.

D. The material shall be non-carbonate. Non-carbonate is defined as less than fifteen percent loss by weight of the aggregate sample when the material is tested in accordance with ASTM D3042.

2.2 PRE-QUALIFICATION TESTING

A. Prior to delivery of the proposed collection layer material to the site, at least two samples from each proposed source shall be tested as follows:

1. Grain Size — ASTM C136
2. Permeability — ASTM D2434
3. Carbonate Content — ASTM D3042
4. Interface Friction Angle — ASTM D5321 (one test per interface per project)

Where material types vary substantially and are not segregated, representative blends anticipated for drainage / protection layer construction should also be sampled and tested.

B. No material shall be placed unless approved by the OWNER.

C. If, in the opinion of the OWNER, the material is unsuitable for the proposed application then the CONTRACTOR shall furnish a suitable source and supporting data as specified in Paragraph 2.2.A to the OWNER.

D. Testing during construction shall be performed in accordance with Part 4 of this Specification.

2.3 CONFORMANCE TESTING

A. The Contractor shall deliver the imported leachate collection layer material to the site and immediately place material or stockpile in designated areas as prescribed by the OWNER or ENGINEER. The leachate collection layer material will need to be stockpiled on-site and available to be sampled by the Owner's Representative prior to the intended use of the material.

B. The Owner's Representative reserves the right to visit the borrow areas to collect additional samples. The Contractor shall allow and/or arrange for the Owner's Representative's legal entry onto off-site borrow area properties if necessary.

C. Carbonate content of the leachate collection layer shall be tested by the Owner's Representative at a minimum frequency of one sample per borrow source.


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## PART 3 – EXECUTION

3.1 INSTALLATION

A. This item shall consist of the placement of leachate collection layer over the geocomposite layer in relatively horizontal lifts. The CONTRACTOR shall provide all the required materials, labor, and equipment to perform the work in accordance with these Specifications.

B. The leachate collection layer shall be installed as shown by the details on the Contract Documents. The leachate collection layer shall cover the base of the lined area as illustrated on the Contract Documents.

C. No material shall be placed until the Owner's Representative has approved the installation of the underlying geosynthetics.

D. All underlying geosynthetic materials shall remain free of bubbles or wrinkles to the satisfaction of the Owner's Representative.

E. The CONTRACTOR shall use extreme care in the placing of the leachate collection layer material over the underlying geosynthetics. The material shall be placed in a manner that will maintain a minimum thickness of 12 inches of material between the underlying geosynthetics and low ground pressure (less than or equal to 8 psi) spreading equipment. A minimum depth of 36 inches shall be maintained between underlying geosynthetics and rubber tired and heavy equipment. In areas such as entrances to the cell over berms or similar places likely to form stress concentrations due to traffic, the OWNER or Owner's Representative may require a minimum thickness of greater than 48 inches. If on-road dump trucks are used to deliver leachate collection layer material into the cell, five foot thick minimum access / dump roads should be constructed into the cell.

F. Leachate collection layer material is to be placed from the bottom of slope up, and not from the top down.

G. The CONTRACTOR shall take care to ensure that:

1. The geomembrane and geocomposite remain intact during the installation of the leachate collection layer material.
2. No foreign material is mixed into the leachate collection layer that may produce clogging or restrict the ability of the layer to transmit liquid.
3. Only low ground pressure vehicles (8 psi or less), such as ATV's, approved by the OWNER and Owner's Representative shall drive on either the uncovered geomembrane or geocomposite.

H. Where applicable, the CONTRACTOR shall ensure that the leachate collection layer material is free of any foreign objects to the complete satisfaction of the OWNER.

I. The CONTRACTOR shall exercise care during the stockpiling and handling of the leachate collection layer material to avoid the inclusion of fine-grained soil particles or other deleterious materials.

J. The OWNER reserves the right to direct the CONTRACTOR to uncover suspected damage areas of the liner system and dictate removal of any equipment or operator determined to cause damage or distress to the liner system. Costs associated with exposing the liner system and any necessary repair is the at the sole expense of the CONTRATOR. The extent of exposure and repairs shall be completed to the satisfaction of the OWNER.

K. The OWNER reserves the right to direct the CONTRACTOR to replace an equipment operator who displays reckless operation of equipment that threatens damage to the liner system. It is the CONTRACTOR's responsibility to provide operators with experience in


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liner installation for the placement of leachate collection layer material over the liner system.

L. The CONTRATOR shall control and repair rainfall washouts or runoff damage to drainage layers or liner system components. The CONTRACTR should avoid exposing large areas of liner, which promotes rapid runoff, and plan an orderly progression of installation and protection of the drainage layers and liner components. All repairs to damaged components shall be completed at no cost to the OWNER.

M. Rain covers (polyethylene tarps) may be placed over newly constructed leachate collection layers in order to protect the material from rainfall washouts, runoff damage, or to limit infiltration into the leachate collection layer by diverting surface runoff. The type of rain cover, the area to be covered, and the installation method must be approved by the OWNER prior to installation.

## PART 4 – CONSTRUCTION QUALITY CONTROL

4.1 GENERAL

A. The OWNER or Owner's Engineer reserves the right to reject any material that appears to not be representative of the samples taken for testing. If there is a significant change in the leachate collection layer material during the delivery or placement of the material, additional testing may be performed by the Owner's Representative to characterize the new materials. The material shall be removed and replaced with acceptable material at no cost to the OWNER.

B. The hydraulic conductivity and grain-size distribution of the leachate collection layer material shall be tested by the Owner's Representative at a minimum frequency of one sample for every 5,000 cubic yards of in-place material. The minimum acceptable hydraulic conductivity, as tested in the laboratory, is $1x10^{-3}$ cm/sec.

C. The CONTRACTOR is responsible for implementing a construction control grid. The control grid shall be placed and maintained by a professional surveyor licensed by the Commonwealth of Virginia. The control grid shall have defined positions every 50 feet across the area of the proposed liner. All aspects of construction shall be defined by the control grid, including but not limited to, tops and toes of slope, leachate collection headers, laterals and cleanout risers, berms, roadways and culverts. The construction control grid shall be established in rectangular coordinates.

D. The as-built thickness of the leachate collection layer material shall be determined by comparison of as-built survey of the top of the geocomposite layer to the top of the completed collection layers (leachate drainage layer and protective layer).

*** * * * * END OF SECTION * * * * ***


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# SECTION 02233

# AGGREGATE

## PART 1 – GENERAL

### 1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing, placing and compacting the stone as shown, specified or required.

B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

### 1.2 RELATED SECTIONS

A. Section 02232 – Leachate Collection Layer

### 1.3 REFERENCES

A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. Virginia Department of Transportation (VDOT) Road and Bridge Specifications (VDOT Standard Specifications), latest edition.
2. American Society for Testing and Materials (ASTM) International:

| | | |
|---|---|---|
| a. | ASTM C136 | Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates |
| b. | ASTM D2488 | Standard Practice for Description and Identification of Soils (Visual-Manual Procedures) |

### 1.4 DEFINITIONS

A. FINE AGGREGATE – Natural washed sand or manufactured product meeting the requirements of VDOT A, B, or No. 10 sand. Fine Aggregate used as bedding, leachate drainage layer, leachate protective layer, or filter sand. Location and thickness shall be as shown on the Drawings.

B. COARSE AGGREGATE - Crushed stone aggregate meeting the requirements of VDOT No. 3, 57, 78, 8, 21A, or 21B stone. Location and thickness shall be as shown on the Drawings. Gradations for stone aggregate for use in the Leachate Collection Layer shall be VDOT No. 57, 78, or 8 stone. Gradation for stone aggregate for use in the Leachate Collection Sump shall be VDOT No. 3 stone.

### 1.5 SUBMITTALS

A. At least 10 business days prior to delivery of the material to the site, the CONTRACTOR shall provide to the OWNER the locations of any proposed off-site sources for aggregates. The CONTRACTOR shall also provide Material Supplier data from the proposed borrow source to the OWNER for review. The Material Supplier data (cut sheets) should provide testing data results for the proposed material showing that it meets the minimum VDOT gradation specifications and the requirements described in this specification.

B. During delivery of the aggregate materials to the site, the contractor shall provide the shipping manifests detailing quantities, source, and supplier to the OWNER.


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## PART 2 – PRODUCTS

2.1 MATERIAL

A. The material shall be clean, sound, tough, durable, angular, subangular, subrounded or round stone, and free from slag, cinders, ashes, rubbish, or other deleterious material. Subangular, angular, subrounded, and round shall be as defined in ASTM D2488 - Standard Practice for Description and Identification of Soils (Visual-Manual Procedures).

B. Crushed aggregate specified on the Contract Documents shall meet the requirements and gradations of the VDOT Standard Specifications. Location and thickness shall be as shown on the Contract Documents.

C. The CONTRACTOR shall maintain a uniform gradation of coarse aggregate.

D. Leachate Collection System Materials:

1. Coarse Aggregate

a. Coarse aggregate for use in the leachate collection layer shall meet the gradation requirements of VDOT No. 57, 78, or 8 stone, and have a maximum particle size of 1 ½ inches.
b. Coarse aggregates for use in the leachate collection layer shall have a minimum hydraulic conductivity of $1x10^{-3}$ cm/sec.

2. Fine Aggregate

a. Fine aggregate for use in the leachate collection layer shall be natural washed sand or manufactured product and shall meet the gradation requirements of VDOT A, B, or No. 10 sand.
b. Fine aggregates for use in the leachate collection layer shall have a minimum hydraulic conductivity of $1x10^{-3}$ cm/sec.
c. Fine aggregate for use as filter sand shall meet the requirements below.

| Gradation | Minimum Size (mm) | Maximum Size (mm) |
|---|---|---|
| $D_{90}$ | - | 20 |
| $D_{60}$ | 0.7 | 3.5 |
| $D_{15}$ | 0.14 | 0.7 |
| $D_{10}$ | 0.12 | - |
| $D_5$ | 0.075 | - |

E. Aggregate shall be stored in designated areas approved by the OWNER. The CONTRACTOR is responsible for maintaining the stone free of contamination, and any stone determined by the OWNER to be contaminated shall not be incorporated into the work.

2.2 TESTING

A. The CONTRACTOR shall submit to the Owner's Representative and OWNER certification that the materials proposed for use as coarse or fine aggregate comply with specifications for the proposed application. The certification shall include, but not necessarily be limited to Grain Size (ASTM C136) testing.

B. Additional confirmatory testing may be required by the Owner's Representative to confirm compliance with the specifications.

C. No material shall be placed unless approved by the Owner's Representative.


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## PART 3 – EXECUTION

3.1 PLACEMENT

A. A uniform layer of coarse aggregate shall be placed to the lines, depths and grades as shown on the Contract Documents.

B. Backfilling of coarse aggregate shall be performed by the CONTRACTOR in a manner such that the material is kept clean and free of foreign materials.

C. For pipe bedding, the bedding and backfill shall be compacted with the compaction effort acceptable to the Owner's Representative. The compaction effort shall be applied to both the bedding and the backfill around the pipes. The method of compaction shall not damage the pipe, geotextile or the flexible membrane liner.

D. The Owner's Representative will at any time inspect the stone in the trenches or in stockpile on-site for contamination and, if necessary, reject all or portions of the stone.

3.2 FIELD QUALITY CONTROL

A. The Owner's Representative shall be responsible for monitoring the placement and/or compaction of the aggregate materials. CONTRACTOR will be responsible for placing aggregate to the lines and grades detailed in the Contract Documents.

B. Aggregates shall be placed to ≥0.0 to 0.3 ft of the total thickness shown in the Contract Documents.

C. Placement shall be to the extent and location shown on the Contract Documents.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02235

# VEGETATIVE SUPPORT LAYER

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. Furnish all labor, materials, equipment, and incidentals necessary to complete the placement of vegetative support soil shown in the Contract Documents and specified herein. The work shall include the earthwork required for vegetative layer placement and all related work.

B. Comply with applicable codes, ordinances, rules, regulations, and laws of local, municipal, State, or Federal authorities having jurisdiction.

1.2 RELATED SECTIONS

A. Section 02200 - Earthwork

1.3 QUALITY CONTROL

CONTRACTOR shall provide vegetative support soil samples to the local agricultural agent, in size and quantity necessary, for testing and evaluation. The CONTRACTOR shall furnish and apply the types and quantities of soil conditioner, fertilizer, and seed as recommended by the local agricultural agent.

1.4 SUBMITTALS

A. At least two weeks prior to the proposed placement of vegetative support soil, The CONTRACTOR shall submit the test results and recommendation of the local agricultural agent to the Owner's Representative for review. Information on soil conditioner and/or fertilizer shall also be submitted if they are recommended.

B. No material shall be placed unless approved by the OWNER and ENGINEER.

## PART 2– PRODUCTS

2.1 MATERIALS

A. Soil material used as vegetative support soil shall be loamy fine sand, loamy sand, sandy clay, sandy clay loam, fine sandy loam, clay loam, silty clay, or sandy loam as defined by the U.S. Department of Agriculture textural classification chart; and shall be suitable to support vegetative growth.

B. Soil material used as vegetative support soil shall be free of debris, trash, stumps, rocks, roots, noxious weeds, or other non-soil materials.

C. Soil material used as the vegetative layer shall have a pH range of 6 to 7.5, soluble salts less than 500 ppm, organic matter content not less than 1% by weight, and no substance toxic to plant growth.

## PART 3 – EXECUTION

3.1 INSTALLATION

A. Unless otherwise directed by the OWNER or ENGINEER, areas designated to receive vegetative support soil shall be graded, shaped, and then scarified or tilled by disking, harrowing, or other approved methods to a depth of approximately 2 inches. Soil shall be applied only when the subsoil is in a loose, friable condition.


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B. Subsoil on slopes that have been horizontally grooved in accordance with the Contract Drawings shall not be loosened.

C. No vegetative layer soils shall be placed until soil placement (backfill, fill, etc.) is complete and approved by the OWNER.

D. The vegetative support layer shall be installed in accordance with Section 02200 - Earthworks.

E. Topsoil shall not be used in muddy or frozen conditions. After topsoil has been applied, large clods, hard lumps, and unacceptably large stones; brush; roots; stumps; litter, and foreign material shall be removed from the area. When the operation is complete, the area shall be in a condition to receive seed, sod, or plants without further soil preparation. Areas shall be seeded within 7 days after topsoil is applied

F. The CONTRACTOR shall take care to ensure that underlying soil remains intact and does not become mixed with the vegetative layer during installation.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02240

# GEOSYNTHETIC CLAY LINER (GCL)

## PART 1 – GENERAL

### 1.1 DESCRIPTION OF WORK

A. The Work in this Section of the Specifications includes supply of all labor, materials, and equipment, and performance of all Work necessary for the manufacturing, storage, delivery, installation, and testing of the Geosynthetic Clay Liner (GCL) portions of the liner system, including installation as herein specified and as shown on the Contract Documents.

### 1.2 RELATED SECTIONS

A. Other specification sections that contain requirements relating to this work include, but are not limited to, the following:

1. Section 02200 – Earthwork

### 1.3 REFERENCES

A. Quality Assurance/Quality Control Plan

B. American Society for Testing and Materials (ASTM) International:

| | | |
|---|---|---|
| 1. | ASTM D4643 | Standard Test Method for Determination of Water Content of Soil and Rock by Microwave Oven Heating |
| 2. | ASTM D5261 | Standard Test Method for Measuring Mass per Unit Area of Geotextiles |
| 3. | ASTM D5887 | Standard Test Method for Measurement of Index Flux Through Saturated Geosynthetic Clay Liner Specimens Using a Flexible Wall Permeameter |
| 4. | ASTM D5888 | Standard Guide for Storage and Handling of Geosynthetic Clay Liners |
| 5. | ASTM D5889 | Standard Practice for Quality Control of Geosynthetic Clay Liners |
| 6. | ASTM D5890 | Standard Test Method for Swell Index of Clay Mineral Component of Geosynthetic Clay Liners |
| 7. | ASTM D5891 | Standard Test Method for Fluid Loss of Clay Component of Geosynthetic Clay Liners |
| 8. | ASTM D5993 | Standard Test Method for Measuring Mass Per Unit Area of Geosynthetic Clay Liners |
| 9. | ASTM D6072 | Standard Practice for Obtaining Samples of Geosynthetic Clay Liners |
| 10. | ASTM D6243 | Standard Test Method for Determining the Internal and Interface Shear Strength of Geosynthetic Clay Liner by the Direct Shear Method |
| 11. | ASTM D6496 | Standard Test Method for Determining Average Bonding Peel Strength Between the Top and Bottom Layers of Needle-Punched Geosynthetic Clay Liners. |
| 12. | D6768 | Standard Test Method for Tensile Strength of Geosynthetic Clay Liners. |

C. Geosynthetics Institute (GSI)

| | | |
|---|---|---|
| 1. | GRI-GCL3 | Standard Specification for Test Methods, Required Properties and Testing Frequencies of Geosynthetic Clay Liner (GCL) |


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## 1.4 SUBMITTALS

A. A. The following submittals shall be submitted to the OWNER or Owner's Representative for review prior to delivery of geomembrane to the site:

1. No material shall be delivered to the site until the material and performance documentation and certifications have been received and reviewed by the OWNER or Owner's Representative. Documentation shall include quality control (QC) test results on the manufactured GCL.
2. Installer shall submit to the OWNER and Owner's Representative evidence of the prequalifications required in Section 1.04, as well as experience and qualifications of the proposed installation crew.
3. The Manufacturer shall supply the following product data to the OWNER or Owner's Representative:

    a. Manufacturer's certified raw and roll material data sheets. The certified data sheets shall be attested to by a person having legal authority to bind the GCL manufacturing company. Certified test results shall be submitted at the frequencies specified in Section 2.01 of this Specification at least 7 days prior to shipment of the GCL.
    b. Manufacturer's warranty statement.
    c. Qualification statements for the manufacturer, QC inspector, and QC laboratory, including resumes of key personnel involved in this project.
    d. Manufacturer's QC laboratory test results including description of equipment and test methods. Results shall include internal shear strength test results at least 25 days prior to deployment.

4. In the event material is delivered to the site prior to the receipt of the MQC certificates, the material without certificates will be stored separately from the material with certificates. Material with unacceptable MQC data will be segregated from approved material and shall be marked for rejection. The GCL will be rejected if it is found to have defects, rips, holes, flaws, deterioration or other damage deemed unacceptable by the Owner's Representative.

B. The following submittals shall be provided to the OWNER a minimum of two weeks prior to installation of the GCL:

1. Manufacturer and Installer's Qualifications.
2. Manufacturer's quality control program and/or manual that outlines the factory and field quality control procedures to be utilized for both the manufacturing process and fabrication and installation of the GCL. This shall address, at a minimum, GCL delivery, storage, handling, installation, sewing, and repair.

    a. Manufacturer's recommended product defect repair and construction repair procedures.
    b. Manufacturer's recommended field installation procedures and techniques, including methods, overlap, personnel identification, QA/QC and preparation of materials.
    c. Installation subcontractor's daily QC log format to be used during GCL installation.

3. Installer shall supply shop drawings that include, at a minimum, a panel diagram with details. The panel diagram shall indicate the proposed GCL panel layout for approval. This approval will be for concept only; the actual panel layout will be determined by site conditions. This diagram should be in sufficient detail to provide an accurate representation of the field seaming that will be completed. Any revisions to the panel diagram shall be approved by the OWNER or Owner's Representative prior to further installation operations.


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4. The proposed layout of the panels shall be set and approved, ensuring efficiency of material, minimization of field seams, and proper placement of field seams. Field seams should be placed where normally applied stress will be minimal. All seams and slopes steeper than 15 percent shall be completed parallel to the line of maximum slope.

C. During installation; Submitted daily:

1. Documentation of daily activities.
2. Construction progress reports clearly showing GCL placed by date.

D. Within two weeks upon completion of installation:

1. All typed field data including reports/logs for field quality control work completed by the Installer.
2. Certification statement signed by the Installation Supervisor that GCL installation is complete and in accordance with these Specifications, with details of any changes or exceptions noted.
3. Statement of material and installation warranties.
4. Copies of the warranties to be provided to the OWNER at the completion of installation.

1.5 QUALIFICATIONS

A. GCL Manufacturer shall have produced the proposed GCL using the same bentonite, geomembrane, geotextiles, sewing thread, and adhesive for at least 5 completed projects and shall have produced a minimum of 2,000,000 square feet of the proposed GCL.

B. GCL Installer shall have installed GCL at a minimum of 5 projects of comparable scope and complexity and shall have installed a minimum of two million square feet of the proposed GCL.

## PART 2– PRODUCTS

2.1 MATERIAL

A. The GCL shall be a manufactured product consisting of a sodium montmorillonite clay (bentonite) layer evenly distributed between two nonwoven, needle punched geotextiles. The GCL shall be manufactured with a longitudinal overlap line (along the length of the sheet) indicating a 6-inch overlap, as required by this specification, to allow for continuous inspection by the Owner's Representative that the required overlap is achieved.

B. GCL shall conform to the property requirements listed in this specification and shall be free of tears, holes, or other defects that may affect its serviceability.

C. Encapsulating geotextiles shall be mechanically bonded together using a needle punch process. Needle punched GCLs shall be continuously inspected for broken needles using an in-line metal detector and broken needles shall be removed.

D. The minimum manufactured GCL sheet width shall be 13.5 feet and the minimum manufactured GCL sheet length shall be 98 feet.


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E. Bentonite Clay Properties

| Property | Test Method | Value | Manufacturing QC Testing Frequency |
|---|---|---|---|
| Swell Index (min avg) | ASTM D5890 | 24 ml/2g | 1 per 100,000 lbs |
| Fluid loss (max) | ASTM D5891 | 18 ml | 1 per 100,000 lbs |

F. Geotextile Properties

| Property | Test Method | Value | Manufacturing QC Testing Frequency |
|---|---|---|---|
| Mass/Unit Area (min avg) | ASTM D5261 | 5.9 oz/yd$^2$ | 1 per 200,000 ft$^2$ |

G. GCL (as manufactured) Properties

1. The GCL shall be manufactured from new, first quality materials.
2. The GCL shall be internally reinforced (needle-punched) and suitable for installation on slopes in excess of 3H:1V (18.4°)

| Property | Test Method | Specified value | Manufacturing QC Testing Frequency |
|---|---|---|---|
| Mass/Unit Area (GCL) (1) | D5993 | 0.81 lb/ft$^2$ | 1 per 45,000 ft$^2$ |
| Mass/Unit Area (bentonite) (1) | D5993 | 0.75 lb/ft$^2$ | 1 per 45,000 ft$^2$ |
| Moisture Content (max) | D5993 | 35% | 1 per 45,000 ft$^2$ |
| Tensile strength (M.D.) | D6768 | 23 lb/in | 1 per 225,000 ft$^2$ |
| Peel strength | D6496 | 3.5 lb/in | 1 per 45,000 ft$^2$ |
| Permeability (max)<br>• Final Cover<br>• Bottom Liner | D5887 | <br>5x10$^{-9}$ cm/s<br>3.4x10$^{-9}$ cm/s | 1 per 250,000 ft$^2$ |

1. Mass of the GCL and bentonite is measured after oven drying per ASTM D5993

## 2.2 ACCESSORY BENTONITE

A. The granular bentonite or bentonite sealing compound used for seaming, penetration sealing, and repairs, shall be made from the same natural sodium bentonite as used in the GCL and shall be used as recommended by the GCL manufacturer.

## 2.3 STRENGTH REQUIREMENTS

A. Internal friction testing and interface friction testing of the GCL against the underlying soil subgrade surface and the overlying Geomembrane shall be greater than or equal to 13.5°, or equivalent shear strength, as determined by ASTM D5321 and ASTM D6243 and approved by the ENGINEER. Frequency shall be 1 per project per interface.

1. Each direct shear test shall determine internal and interface strength at normal stresses of 2,000 pounds per square foot (psf), 5,000 psf, 10,000 psf, and 20,000 psf. Tests shall be completed under fully saturated conditions (saturation time of 15 minutes), have a seat time of 15 minutes, and have a shear rate of 0.04 inches per minute (in/min).
2. The direct shear test shall be completed using installation procedures used under actual field conditions.
3. Additional samples shall be collected and tested if the material does not meet the minimum requirements of this Technical Specification.


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B. The friction requirements and test conditions shall be confirmed by the Engineer prior to selection of landfill base liner materials.

C. Interface friction testing should be performed prior to approval of geosynthetics submittal using site specific soils and the specified GCL proposed for the liner system to verify that the minimum interface friction can be achieved.

2.3 MANUFACTURING QUALITY CONTROL

A. The GCL shall be sampled per ASTM D6072 and tested by the Manufacturer in accordance with tables provided herein and the manufacturer's approved QC manual. The samples shall be tested for the properties listed in Section 2.2, with at least one set of tests per production lot.

B. Test results not meeting the requirements specified in Section 2.2 shall result in the rejection of applicable rolls. The manufacturer's QC manual shall describe procedures used to determine rejection of applicable rolls. At a minimum, rolls produced immediately prior to and immediately after the failed roll shall be tested for the same failed parameter. Testing shall continue until a minimum of three successive rolls on both sides of the original failing roll pass the failed parameter.

C. The GCL manufacturer shall provide the CONTRACTOR or other designated party with manufacturing QC certifications for each shipment of GCL. The certifications shall be signed by a responsible party employed by the GCL manufacturer.

2.4 CQA CONFORMANCE TESTING

A. The GCL shall be sampled by Owner’s Representative or sent directly from the manufacturer per ASTM D6072 and tested by the Owner’s independent testing laboratory. The samples shall be tested at the frequencies shown below, with at least one set of tests per production lot.

B. Test results not meeting the requirements below shall result in the rejection of applicable rolls. At a minimum, rolls produced immediately prior to and immediately after the failed roll shall be tested for the same failed parameter.

| Property | Test Method | Specified value | QA Testing Frequency |
|---|---|---|---|
| Moisture Content (max) | D5993 | 35% | 1 per 250,000 $ft^2$ |
| Tensile strength (M.D.) | D6768 | 23 lb/in | 1 per 250,000 $ft^2$ |
| Peel strength | D6496 | 3.5 lb/in | 1 per 250,000 $ft^2$ |
| Permeability (max)<br>• Final Cover<br>• Bottom Liner | D5887 | <br>$5x10^{-9}$ cm/s<br>$3.4x10^{-9}$ cm/s | 1 per 250,000 $ft^2$ |
| Internal and Interface Friction | D5321 and D6243 | 13.5° | 1 per project per interface |

2.5 WARRANTY

A. Material shall be warranted, on a pro-rata basis against Manufacturer’s defects for a period of one year from the date of installation.

B. Installation shall be warranted against defects in workmanship for a period of one year from the date of construction certification.


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## PART 3– EXECUTION

### 3.1 DELIVERY, STORAGE, AND HANDLING

A. The GCL shall be supplied in rolls wrapped in impermeable and opaque protective covers. GCL rolls and wrapping shall be marked or tagged with the following information:

1. Manufacturer's name.
2. Product Identification.
3. Lot or batch number.
4. Roll number.
5. Roll dimensions.
6. Any special handling required, e.g., "this side up".

B. Care shall be taken to prevent damage to the protective wrapping surrounding the GCL rolls. Holes or other areas that might permit leakage shall be patched with waterproof materials.

C. Delivery, storage, and handling of GCL shall be in accordance with ASTM D5888.

D. Acceptance at Site:

1. The Owner's Representative shall be present during delivery and unloading of the GCL.
2. The Owner's Representative shall conduct visual observations of each roll for defects and damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected.
3. Defected or damaged rolls or portions of rolls will be rejected and shall be removed from site and replaced with new rolls.
4. Rolls or portions of rolls without proper identification or labeling will be rejected and shall be removed from site.

E. Storage and Protection

1. The OWNER will provide on-site storage for GCL rolls from time of delivery until deployment.

    a. The Installer shall store GCL in the original, unopened packaging in a level, dry, well-drained, stable area that provides protection against precipitation, standing water, ultraviolet radiation, oils and chemicals, open flames and sparks, temperatures in excess of 160°, vandalism and animals, and any other environmental condition that may cause damage to the GCL.
    b. Field storage shall be in flat dry areas where water cannot accumulate and the GCL rolls can be protected from damage. Storage of the rolls on blocks or pallets shall be allowed, provided the GCL rolls are fully supported to the satisfaction of the OWNER or Owner's Representative. Stacks of GCL rolls shall be no greater than three high. Rolls shall be covered with a waterproof tarpaulin or plastic sheet if stored outdoors.
    c. GCL shall be handled in such a way as to minimize bending of the rolls. This may be accomplished using a pipe or solid bar, spreader bar, stinger bar (if bar is at least ¾ the length of the GCL roll width and prevents bending of the GCL), or a manufacturer-approved method.
    d. Rolls shall not be dragged, lifted by one end, or dropped to the ground from the delivery vehicle.


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3.2 WEATHER CONDITONS

A. The CONTRACTOR shall not attempt deployment of GCL during precipitation events or on slopes with frost or precipitation accumulation without prior authorization of the Owner's Representative and implementation of proper safety precautions.

3.3 SUBGRADE PREPARATION

A. The GCL subgrade shall conform to the requirements described in Section 02200 – Earthworks of these specifications.

B. Each day GCL is placed, the Owner's Representative and Installer shall inspect the prepared subgrade on which the GCL is to be placed and certify in writing that the surface is acceptable.

C. Repairs to the subgrade shall be performed at no additional cost to the OWNER.

3.4 PLACEMENT

A. GCL shall be installed as soon as practical after completion and approval of the subgrade. Rolls shall be delivered to the work area in their original packaging. Immediately prior to deployment, the packaging shall be carefully removed without damaging the GCL.

B. On side slopes, GCL shall be anchored at the top and deployed down the slope to minimize wrinkles. Dragging of GCL panels over the ground surface shall be minimized. The Owner's Representative has the option of requiring the use of a slip-sheet. Deployed GCL panels shall lie flat on the subgrade surface, with no wrinkles or folds.

C. GCL that has been hydrated prior to being covered by the geomembrane, shall be removed and replaced. Hydrated GCL is defined as material that has become soft as determined by squeezing the material with finger pressure or material that has exhibited swelling.

D. Equipment used to deploy GCL must not cause excessive rutting of the subgrade. Installation personnel must not smoke or wear damaging shoes on GCL; and GCL should not be placed during excessive winds. Vehicle traffic other than low contact pressure vehicles (8 psi or less) must not be allowed on the deployed GCL.

3.5 ANCHOR TRENCH

A. Anchor trenches shall be placed a minimum of 24 inches back from the edge of slopes to be covered. Anchor trenches shall be a minimum of 24 inches deep and 12 inches wide. The front edge of the trench shall be rounded to eliminate sharp corners that could damage the GCL. The GCL shall extend down the front wall and across the bottom of the anchor trench.

B. The anchor trench shall be adequately drained to prevent ponding or hydration of the GCL while the trench is open. Anchor trenches will be backfilled and compacted by the Contractor to prevent access of water to the edge of the geosynthetics.

C. The GCL may be placed in the same anchor trench as the overlaying geomembrane liner.

3.6 SEAMS

A. On side slopes, GCL shall be placed with seams oriented parallel to the line of maximum slope and shall be free of tension or stress upon completion of the installation.

B. Panels shall be positioned with the overlap recommended by the manufacturer, but not less than 6 inches after shrinkage for panel sides or 12 inches after shrinkage for panel ends. Panels specifically marked for seam overlap dimensions shall follow manufacturer's recommendations.


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C. Dirt or other foreign matter shall be removed from the overlap area immediately prior to seaming.

D. Granular bentonite of the same type as the bentonite used for the GCL shall be placed along the entire overlap width at a minimum rate of 0.25 pounds per linear foot or as recommended by the manufacturer. Panels not requiring supplemental bentonite shall be installed and overlapped per the manufacturer's recommendations.

E. Overlaps that occur on slopes shall be constructed with the up slope GCL shingled over the down slope GCL with a minimum overlap of three feet. Overlap seams may be placed only in the lower half of the slope and must be staggered.

3.7 PROTECTION

A. Only those GCL panels that can be anchored and covered in the same day shall be unpacked and installed. If exposed GCL cannot be permanently covered with geomembrane before the end of a working day, it shall be temporarily covered with plastic or other waterproof material to prevent hydration.

B. The overlying geosynthetics and soil layers shall be deployed in such a manner as to ensure that the GCL is not damaged. Textured geomembranes shall not be dragged across previously installed GCL. A smooth rubsheet may be placed between the GCL and textured geomembrane to prevent damage. The rubsheet will be removed when the geomembrane is in position. Other methods may be employed at the discretion of the Owner's Representative.

C. Generators, gasoline or solvent cans, tools, or supplies must not be stored directly on the GCL.

3.8 REPAIRS

A. Holes or tears in GCL shall be repaired by placing a patch of GCL extending a minimum of 12 inches beyond the edges of the hole or tear on all sides. Granular bentonite shall be applied in the overlap area.

B. Patches shall be secured with construction adhesive, heat bonded, or other approved methods as recommended by the manufacturer.

C. The GCL shall not be covered prior to inspection and approval by the Owner's Representative. No equipment shall be operated on the top surface of the GCL without permission from the OWNER or the Owner's Representative.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02271

# STONE RIPAP AND GROUTED RIPRAP

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing and placing stone riprap, as shown, specified or required.

B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

## PART 2 – PRODUCTS

2.1 MATERIALS

A. Riprap aggregate shall consist of hard, durable, subangular material. It shall be free from any considerable amount of flat, laminated or elongated particles; and shall be free from cracks, overburden shells, clay, organic matter, or other deleterious matter.

B. Rip rap aggregate shall meet the requirements and gradations of Dry Riprap as defined by the Virginia Department of Transportation Road and Bridge Specifications (VDOT Standard Specifications), Section 414 and meet or exceed VESCH Section 3.19. Class, location, and thickness shall be as shown on the Contract Documents.

C. The riprap shall be composed of an evenly distributed mixture such that 50 percent of the mixture by weight shall be larger than the $d_{50}$ size as indicated on the Contract Drawings. The diameter of the largest stone size in such a mixture shall be at least 2.0 times the $d_{50}$ size. The diameter of the smallest stone size in such a mixture shall be greater than 0.5 times the $d_{50}$ size.

D. The breadth or thickness of a single stone shall not be less than 1/3 its' length.

E. Crushed concrete meeting the gradation requirements shall be an acceptable substitute for stone riprap.

F. Cement grout for grouted riprap shall consist of one-part cement and three parts VDOT Standard Specifications A, B, or C sand, thoroughly mixed with water to produce grout having a thick, flowable consistency.

2.2 SUBMITTALS

Submit manufacturer's certification of material properties as outlined in Paragraph 2.1 to the ENGINEER.

## PART 3 – EXECUTION

3.1 INSTALLATION – LOOSE RIPRAP

A. Stone riprap shall be placed to thicknesses as indicated on Contract Documents.

B. With the exception of grouted riprap, and unless otherwise indicated on the Contract Documents, all riprap shall be placed on a nonwoven geotextile underlayment of 8 oz. per square yard (which shall meet or exceed VESCH Section 3.19 requirements relating to geotextile underlayment and Section 02595 – Geotextile of these specifications). The edges of the geotextile shall be sufficiently anchored to prevent movement during rock placement.


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C. Stone riprap shall be placed in a manner that will not damage geotextile, synthetics, utilities or other facilities. Riprap shall not be dropped from a height exceeding three feet.

D. The tolerance in riprap thickness in place shall be -0 to +0.3 feet.

E. No material shall be placed in areas not indicated on the Contract Documents unless approved by the OWNER.

3.2 INSTALLATION – GROUTED RIPRAP

A. Grout shall consist of 1-part hydraulic cement and 3-parts sand, thoroughly mixed with water to produce grout having a thick, flowable consistency.

B. Stones shall be of the same sizes and placed in the same manner as specified for dry riprap, Class I. Care shall be taken during placing to keep earth or sand from filling spaces between stones. After stones are in place, spaces between them shall be filled with grout from bottom to top and the surface swept with a stiff broom.

C. Riprap shall not be grouted in freezing weather. In hot, dry weather, the work shall be protected from sunlight and kept moist for at least three days after grouting by the use of saturated burlap or other suitable method.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02510

# PERMANENT DRAINAGE

## PART 1 – GENERAL

1.1 SUMMARY

A. This Section includes furnishing and installing all piping, fittings / bends, and associated appurtenances for the reinforced concrete pipe culvert installation.

1.2 SUBMITTALS

A. Submit in accordance with Section 01300 – Submittals.

B. Product and material data sheets indicating products/materials meet or exceed the standards set forth in this Section.

C. Manufacturer's standard drawings and catalog cuts for joints and fittings.

D. Materials list of items proposed to be provided under this Section.

1.3 REFERENCE SPECIFICATIONS, CODES, AND STANDARDS

Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced Specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. American Association of State and Highway Transportation Officials (AASHTO):

| | | |
|---|---|---|
| a. | AASHTO M86M | Standard Specification for Concrete Sewer, Storm Drain, and Culvert Pipe |
| b. | AASHTO M170 | Standard Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe |

2. American Society for Testing and Materials (ASTM) International:

| | | |
|---|---|---|
| a. | ASTM C76 | Standard Specification for Reinforced Concrete Culvert, Storm Drain and Sewer Pipe |
| b. | ASTM C150 | Standard Specification for Portland Cement |
| c. | ASTM C443 | Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets |

1.4 QUALITY ASSURANCE

A. Use adequate numbers of skilled workmen who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specific requirements and the methods needed for proper performance of the work of this Section.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Piping, fittings, and appurtenances shall be handled in such a manner to ensure delivery to the location as shown on the Contract Documents in a sound, undamaged condition. Before installation, the OWNER shall be provided an opportunity to examine the piping, fittings, and appurtenances for damage and defects. Damaged or defective piping, fittings, and appurtenances may be rejected. Piping, fittings, and appurtenances found to be defective before or after installation shall be removed and replaced with acceptable material at no additional cost to the OWNER.


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B. Piping, fittings, and appurtenances shall be handled using approved strapping and equipment. CONTRACTOR shall not use chains, wire rope, forklifts, or other methods or equipment that may gouge, scrape, or otherwise damage the pipe. Carry, do not drag pipe to the trench.

C. Piping, fittings, and appurtenances shall be kept safe from damage while being stored. The interior of all piping and fittings shall be kept free from dirt and other foreign materials at all times. Gaskets shall be stored in a cool location out of direct sunlight.

1.6 WARRANTY

A. CONTRACTOR shall warranty all materials and workmanship for a period of one (1) year from date of beneficial use. Defects or failures shall be promptly replaced with new parts by CONTRACTOR at no additional cost to the OWNER within the warranty period.

## PART 2 – PRODUCTS

2.1 REINFORCED CONCRETE PIPE (RCP)

A. General. Precast concrete pipe, which does not conform to ASTM C76, or to any other requirement specified herein, shall not be approved for storm sewer or culvert installations.

B. Allowable ASTM Specifications. All Material, manufacturing operations, testing, inspection, and making of concrete pipe shall conform to the requirements of ASTM C76.

C. Diameter of Pipe. The diameter indicated on the Contract Documents shall mean the inside diameter of the pipe.

D. Quality of Pipes

1. All reinforced concrete pipe shall be of the tongue and groove or bell and spigot type cast of best quality of concrete, free from imperfections of any kind, and shall have a smooth, dense finish without honeycombing, blowouts, broken ends or other faults. Concrete tongue and groove ends shall be properly designed for the type of rubber gasket to be used. Pipe shall be machine cast outside of the trench, in forms true to shape and dimensions, rigid, smooth, and substantially watertight. Care shall be used to assure that tongue and groove will be truly round and of proper shape and dimensions to produce pulled-up, tight joints. Pipe joints out of round or shape so that joints cannot be properly pulled will be rejected.

2. Lifting Holes. No lift holes will be permitted in pipes 42 inches in diameter and smaller.

3. Markings:

    a. The following shall be clearly marked on both the interior and exterior surface of the pipe:

        1) Appropriate ASTM Specification: ASTM C76.
        2) Class and size.
        3) Date of manufacture.
        4) Name or trademark of manufacturer.

4. All reinforced concrete pipe shall have circumferential reinforcing steel in the bell of the pipe.

5. Wall Thickness and Class of Pipe. The wall thickness and reinforcing steel, if any, shall comply with ASTM C76.


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E. Fittings and Specials. Fittings and specials shall be made up of pipe segments having the same structural qualities as the adjoining pipe and shall have the interior treated the same as the pipe.

F. Cement. Unless otherwise required by ENGINEER, or specified otherwise on the Contract Documents, Type II Modified Portland Cement complying with the requirements of ASTM C150 will normally be acceptable in the manufacture of concrete pipe.

G. Pipe Joints.

1. All reinforced circular concrete pipe shall be joined by a rubber compression type gasket joint as per ASTM C443.

    a. The bell and spigot or tongue and groove end of the pipe shall be especially prepared for the use of the gasketed joint during manufacture, by the use of steel or cast-iron forms, to produce a smooth, accurately dimensioned and truly concentric circular joint.

    b. Forms shall be accurately dimensioned and machined to the joint dimensions, and shall be circular, within a tolerance of 3/64-inch.

    c. All inside surfaces of the bell or outside surfaces of the spigot, or both, on which the rubber gasket may bear during the closure of the joint and at any degree of partial closure shall be parallel within one degree and have an angle of not more than 2 degrees with the longitudinal axis of the pipe.

    d. The clear distance along the parallel or concentric curved surfaces on both sides of the gasket shall be not less than 3/4-inch, and the distance from either side of the gasket to the end of the bell or spigot shall be not less than 3/4-inch.

2. The gasket spaces between the bell and spigot shall be so shaped as to provide either grooves or shoulders that will prevent the gasket from disengaging from its compression surfaces or being blown out by hydrostatic pressures. The gasket shall be the sole element used in sealing the joint from either internal or external hydrostatic pressures.

3. The gasket shall not be stretched more than 20 percent or less than 10 percent when placed on the spigot. Stretched gasket diameters referred to will be nominal diameters reduced by 0.5 percent for each 1 percent of stretch actually used. Where the gasket is not largely confined in a preformed groove formed into the outer surface of the spigot, the gasket shall be of such size that when the joint is off center sufficiently to cause the outer surface of the spigot and the inner surface of the bell to come into contact, the deformation in the stretched rubber gasket will not exceed 40 percent at the point of contact; and at the diametrically opposite point across the pipe, the deformation shall not be less than 20 percent of the normal gasket diameter or a thickness before deformation. Where the gasket is largely confined within a rectangular preformed groove, the gasket deformations, as prescribed above, shall be not more than 50 percent or less than 20 percent.

4. Gaskets for the joints shall be of sufficient cross-sectional area and length to fill the space provided in the joint when the pipe is laid and of a shape that when the joint is assembled, the gasket will be compressed to form a watertight seal. All rubber gaskets shall be extruded or molded and cured in such a manner that any cross section will be dense, homogeneous and free of porosity, blisters, pitting and other imperfections. The gaskets shall be extruded or molded to the specified sizes within a tolerance of plus or minus 1/32-inch of any diameter, measured at any cross section.


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5. Mortared Joints. Mortared joints shall only be used in special circumstances and only where specifically authorized by ENGINEER. It is the intent of these specifications to limit the use of mortared joints to the minimum extent possible except where unusual field conditions require deviation from the jointing material specified.

H. Waterstop for Connection to Cast-in-Place Structures

1. Whenever a reinforced concrete pipe (RCP) is connected to a cast-in-place structure, the surface of the RCP in contact with the structure shall be provided with two wraps of Waterstop.

2. Waterstop shall be secured to RCP with an approved adhesive.

a. Installation shall not proceed when work areas are flooded to the extent that would cause bentonite waterstop to hydrate; nor when precipitation can be reasonably anticipated before bentonite waterstop can be properly installed or protected.

b. Construction Joints: all applicable vertical and horizontal construction pour joints to receive waterstop must be encapsulated with a minimum of three (3) inches of concrete on all sides. A compatible adhesive must be used with the waterstop.

c. Follow waterstop manufacturer's installation procedures for application of the waterstop.

I. Protective Coatings. Normally, no additional exterior or interior protective coatings shall be required for concrete pipe. However, whenever adverse corrosive conditions warrant additional interior protection, those pipe segments will be noted on the Contract Documents.

J. Refer to the Plans and Section 02200 – Earthwork for backfill and compaction requirements.

## PART 3 – EXECUTION

3.1 GENERAL INSTALLATION REQUIREMENTS

A. The pipe and pipe coating shall be inspected by ENGINEER for damage or defects before being placed in the trench. Damaged or defective pipe shall not be installed.

B. All pipes that do not meet the requirements of Part 2 of this section will be rejected and replaced at CONTRACTOR'S expense.

C. Proper equipment, implements, tools and facilities shall be provided and used by CONTRACTOR for safe and convenient installation of the type of pipe being installed.

D. The use of water or other liquids to facilitate spoil removal is prohibited.

E. Where seeding or sodding is disturbed by excavation or backfill operations, such areas shall be replaced by seeding in accordance with permanent seeding requirements (as referenced in Section 02936 – Seeding).

F. Use equipment, materials, and methods to ensure installed pipe conforms to the grades and alignments shown on the Contract Documents or as instructed by the OWNER.

1. Installed pipe shall not deviate from the design grade and alignment by more than one(1) inch per 100 feet unless approved by the OWNER.


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2. Record grade and alignment measurements in a field book for each piece of pipe and appurtenance installed and at each turn, fitting, junction, or change in grade. Furnish a copy of measurements to the OWNER at the completion of the project.

G. Thoroughly clean the interior of all pipe, fittings, and appurtenances prior to installation. Exclude foreign materials from entering the pipeline throughout installation.

H. If required, cut pipe in a clean and workmanlike manner using a mechanical cutter only, without damage to the pipe.

I. Support pipe with backfill materials before backfilling around and above pipe.

1. Place and compact material around and above pipe in a manner which will not damage or displace the pipe, and in accordance with Section 02200 – Earthwork.

3.2 PIPE

A. Storm sewer pipe shall be installed in accordance with the manufacturer's recommendations for installing the type of pipe used, unless otherwise shown on the Contract Documents.

B. Do not allow excavation over the limits of the pipe installation as specified. Shore the trench wall as necessary to protect workmen, the public, structures, roadways and other improvements.

C. All piping shall be erected to accurate lines and grades with no abrupt changes in line or grade other than as indicated on the Contract Documents. Joint assembly shall be in accordance with the manufacturer’s recommendation including the Joint Extension process to allow for axial expansion.

D. Pipe with lifting holes shall be installed such that the lifting holes are in the crown of the pipe. All lifting holes shall be properly grouted with cement mortar immediately after the pipe is installed and prior to commencement of backfilling.

E. Pipe with lifting anchors shall be installed such that the lifting anchors are in the crown of the pipe. All lifting anchor recesses in the wall of the pipe at the lifting anchors need not be grouted.

3.3 PIPE FITTINGS

A. Pipe fittings shall be laid so as to form a close concentric joint with the adjoining pipe to avoid sudden offsets of the flow line. Pipe sections shall be joined together in accordance with the manufacturer's recommendations.

B. Pipe fittings and appurtenances shall be carefully lowered into the trench with suitable tools or equipment to prevent damage to the pipe and protective coatings and linings. Pipe and accessory materials shall not be dropped or dumped into the trench.

3.4 GASKETS

A. No gaskets that show signs of deterioration, such as surface cracking or checking, shall be installed in a pipe joint. The neoprene gaskets used, when the air temperature is ten degrees Fahrenheit (10°F) or lower shall be warmed to temperature of sixty degrees Fahrenheit (60°F) for a period of thirty (30) minutes before being placed on the pipe.

3.5 PROTECTION AND CLEANING

A. Avoid equipment traffic over pipes and fittings until covered to a depth sufficient to prevent damage or breakage.


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B. CONTRACTOR shall be responsible for removing and cleaning any foreign debris that enters the pipeline system. All costs associated with the removal of foreign debris from the pipeline system shall be considered incidental to the Contract and no additional compensation will be allowed to CONTRACTOR.

C. All piping shall be clear and free from debris at the time of final acceptance.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02590
# GEOCOMPOSITE

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, tools, and equipment necessary for the installation of geocomposite (or geonet composite) in the location and to the dimensions shown on the Contract Documents, and in accordance with this specification.

1.2 RELATED SECTIONS

A. Section 02595 – Geotextile

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM) International:

| | | |
|---|---|---|
| 1. | ASTM D D792 | Standard Test Methods for Density and Specific Gravity (Relative Density) of Plastics by Displacement |
| 2. | ASTM D1505 | Standard Test Method for Density of Plastics by the Density-Gradient Technique |
| 3. | ASTM D1603 | Standard Test Method for Carbon Black in Olefin Plastics |
| 4. | ASTM D4716 | Standard Test Method for Determining the (In-Plane) Flow Rate Per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head |
| 5. | ASTM D5035 | Standard Test Method for Breaking Force and Elongation of Textile Fabrics (Strip Method) |
| 6. | ASTM D5199 | Standard Test Method for Measuring the Nominal Thickness of Geotextiles and Geosynthetics |
| 7. | ASTM D5261 | Standard Test Method for Measuring the Mass per Unit Area of Geotextiles |
| 8. | ASTM D5321 | Standard Test Method for Determining the Shear Strength of Soil- Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear |
| 9. | ASTM D7005 | Standard Test Method for Determining the Bond Strength (Ply Adhesion) of Geocomposites |
| 10. | ASTM D7179 | Standard Test Method for Determining Geonet Breaking Force |

1.4 QUALIFICATIONS

A. The CONTRACTOR shall provide the services of a Geocomposite Manufacturer and INSTALLER, who shall meet the following qualifications. The CONTRACTOR shall accept and retain full responsibility for all materials and installation and shall be held responsible for any defects in the completed system.

1. Manufacturer

a. The Geocomposite Manufacturer shall be responsible for the production and delivery of geocomposite rolls and shall be a well-established firm with more than five years of experience in the manufacture of geocomposite. The Manufacturer shall submit a statement to the OWNER listing:

1) Certified minimum property values of the proposed geocomposite and the tests used to determine those properties.
2) Production capacity available and projected delivery dates for this project.


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2. Installer

   a. The Installer shall have at least five years of experience with geonet composite installation. In addition, the Installer shall have completed a minimum of five projects with the same material and of similar scope to that indicated for this project. The Installer shall have a successful installation and maintenance record of in-service performance.
   b. The Installer shall have on-site at all times during the installation an individual experienced in the installation of geonet composite. The designated individual shall be responsible for assuring that the geonet composite is installed according to this Specification and the construction drawings. The appointment shall be subject to approval by the OWNER or ENGINEER.

1.5 SUBMITTALS

A. Prior to Material Delivery

1. No material shall be delivered to the site until the material and performance documentation and certifications have been received and reviewed by the OWNER or Owner's Representative. Documentation shall include quality control (QC) test results on the manufactured geocomposite.

2. The Manufacturer shall supply the Owner's Engineer with samples of the geonet composite taken from rolls that will be delivered to the site to complete pre-delivery/pre-construction interface shear testing. Each sample must be properly identified to include: manufacturer, model, lot, and roll numbers. No material shall be delivered to the site until the interface shear testing has been completed and the material has been approved by the OWNER or Owner's Representative.

3. Installer shall submit to the OWNER and Owner's Engineer evidence of the prequalifications required in Section 1.4, as well as experience and qualifications of the proposed installation crew.

4. The Manufacturer shall supply the following product data to the OWNER or Owner's Engineer:

   a. Manufacturer's certified raw and roll material data sheets. The certified data sheets shall be attested to by a person having legal authority to bind the geocomposite manufacturing company. Certified test results shall be submitted at the frequencies specified in Part 2 of this Specification at least 7 days prior to shipment of the geocomposite.
   b. Manufacturer's warranty statement.
   c. Qualification statements for the manufacturer, QC inspector, and QC laboratory, including resumes of key personnel involved in this project.
   d. Manufacturer's QC laboratory test results including description of equipment and test methods. Results shall include transmissivity test results at least 25 days prior to deployment.

1.6 QUALITY ASSURANCE PROGRAM

A. Manufacturer and installer shall participate in and conform to the items and requirements of the quality assurance program as outlined in this Specification and the Construction Quality Assurance Plan (CQAP Plan).

B. The OWNER will engage and pay for the services of an Owner's Representative and testing laboratory to monitor the geomembrane installation and complete conformance testing.


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1.7 WARRANTY

A. Material shall be warranted on a pro-rata basis against Manufacturer's defects for a period of at least one-year from the date of geonet composite installation completion.

B. Installation shall be warranted against defects in workmanship for a period of at least one-year from the date of geonet composite installation completion.

## PART 2 – PRODUCTS

2.1 GEOTEXTILE

A. The geotextile component of the geocomposite shall consist of an 8oz/yd$^2$ non-woven, needle-punched geotextile conforming to the requirements of Section 02595 – Geotextile of these Specifications.

2.2 GEONET

A. Resin used to manufacture the geonet component of the geocomposite shall be new first quality, compounded polyethylene resin. The Manufacturer shall furnish geocomposite having properties meeting the requirements below.

| Property | Test Method | 250-mil GC | 275-mil GC | Manufacturing QC Testing Frequency | QA Testing Frequency |
|---|---|---|---|---|---|
| Thickness (min avg) | ASTM D5199 | 250 mil | 275 mil | 1 per 100,000 ft$^2$ | 1 per 250,000 ft$^2$ |
| Density (min avg) | ASTM D792 or ASTM D1505 | 0.940 g/cm$^3$ | 0.940 g/cm$^3$ | 1 per 100,000 ft$^2$ | 1 per 250,000 ft$^2$ |
| Tensile Strength (min avg) | ASTM D5035/D7179 | 55 lb | 65 lb | 1 per 100,000 ft$^2$ | 1 per 250,000 ft$^2$ |
| Carbon Black Content (range) | ASTM D1603 | 2%-3% | 2%-3% | 1 per 100,000 ft$^2$ | 1 per 250,000 ft$^2$ |

2.3 GEOCOMPOSITE

A. The HDPE geonet composites shall be of the thicknesses shown on the Contract Drawings and shall meet the minimum properties shown in paragraph C below.

B. Geonet composite material shall meet the interface friction angle requirements contained in Section 02200 – Earthwork of these Specifications.

C. Finished Geocomposite Material Properties

| Property | Test Method | Test Value | Manufacturing QC Testing Frequency | QA Testing Frequency |
|---|---|---|---|---|
| Ply adhesion (min avg) | ASTM D7005 | 1.0 lb/in | 1 per 100,000 ft$^2$ | 1 per 250,000 ft$^2$ |
| Transmissivity, 250 mil and 275 mil (min avg) (1) | ASTM D4716 | (2) | 1 per project | 1 per 500,000 ft$^2$ |
| Transmissivity, 250 mil only (min avg) (3a) (5) | ASTM D4716 | 9.0x10$^{-4}$ m$^2$/s (4a)<br>2.2x10$^{-4}$ m$^2$/s (4b) | N/A | 1 per 500,000 ft$^2$ |
| Transmissivity, 250 mil only (3b) (4) (5) | ASTM D4716 | (6) | N/A | 1 per project |
| Transmissivity, 275 mil only (3c) (4a) (5) | ASTM D4716 | 1.13x10$^{-3}$ m$^2$/s | N/A | 1 per 500,000 ft$^2$ |

Notes:
1. Transmissivity shall be measured in a 12-inch x 12-inch box using the same boundary conditions, load, duration, and gradient as those used by the manufacturer to establish the min. avg for the required test value.
2. Required value shall be taken from manufacturer's standard material specification sheet for the selected geocomposite material.
3. Transmissivity shall be measured in a 12-inch x 12-inch box using a 100-hour duration and the following gradient and boundary conditions:


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   a. 0.05 and Soil/Geocomposite/Geomembrane
   b. 0.05 and Aggregate/Geocomposite/Geomembrane
   c. 0.33 and Soil/Geocomposite/Geomembrane
4. Load conditions for transmissivity testing shall be as follows:
   a. 1,000 psf
   b. 10,000 psf
5. Engineer may approve lower transmissivity values based on analysis of design calculations.
6. Value shall be reviewed and approved by Engineer.

2.4 MANUFACTURING QUALITY CONTROL

A. The CONTRACTOR shall require that the Geocomposite Manufacturer sample and test the geocomposite to demonstrate that the material conforms to the requirements of this Section.

B. Any geocomposite sample that does not comply with this Section shall result in rejection of the roll from which the sample was obtained. The CONTRACTOR shall replace any rejected rolls at no additional cost to the OWNER.

C. Additional sample testing may be performed, at the Geocomposite Manufacturer's discretion and expense, to more closely identify any non-complying rolls and/or to qualify individual rolls.

D. The manufacturer shall test the materials at the frequencies shown in Section 2.2 and 2.3 of this Specification to demonstrate that its properties conform to the specified values.

**PART 3– EXECUTION**

3.1 LABELING, DELIVERY, HANDLING, AND STORAGE

A. Each roll of geonet composite delivered to the site shall be labeled by the Manufacturer. The label shall clearly state the Manufacturer’s name, product identification, lot or batch number, length and width of roll, and roll number.

B. The rolls of geonet composite shall be packaged and shipped by appropriate means to prevent damage to the material and to facilitate off-loading.

C. Equipment used to unload and handle geocomposite shall be sufficient to support the roll weight without damage to the geocomposite. Geocomposite shall be unloaded and handled using a stinger, spreader bar assembly, straps/slings provided by the geocomposite manufacturer or approved equal. Pushing, sliding, or dragging of geocomposite rolls is not permitted.

D. Prior to mobilization of the Installer, the CONTRACTOR shall be responsible for all on site storage of the geonet composite material. Once the Installer has mobilized on site, all storage of the geonet composite material shall be the responsibility of the Installer. The CONTRACTOR/Installer shall provide a suitable storage site that will protect the geonet composite from punctures, abrasions, excessive moisture, and dirt. The on-site storage location for the geonet composite material should be level, smooth, elevated, and dry. The geonet composite shall not be stored on wooden pallets. The storage place should be protected from theft and vandalism and, if possible, should be adjacent to the area to be lined to facilitate installation and minimize handling. Geonet composite rolls shall be stockpiled for storage no more than four rolls high or as approved in writing by the Manufacturer.

E. Prior to mobilization of the Installer, the CONTRACTOR shall be responsible for all on site handling of the geonet composite material. Once the Installer has mobilized on-site, all handling of the geonet composite material shall be the responsibility of the Installer. The materials are to be handled so as to prevent damage. The CONTRACTOR responsible for off-loading of the geonet composite material shall contact the Manufacturer prior to delivery


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to confirm transport type, equipment, and procedures necessary for proper handling. Instructions for moving geonet composite rolls shall be provided by the Manufacturer upon request.

F. After unwrapping the geocomposite from its opaque cover, the geocomposite shall not be left exposed to sunlight for a period in excess of 30 days unless a longer exposure period is approved by the ENGINEER, based on a formal demonstration from the CONTRACTOR that the geotextile component of the geocomposite is stabilized against U.V. degradation for a period in excess of 30 days.

3.2 SURFACE PREPARATION

A. Prior to commencing any work, the Installer shall carefully inspect the surface and verify that it is clean of all soil, rock, water, and other material that could damage the geonet composite. The CONTRACTOR shall verify that all work is complete to the point where installation of the geonet composite may properly commence without adverse impact.

B. If the CONTRACTOR has any concerns regarding the installed work of other Sections, he/she shall notify the Owner's Representative in writing within 48 hours of the site inspection. Failure to inform the Owner's Representative in writing prior to installation of the geocomposite will be construed as CONTRACTOR's acceptance of the related work of all other Sections.

C. The Geocomposite shall be placed only on Geomembrane that has been approved by the Geomembrane Installer and accepted by the Owner's Representative. The CONTRACTOR shall coordinate with the Geomembrane Installer for optimum scheduling.

3.3 PLACEMENT

A. Geocomposite shall be installed per the approved Manufacturer's recommended procedures and to the lines and grades shown on the Drawings.

B. The Installer shall deploy the geonet composite ensuring that the geonet composite and underlying materials are not damaged. Faulty or damaged geonet composite shall be replaced or repaired.

C. The geonet composite roll shall be installed in the direction of the slope and in the intended direction of flow unless otherwise specified by the ENGINEER.

D. The geonet composite shall be unrolled downslope keeping the net in slight tension to minimize wrinkles and folds. On long, steep slopes, special care should be taken so that only full-length rolls are used at the top of the slope.

E. The geonet composite shall be properly anchored at the anchor trench to resist sliding. Anchor trench compaction equipment shall not come into direct contact with the geonet composite.

F. Care shall be taken during placement of geocomposite not to entrap dirt or excessive dust in the geonet core that could cause clogging of the drainage system, and/or stones that could damage the adjacent liner. If dirt or excessive dust is trapped in the geocomposite, it should be cleaned prior to placement of the next material on top of it.

G. The geonet composite shall be maintained free of dirt, mud, or any other foreign materials at all times during construction. Rolls that are contaminated with these materials shall be cleaned or replaced. Tools shall not be left on, in, or under the geocomposite.

H. Adequate ballast (e.g. sandbags) shall be placed to prevent uplift by wind. Spacing shall be determined by the Installer. Any damage caused by wind uplift shall be the responsibility of the CONTRACTOR and shall be corrected at no cost to the OWNER.


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3.4 INSTALLATION

A. Each component of the geonet composite will be secured or seamed to the like component at overlaps. Adjacent rolls shall be overlapped a minimum of four inches and end-to-end rolls shall be overlapped a minimum of six inches. Fasteners, as recommended by the Manufacturer and approved by the OWNER or ENGINEER, shall be used to join the geonet component of the rolls. Metallic fasteners are not allowed. Fasteners shall be spaced a maximum of five feet along downslope roll overlaps, a maximum of one foot along cross-slope roll overlaps, and a maximum of six inches in an anchor trench. Fasteners shall be of contrasting color from the geonet composite to facilitate visual inspection.

B. Stacking of geonet composite layers more than two layers thick shall not be permitted.

C. Seams

1. The upper geotextile on adjacent and end-to-end panels of geonet composite shall be sewn or heat bonded together with a continuous seam. The sheets of geotextile shall be overlapped a minimum of six inches. All overlaps shall be installed such that the upslope sheet is placed over the downslope sheet.
2. Adjoining geonet composite rolls (end to end) across the roll width should be shingled down in the direction of the slope, with the geonet portion of the top overlapping the geonet portion of the bottom geonet composite a minimum of six inches across the roll width.

D. Upon completion and acceptance by the OWNER or ENGINEER of the geonet composite in an area, the material shall be covered within 14 days of acceptance.

3.5 REPAIR

A. Prior to covering the deployed Geocomposite, each roll shall be inspected for damage resulting from construction.

B. Holes or tears in the geonet composite shall be repaired by placing a patch of geonet composite extending a minimum of two feet beyond the edges of the hole or tear. Approved fasteners, spaced every six inches around the patch, shall be used to fasten the patch to the original roll.

C. If the area to be repaired is more than 50 percent of the width of the panel, the damaged area shall be cut out, and the two portions of the geonet composite shall be joined in accordance with Section 3.4 of this Specification.

3.6 PLACEMENT OF OVERLYING MATERIALS

A. Geocomposite shall not be covered until it is accepted by the Owner’s Representative.

B. The CONTRACTOR shall place the overlying materials in such a manner as to ensure that:

1. no construction equipment operates directly on the geocomposite.
2. the geocomposite and underlying lining materials are not damaged.
3. minimal slippage occurs between the geocomposite and underlying layers.
4. excess tensile stresses are not produced in the geocomposite.

C. Placement of any overlying soil or aggregate material shall be in accordance with Section 02599 – Protection of Geosynthetics.

3.7 PRODUCT PROTECTION

A. The CONTRACTOR shall use all means necessary to protect all prior work, and the materials and completed work of other Sections.


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B. In the event of damage, the CONTRACTOR shall immediately make all repairs and replacements necessary to the approval of the Owner's Representative and at no additional cost to the OWNER.

C. Geonet composite penetration details shall be as recommended by the Manufacturer and as approved by the OWNER or ENGINEER.

3.8 CQA CONFORMANCE TESTING

A. Upon delivery to the site or at the location of the manufacturer, samples of the geocomposite shall be removed by the Owner's Representative or at the factory prior to shipment to the site and sent to the laboratory selected for testing to ensure conformance to this Section and the project CQA Plan.

B. Geocomposite sampling and testing shall be completed by the Owner's Representative and submitted in accordance with this Specification and the procedures outlined in the CQA Plan.

C. Any geocomposite that is not certified in accordance with paragraph 2.3 of this Section, or that conformance testing indicates does not comply with Paragraph 2.3 of this Section shall be rejected and replaced with new material by the CONTRACTOR at no additional cost to the OWNER.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02595

# GEOTEXTILE

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing, and placing geotextile, complete with appurtenances, as shown, specified or required.

B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, state or federal authorities having jurisdiction.

1.2 RELATED SECTIONS

A. Section 02590 – Geocomposite

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM) International:

1. ASTM D4491 Standard Test Methods for Water Permeability of Geotextiles by Permittivity
2. ASTM D4533 Standard Test Method for Trapezoid Tearing Strength of Geotextiles
3. ASTM D4632 Standard Test Method for Grab Breaking Load and Elongation of Geotextiles
4. ASTM D4751 Standard Test Method for Determining Apparent Opening Size of a Geotextile
5. ASTM D5261 Standard Test Method for Measuring Mass per Unit Area of Geotextiles
6. ASTM D6241 Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

B. Geosynthetic Research Institute (GRI) Standard Specifications and Test Methods

1. GT-12 Test Methods and Properties for Nonwoven Geotextiles Used as Protection (or Cushioning) Materials
2. GT-13 Test Methods and Properties for Geotextiles Used as Separation Between Subgrade Soil and Aggregate

1.4 SUBMITTALS

A. The CONTRACTOR shall submit to the OWNER and ENGINEER written certifications signed by the Manufacturer of the woven and non-woven geotextile attesting that the geotextile meets the chemical, physical, and manufacturing requirements specified. The certification shall include:

1. Product identification.
2. Lot number.
3. Geotextile roll numbers affected by shipment.
4. Manufacturer’s QC test results.

B. The following submittals shall be provided to the Project Engineer a minimum of 15 days prior to installation of the geotextile:


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1. Manufacturer's quality control program and/or manual that outlines the factory and field quality control procedures to be utilized for both the manufacturing process and installation of the geotextile. This shall address, at a minimum, geotextile delivery, storage, handling, installation, sewing, and repair should be submitted to the Project Engineer.

C. The contractor shall submit shop drawings to the CQA Consultant showing proposed construction methods: geosynthetics panel arrangements; and tie-in details between geosynthetics, drainage structures, fill materials, and the like.

1.5 QUALIFICATIONS

A. The Geotextile Manufacturer shall be a specialist in the manufacture of polyester and/or polypropylene geotextile and have produced and manufactured a minimum of five million $ft^2$ of said geotextile fabric that was used in successful installations.

## PART 2 – MATERIALS

2.1 GEOTEXTILE

A. Nonwoven Geotextile

1. Nonwoven geotextile shall meet the requirements of AASHTO M288 Survivability Class 2 (Moderate Survivability) and be suitable for fines in excess of 50% in the surrounding material.
2. Nonwoven geotextile shall meet the following properties.

| Property (1) | Test Method | 8-oz Filter GT | 10-oz Separation GT | Manufacturer's QC Testing Frequency |
|---|---|---|---|---|
| Mass/Unit Area (min avg) | ASTM D5261 | 8 oz/$yd^2$ | 10 oz/$yd^2$ | 1 per 100,000 $ft^2$ |
| Grab Tensile Strength | ASTM D4632 | 158 lb | 230 lb | 1 per 100,000 $ft^2$ |
| Grab Tensile Elongation | ASTM D4632 | 50% | 50% | 1 per 100,000 $ft^2$ |
| Trapezoidal Tear Strength | ASTM D4533 | 56 lb | 95 lb | 1 per 100,000 $ft^2$ |
| Puncture Strength (CBR) | ASTM D6241 | 320 lbs | 700 lb | 1 per 100,000 $ft^2$ |
| Apparent Opening Size (AOS) | ASTM D4751 | 0.0084 in | 0.0058 in | 1 per 500,000 $ft^2$ |
| Permittivity | ASTM D4491 | 1.1 $sec^{-1}$ | N/A | 1 per 500,000 $ft^2$ |
| UV Stability (min) (2) | ASTM D7238 | 70% | 70% | Certified by Manufacturer |

1. All values are minimum average roll values (MARV) except AOS, which is a maximum average roll value.
2. Evaluation to be on 2.0-inch strip tensile specimens per ASTM D5035 after 500 lt. hrs. exposure.

3. For geotextile requiring heat burnishing, the required testing will be performed prior to heat burnishing the material.

a. Heat burnishing shall be performed by the manufacturer prior to delivery at the site.
b. Heat-burnished, non-woven geotextile shall be installed with the heat-burnished side down.


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## PART 3 – EXECUTION

### 3.1 PRODUCT LABELING, DELIVERY, STORAGE AND HANDLING

A. Labeling. Each roll delivered to the site shall be wrapped individually in relatively impermeable and opaque protective covers and labeled by the Manufacturer. The label will identify the following:

1. Manufacturer's Name.
2. Product Identification.
3. Length and Width.
4. Roll Number.

B. Delivery - Rolls will be prepared to ship by appropriate means to prevent damage to the material and to facilitate off-loading. The Owner's Representative will perform a visual inspection of all delivered rolls to ensure there has been no damage during shipping.

C. Geotextiles shall be rejected by the Owner's Representative and replaced by the CONTRACTOR if they are found to have defects, rips, holes, flaws, deterioration or other damage at no cost to the OWNER.

D. Storage and protection:

1. Unloading, on-site handling, and storage of the Geotextile are the responsibility of the CONTRACTOR or INSTALLER.
2. Store and protect Geotextile from mud, dust, water, exposure to ultraviolet light, heat, and other sources of damage.
3. Geotextile shall be stored off the ground and continuously supported along their length. Stacking of geotextile rolls for storage should be done in a manner to prevent crushing of the cores or flattening of the rolls. Rolls should be secured to prevent shifting, abrasion, or other adverse movement of the geotextile rolls.

E. Handling

1. The CONTRACTOR and INSTALLER shall handle all rolls in such a manner to ensure they are not damaged in any way.
2. Preserve integrity and readability of geotextile roll labels.
3. Equipment used to unload and handle geotextile shall be sufficient to support the roll weight without damage to the geotextile. Geotextile shall be unloaded and handled using a stinger, spreader bar assembly, straps/slings provided by the geotextile manufacturer or approved equal. Pushing, sliding, or dragging of geotextile rolls is not permitted.

### 3.2 CONFORMANCE TESTING

A. Geotextiles will be tested prior to shipment to ensure that the properties of the finished product are in accordance with the construction specifications. Geotextile samples will have test results for the properties and to the requirements given in Section 2.1 of this Specification.

B. Upon delivery of non-woven geotextile to the Site, the Owner's Representative shall obtain representative samples of the furnished product for conformance testing. The required material properties, test methods, values, and units are presented below. CQA conformance testing is not required for woven geotextiles.


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| Property (1) | Test Method | QA Testing Frequency |
|---|---|---|
| Mass/Unit Area (min avg) | ASTM D5261 | 1 per 250,000 $ft^2$ |
| Grab Tensile Strength | ASTM D4632 | 1 per 250,000 $ft^2$ |
| Grab Tensile Elongation | ASTM D4632 | 1 per 250,000 $ft^2$ |
| Trapezoidal Tear Strength | ASTM D4533 | 1 per 250,000 $ft^2$ |
| Puncture Strength | ASTM D6241 | 1 per 250,000 $ft^2$ |
| Apparent Opening Size (AOS) | ASTM D4751 | 1 per 500,000 $ft^2$ |
| Permittivity | ASTM D4491 | 1 per 500,000 $ft^2$ |

3.3 SITE PREPARATION

A. Site subgrade preparation shall conform to the requirements of this Section, and Section 02200 - Earthwork.

B. The surface to receive geotextile shall be cleared of sharp objects, boulders, stumps, or any materials that may contribute to fabric punctures, shearing, rupturing, or tearing to the satisfaction of the Owner's Representative.

C. The base surface or surface of embankments shall be graded as smooth as possible and compacted with a smooth-drum roller. The subgrade shall be inspected for unstable areas or soft spots, before the geotextile is placed, and additional fill shall be placed and compacted to eliminate those unstable areas.

3.4 INSTALLATION

A. The geotextile shall be placed in the manner and at the locations shown on the Contract Documents. Geotextile shall be laid smooth and free of tension, stress, folds, wrinkles, or creases.

B. When the Geotextiles are placed on slopes, the upslope fabric portion shall be lapped such that it is the upper or exposed Geotextile.

C. Woven geotextile will be overlapped a minimum of 2 feet, with the upgradient roll lapped over the downgradient roll, prior to placing stone.

D. All nonwoven geotextile seams shall be continuously sewn or heat bonded by means approved by the ENGINEER. Nonwoven geotextiles will be overlapped a minimum of 6 inches prior to sewing. Polymeric thread, with chemical resistance properties equal to or exceeding those of the geotextile, shall be used for all sewing. The thread shall be a contracting color (white or other light color) to facilitate seam inspection. The seams shall be sewn to provide a flat (prayer) seam, "J" seam, or "Butterfly-folded" seam and shall be a two-thread, double-lock stitch or a double row of single-thread, chain stich. Spot sewing shall not be allowed.

E. If geotextile is damaged during any step of installation, a piece of geotextile material shall be cut and placed over the damaged area and overlap the undamaged material a minimum of 2 feet in each direction. If the hole or tear width across the roll is more than 50 percent the width of the roll, the damaged area shall be cut out and the two portions of the geotextile shall be sewn together.

F. The geotextile shall be placed on side slopes as shown on the drawings. If necessary, the geotextile shall be positioned by hand after being unrolled to minimize wrinkles. The geotextile shall not be placed in the horizontal direction (i.e. across the slope) on slopes steeper than 10 (horizontal): 1 (vertical), except as part of a patch.


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3.5 PROTECTION

A. After installation, the geotextile should be visually inspected to assure that no objects are present that could potentially harm the geotextile.

B. No vehicles shall be permitted on the geomembrane or non-woven geotextile prior to placement of at least 12 inches of cover material.

C. Any geotextile damaged during its installation or during placement of cover material, as deemed by the Owner's Representative, shall be replaced by the CONTRACTOR at no additional cost to the OWNER.

D. The work shall be scheduled so that the covering of the geotextile with the material to be placed over it is accomplished within 30 days after placement of the geotextile. Failure to comply with this requirement shall require replacement of an additional geotextile at no additional cost to the OWNER.

E. CONTRACTOR's placement techniques and covering schedule shall eliminate or minimize the potential for accumulation of sediment or other debris on the geotextile. CONTRACTOR shall remove accumulated sediment or debris by sweeping, hosing, or other methods accepted by the OWNER, prior to covering. Any geotextile that cannot be adequately cleaned shall be removed and replaced by the CONTRACTOR at no cost to the OWNER.

F. When spot-repairing geotextile with patches, a 3-foot, heat-bonded overlap will be used or by a means approved by the ENGINEER.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02597.a

# HDPE GEOMEMBRANE

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, and equipment, and perform all work necessary for the delivery, storage, installation, and testing of High Density Polyethylene (HDPE) geomembrane. For the location of geomembrane placements and types refer to the Contract Documents.

1.2 REFERENCES

A. American Society for Testing Materials (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 D3895 | Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry |
| 5. | ASTM D4218 | Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique |
| 6. | ASTM D4833 | Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products |
| 7. | ASTM D5397 | Standard Test Method for Evaluation of Stress Crack Resistance of Polyolefin Geomembranes Using Notched Constant Tensile Load Test |
| 8. | ASTM D5596 | Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics |
| 9. | ASTM D5721 | Standard Practice for Air-Oven Aging of Polyolefin Geomembranes |
| 10. | ASTM D5885 | Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry |
| 11. | ASTM D5994 | Standard Test Method for Measuring Core Thickness of Textured Geomembranes |
| 12. | ASTM D6392 | Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods |
| 13. | ASTM D6693 | Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes, nonreinforced, percent break elongation, percent yield elongation, polyethylene, polypropylene, tensile break strength, tensile yield strength. |
| 14. | ASTM D 7238 | Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus |
| 15. | ASTM D7466 | Standard Test Method for Measuring the Asperity Height of Textured Geomembrane |

B. Geosynthetics Institute (GSI)

| | | |
|---|---|---|
| 1. | GRI GM-9 | Cold Weather Seaming of Geomembranes |
| 2. | GRI GM-10 | The Stress Crack Resistance of HDPE Geomembrane Sheet |


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3. GRI GM-11 Accelerated Weathering of Geomembranes Using a Fluorescent UVA-Condensation Exposure Device
4. GRI-GM13 Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
5. GRI-GM19 Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

1.3 SUBMITTALS

A. The following submittals shall be submitted to the OWNER or OWNER's Representative for review prior to delivery of geomembrane to the site:

1. Manufacturing Quality Control (MQC) data (Material Certifications) for the geomembrane to be delivered to the site. Documentation shall include the quality control (QC) test results on the manufactured geomembrane sheet and certification stating the geomembrane roll numbers, base resin type, and lot from which it was produced.

a. Manufacturer shall supply the Owner or Owner's representative with the following resin data:

1) Certification stating that the resin meets the requirements of this Technical Specification
2) Certification stating all resin is from the same Manufacturer
3) A copy of the QC certificates issued by the geomembrane Manufacturer and resin supplier
4) Certification that extrudate resins and/or rod are from one manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane material

b. Manufacturer shall supply the Owner or Owner's representative with the following geomembrane sheet data:

1) Minimum physical properties and test methods used
2) Certification that material reworked from manufacturing process will not exceed 10 percent by weight of material in accordance with GRI GM-13.
3) A copy of the QC certificates issued by the geomembrane Manufacturer.

2. In the event material is delivered to the site prior to the receipt of the MQC certificates, the material without certificates will be stored separately from the material with certificates.

B. The following submittals shall be submitted to the OWNER or Owner's Representative for review prior to installation:

1. Shop drawings, including proposed panel diagram and details of proposed work, pipe boots, and details of sealing around all necessary geomembrane penetrations. The panel diagram must depict and/or note the planned number and orientation of panels, the panel sizes, seam orientation, placement of seams in corners, treatment of tee seams and the Installer's preferred sequence of panel placement. The panels shall be orientated in a manner that minimizes seams. Any revisions to the reviewed panel diagram must be approved by the OWNER or Owner's Representative, in writing, prior to installation.

C. Within 5 days upon completion of installation:


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1. All testing data including reports/logs for field quality control work completed by the INSTALLER.
2. Subgrade surface acceptance certificates signed by INSTALLER for each area that will be covered directly by geomembrane. Deployment of geomembrane will be considered acceptance of subgrade is certificate is not submitted.
3. Certification statement signed by the Installation Supervisor that geomembrane installation is complete and in accordance with these Specifications, with details of any changes or exceptions noted.
4. As-built drawings showing actual geomembrane placement, seams and repairs including typical anchor trench detail.
5. Copies of the material and installation warranties to be provided to the OWNER at the completion of installation.

1.4 PREQUALIFICATIONS

A. Manufacturer:

1. Manufacturer shall have minimum five 5 years continuous experience in manufacture of HDPE or LLDPE geomembrane or experience totaling 10,000,000 $ft^2$ of manufactured HDPE or LLDPE geomembrane for minimum of 10 completed facilities.

B. INSTALLER:

1. INSTALLER shall have minimum five 5 years continuous experience in installation of HDPE or LLDPE geomembrane or experience totaling 2,000,000 $ft^2$ of installed HDPE geomembrane for minimum of 10 completed facilities.
2. Personnel performing seaming operations shall be qualified by experience or successfully passing seaming tests. Minimum of one seamer shall have experience seaming minimum 2,000,000 ft2 of HDPE or LLDPE geomembrane using the same type of seaming apparatus in use at site. Most experienced seamer, "master seamer," shall provide direct supervision, as required, over less experienced seamers.

1.5 QUALITY ASSURANCE PROGRAM

A. Manufacturer, fabricator, and INSTALLER shall participate in and conform to items and requirements of a quality assurance program as outlined in this Specification and the Construction Quality Assurance (CQA) Plan.

B. The OWNER will engage and pay for the services of an Owner’s Representative and testing laboratory to monitor the geomembrane installation and complete conformance testing.

1.6 WARRANTY

A. The material shall be warranted on a pro-rata basis against Manufacturer’s defects for a period of five years from the date of geomembrane completion.

B. The installation shall be warranted against defects in workmanship for a period of one year from the date of geomembrane completion.

## PART 2 – PRODUCTS

2.1 GEOMEMBRANE

A. Polyethylene Resin


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1. The resin shall be virgin material with no more than 10% rework. If rework is used, it must be the same formulation of the parent material.
2. No post-consumer resin of any type shall be added to the formulation.
3. Use of geomembrane recycled during manufacturing process shall be permitted with written approval from OWNER and if recycled geomembrane does not exceed 2% by weight.
4. Geomembrane manufactured from non-complying resin shall be rejected.
5. The extrudate rod and/or bead shall be made from same type of resin as the geomembrane. Additives shall be thoroughly dispersed, and the material shall be free of contamination by moisture or foreign matter.

B. Geomembrane Characteristics

1. Contain maximum of 1% by weight of additives, fillers, or extenders (not including carbon black).
2. Contain between 2% and 3% by weight of carbon black for ultraviolet light resistance
3. No pinholes, bubbles or other surface features that compromise geomembrane integrity are allowed. Geomembrane shall be free of blisters, non-dispersed raw materials, or other signs of contamination resulting from the manufacturing process. Geomembrane rolls or portions of rolls with these defects shall be rejected.
4. Textured High Density Polyethylene (HDPE) shall meet the material properties below.


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| Testing Properties | Testing Method | 40-mil HDPE | 60-mil HDPE | Manufacturer QC Testing Frequency (13) |
|---|---|---|---|---|
| Thickness (min avg)<br>• Lowest individual (8 of 10)<br>• Lowest individual (any) | ASTM D5994 | 38 mil<br>36 mil<br>34 mil | 57 mil<br>54 mil<br>51 mil | 1 per Roll |
| Asperity Height (min avg) (1) (2) | ASTM D7466 | 16 mil | 16 mil | 1 per 50,000 sf |
| Density | ASTM D1505 or ASTM D792 | 0.940 g/cc | 0.940 g/cc | 1 per 50,000 sf |
| Tensile Properties (min. avg) (3)<br>• Yield strength<br>• Break strength<br>• Yield elongation<br>• Break elongation | ASTM D6693 Type IV | 84 lb/in<br>60 lb/in<br>12%<br>100% | 126 lb/in<br>90 lb/in<br>12%<br>100% | 1 per 50,000 sf |
| Tear Resistance (min. avg) | ASTM D1004 | 28 lb | 42 lb | 1 per 50,000 sf |
| Puncture Resistance (min. avg) | ASTM D4833 | 60 lb | 90 lb | 1 per 50,000 sf |
| Stress Crack Resistance (4) | ASTM D5397 (App) | 500 hr | 500 hr | (12) |
| Carbon Black Content (range) (5) | ASTM D4218 | 2.0% - 3.0% | 2.0% - 3.0% | 1 per 50,000 sf |
| Carbon Black Dispersion | ASTM D 5596 | (6) | (6) | 1 per 100,000 sf |
| Oxidative Induction Time (OIT) (min avg) (7)<br>• Standard OIT<br>• High Pressure OIT | <br>ASTM D3895<br>ASTM D5885 | <br>100<br>400 | <br>100<br>400 | (12) |
| Oven Aging at 85°C (7) (8)<br>• Standard OIT, % retained after 90 days<br>• High Pressure OIT, % retained after 90 days | ASTM D5721<br>ASTM D3895<br><br>ASTM D5885 | <br>55%<br><br>80% | <br>55%<br><br>80% | (12) |
| UV Resistance (9)<br>• Standard OIT (min avg)<br>• High Pressure OIT - % retained after 1600 hours | ASTM D7238<br>ASTM D3895<br>ASTM D5885 | <br>N.R. (10)<br>50% | <br>N.R. (10)<br>50% | (12) |

1. The lowest individual reading must be ≥ 12 mils.
2. Test each side of the textured geomembrane recording a measurement every lineal foot of textured roll width.
3. Machine direction (MD) and cross machine direction (XMD) average values should be based on 5 test specimens each direction.
   a. Yield elongation is calculated using a gage length of 1.3 inches.
   b. Break elongation is calculated using a gage length of 2.0 inches.
4. The SP-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 of the same sample.
5. Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
6. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   a. 9 in Categories 1 or 2, and
   b. 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.
12. Manufacturer may provide certification letter.
13. Testing frequencies listed are the minimum.


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## 2.2 SEAMING AND TESTING EQUIPMENT

A. Welding:

1. Maintain on-site minimum of 2 spare operable seaming apparatus, unless otherwise agreed upon at the pre-construction meeting.
2. Seaming equipment shall not damage geomembrane.
3. Use extrusion welding apparatus equipped with gauges giving temperature of extrudate at nozzle of apparatus or utilize hand-held gauges to measure extrudate temperatures.
4. Use fusion-welding apparatus that are self-propelled devices equipped with gauges indicating temperature of the heating element and speed of travel.
5. Place electric generator on smooth base with rub sheet such that no damage occurs to geomembrane.

B. Vacuum Testing Equipment:

1. Vacuum box assembly consisting of: rigid housing, transparent viewing window, soft neoprene gasket attached to bottom of housing, porthole or valve assembly, and vacuum gauge all in good working condition. The assembly shall be capable of maintaining a minimum 4 psi vacuum.
2. Pump assembly equipped with pressure controller and pipe connections.
3. Pressure/vacuum rubber hose with fittings and connections.
4. Soapy solution to wet test area.
5. Means of applying soapy solution.

C. Air Pressure Testing Equipment:

1. Air pump (manual or motor driven), equipped with pressure gauge, capable of generating, sustaining, and measuring pressure between 20 and 35 psi, and mounted on rub sheet to protect geomembrane.
2. Rubber hose with fittings and connections.
3. Sharp hollow needle, or other approved pressure feed device.
4. Air pressure monitoring device.

D. Tensiometer Testing Equipment:

1. Tensiometer shall be capable of maintaining constant jaw separation rate of 2 inches per minute, and shall be calibrated, with certificate of calibration less than one 1 year old kept with tensiometer.

## 2.3 MANUFACTURER QUALITY CONTROL

A. Tests, Inspections shall be performed by geomembrane manufacturer in accordance with the frequencies outlined in section 2.1 of this Specification and as follows:

1. Test geomembranes to demonstrate that resin meets this Specification.
2. Continuously monitor geomembrane during manufacturing process for inclusions, bubbles, or other defects. Geomembranes which exhibit defects shall not be acceptable for installation.
3. Monitor thickness continuously during manufacturing process.
4. Tests shall be conducted for following properties in accordance with test methods specified in the following table. Samples not complying with Specifications shall result in rejection of rolls. At geomembrane manufacturer's discretion and expense, additional testing of individual rolls may be performed to identify and reject non-complying rolls and to approve individual rolls.


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## PART 3 – EXECUTION

3.1 QUALITY ASSURANCE SAMPLING

A. CONTRACTOR or INSTALLER shall make rolls available and assist the Owner's Representative in obtaining material inventory and material samples. Samples shall be tested in accordance with the test methods specified in the following table:

| Testing Properties | Testing Method | Conformance QA Testing Frequency (4) |
|---|---|---|
| Thickness (min avg)<br>• Lowest individual (8 of 10)<br>• Lowest individual (any) | ASTM D5994 | 1 per 250,000 sf |
| Asperity Height (min avg) (1) (2) | ASTM D7466 | 1 per 250,000 sf |
| Density | ASTM D1505 or ASTM D792 | 1 per 250,000 sf |
| Tensile Properties (min. avg) (3)<br>• Yield strength<br>• Break strength<br>• Yield elongation<br>• Break elongation | ASTM D6693 Type IV | 1 per 250,000 sf |
| Tear Resistance (min. avg) | ASTM D1004 | 1 per 250,000 sf |
| Puncture Resistance (min. avg) | ASTM D4833 | 1 per 250,000 sf |
| Carbon Black Content (range) (5) | ASTM D4218 | 1 per 250,000 sf |
| Carbon Black Dispersion (6) | ASTM D5596 | 1 per 250,000 sf |

1. The lowest individual reading must be ≥ 12 mils.
2. Test each side of the textured geomembrane recording a measurement every lineal foot of textured roll width.
3. Machine direction (MD) and cross machine direction (XMD) average values should be based on 5 test specimens each direction.
   a. Yield elongation is calculated using a gage length of 1.3 inches.
   b. Break elongation is calculated using a gage length of 2.0 inches.
4. Testing frequencies listed are the minimum.
5. Other methods such as D4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
6. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   a. 9 in Categories 1 or 2, and
   b. 1 in Category 3.

B. Rolls shall be sampled at 3 ft by the roll width. Samples shall be shipped to the Geosynthetic QA Laboratory for testing prior to roll shipment.

C. Rolls represented by quality assurance testing shall be rejected if test failure occurs. INSTALLER may at their expense request additional testing to validate individual rolls. Rolls bracketed by passing tests will be allowed to be deployed and seamed.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Labels on each roll shall identify the thickness, length, width, and manufacturer's mark number. The roll shall also indicate the date, lot and batch number of the roll, the square feet in the roll, and the total roll weight as measured after manufacture. Should the total weight not meet the minimum weight based upon the minimum


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material density, the material thickness, and square footage provided, the delivered material will be rejected for use.

2. Transportation, handling, and storage of the membrane shall be in accordance with written instructions from the manufacturer. These instructions shall be supplied prior to delivery of the material. In general, equipment used shall be adequate to handle the rolls of membrane without risk of damage to the material. Extreme care will be taken whenever handling the material. The rolls of membrane shall be stored on a surface free of sticks, rocks, roots, or other matter that may damage the material. Upon delivery, QC and QA personnel shall inspect each roll of material for damage. This inspection shall be recorded and included in the QA/QC reports
3. Protect geomembrane from excessive heat, cold, puncture, cutting, or other damaging or deleterious conditions during loading, transport, and unloading at site.
4. The CONTRACTOR or INSTALLER is responsible for the submittal of shipping manifests and all other relevant documents to the Owner's Representative.

B. Acceptance at Site:

1. Conduct surface observations of each roll for defects and damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected.
2. Defected or damaged rolls or portions of rolls will be rejected and shall be removed from site and replaced with new rolls at no cost to the OWNER.
3. Rolls or portions of rolls without proper identification or labeling will be rejected and shall be removed from site and replaced with new rolls and no cost to the OWNER.

C. Storage and Protection:

1. All on-site storage and handling is the responsibility of the CONTRACTOR or INSTALLER.
2. Equipment used to unload and handle geomembrane shall be sufficient to support the roll weight without damage to the geomembrane. Geomembrane shall be unloaded and handled using a stinger, spreader bar assembly, straps/slings provided by the geomembrane manufacturer or approved equal. Pushing, sliding, or dragging of geomembrane rolls is not permitted.
3. Upon arrival to the site the INSTALLER shall protect geomembrane from dirt, water, and other sources of damage.
4. Stacking of geomembrane rolls for storage should be done in a manner to prevent crushing of the cores or flattening of the rolls. Rolls should be secured to prevent shifting, abrasion, or other adverse movement of the geomembrane rolls. Geomembrane rolls with folds or creases will be rejected and shall be preplaced at no cost to the OWNER.
5. Preserve integrity and readability of geomembrane roll labels.

## 3.3 PREPARATION

A. Surface Preparation:

1. The CONTRACTOR is responsible for preparing supporting surface for geomembrane placement.
2. After prepared surface has been accepted in accordance with the CQA Plan, report to OWNER any change in supporting surface condition that may require repair work. Maintain prepared surface.
3. Do not place geomembrane onto an area that has become softened by precipitation or cracked due to desiccation. Observe and report surface condition daily to evaluate degree of softening and desiccation cracking.
4. Repair damage to prepared surface caused by installation activities at INSTALLER'S expense.


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## 3.4 INSTALLATION

A. Panel Nomenclature:

1. Field panel is defined as a roll or portion of roll cut and seamed in field, excluding patches and cap strips.
2. Identify each field panel with identification code (number or letter-number) consistent with INSTALLER'S layout plan. This identification code shall be agreed upon by the OWNER and INSTALLER, and Owner's Representative.
3. Writing on liner with colored markers shall be as agreed upon in the Pre-Construction Meeting. Only authorized personnel shall be permitted to write on liner.

B. Protection:

1. Do not use equipment that damages geomembrane.
2. Ensure prepared surface underlying geomembrane has not deteriorated since previous acceptance and remains acceptable immediately prior to geomembrane deployment.
3. Keep geosynthetic elements immediately underlying geomembrane clean and free of debris.
4. Do not permit personnel to smoke or wear shoes that can damage geomembrane while working on geomembrane. Personnel shall not bring glass bottles on geomembrane.
5. Unroll panels in manner that does not cause excessive scratches or crimps in geomembrane and does not damage supporting soil.
6. Place panels in manner that minimizes wrinkles (especially differential wrinkles between adjacent panels).
7. Prevent wind uplift by providing adequate temporary loading and/or anchoring (e.g., sandbags) that shall not damage geomembrane. In case of high winds, continuous loading is recommended along panel edges.
8. Protect geomembrane in areas where excessive traffic is expected with geotextiles, extra geomembrane, or other suitable materials.

C. Field Panel Deployment:

1. Install field panels at locations indicated on INSTALLER'S layout plan.
2. Replace seriously damaged (torn, twisted or crimped) field panels, or portions thereof, at no cost to the OWNER. Repair less serious damage as specified herein. The Owner's Representative shall determine if material shall be repaired or replaced.
3. Remove damaged panels or portions of damaged panels that have been rejected from work area.
4. Do not proceed with deployment at ambient temperature below 32°F or above 104°F unless otherwise authorized in writing by the OWNER.
5. Do not deploy during precipitation, in presence of excessive moisture, (fog, dew), in areas of ponded water or in presence of excessive winds.
6. Do not undertake deployment if weather conditions will preclude material seaming on same day as deployment.
7. Do not deploy more geomembrane field panels in one day than can be seamed during that day.

D. Seam Layout:

1. When possible, orient seams parallel to line of maximum slope, i.e., oriented along, not across, slope.


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2. When possible, no horizontal seam shall be closer than 5 feet from top or toe of slope. Horizontal seams on the slope shall be staggered a minimum of 10 feet on adjacent panels.
3. In general, maximize lengths of field panels and minimize number of field seams.
4. Align geomembrane panels to have nominal overlap of 3 inches for extrusion welding and 4 to 6 inches for fusion welding. Final overlap shall be sufficient to allow peel tests to be performed on seam.

E. Temporary Bonding:

1. Hot air device (liester) may be used to temporarily bond geomembrane panels to be extrusion welded.
2. Do not damage geomembrane when temporarily bonding adjacent panels. Apply minimal amount of heat to lightly tack geomembrane panels together. Control temperature of hot air at nozzle of any temporary welding apparatus to prevent damage to geomembrane.
3. Do not use solvent or adhesive.

F. Seaming Methods:

1. Approved processes for field seaming are extrusion fillet welding and fusion welding. Proposed alternate processes shall be documented and submitted to the OWNER for approval. Alternate procedures shall be used only after being approved in writing by the OWNER.
2. Seams shall meet following requirements (per GRI GM-19a):

| Property | Method | 40-mil HDPE | 60-mil HDPE |
|---|---|---|---|
| Hot Wedge (Fusion) Seams (1)(2)<br>• Shear strength (3)<br>• Shear elongation at break (4)<br>• Peel strength (3)<br>• Peel separation | ASTM D6392 | 80 lb/in<br>50%<br>60 lb/in<br>25% | 120 lb/in<br>50%<br>91 lb/in<br>25% |
| Extrusion Fillet Seams (2)<br>• Shear strength (3)<br>• Shear elongation at break (4)<br>• Peel strength (3)<br>• Peel separation | ASTM D6392 | 80 lb/in<br>50%<br>52 lb/in<br>25% | 120 lb/in<br>50%<br>78 lb/in<br>25% |

1. Maximum of one-non FTB (Film Tearing Bond) per five specimens tested is acceptable provided that strength requirements are met on that sample. Film Tearing Bond (FTB) definition: A failure in the ductile mode of one of the bonded sheets by tearing prior to complete separation to the bonded area. Examples of FTB and the associated locus of break codes are provided in ASTM D6392.
2. Destructive seams will be evaluated for strength parameters according to ASTM D6392 (excluding Section 6.3 “Conditioning”).
3. For double fusion welded seams, both tracks shall be tested for compliance with the minimum property values listed above.
4. Elongation measurements should be omitted for field testing.

3. Use fusion welding as primary method of seaming adjacent field panels.

a. Cross seam tees associated with fusion welding or extrusion welding shall be patched to a minimum distance of 6 inches on each side of tee.
b. Place welder on protective pad to prevent geomembrane damage between seaming.
c. When subgrade conditions dictate, use movable protective layer (e.g. extra piece of geomembrane) directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between sheets and prevent


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debris from collecting around pressure rollers. Protective layer is to be removed from under the geomembrane seams.

4. Use extrusion fillet welding as secondary method for seaming between adjacent panels and as primary method of welding for detail and repair work.

    a. Purge heat-degraded extrudate from barrel of extruder under following conditions:

        1) Prior to beginning seam.
        2) Whenever extruder has been inactive.

    b. Place smooth insulating plate or fabric beneath hot welding apparatus after usage.
    c. Use clean and dry welding rods or extrudate pellets.
    d. Complete grinding process without damaging geomembrane within 1 hour of seaming operation.
    e. Minimize exposed grinding marks adjacent to extrusion weld. Do not allow exposed grinding marks to extend more than ¼ inch outside finished seam area and grind perpendicular to seam.

G. Seaming Procedures:

1. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. The Installer shall demonstrate that acceptable seaming can be achieved by completing acceptable trial welds.
2. General Seaming Procedures: (Ambient temperature between 32°F and 104°F).

    a. Do not field seam without master seamer being present.
    b. Dry conditions, i.e., no precipitation nor other excessive moisture, such as fog or dew.
    c. No excessive winds.
    d. If required, provide firm substrate by using extra piece of geomembrane, or similar hard surface directly under seam overlap to achieve proper support for seaming apparatus.
    e. Align seams with fewest possible number of wrinkles and fish mouths.
    f. Extend seams to outside edge of panels placed in anchor trench.
    g. Prior to seaming, ensure that seam area is clean and free of moisture, dust, dirt, debris or foreign material.
    h. Fish mouths or wrinkles at seam overlaps shall be cut along ridge of wrinkle in order to achieve flat overlap. Cut fish mouths or wrinkles shall be seamed and any portion where overlap is inadequate shall be patched with an oval or round patch of same geomembrane extending minimum of 6 inches. beyond cut in each direction.

3. Cold Weather Seaming Procedures (ambient temperature is below 32°F).

    a. Owner’s Representative shall determine geomembrane surface temperatures at intervals of at least once per 100 ft of seam length to determine if preheating is required. For extrusion welding, preheating shall be required if surface temperature of geomembrane is below 32°F.
    b. Preheating may be waived by the OWNER based on recommendation from Owner’s Representative, if demonstrated to Owner’s Representative’s satisfaction that welds of equivalent quality may be obtained without preheating at expected temperature of installation.
    c. If preheating is required, Owner’s Representative shall observe areas of geomembrane that have been preheated by hot air device prior to seaming, to ensure they have not been subjected to excessive melting.


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d. Owner's Representative shall confirm that surface temperatures have not lowered below minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for seam area.
e. Preheating devices used shall be pre-approved by the OWNER prior to use.
f. Additional destructive seam tests shall be taken at interval between 250 ft and 500 ft of seam length, at Owner's Representative discretion.
g. Sheet grinding may be performed before preheating, if applicable.
h. Trial seaming shall be conducted under same ambient temperature and preheating conditions as actual seams. New trial seams shall be conducted if ambient temperature drops by more than 10°F from initial trial seam test conditions. New trial seams shall be conducted upon completion of seams in progress during temperature drop.

4. Warm Weather Procedures (ambient temperature is above 104°F).

a. No seaming of geomembrane is permitted unless demonstrated to the Owner's Representative that geomembrane seam quality will not be compromised.
b. Trial seaming shall be conducted under same ambient temperature conditions as actual seams. New trial seams shall be conducted if ambient temperature rises by more than 5° F from initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during temperature rise.
c. At option of the Owner's Representative, additional destructive seam tests may be required for any suspect areas.

H. Repair Procedures:

1. Repair portions of geomembrane exhibiting flaw or failing destructive or nondestructive test.
2. Final decision as to repair procedure shall be agreed upon between OWNER, INSTALLER, and ENGINEER.
3. Acceptable repair procedures include following:

a. Patching. Piece of same geomembrane material extrusion welded into place. Use to repair large holes, tears, non-dispersed raw materials, and contamination by foreign matter. All panel intersections shall be patched.
b. Spot welding or seaming: Bead of molten extrudate placed on flaw. Use to repair small tears, pinholes, or other minor, localized flaws.
c. Capping. Strip of same geomembrane material extrusion welded into place over inadequate seam. Use to repair large lengths of failed seams.
d. Removal and replacement. Remove bad seam and replace with strip of same geomembrane material welded into place. Use to repair large lengths of failed seams.
e. Extrusion welding flap. Repairs of this type shall not be used unless approved by Owner's Representative and shall not exceed 100 ft in length.

4. For each repair method:

a. Ensure surfaces are clean, dry, and prepared in accordance with specified seaming process.
b. Surfaces of the geomembrane that are to be repaired by extrusion welds shall be lightly abraded with a disc grinder or equivalent to ensure cleanliness.
c. Ensure seaming equipment used in repairing procedures meet requirements of this Specification.


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d. Extend patches or caps at least 6 inches beyond edge of defect. Round corners of patches with radius of approximately 6 inches.
e. INSTALLER shall nondestructively test each repair. Owner's Representative shall number, log, and record nondestructive testing results for each repair. Repair log shall include a description of the location of the repair.

5. Do not place overlying layers over locations which have been repaired until appropriate acceptable nondestructive and destructive (laboratory) test results are obtained.

I. Anchor Trench:

1. The CONTRACTOR shall excavate anchor trenches, unless otherwise specified, to lines and grades shown on the Contract Documents, prior to geomembrane placement. Anchor trench shall be drained to prevent ponding or softening of adjacent soils while trench is open.
2. Slightly rounded corners shall be provided in anchor trench to avoid sharp bends in geomembrane.
3. If anchor trench is excavated in clay material susceptible to desiccation, amount of trench open at any time should be minimized.
4. Remove construction-related debris from anchor trench.
5. The CONTRACTOR shall backfill and compact anchor trench as soon as practical after geomembrane installation is completed. Take care when backfilling trenches to prevent damage to geosynthetics

## 3.5 FIELD QUALITY CONTROL

A. Visual Inspection:

1. Owner's Representative will examine seam and non-seam areas of geomembrane for identification of defects, holes, blisters, non-dispersed raw materials, and any sign of contamination by foreign matter.
2. Clean and wash geomembrane surface if Owner's Representative determines that amount of dust or mud inhibits examination.
3. Do not seam any geomembrane panels that have not been examined for flaws by Owner's Representative.
4. Nondestructively test all seams and any non-seam areas identified by Owner's Representative.

B. Trial Seams:

1. Make trial seams on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming.
2. Make trial seams at beginning of each seaming period, following restart of welding equipment, upon change of seamers, and at least once every 4 to 6 hours, for each production seaming apparatus used that day. Each seamer shall make at least 1 trial seam each day.
3. Make trial seams under same conditions as actual seams.
4. Make trial seams only under observation of Owner's Representative.
5. Seam overlap shall be as indicated for finished seam.
6. Make trial seam sample shall be at least 5 feet long by 1 foot wide (after seaming) with seam centered lengthwise.
7. For fusion welds, cut 9 specimens from sample with 1-inch-wide die. These specimen locations shall be selected randomly along trial seam sample by Owner's Representative. Test 3 specimens in peel and 3 specimens in outside peel, and 3 specimens in shear using field tensiometer. Samples shall fail in sheet or exceed the specified peel and shear criteria stated in this Specification.


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8. For extrusion welds six one-inch wide by six-inch long test strips shall be cut from the trial seam. Quantitatively test three specimens for peel and three specimens for bonded seam strength (shear).
9. If specimen fails, entire trial seam operation shall be repeated. If additional specimen fails, do not use seaming apparatus and seamer until deficiencies are corrected and 2 consecutive successful trial welds are achieved.
10. The remainder of the successful trial seam is to be retained by Owner's Representative for possible laboratory destructive seam testing until project completion.

C. Nondestructive Seam Testing:

1. General:

   a. Purpose of nondestructive tests is to check continuity of seams. It will not provide quantitative information on seam strength.
   b. Nondestructively test field seams over their full length using vacuum test for extrusion seams, air pressure for double-fusion seams or other OWNER approved method. Document results.
   c. Perform nondestructive testing as seaming work progresses.
   d. Nondestructive seam testing shall be performed for all seams.

2. Vacuum Testing for extrusion seam:

   a. Energize vacuum pump and reduce tank pressure to approximately 4 psi gauge pressure.
   b. Wet strip of geomembrane approximately 12 inch by 48 inch with soapy solution.
   c. Place box over wetted area.
   d. Close bleed valve and open vacuum valve.
   e. Ensure that leak-tight seal is created.
   f. For minimum of 10 seconds, apply vacuum and examine geomembrane through viewing window for presence of soap bubbles.
   g. If no bubbles appear within 10 seconds, close vacuum valve and open bleed valve, move box over to next adjoining area with minimum 3 inch overlap and repeat process.
   h. Mark and repair areas where soap bubbles appear.

3. Air Pressure Testing for double-fusion seam:

   a. Seal both ends of seam to be tested.
   b. Insert needle or other approved pressure feed device into air channel created by fusion weld.
   c. Insert protective cushion between air pump and geomembrane.
   d. Pressurize air channel to 30 psi. Close valve and allow pressure to stabilize for approximately 2 minutes.
   e. Observe air pressure 5 minutes after initial 2-minute stabilization period ends. If pressure loss exceeds 4 psi or pressure does not stabilize, locate faulty area and repair.
   f. Cut opposite end of tested seam area once testing is completed to verify continuity of air channel. If air does not escape, locate blockage and retest unpressurized area. Repair cut end of air channel.
   g. Remove needle or other approved pressure feed device and repair hole in geomembrane.

4. Inaccessible Seams:

   a. Cap-strip seams that cannot be nondestructively tested.


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b. Cap-strip material shall be composed of same type and thickness geomembrane as geomembrane to be capped.
c. Examine cap-stripping operations with Owner's Representative for uniformity and completeness. Document observations.

D. Destructive Seam Testing:

1. General:

a. Perform destructive seam test as seaming progresses.
b. The destructive seam sample shall fail if the grips of testing machine cannot be closed on sample test flap (available flap is 1/2 inch long or less) due to excessive temporary welding.
c. Destructive seam tests shall satisfy the seam strength requirements in Paragraph 3.3.F.(2). Failing seams shall be tracked and repaired.

2. Location and frequency:

a. Test at minimum frequency of 1 test location per 500 ft of production seam welding length performed by each fusion welding machine, and 1 test per 150 ft of production seam extrusion welding.
b. Test locations shall be determined during seaming, at the discretion of the Owner's Representative.
c. INSTALLER will not be informed in advance of locations where seam samples will be taken.
d. OWNER reserves right to increase frequency of testing in accordance with performance results of samples previously tested.

3. Sampling Procedures:

a. Cut samples at locations chosen by Owner's Representative.
b. Owner's Representative shall number each sample and record sample number and location in panel layout drawing.
c. Repair holes in geomembrane resulting from destructive seam sampling immediately in accordance with repair procedures described in this Specification.
d. Continuity of repair and seams shall be tested in accordance with vacuum testing requirements.

4. Sample Dimensions: Take two, 1-inch-wide samples for field testing prior to cutting full laboratory sample.

a. Field Testing: Cut 1-inch-wide samples, 6 inches long with seam centered parallel to width. Distance between these 2 samples shall be 42 inches Test both samples on field tensiometer in peel. If both samples pass field test, take sample for laboratory testing.
b. Laboratory Testing: Take laboratory test sample from between samples taken for field testing. Cut sample for laboratory testing 12 inches wide by a minimum 42 inches long with seam centered lengthwise. Cut this sample into three parts. Owner's Representative shall distribute parts as follows:

1) One part to INSTALLER for optional laboratory testing, a minimum 12 inches by 12 inches.
2) One part to Geosynthetic Quality Assurance Laboratory (QAL) for testing, a minimum 12 inches by 18 inches.
3) One part to OWNER for archive storage, a minimum 12 inches by 12 inches.

5. Destructive Test Failure Procedures:


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When sample fails destructive testing, whether test is conducted by Geosynthetic QAL or by field tensiometer, INSTALLER has following options:

a. Repair seam between any 2 passing destructive test locations.
b. Trace welding path to intermediate point (10 ft minimum from point of failed test in each direction) and take small sample with 1-inch-wide die for an additional field test at each location. If these additional samples pass test, then take full laboratory samples. If these laboratory samples pass tests, repair seam between these locations. If either sample fails, repeat process to establish zone in which seam should be repaired.
c. Acceptable repaired seams shall be bound by 2 locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 ft of repaired seam, Owner's Representative may have INSTALLER destructive test repair seam.
d. When sample fails, OWNER may require additional testing of seams that were welded by same welder and/or welding apparatus during same time shift.

E. Repair Verification:

1. Owner's Representative shall observe number and log each repair.
2. Nondestructively test each repair.
3. Nondestructive test results that pass shall indicate adequate repair.
4. Repairs more than 150 ft long require destructive test sampling.
5. Failed destructive or nondestructive tests indicate that repair shall be redone and retested until passing test results.

F. Large Wrinkles: Wrinkle is considered to be large when geomembrane can be folded over onto itself.

1. When seaming of geomembrane is completed, and prior to placing overlying materials, Owner's Representative shall identify all excessive geomembrane wrinkles, which should be cut and re-seamed.
2. Cut and re-seam all wrinkles identified by Owner's Representative. Seams produced while repairing wrinkles shall be nondestructively tested.
3. Repair wrinkles identified by Owner's Representative. Repair during coldest part of installation period.

G. Final Inspection, Acceptance, and Covering

1. A final visual inspection of geomembrane components (panels, seams, repairs, etc.) and review of all installation paperwork provided by the INSTALLER shall be completed by the Owner's Representative prior to accepting the geomembrane. The INSTALLER's field superintendent or designated quality control technician shall approve the geomembrane prior to the final inspection by the Owner's Representative. CONTRACTOR or INSTALLER is responsible for cleaning, sweeping, or other measures necessary of the geomembrane surface to allow inspection by the Owner's Representative.
2. No geomembrane shall be covered until it has been accepted by the Owner's Representative. Once accepted, the geomembrane shall be covered as soon as possible in accordance with the Contract Documents and Specifications.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02597.b

# LLDPE GEOMEMBRANE

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, and equipment, and perform all work necessary for the delivery, storage, installation, and testing of Linear Low Density Polyethylene (LLDPE) geomembrane. For the location of geomembrane placements and types refer to the Contract Documents.

1.2 REFERENCES

A. American Society for Testing Materials (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 D3895 | Standard Test Method for Oxidative-Induction Time of Polyolefins by Differential Scanning Calorimetry |
| 5. | ASTM D4218 | Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique |
| 6. | ASTM D4833 | Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products |
| 7. | ASTM D5596 | Standard Test Method for Microscopic Evaluation of the Dispersion of Carbon Black in Polyolefin Geosynthetics |
| 8. | ASTM D 5617 | Test Method for Multi-Axial Tension Test for Geosynthetics |
| 9. | ASTM D5721 | Standard Practice for Air-Oven Aging of Polyolefin Geomembranes |
| 10. | ASTM D5885 | Standard Test Method for Oxidative Induction Time of Polyolefin Geosynthetics by High-Pressure Differential Scanning Calorimetry |
| 11. | ASTM D5994 | Standard Test Method for Measuring Core Thickness of Textured Geomembranes |
| 12. | ASTM D6392 | Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods |
| 13. | ASTM D6693 | Standard Test Method for Determining Tensile Properties of Nonreinforced Polyethylene and Nonreinforced Flexible Polypropylene Geomembranes, nonreinforced, percent break elongation, percent yield elongation, polyethylene, polypropylene, tensile break strength, tensile yield strength. |
| 14. | ASTM D 7238 | Standard Test Method for Effect of Exposure of Unreinforced Polyolefin Geomembrane Using Fluorescent UV Condensation Apparatus |
| 15. | ASTM D7466 | Standard Test Method for Measuring the Asperity Height of Textured Geomembrane |

B. Geosynthetics Institute (GSI)

| | | |
|---|---|---|
| 1. | GRI GM-9 | Cold Weather Seaming of Geomembranes |
| 2. | GRI GM-11 | Accelerated Weathering of Geomembranes Using a Fluorescent UVA-Condensation Exposure Device |


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3. GM-17 Test Methods, Test Properties, and Testing Frequency for Linear Low-Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
4. GRI-GM19 Seam Strength and Related Properties of Thermally Bonded Polyolefin Geomembranes

1.3 SUBMITTALS

A. The following submittals shall be submitted to the OWNER or OWNER's Representative for review prior to delivery of geomembrane to the site:

1. Manufacturing Quality Control (MQC) data (Material Certifications) for the geomembrane to be delivered to the site. Documentation shall include the quality control (QC) test results on the manufactured geomembrane sheet and certification stating the geomembrane roll numbers, base resin type, and lot from which it was produced.

a. Manufacturer shall supply the Owner or Owner's representative with the following resin data:

1) Certification stating that the resin meets the requirements of this Technical Specification
2) Certification stating all resin is from the same Manufacturer
3) A copy of the QC certificates issued by the geomembrane Manufacturer and resin supplier
4) Certification that extrudate resins and/or rod are from one manufacturer, is the same resin type, and was obtained from the same resin supplier as the resin used to manufacture the geomembrane material

b. Manufacturer shall supply the Owner or Owner's representative with the following geomembrane sheet data:

1) Minimum physical properties and test methods used
2) Certification that material reworked from manufacturing process will not exceed 10 percent by weight of material in accordance with GRI GM-17.
3) A copy of the QC certificates issued by the geomembrane Manufacturer.

2. In the event material is delivered to the site prior to the receipt of the MQC certificates, the material without certificates will be stored separately from the material with certificates.

B. The following submittals shall be submitted to the OWNER or Owner's Representative for review prior to installation:

1. Shop drawings, including proposed panel diagram and details of proposed work, pipe boots, and details of sealing around all necessary geomembrane penetrations. The panel diagram must depict and/or note the planned number and orientation of panels, the panel sizes, seam orientation, placement of seams in corners, treatment of tee seams and the Installer's preferred sequence of panel placement. The panels shall be orientated in a manner that minimizes seams. Any revisions to the reviewed panel diagram must be approved by the OWNER or Owner's Representative, in writing, prior to installation.

C. Within 5 days upon completion of installation:


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1. All testing data including reports/logs for field quality control work completed by the INSTALLER.
2. Subgrade surface acceptance certificates signed by INSTALLER for each area that will be covered directly by geomembrane. Deployment of geomembrane will be considered acceptance of subgrade is certificate is not submitted.
3. Certification statement signed by the Installation Supervisor that geomembrane installation is complete and in accordance with these Specifications, with details of any changes or exceptions noted.
4. As-built drawings showing actual geomembrane placement, seams and repairs including typical anchor trench detail.
5. Copies of the material and installation warranties to be provided to the OWNER at the completion of installation.

1.4 PREQUALIFICATIONS

A. Manufacturer:

1. Manufacturer shall have minimum five 5 years continuous experience in manufacture of LLDPE geomembrane or experience totaling 10,000,000 $ft^2$ of manufactured LLDPE geomembrane for minimum of 10 completed facilities.

B. INSTALLER:

1. INSTALLER shall have minimum five 5 years continuous experience in installation of HDPE or LLDPE geomembrane or experience totaling 2,000,000 $ft^2$ of installed HDPE or LLDPE geomembrane for minimum of 10 completed facilities.
2. Personnel performing seaming operations shall be qualified by experience or successfully passing seaming tests. Minimum of one seamer shall have experience seaming minimum 2,000,000 ft2 of HDPE or LLDPE geomembrane using the same type of seaming apparatus in use at site. Most experienced seamer, "master seamer," shall provide direct supervision, as required, over less experienced seamers.

1.5 QUALITY ASSURANCE PROGRAM

A. Manufacturer, fabricator, and INSTALLER shall participate in and conform to items and requirements of a quality assurance program as outlined in this Specification and the Construction Quality Assurance (CQA) Plan.

B. The OWNER will engage and pay for the services of an Owner's Representative and testing laboratory to monitor the geomembrane installation and complete conformance testing.

1.6 WARRANTY

A. The material shall be warranted on a pro-rata basis against Manufacturer's defects for a period of five years from the date of geomembrane completion.

B. The installation shall be warranted against defects in workmanship for a period of one year from the date of geomembrane completion.

## PART 2 – PRODUCTS

2.1 GEOMEMBRANE

A. Polyethylene Resin

1. The resin shall be virgin material with no more than 10% rework. If rework is used, it must be the same formulation of the parent material.


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2. No post-consumer resin of any type shall be added to the formulation.
3. Use of geomembrane recycled during manufacturing process shall be permitted with written approval from OWNER and if recycled geomembrane does not exceed 2% by weight.
4. Geomembrane manufactured from non-complying resin shall be rejected.
5. The extrudate rod and/or bead shall be made from same type of resin as the geomembrane. Additives shall be thoroughly dispersed, and the material shall be free of contamination by moisture or foreign matter.

B. Geomembrane Characteristics

1. Contain maximum of 1% by weight of additives, fillers, or extenders (not including carbon black).
2. Contain between 2% and 3% by weight of carbon black for ultraviolet light resistance
3. No pinholes, bubbles or other surface features that compromise geomembrane integrity are allowed. Geomembrane shall be free of blisters, non-dispersed raw materials, or other signs of contamination resulting from the manufacturing process. Geomembrane rolls or portions of rolls with these defects shall be rejected.
4. Textured Linear Low Density Polyethylene (LLDPE) shall meet the material properties below.


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| Testing Properties | Test Method | 40-mil LLDPE | 50-mil LLDPE Super Gripnet® | 50-mil LLDPE MicroDrain® | Manufacturer QC Testing Frequency (12) |
|---|---|---|---|---|---|
| Thickness (min avg)<br>• Lowest individual (8 out of 10 values)<br>• Lowest individual (any) | ASTM D5994 | 38 mil<br>36 mil<br>34 mil | Nom. (-5%)<br>-10%<br>-15% | Nom. (-5%)<br>-10%<br>-15% | 1 per roll |
| Asperity Height (min. avg) (1) (2)<br>• Asperity Height<br>• Drainage Stud Height<br>• Friction Stud Height | ASTM D7466 | 16 mil<br>N/A<br>N/A | N/A<br>130 mil<br>175 mil | 20 mil<br>130 mil<br>N/A | 1 per 50,000 ft$^2$ |
| Density (max) | ASTM D1505/ D792 | 0.939 g/mL | 0.939 g/mL | 0.939 g/mL | 1 per 50,000 ft$^2$ |
| Tensile Properties (min avg) (3)<br>• Break strength<br>• Break elongation | ASTM D 6693 Type IV | 60 lb/in<br>250% | 75 lb/in<br>250% | 75 lb/in<br>250% | 1 per 50,000 ft$^2$ |
| 2% Modulus (max) | ASTM D5323 | 2400 lb/in | 3000 lb/in | 3000 lb/in | (11) |
| Tear Resistance (min avg) | ASTM D 1004 | 22 lb | 27 lb | 27 lb | 1 per 50,000 ft$^2$ |
| Puncture Resistance (min. avg) | ASTM D 4833 | 44 lb | 55 lb | 55 lb | 1 per 50,000 ft$^2$ |
| Axi-Symmetric Break Resistance Strain (min) | ASTM D5617 | 30% | 30% | 30% | (11) |
| Carbon Black Content | ASTM D 1603 (4) | 2%– 3% | 2%– 3% | 2%– 3% | 1 per 50,000 ft$^2$ |
| Carbon Black Dispersion (5) | ASTM D 5596 | (5) | (5) | (5) | 1 per 50,000 ft$^2$ |
| Oxidative Induction Time (OIT) (min avg) (6)<br>• Standard OIT<br>• High Pressure OIT | ASTM D3895<br>ASTM D5885 | 100<br>400 | 100<br>400 | 100<br>400 | (11) |
| Oven Aging at 85°C (6)(7)<br>• Standard OIT, % retained after 90 days<br>• High Pressure OIT, % retained after 90 days | ASTM D5721<br>ASTM D3895<br>ASTM D5885 | 35%<br>60% | 35%<br>60% | 35%<br>60% | (11) |
| UV Resistance (8)<br>• Standard OIT (min avg)<br>• High Pressure OIT - % retained after 1600 hours (10) | ASTM D7238<br>ASTM D3895<br>ASTM D5885 | N. R. (9)<br>35% | N. R. (9)<br>35% | N. R. (9)<br>35% | (11) |

1. The lowest individual reading must be ≥ 12 mils for 40-mil LLDPE and 16 mils for 50-mil LLDPE.
2. Test each side of the 40-mil textured geomembrane recording a measurement every lineal foot of textured roll width. Test the underside of the 50-mil Super Gripnet® and MicroDrain® Liner recording a measurement every lineal foot of textured roll width.
3. Machine direction (MD) and cross machine direction (XMD) average values should be based on 5 test specimens each direction. Break elongation is calculated using a gage length of 2.0 inches at 2.0 in/min.
4. Other methods such as D4218 (muffle furnace) or microwave method are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   a. 9 in Categories 1 or 2
   b. 1 in Category 3
6. The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.
7. It is also recommended to evaluate samples at 30 and 60 days to compare with the 90-day response.
8. The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
9. 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.
10. UV resistance is based on percent retained value regardless of the original HP-OIT value.
11. Manufacturer may provide certification letter.
12. Testing frequencies listed are the minimum.


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## 2.2 SEAMING AND TESTING EQUIPMENT

A. Welding:

1. Maintain on-site minimum of 2 spare operable seaming apparatus, unless otherwise agreed upon at the pre-construction meeting.
2. Seaming equipment shall not damage geomembrane.
3. Use extrusion welding apparatus equipped with gauges giving temperature of extrudate at nozzle of apparatus or utilize hand-held gauges to measure extrudate temperatures.
4. Use fusion-welding apparatus that are self-propelled devices equipped with gauges indicating temperature of the heating element and speed of travel.
5. Place electric generator on smooth base with rub sheet such that no damage occurs to geomembrane.

B. Vacuum Testing Equipment:

1. Vacuum box assembly consisting of: rigid housing, transparent viewing window, soft neoprene gasket attached to bottom of housing, porthole or valve assembly, and vacuum gauge all in good working condition. The assembly shall be capable of maintaining a minimum 4 psi vacuum.
2. Pump assembly equipped with pressure controller and pipe connections.
3. Pressure/vacuum rubber hose with fittings and connections.
4. Soapy solution to wet test area.
5. Means of applying soapy solution.

C. Air Pressure Testing Equipment:

1. Air pump (manual or motor driven), equipped with pressure gauge, capable of generating, sustaining, and measuring pressure between 20 and 35 psi, and mounted on rub sheet to protect geomembrane.
2. Rubber hose with fittings and connections.
3. Sharp hollow needle, or other approved pressure feed device.
4. Air pressure monitoring device.

D. Tensiometer Testing Equipment:

1. Tensiometer shall be capable of maintaining constant jaw separation rate of 2 inches per minute, and shall be calibrated, with certificate of calibration less than one 1 year old kept with tensiometer.

## 2.3 MANUFACTURER QUALITY CONTROL

A. Tests, Inspections shall be performed by geomembrane manufacturer in accordance with the frequencies outlined in section 2.1 of this Specification and as follows:

1. Test geomembranes to demonstrate that resin meets this Specification.
2. Continuously monitor geomembrane during manufacturing process for inclusions, bubbles, or other defects. Geomembranes which exhibit defects shall not be acceptable for installation.
3. Monitor thickness continuously during manufacturing process.
4. Tests shall be conducted for following properties in accordance with test methods specified in the following table. Samples not complying with Specifications shall result in rejection of rolls. At geomembrane manufacturer's discretion and expense, additional testing of individual rolls may be performed to identify and reject non-complying rolls and to approve individual rolls.


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## PART 3 – EXECUTION

3.1 QUALITY ASSURANCE SAMPLING

A. CONTRACTOR or INSTALLER shall make rolls available and assist the Owner's Representative in obtaining material inventory and material samples. Samples shall be tested in accordance with the test methods specified in the following table:

| **Testing Properties** | **Test Method** | **Conformance QA Testing Frequency** |
|---|---|---|
| Thickness (min avg)<br>• Lowest individual (8 out of 10 values)<br>• Lowest individual (any) | ASTM D5994 | 1 per 250,000 $ft^2$ |
| Asperity Height (min. avg) (1) (2) | ASTM D7466 | 1 per 250,000 $ft^2$ |
| Density (max) | ASTM D1505/ D792 | 1 per 250,000 $ft^2$ |
| Tensile Properties (min avg) (3)<br>• Break strength<br>• Break elongation | ASTM D 6693, Type IV | 1 per 250,000 $ft^2$ |
| Tear Resistance (min avg) | ASTM D 1004 | 1 per 250,000 ft2 |
| Puncture Resistance (min. avg) | ASTM D 4833 | 1 per 250,000 ft2 |
| Carbon Black Content | ASTM D 1603 (4) | 1 per 250,000 ft2 |
| Carbon Black Dispersion (5) | ASTM D 5596 | 1 per 250,000 ft2 |

1. The lowest individual reading must be ≥ 12 mils for 40-mil LLDPE and 16 mils for 50-mil LLDPE..
2. Test each side of the textured geomembrane recording a measurement every lineal foot of textured roll width.
3. Machine direction (MD) and cross machine direction (XMD) average values should be based on 5 test specimens each direction. Break elongation is calculated using a gage length of 2.0 inches at 2.0 in/min.
4. Other methods such as D4218 (muffle furnace) or microwave method are acceptable if an appropriate correlation to D1603 (tube furnace) can be established.
5. Carbon black dispersion (only near spherical agglomerates) for 10 different views:
   a. 9 in Categories 1 or 2, and
   b. 1 in Category 3.

B. Rolls shall be sampled at 3 ft by the roll width. Samples shall be shipped to the Geosynthetic QA Laboratory for testing prior to roll shipment.

C. Rolls represented by quality assurance testing shall be rejected if test failure occurs. INSTALLER may at their expense request additional testing to validate individual rolls. Rolls bracketed by passing tests will be allowed to be deployed and seamed.

3.2 DELIVERY, STORAGE, AND HANDLING

A. Packing and Shipping:

1. Labels on each roll shall identify the thickness, length, width, and manufacturer's mark number. The roll shall also indicate the date, lot and batch number of the roll, the square feet in the roll, and the total roll weight as measured after manufacture. Should the total weight not meet the minimum weight based upon the minimum material density, the material thickness, and square footage provided, the delivered material will be rejected for use.
2. Transportation, handling, and storage of the membrane shall be in accordance with written instructions from the manufacturer. These instructions shall be supplied prior to delivery of the material. In general, equipment used shall be adequate to handle the rolls of membrane without risk of damage to the material.


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Extreme care will be taken whenever handling the material. The rolls of membrane shall be stored on a surface free of sticks, rocks, roots, or other matter that may damage the material. Upon delivery, QC and QA personnel shall inspect each roll of material for damage. This inspection shall be recorded and included in the QA/QC reports

3. Protect geomembrane from excessive heat, cold, puncture, cutting, or other damaging or deleterious conditions during loading, transport, and unloading at site.
4. The CONTRACTOR or INSTALLER is responsible for the submittal of shipping manifests and all other relevant documents to the Owner's Representative.

B. Acceptance at Site:

1. Conduct surface observations of each roll for defects and damage. This examination shall be conducted without unrolling rolls unless defects or damages are found or suspected.
2. Defected or damaged rolls or portions of rolls will be rejected and shall be removed from site and replaced with new rolls at no cost to the OWNER.
3. Rolls or portions of rolls without proper identification or labeling will be rejected and shall be removed from site and replaced with new rolls and no cost to the OWNER.

C. Storage and Protection:

1. All on-site storage and handling is the responsibility of the CONTRACTOR or INSTALLER.
2. Equipment used to unload and handle geomembrane shall be sufficient to support the roll weight without damage to the geomembrane. Geomembrane shall be unloaded and handled using a stinger, spreader bar assembly, straps/slings provided by the geomembrane manufacturer or approved equal. Pushing, sliding, or dragging of geomembrane rolls is not permitted.
3. Upon arrival to the site the INSTALLER shall protect geomembrane from dirt, water, and other sources of damage.
4. Stacking of geomembrane rolls for storage should be done in a manner to prevent crushing of the cores or flattening of the rolls. Rolls should be secured to prevent shifting, abrasion, or other adverse movement of the geomembrane rolls. Geomembrane rolls with folds or creases will be rejected and shall be preplaced at no cost to the OWNER.
5. Preserve integrity and readability of geomembrane roll labels.

## 3.3 PREPARATION

A. Surface Preparation:

1. The CONTRACTOR is responsible for preparing supporting surface for geomembrane placement. The subgrade shall be free of particles greater than 1/2 inch in diameter, sticks, roots, sharp objects, or other material which may damage the geomembrane. The subgrade shall also be free of excessive moisture or standing water.
2. After prepared surface has been accepted in accordance with the CQA Plan, report to OWNER any change in supporting surface condition that may require repair work. Maintain prepared surface.
3. Do not place geomembrane onto an area that has become softened by precipitation or cracked due to desiccation. Observe and report surface condition daily to evaluate degree of softening and desiccation cracking.
4. Repair damage to prepared surface caused by installation activities at INSTALLER'S expense.

## 3.4 INSTALLATION

A. Panel Nomenclature:


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1. Field panel is defined as a roll or portion of roll cut and seamed in field, excluding patches and cap strips.
2. Identify each field panel with identification code (number or letter-number) consistent with INSTALLER'S layout plan. This identification code shall be agreed upon by the OWNER and INSTALLER, and Owner's Representative.
3. Writing on liner with colored markers shall be as agreed upon in the Pre-Construction Meeting. Only authorized personnel shall be permitted to write on liner.

B. Protection:

1. Do not use equipment that damages geomembrane.
2. Ensure prepared surface underlying geomembrane has not deteriorated since previous acceptance and remains acceptable immediately prior to geomembrane deployment.
3. Do not permit personnel to smoke or wear shoes that can damage geomembrane while working on geomembrane. Personnel shall not bring glass bottles on geomembrane.
4. Unroll panels in manner that does not cause excessive scratches or crimps in geomembrane and does not damage supporting soil.
5. Place panels in manner that minimizes wrinkles (especially differential wrinkles between adjacent panels).
6. Prevent wind uplift by providing adequate temporary loading and/or anchoring (e.g., sandbags) that shall not damage geomembrane. In case of high winds, continuous loading is recommended along panel edges.
7. Protect geomembrane in areas where excessive traffic is expected with geotextiles, extra geomembrane, or other suitable materials.

C. Field Panel Deployment:

1. Install field panels at locations indicated on INSTALLER'S layout plan.
2. Replace seriously damaged (torn, twisted, or crimped) field panels, or portions thereof, at no cost to the OWNER. Repair less serious damage as specified herein. The Owner's Representative shall determine if material shall be repaired or replaced.
3. Remove damaged panels or portions of damaged panels that have been rejected from work area.
4. Do not proceed with deployment at ambient temperature below 32°F or above 104°F unless otherwise authorized in writing by the OWNER.
5. Do not deploy during precipitation, in presence of excessive moisture, (fog, dew), in areas of ponded water or in presence of excessive winds.
6. Do not undertake deployment if weather conditions will preclude material seaming on same day as deployment.
7. Do not deploy more geomembrane field panels in one day than can be seamed during that day.

D. Seam Layout:

1. When possible, orient seams parallel to line of maximum slope, i.e., oriented along, not across, slope.
2. When possible, no horizontal seam shall be closer than 5 feet from top or toe of slope. Horizontal seams on the slope shall be staggered a minimum of 10 feet on adjacent panels.
3. In general, maximize lengths of field panels and minimize number of field seams.
4. Align geomembrane panels to have nominal overlap of 4 inches for extrusion welding and 4 to 6 inches for fusion welding. Final overlap shall be sufficient to allow peel tests to be performed on seam.


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E. Temporary Bonding:

1. Hot air device (liester) may be used to temporarily bond geomembrane panels to be extrusion welded.
2. Do not damage geomembrane when temporarily bonding adjacent panels. Apply minimal amount of heat to lightly tack geomembrane panels together. Control temperature of hot air at nozzle of any temporary welding apparatus to prevent damage to geomembrane.
3. Do not use solvent or adhesive.

F. Seaming Methods:

1. Approved processes for field seaming are extrusion fillet welding and fusion welding. Proposed alternate processes shall be documented and submitted to the OWNER for approval. Alternate procedures shall be used only after being approved in writing by the OWNER.
2. Seams shall meet following requirements (per GRI GM-19a):

| Property | Method | 40-mil LLDPE | 50-mil LLDPE |
|---|---|---|---|
| Hot Wedge (Fusion) Seams (1)(2)<br>• Shear strength (3)<br>• Shear elongation at break (4)<br>• Peel strength (3)<br>• Peel separation | ASTM D6392 | 60 lb/in<br>50%<br>50 lb/in<br>25% | 75 lb/in<br>50%<br>63 lb/in<br>25% |
| Extrusion Fillet Seams (2)<br>• Shear strength (3)<br>• Shear elongation at break (4)<br>• Peel strength (3)<br>• Peel separation | ASTM D6392 | 60 lb/in<br>50%<br>44 lb/in<br>25% | 75 lb/in<br>50%<br>57 lb/in<br>25% |

1. Maximum of one-non FTB (Film Tearing Bond) per five specimens tested is acceptable provided that strength requirements are met on that sample. Film Tearing Bond (FTB) definition: A failure in the ductile mode of one of the bonded sheets by tearing prior to complete separation to the bonded area. Examples of FTB and the associated locus of break codes are provided in ASTM D6392.
2. Destructive seams will be evaluated for strength parameters according to ASTM D6392 (excluding Section 6.3 “Conditioning”).
3. For double fusion welded seams, both tracks shall be tested for compliance with the minimum property values listed above.
4. Elongation measurements should be omitted for field testing.

3. Use fusion welding as primary method of seaming adjacent field panels.

   a. Cross seam tees associated with fusion welding or extrusion welding shall be patched to a minimum distance of 6 inches on each side of tee.
   b. Place welder on protective pad to prevent geomembrane damage between seaming.
   c. When subgrade conditions dictate, use movable protective layer (e.g. extra piece of geomembrane) directly below each overlap of geomembrane that is to be seamed to prevent buildup of moisture between sheets and prevent debris from collecting around pressure rollers. Protective layer is to be removed from under the geomembrane seams.

4. Use extrusion fillet welding as secondary method for seaming between adjacent panels and as primary method of welding for detail and repair work.

   a. Purge heat-degraded extrudate from barrel of extruder under following conditions:


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1) Prior to beginning seam.
2) Whenever extruder has been inactive.

b. Place smooth insulating plate or fabric beneath hot welding apparatus after usage.
c. Use clean and dry welding rods or extrudate pellets.
d. Complete grinding process without damaging geomembrane within 1 hour of seaming operation.
e. Minimize exposed grinding marks adjacent to extrusion weld. Do not allow exposed grinding marks to extend more than ¼ inch outside finished seam area and grind perpendicular to seam.

G. Seaming Procedures:

1. Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. The Installer shall demonstrate that acceptable seaming can be achieved by completing acceptable trial welds.
2. General Seaming Procedures: (Ambient temperature between 32°F and 104°F).

a. Do not field seam without master seamer being present.
b. Dry conditions, i.e., no precipitation nor other excessive moisture, such as fog or dew.
c. No excessive winds.
d. If required, provide firm substrate by using extra piece of geomembrane, or similar hard surface directly under seam overlap to achieve proper support for seaming apparatus.
e. Align seams with fewest possible number of wrinkles and fish mouths.
f. Extend seams to outside edge of panels placed in anchor trench.
g. Prior to seaming, ensure that seam area is clean and free of moisture, dust, dirt, debris or foreign material.
h. Fish mouths or wrinkles at seam overlaps shall be cut along ridge of wrinkle in order to achieve flat overlap. Cut fish mouths or wrinkles shall be seamed and any portion where overlap is inadequate shall be patched with an oval or round patch of same geomembrane extending minimum of 6 inches. beyond cut in each direction.

3. Cold Weather Seaming Procedures (ambient temperature is below 32°F).

a. Owner's Representative shall determine geomembrane surface temperatures at intervals of at least once per 100 ft of seam length to determine if preheating is required. For extrusion welding, preheating shall be required if surface temperature of geomembrane is below 32°F.
b. Preheating may be waived by the OWNER based on recommendation from Owner's Representative, if demonstrated to Owner's Representative's satisfaction that welds of equivalent quality may be obtained without preheating at expected temperature of installation.
c. If preheating is required, Owner's Representative shall observe areas of geomembrane that have been preheated by hot air device prior to seaming, to ensure they have not been subjected to excessive melting.
d. Owner's Representative shall confirm that surface temperatures have not lowered below minimum surface temperatures specified for welding due to winds or other adverse conditions. It may be necessary to provide wind protection for seam area.
e. Preheating devices used shall be pre-approved by the OWNER prior to use.
f. Additional destructive seam tests shall be taken at interval between 250 ft and 500 ft of seam length, at Owner's Representative discretion.
g. Sheet grinding may be performed before preheating, if applicable.


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h. Trial seaming shall be conducted under same ambient temperature and preheating conditions as actual seams. New trial seams shall be conducted if ambient temperature drops by more than 10°F from initial trial seam test conditions. New trial seams shall be conducted upon completion of seams in progress during temperature drop.

4. Warm Weather Procedures (ambient temperature is above 104°F).

a. No seaming of geomembrane is permitted unless demonstrated to the Owner's Representative that geomembrane seam quality will not be compromised.
b. Trial seaming shall be conducted under same ambient temperature conditions as actual seams. New trial seams shall be conducted if ambient temperature rises by more than 5° F from initial trial seam test conditions. Such new trial seams shall be conducted upon completion of seams in progress during temperature rise.
c. At option of the Owner's Representative, additional destructive seam tests may be required for any suspect areas.

H. Repair Procedures:

1. Repair portions of geomembrane exhibiting flaw or failing destructive or nondestructive test.
2. Final decision as to repair procedure shall be agreed upon between OWNER, INSTALLER, and ENGINEER.
3. Acceptable repair procedures include following:

a. Patching. Piece of same geomembrane material extrusion welded into place. Use to repair large holes, tears, non-dispersed raw materials, and contamination by foreign matter. All panel intersections shall be patched.
b. Spot welding or seaming: Bead of molten extrudate placed on flaw. Use to repair small tears, pinholes, or other minor, localized flaws.
c. Capping. Strip of same geomembrane material extrusion welded into place over inadequate seam. Use to repair large lengths of failed seams.
d. Removal and replacement. Remove bad seam and replace with strip of same geomembrane material welded into place. Use to repair large lengths of failed seams.
e. Extrusion welding flap. Repairs of this type shall not be used unless approved by Owner's Representative and shall not exceed 100 ft in length.

4. For each repair method:

a. Ensure surfaces are clean, dry, and prepared in accordance with specified seaming process.
b. Surfaces of the geomembrane that are to be repaired by extrusion welds shall be lightly abraded with a disc grinder or equivalent to ensure cleanliness.
c. Ensure seaming equipment used in repairing procedures meet requirements of this Specification.
d. Extend patches or caps at least 6 inches beyond edge of defect. Round corners of patches with radius of approximately 6 inches.
e. INSTALLER shall nondestructively test each repair. Owner's Representative shall number, log, and record nondestructive testing results for each repair. Repair log shall include a description of the location of the repair.


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5. Do not place overlying layers over locations which have been repaired until appropriate acceptable nondestructive and destructive (laboratory) test results are obtained.

I. Anchor Trench:

1. The CONTRACTOR shall excavate anchor trenches, unless otherwise specified, to lines and grades shown on the Contract Documents, prior to geomembrane placement. Anchor trench shall be drained to prevent ponding or softening of adjacent soils while trench is open.
2. Slightly rounded corners shall be provided in anchor trench to avoid sharp bends in geomembrane.
3. If anchor trench is excavated in clay material susceptible to desiccation, amount of trench open at any time should be minimized.
4. Remove construction-related debris from anchor trench.
5. The CONTRACTOR shall backfill and compact anchor trench as soon as practical after geomembrane installation is completed. Take care when backfilling trenches to prevent damage to geosynthetics

## 3.5 FIELD QUALITY CONTROL

A. Visual Inspection:

1. Owner's Representative will examine seam and non-seam areas of geomembrane for identification of defects, holes, blisters, non-dispersed raw materials, and any sign of contamination by foreign matter.
2. Clean and wash geomembrane surface if Owner's Representative determines that amount of dust or mud inhibits examination.
3. Do not seam any geomembrane panels that have not been examined for flaws by Owner's Representative.
4. Nondestructively test all seams and any non-seam areas identified by Owner's Representative.

B. Trial Seams:

1. Make trial seams on fragment pieces of geomembrane liner to verify that conditions are adequate for production seaming.
2. Make trial seams at beginning of each seaming period, following restart of welding equipment, upon change of seamers, and at least once every 4 to 6 hours, for each production seaming apparatus used that day. Each seamer shall make at least 1 trial seam each day.
3. Make trial seams under same conditions as actual seams.
4. Make trial seams only under observation of Owner's Representative.
5. Seam overlap shall be as indicated for finished seam.
6. Make trial seam sample shall be at least 5 feet long by 1 foot wide (after seaming) with seam centered lengthwise.
7. For fusion welds, cut 9 specimens from sample with 1-inch-wide die. These specimen locations shall be selected randomly along trial seam sample by Owner's Representative. Test 3 specimens in peel and 3 specimens in outside peel, and 3 specimens in shear using field tensiometer. Samples shall fail in sheet or exceed the specified peel and shear criteria stated in this Specification.
8. For extrusion welds six one-inch wide by six-inch long test strips shall be cut from the trial seam. Quantitatively test three specimens for peel and three specimens for bonded seam strength (shear).
9. If specimen fails, entire trial seam operation shall be repeated. If additional specimen fails, do not use seaming apparatus and seamer until deficiencies are corrected and 2 consecutive successful trial welds are achieved.


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10. The remainder of the successful trial seam is to be retained by Owner's Representative for possible laboratory destructive seam testing until project completion.

C. Nondestructive Seam Testing:

1. General:

a. Purpose of nondestructive tests is to check continuity of seams. It will not provide quantitative information on seam strength.
b. Nondestructively test field seams over their full length using vacuum test for extrusion seams, air pressure for double-fusion seams or other OWNER approved method. Document results.
c. Perform nondestructive testing as seaming work progresses.
d. Nondestructive seam testing shall be performed for all seams.

2. Vacuum Testing for extrusion seam:

a. Energize vacuum pump and reduce tank pressure to approximately 4 psi gauge pressure.
b. Wet strip of geomembrane approximately 12 inch by 48 inch with soapy solution.
c. Place box over wetted area.
d. Close bleed valve and open vacuum valve.
e. Ensure that leak-tight seal is created.
f. For minimum of 10 seconds, apply vacuum and examine geomembrane through viewing window for presence of soap bubbles.
g. If no bubbles appear within 10 seconds, close vacuum valve and open bleed valve, move box over to next adjoining area with minimum 3 inch overlap and repeat process.
h. Mark and repair areas where soap bubbles appear.

3. Air Pressure Testing for double-fusion seam:

a. Seal both ends of seam to be tested.
b. Insert needle or other approved pressure feed device into air channel created by fusion weld.
c. Insert protective cushion between air pump and geomembrane.
d. Pressurize air channel to 30 psi. Close valve and allow pressure to stabilize for approximately 2 minutes.
e. Observe air pressure 5 minutes after initial 2-minute stabilization period ends. If pressure loss exceeds 4 psi or pressure does not stabilize, locate faulty area and repair.
f. Cut opposite end of tested seam area once testing is completed to verify continuity of air channel. If air does not escape, locate blockage and retest unpressurized area. Repair cut end of air channel.
g. Remove needle or other approved pressure feed device and repair hole in geomembrane.

4. Inaccessible Seams:

a. Cap-strip seams that cannot be nondestructively tested.
b. Cap-strip material shall be composed of same type and thickness geomembrane as geomembrane to be capped.
c. Examine cap-stripping operations with Owner's Representative for uniformity and completeness. Document observations.

D. Destructive Seam Testing:


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1. General:

    a. Perform destructive seam test as seaming progresses.
    b. The destructive seam sample shall fail if the grips of testing machine cannot be closed on sample test flap (available flap is 1/2 inch long or less) due to excessive temporary welding.
    c. Destructive seam tests shall satisfy the seam strength requirements in Paragraph 3.3.F.(2). Failing seams shall be tracked and repaired.

2. Location and frequency:

    a. Test at minimum frequency of 1 test location per 500 ft of production seam welding length performed by each fusion welding machine, and 1 test per 150 ft of production seam extrusion welding.
    b. Test locations shall be determined during seaming, at the discretion of the Owner's Representative.
    c. INSTALLER will not be informed in advance of locations where seam samples will be taken.
    d. OWNER reserves right to increase frequency of testing in accordance with performance results of samples previously tested.

3. Sampling Procedures:

    a. Cut samples at locations chosen by Owner's Representative.
    b. Owner's Representative shall number each sample and record sample number and location in panel layout drawing.
    c. Repair holes in geomembrane resulting from destructive seam sampling immediately in accordance with repair procedures described in this Specification.
    d. Continuity of repair and seams shall be tested in accordance with vacuum testing requirements.

4. Sample Dimensions: Take two, 1-inch-wide samples for field testing prior to cutting full laboratory sample.

    a. Field Testing: Cut 1-inch-wide samples, 6 inches long with seam centered parallel to width. Distance between these 2 samples shall be 42 inches Test both samples on field tensiometer in peel. If both samples pass field test, take sample for laboratory testing.
    b. Laboratory Testing: Take laboratory test sample from between samples taken for field testing. Cut sample for laboratory testing 12 inches wide by a minimum 42 inches long with seam centered lengthwise. Cut this sample into three parts. Owner's Representative shall distribute parts as follows:

        1) One part to INSTALLER for optional laboratory testing, a minimum 12 inches by 12 inches.
        2) One part to Geosynthetic Quality Assurance Laboratory (QAL) for testing, a minimum 12 inches by 18 inches.
        3) One part to OWNER for archive storage, a minimum 12 inches by 12 inches.

5. Destructive Test Failure Procedures:

    When sample fails destructive testing, whether test is conducted by Geosynthetic QAL or by field tensiometer, INSTALLER has following options:

    a. Repair seam between any 2 passing destructive test locations.
    b. Trace welding path to intermediate point (10 ft minimum from point of failed test in each direction) and take small sample with 1-inch-wide die for an


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additional field test at each location. If these additional samples pass test, then take full laboratory samples. If these laboratory samples pass tests, repair seam between these locations. If either sample fails, repeat process to establish zone in which seam should be repaired.

c. Acceptable repaired seams shall be bound by 2 locations from which samples passing laboratory destructive tests have been taken. In cases exceeding 150 ft of repaired seam, Owner's Representative may have INSTALLER destructive test repair seam.

d. When sample fails, OWNER may require additional testing of seams that were welded by same welder and/or welding apparatus during same time shift.

E. Repair Verification:

1. Owner's Representative shall observe number and log each repair.
2. Nondestructively test each repair.
3. Nondestructive test results that pass shall indicate adequate repair.
4. Repairs more than 150 ft long require destructive test sampling.
5. Failed destructive or nondestructive tests indicate that repair shall be redone and retested until passing test results.

F. Large Wrinkles: Wrinkle is considered to be large when geomembrane can be folded over onto itself.

1. When seaming of geomembrane is completed, and prior to placing overlying materials, Owner's Representative shall identify all excessive geomembrane wrinkles, which should be cut and re-seamed.
2. Cut and re-seam all wrinkles identified by Owner's Representative. Seams produced while repairing wrinkles shall be nondestructively tested.
3. Repair wrinkles identified by Owner's Representative. Repair during coldest part of installation period.

G. Final Inspection, Acceptance, and Covering

1. A final visual inspection of geomembrane components (panels, seams, repairs, etc.) and review of all installation paperwork provided by the INSTALLER shall be completed by the Owner's Representative prior to accepting the geomembrane. The INSTALLER's field superintendent or designated quality control technician shall approve the geomembrane prior to the final inspection by the Owner's Representative. CONTRACTOR or INSTALLER is responsible for cleaning, sweeping, or other measures necessary of the geomembrane surface to allow inspection by the Owner's Representative.
2. No geomembrane shall be covered until it has been accepted by the Owner's Representative. Once accepted, the geomembrane shall be covered as soon as possible in accordance with the Contract Documents and Specifications.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02599

# PROTECTION OF GEOSYNTHETICS

## PART 1 – GENERAL

NOT USED

## PART 2 – PRODUCTS

NOT USED

## PART 3 – EXECUTION

3.1 PLACEMENT

A. A protective layer of soils or CCR shall be placed to the lines and grades and nominal thickness shown on the Contract Documents.

B. In areas where a Geotextile is already shown on the Contract Documents, an additional Cushion Geotextile may be required by the Engineer. Prior to placement of protective soils, the Contractor shall provide a detailed plan of operation to the Engineer. The plan shall include the locations of main haul roads, means of material hauling, placement, and grading.

C. Where protective soils are placed over the Leachate Collection Layer, hauling, placement and spreading of soils shall be conducted to prevent rutting, displacement, or erosion of Leachate Collection Layer materials.

D. Hauling vehicles shall not damage the subgrade surface. Areas where rutting, pumping or other subgrade damage is observed shall be repaired by the Contractor. Construction of temporary haul roads required shall be the responsibility of the Contractor.

E. When protective soils are placed directly over geosynthetic layers, extreme caution shall be exercised by the CONTRACTOR to prevent damage to these geosynthetic materials. The CONTRACTOR shall be responsible for repair of all damage resulting from placement of protective soils

F. Protective soils, drainage layer material, or CCR placed on disposal unit base or sideslopes shall be as specified below:

1. The initial 1-ft lift of protective soils or drainage layer material shall be placed and spread with low ground pressure equipment (8 psi ground pressure or less) as approved by the Engineer to reduce potential geosynthetics damage. The exposed geomembrane, placed drainage media, or other geosynthetic material surface shall be off-limits to construction traffic.
2. Equipment used to spread protective soils or drainage layer material, regardless of the nature of the material, shall operate on at least 1-ft. of cover material overlying the geomembrane, drainage media, or other geosynthetics.
3. Once a minimum of 1-ft of protective soils or drainage layer material are in-place, tracked vehicles may be used to place additional protective soils and grade the surface of the protective soils. The equipment shall be included in the Contractor's deployment plan and shall be approved in advance by the Engineer.
4. Any hauling equipment (dump trucks, etc.) operating within the disposal unit limits where geomembrane has been installed shall have a minimum of 3-ft. of protective soils and leachate collection system aggregate between the vehicle’s wheels and the geomembrane. All access ramps leading into the disposal unit limits shall be constructed with concrete, as shown on the Drawings, until a minimum of 3-ft. of


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protective soils and leachate collection system aggregate between the vehicle's wheels and the geomembrane is present.

G. Protective soils or CCR shall be placed on side slopes from the base of the slope upward. The Contractor shall place and compact soil for toe buttress, where indicated on the Contract Documents, prior to placement of protective soils on slopes. No protective soils shall be placed or spread from the crest of the slope in a direction downward toward the toe of slope.

H. Low ground pressure equipment (8 psi ground pressure or less) shall be used to place protective soils on side slopes. The equipment shall be operated in a direction straight up and down the slope (i.e., normal to the slope axis). Equipment shall not be turned on slopes. If excess tension in geosynthetic layers above the equipment is observed, the Contractor shall reduce the quantity of soil pushed up the slope by the equipment or use lighter weight equipment.

I. The leading edge of protective soils placed up the side slopes shall be sloped or graded in such a way that surface water runoff is not trapped or impounded.

J. Engineer shall approve equipment and methods of placement, spreading, grading, and sealing of the protective soils.

K. Protective soils shall be placed on geosynthetics in a manner that minimizes development of folds in the geomembrane or other geosynthetics. Any portions of the geomembrane or other geosynthetics that develop crimps shall be repaired by the Geomembrane Installer at Contractor's expense. If during spreading, excessive wrinkles develop, the Contractor shall adjust placement and spreading methods, or cease spreading until the geomembrane cools and wrinkles decrease in size. Excessive wrinkles that cannot be eliminated by amended placement and spreading methods shall be cut and repaired by the Geomembrane Installer in a method approved by the Engineer.

L. Protective soils shall not be placed over standing water. Protective soils shall not be deeply compacted within the disposal unit limits, except where specified on the Contract Documents.

M. The Contractor shall manage all surface water during placement of protective soils. Sediment from the protective soils shall be managed to prevent washing and fouling of exposed geosynthetic or drainage materials.

N. Protective soils shall be placed to the lines and grades as shown on the Contract Documents. Material placed beyond these limits shall be removed at Contractor's expense.

O. Any damage to the underlying Leachate Collection Layer, geomembrane, geotextiles or drainage media shall be repaired in accordance with the applicable section of these Specifications at Contractor's expense.

P. The Engineer may require test areas to be established and evaluated to assess potential damage to underlying materials due to equipment operations by the Contractor. The Contractor shall construct the test areas to full depth using the actual equipment proposed for Cover placement. The test areas shall be outside the Work limits, use scrap materials not to be re-used in construction, and model construction conditions as closely as is practical. Test area parameters shall be determined by the Engineer and Contractor in advance of construction of the protective soils.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02650

# LEACHATE COLLECTION AND CONVEYANCE PIPE

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing, placing and compacting the drainage conveyance pipe as shown, specified or required.

B. Comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction.

1.2 RELATED SECTIONS

A. Section 02200 - Earthwork

B. Section 02232 - Leachate Collection Layer

C. Section 02651 - HDPE Pipe and Appurtenances

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM) International:

| | | |
|---|---|---|
| 1. | ASTM D1248 | Standard Specification for Polyethylene Plastics Molding and Extrusion Materials |
| 2. | ASTM D2837 | Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials |
| 3. | ASTM D3350 | Standard Specification for Polyethylene Plastics Pipe and Fittings Materials |
| 4. | ASTM F714 | Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter |

B. Construction Quality Assurance (CQA) Plan Dominion – Bremo Power Station

1.4 SUBMITTALS

The CONTRACTOR shall submit manufacturer’s data sheets, certification of compliance with specifications for all pipes, fittings and appurtenances and leak testing requirements.

1.5 QUALITY ASSURANCE

A. Pipe installation shall be performed by skilled workers. Each pipe laying crew shall have a pipe laying foreman.

B. Pipe fusion shall be performed by qualified technicians using equipment and procedures approved or provided by the pipe manufacturer.

C. Pipe shall be accurately installed to the lines and grades shown on the Contract Documents, or as approved by the OWNER, so that inverts are smooth.

D. Deflections in horizontal alignment at joints are not permitted without the written consent of the OWNER. If so approved, the deflections shall not exceed one-half the manufacturer's recommendation.

E. The OWNER shall be notified in advance whenever an existing pipeline location conflicts with the proposed locations of the Work.


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F. Pipe and fittings of the same type shall be the products of a single manufacturer.

G. All piping shall be of the type and size as shown on the Contract Documents and described in this Section of the Specifications.

## PART 2 – MATERIALS

2.1 PIPE AND FITTINGS

A. Piping resins shall be high performance, high molecular weight, high density polyethylene conforming to ASTM D1248 (Type III, Class C, Category 5, Grade P34), and ASTM D3350 (Cell Classification PE345434C). The pipe and fittings shall be manufactured from pre-compounded resin manufactured by the pipe manufacturer, with a minimum of two (2) percent carbon black to withstand outdoor exposure without loss of properties. In-plant blending of non-compounded resins is not acceptable. All polyethylene pipe shall meet the requirements of ASTM F714 for SDR-11 pipe. Each pipe length shall be marked with the manufacturer's name or trademark, size, material code, and standard dimension ratio.

B. The pipe shall contain no recycled compound except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. The pipe shall be homogeneous throughout and free of visible cracks, holes (other than those manufactured), foreign inclusions, or other deleterious defects, and shall be identifiable in color, density, melt index, and other physical properties.

C. The polyethylene pipe manufacturer shall provide certification that stress regression testing has been performed on the specific product. This stress regression testing shall have been done in accordance with ASTM D2837, Class PE3408, and the manufacturer shall provide a product supplying a minimum hydrostatic design basis (HDB) of 1,600 psi at 63.4 degrees F, as determined in accordance with ASTM D2837.

2.2 TRACER WIRE

A. For open cut pipe installations, tracer wire shall be #12 AWG solid copper with 30 mil HMWPE or 60 mil PVC insulation, green in color.

B. For trenchless pipe installations, tracer wire shall be #12 AWG solid copper clad steel core with 45 mil HMWPE insulation, green in color. Wire shall be expressly specified for use in trenchless tracer wire applications.

## PART 3 – EXECUTION

3.1 DELIVERY, STORAGE, AND HANDLING

A. All pipes and fittings shall be carefully handled when loading and unloading. Lift by hoists or lower on skidways in a manner to avoid shock.

B. Where required, due to weight of material and for the safety and protection of workmen, materials, equipment, property, and the work, use derricks, ropes, or other suitable equipment for lowering pipe into trenches. Take particular care to avoid damaging the pipe.

C. Pipe and fittings shall be protected against the damaging ultraviolet rays of the sun when stored for any period. Such protection shall consist of canvas covering, or other material as recommended by the manufacturer. Plastic sheets shall not be used which may allow excessive temperatures to develop where pipe is stored. All pipe which has been distorted or otherwise negatively affected by high temperatures shall be rejected, regardless of the pipe's appearance after return to ambient temperatures. Rejected pipe shall be marked by the Owner's Representative and removed from the site of the work at the sole expense the CONTRACTOR.


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D. The manufacturer's recommended procedures for pipe stacking shall be followed. When pipe is stacked for storage, the heaviest series of pipe shall be placed at the bottom.

E. Pipe and fittings shall be protected from damage by sharp objects through all phases of work.

F. If any defective pipe is discovered after being laid or placed, removal and replacement with a sound pipe will be required without cost to the OWNER.

3.2 INSPECTION - GENERAL

A. Each length of pipe and each fitting shall be carefully inspected prior to placement. All materials not meeting the requirements of these Specifications, or otherwise found defective or unsatisfactory by the Owner's Representative, shall be rejected and immediately marked and removed from the job site by the CONTRACTOR and replaced at no cost to the OWNER.

B. Bedding, sub-bedding, and other trench conditions shall be carefully inspected prior to laying pipe in each stretch of open trench. All conditions shall be made available to the Owner's Representative for inspection purposes, and the Owner's Representative shall be further advised where, in the CONTRACTOR's opinion, unstable or otherwise deleterious conditions exist.

C. Each section of completed pipeline shall be inspected prior to backfilling. Backfilling operations shall not be initiated prior to inspection by the Owner's Representative.

D. All non-perforated sections of pipe shall be pressure tested prior to acceptance.

3.3 PREPARATION

A. Pipe and fitting interiors and joint surfaces shall be thoroughly cleaned prior to installation. Pipe and fittings shall be maintained clean.

3.4 PIPE INSTALLATION

A. Pipes and fittings shall be carefully lowered into place.

B. Pipe and fittings shall be installed so that there will be no deviation at the joints and so that inverts present a smooth surface. Pipe and fittings which do not fit together to form a tight-fitting joint are not permitted.

C. All HDPE joints shall be welded unless otherwise specified on the Contract Documents.

D. Pipes shall be installed in the locations and to the required lines and grades as shown on the Contract Documents and provided in these Specifications, using an approved method of control. The OWNER has the authority to order the removal or relaying of all pipe laid contrary to the specifications, his instructions, or during his absence.

E. Excavations shall be maintained free of water during the progress of the Work. No pipes shall be laid in water nor shall there be any joints made up in water. All slides or cave-ins of the trenches or cuts shall be remedied to the satisfaction of the OWNER.

F. Cleanliness of installed pipe and fitting interiors shall be maintained throughout the Work.

G. All adjustments to the line and grade of pipe shall be done by scraping away or compacted filling of the bedding stone under the barrel of the pipe, and not by blocking or wedging.

H. Fittings shall be installed as required and in accordance with the Contract Documents and Specifications. The installation of fittings after the pipeline has been laid will not be permitted without the written approval of the OWNER. In such cases, complete details


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pertaining to the proposed type of fittings and the installation procedure shall be submitted by the CONTRACTOR to the OWNER for review and approval before such work can be performed.

I. Approval by the OWNER is required prior to changing the location of any of the Work due to field conditions. Changes in pipe sizes are prohibited without prior written consent from the OWNER.

J. All installed piping shall form completely connected systems including connections to and appurtenances specified in other sections to result in a satisfactorily operating installation.

K. All pipe shall be so laid that after the line is completed, the interior surface thereof shall conform accurately to the established grade and alignment. No deflections shall be allowed at joints.

L. Pipe lengths of at least 20 feet shall be utilized, except that shorter random lengths may be utilized where wyes and tees, and similar circumstances are present, only inasmuch as is necessary to properly effect the joint(s) in the desired location. In all cases, the number of pipe joints shall be minimized. In the case of random lengths of pipe, the CONTRACTOR shall provide proper smooth and square ends prior to assembling.

M. All pipe ends not terminated by another specific fitting shall be capped with a slip cap. Caps shall not be bonded to the pipe unless otherwise specifically noted on the Contract Documents.

N. The Contractor shall perform hydrostatic testing under the observation of the Owner's Representative according to Section 02651 – HDPE Pipe and Appurtenances, of the Technical Specifications. Any portion of piping failing the pressure test shall be repaired. Damaged pipe shall be removed and replaced when pipe damage cannot be satisfactorily repaired. If the test fails, the failing section shall be located, removed, and rejoined.

3.5 TRACER WIRE

A. Install tracer wire for all non-perforated, non-metallic underground piping installations where indicated on the Contract Documents and where allowed by code. Use on other perforated pipes (e.g. toe drain) where shown on the Contract Documents.

B. Do not install tracer wire on the perforated leachate collection pipes or sideslope risers within the lined landfill area.

C. Secure wire to top of pipe at maximum eight (8) foot intervals using plastic tape or cable ties. Run wire to the side of fittings and valves where required.

D. Provide terminal access to each end of tracer wire at convenient locations (e.g. cleanouts, pump vaults, etc.).

E. After installation of pipe with tracer wire, verify the electrical continuity of the installed wire run.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02651

# HDPE PIPE & APPURTENANCES

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish all labor, materials, equipment, tools and appurtenances required to complete the work of furnishing and placing High Density Polyethylene (HDPE) and manholes, complete with appurtenances, as shown, specified or required.

1.2 RELATED SECTIONS

A. Section 02650 – Leachate Collection and Conveyance Pipe

1.3 REFERENCES

A. Work shall comply with codes and standards of the Plastic Pipe Institute (PPI)

B. American Society for Testing and Materials (ASTM) International:

| | | |
|---|---|---|
| 1. | ASTM D638 | Tensile Properties of Plastics |
| 2. | ASTM D790 | Flexural Properties of Unreinforced and Reinforced Plastics and Electrical Insulating Materials |
| 3. | ASTM D1238 | Flow Rates of Thermoplastics by Extrusion Plastometer |
| 4. | ASTM D1248 | Polyethylene (PE) Plastics Molding and Extrusion Materials |
| 5. | ASTM D1505 | Density of Plastics by the Density-Gradient Technique |
| 6. | ASTM D2837 | Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials |
| 7. | ASTM D3035 | Polyethylene (PE) Plastic Pipe Based on Controlled Outside Diameter |
| 8. | ASTM D3261 | Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing |
| 9. | ASTM D3350 | Specification for Polyethylene (PE) Plastics Pipe and Fittings Materials |
| 10. | ASTM F477 | Standard Specifications for Elastomeric Seals (Gaskets) for Joining Plastic Pipe |
| 11. | ASTM F714 | Standard Specifications for 3" 63" Polyethylene (PE) Pipe |
| 12. | ASTM F2164-02 | Standard Practice for Field Leak Testing of Polyethylene (PE) Pressure Piping Systems Using Hydrostatic Pressure |

1.4 SUBMITTALS

A. The CONTRACTOR shall submit evidence of the qualifications required by the CQA Plan and any other such pre-qualification data, references and project experience information as requested for the Project.

B. CONTRACTOR shall provide Manufacturer's technical data sheets for HDPE pipe, manholes, and appurtenances.

C. Provide all test results of the HDPE piping system and manhole prior to substantial completion of the Project. Testing report shall include, at a minimum, the following information:

1. The length and diameter of the section of line tested
2. A complete description of test procedures and methos, including:

    a. Trench backfilling and pipe cleaning status
    b. Types of location of plugs used.


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c. Stabilization time period and water pressure.
d. The allowed time by specifications.
e. The actual test time.
f. The water pressure at the beginning and end of the test.

3. The name of the inspector/testor and the date and time of all testing, including retesting.
4. A description of any repairs made.

1.5 QUALIFICATIONS

A. The CONTRACTOR shall have at least five years experience with installation of the HDPE and Appurtenances. In addition, the CONTRACTOR shall have completed a minimum of five projects with the same material and of similar scope to that indicated for this project. The CONTRACTOR shall have a successful installation and maintenance record of in-service performance.

## PART 2 – PRODUCTS

2.1 SOLID WALL PIPE

A. Acceptable Manufacturers

1. Plexco EHMW PE 4710
2. Phillips Driscoplex 8700 PE 4710
3. Poly Pipe 4710
4. Approved Equal

B. Materials

1. Material shall be extra high molecular weight HDPE pipe (Type 3408 resin).
2. Pipe shall be PE4710 of the SDR indicated on the Construction Drawings or in the Technical Specifications. Pipe shall conform to all applicable referenced standards.
3. ASTM D3350 minimum cell classification value 345434C.
4. All pipe and fittings shall be provided by a single manufacturer and be manufactured according to ASTM D3035 and ASTM F714.
5. The HDPE pipe shall have the following typical physical properties listed in Table 1, as determined by the appropriate test method.

**Table 1: Typical Physical Properties for HDPE Pipe**

| Property | Test Method | Typical Value |
|---|---|---|
| Density | ASTM D1505 | 0.955 g/cm$^3$ |
| Melt Flow Index | ASTM D1238 (190°C, 2.16 kg) | ≤ 0.15 g/10 min, Condition E |
| Tensile Yield Strength | ASTM D638 | 3,000 psi |
| Flexural Modulus | ASTM D790 | 110,000 psi |
| Hydrostatic Design Stress | ASTM D2837 (@73°F) | 1,600 psi |

C. Fittings

1. Fittings shall be ASTM D3350 butt heat fusion molded or factory fabricated.
2. Fittings shall be pressure rated to match the system piping to which they are fused. All backing flanges are to be stainless steel or epoxy coated.
3. Dimensions of fittings shall conform to standard dimensions and tolerances in accordance with ASTM D3261. Fittings shall conform to all applicable reference standards.


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D. Flexible mechanical couplings for buried and exposed service pipe connections shall be stainless steel suitable for use with HDPE pipe.

E. Perforated HDPE pipe shall have shop-fabricated holes of the size, spacing, and location indicated on the Construction Drawings.

F. Gaskets shall be polyisoprene or approved equal satisfying the requirements of ASTM F477.

## PART 3 – EXECUTION

3.1 LABELING, DELIVERY, STORAGE, AND HANDLING

A. Labeling – Pipe (including manhole) delivered to the site shall be new, clean and labeled by the Manufacturer with the following:

1. Manufacturer's name
2. Nominal pipe size
3. Plastic type
4. Standard Dimension Ration (SDR)
5. Extrusion date, period of manufacture or lot and/or batch number

B. Delivery – The pipe shall be packaged and shipped by appropriate means to prevent damage to the material and to facilitate off-loading. Transportation of the pipe to the site shall be the responsibility of the Manufacturer or Distributor.

C. Upon delivery to the site, the CONTRACTOR and the OWNER or ENGINEER shall have the right to complete an inspection of all pipe for apparent defects and damage. The OWNER or ENGINEER shall indicate to the CONTRACTOR the following:

1. Pipe that should be rejected due to unrepairable damage.
2. Pipe that should be re-inspected upon placement due to a suspected repairable damage.

D. Piping damaged en route to the site or during the unloading will be rejected and shall be removed from the site and replaced with new pipe that meets these Technical Specifications.

E. Storage – The CONTRACTOR shall be responsible for all on-site storage of the pipe and appurtenances. The CONTRACTOR shall provide a suitable storage site that will protect the pipe and appurtenances from marring, crushing or puncture damage. Pipe and appurtenances shall be unloaded and stored on-site on pallets in accordance with the Manufacturer's recommendations. Limit maximum stacking height to six feet. The storage place should be protected from theft and vandalism, and if possible, should be adjacent to the work area to facilitate installation and minimize handling.

F. A Manufacturer's representative shall have the right to verify that the pipe and appurtenances are stored in accordance with the Manufacturer's recommendations.

G. Handling – The CONTRACTOR shall be responsible for all on-site handling of the pipe and appurtenances. The pipe and appurtenances are to be handled so as to prevent damage.

H. Pipe and appurtenances damaged or otherwise determined to be unsuitable by the OWNER or ENGINEER following initial storage and acceptance by the Manufacturer's representative and/or CONTRACTOR shall be replaced by the CONTRACTOR at no additional cost to the OWNER.


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3.2 GENERAL

A. The CONTRACTOR shall have an individual experienced in the installation of the HDPE Pipe and Appurtenances on-site at all times during the installation. The designated individual shall be responsible for ensuring that the HDPE Pipe and Appurtenances are installed according to this specification and the Construction Documents. The appointment shall be subject to approval by the OWNER or ENGINEER.

B. The CONTRACTOR shall provide all required Manufacturer's certifications and technical data sheets for all HDPE Pipe and Appurtenances.

C. The CONTRACTOR shall visually inspect in-place all pipes (i.e., pipe lengths and associated welds) and appurtenances for holes, blemishes, penetrations or other detrimental defects.

3.3 QUALITY CONTROL

A. Pipe may be rejected for failure to conform to the Technical Specifications, or any of the following:

1. Fractures or cracks passing through pipe wall, except for a single crack not exceeding two inches in length at either end of pipe that can be cut off and discarded. Pipes within one shipment shall be rejected if defects exist in more than five percent of the shipment or delivery.
2. Cracks sufficient to impair strength, durability or serviceability of pipe, defects indicating improper proportioning, mixing and molding, or damaged ends, where such damage prevents making a satisfactory joint.
3. Damage due to handling or installation. Scratches and gouges exceeding 10 percent of the wall thickness shall be considered excessive and may be rejected by the OWNER or ENGINEER.

B. Acceptance of fittings, stubs or other specially fabricated pipe sections shall be based on visual inspection at the job site and documentation of conformance to these Technical Specifications.

C. A professional land surveyor licensed in the Commonwealth of Virginia and approved by the OWNER or ENGINEER shall as-built survey all pipes and fittings placed. Top of pipes shall be surveyed every 100 feet on center. The as-built survey shall be submitted to the OWNER or ENGINEER within five days of installation.

3.4 INSTALLATION

A. General

1. Layout piping as shown on the plans. Any deviation from the layout shown must be approved by the ENGINEER.
2. Piping shall be cut from measurements taken at the site and not from the plans. All necessary provisions shall be taken in laying out piping to provide for expansion and contraction caused by temperature fluctuations.
3. Pipe shall be carried manually or by mechanical equipment with flat forks or fabric slings. Cables and chains shall not be used. Pipe shall be assembled and welded immediately adjacent to its final location and set or carefully rolled into position. Pipe shall not be dragged on the ground.

B. Inspection of Piping

1. Carefully inspect all pipe and fittings before installation, removing all dirt. The pipe shall be installed with markings up for visual inspection and verification.


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2. Solid wall pipes shall have smooth exterior and interior surfaces, be first quality, free from cracks, blisters and other imperfections, and true to shape or form throughout each length. Piping judged by the OWNER or ENGINEER to be unacceptable shall be removed from the site, and new undamaged pipe shall be provided at no extra cost to the OWNER.
3. The interior of the pipeline shall be kept free from all dirt, joint material and other foreign materials as the work progresses. Tight-fitting stoppers or bulkheads shall be securely placed at the ends and any other openings of the pipe when work is stopped temporarily or at the end of the day's work. This is to prevent dirt, trash or animals from entering the pipe.

C. Solid Wall Pipe Jointing

1. The CONTRACTOR shall provide qualified fusion operators and weld in accordance with the Manufacturer's recommendation for butt fusion methods.
2. Butt fusion equipment for joining procedures shall be capable of meeting conditions recommended by the Pipe Manufacturer (i.e., temperature requirements, alignment, and fusion pressures).
3. For cleaning pipe ends, solutions such as detergents and solvents, when required, shall be used in accordance with the Manufacturer's recommendations. Solvents shall not be used unless approved by the OWNER or ENGINEER.
4. Do not bend pipe to greater degree than minimum radius recommended by the Manufacturer for type and grade.
5. Do not subject pipe to strains that will overstress or buckle piping or impose excessive stress on joints.
6. Before butt fusing pipe, inspect each length for presence of dirt, sand, mud, shavings and other debris or animals. Remove debris from pipe.
7. Cover open ends of fused pipe at the end of each working day. Cap ends to prevent entry by animals or debris.
8. Use compatible fusion techniques when polyethylene pipes of different melt indexes are fused together. Refer to Manufacturer's specifications for compatible fusion.
9. During fusion procedures, check the heater plate temperature routinely to ensure the proper temperature is maintained. Flexible mechanical couplings shall only be used at the specific locations indicated on the Construction Documents or as approved by the OWNER or ENGINEER.

D. Pipe Placement

1. Grade control equipment shall be of a type to accurately maintain design grades and slopes during installation of pipe.
2. Unless otherwise specifically stated, install pipe in accordance with Manufacturer's recommendations.
3. Maximum lengths of joined pipe to be handled as one section shall be placed according to Manufacturer's recommendations as to pipe size, pipe SDR and topography so as not to cause excessive gouging or surface abrasion. Maximum length of fused pipe to be handled as one section shall not to exceed 400 feet.
4. Cap pipe sections longer than single joint (typically 40 feet) on both ends during placement except during fusing operations.
5. Remove dirt or debris from inside of pipe before backfilling.
6. Notify the OWNER or ENGINEER prior to installing pipe into trench, and allow time for inspection. Correct irregularities found during inspection.
7. Complete tie-ins within trench whenever possible to prevent overstressed connections.
8. Allow pipe sufficient time to adjust to trench temperature prior to testing, fusion welding, segment tie-ins or backfilling activity.
9. When placing pipe in trench allow for thermal contraction and expansion (minimum 12 inches per 100 feet).


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## 3.5 EMBEDMENT AND BACKFILL

A. HDPE pipe and fittings shall be installed in full compliance with the Manufacturer's recommendations.

B. The pipe shall be completely surrounded with bedding, haunching and initial backfill materials that provide stable and permanent support to the pipe.

C. Care should be taken to ensure that the haunching of the pipe is completed without disturbing the pipe. Initial backfill shall be placed in four-inch lifts and hand tamped to assure compaction.

## 3.6 DUAL CONTAINMENT FORCEMAIN TESTING

### A. General

1. The total test time, including initial pressurization, initial expansion and time at test pressure shall not exceed eight hours. If the test is not completed in eight hours, the pressure in the test section shall be released and the section allowed to “relax” for at least eight hours before initiating another test.
2. Pipelines shall be pressure tested in the presence of the OWNER or ENGINEER prior to backfilling. Provide a minimum of seven days’ notice to the OWNER or ENGINEER before completing test.
3. Provide necessary piping connections between the section of line being tested and nearest available source of water or air supply, together with test pressure equipment, meters, pressure gauge and other equipment, materials, and facilities necessary to make specified tests.
4. Provide bulkheads, flanges, valves, bracing, blocking or other temporary sectionalizing devices required.

### B. Preparation

1. Remove or isolate valves, flowmeters, and instruments that may not withstand the required test pressure from within the test sections. Reconnect pipes with temporary fittings. Vent isolated equipment.
2. Flush the pipe with clean water until the pipe section to be tested is clean and free of dirt, sand, pipe shavings or other foreign material.
3. Plug pipe outlets with test plugs, blind flanges or other devices suitable for the test pressure. Brace securely to prevent blowouts. Verify that the test pressure does not exceed any component of the pipe system.
4. Restrain or remove expansion joints.
5. Pressurizing equipment shall include a regulator set to avoid over-pressurizing and damaging an otherwise acceptable line.

### C. Test Procedure

1. Complete test in accordance with OSHA requirements. Provide adequate safety equipment, and implement appropriate procedures to avoid injury or damage.
2. Verify that the specified test pressure did not exceed the allowable pressures recommended by the Manufacturers of the test section components.
3. Allow sufficient time for pipe and test media temperatures to equilibrate with ambient temperature.
4. Add water or air slowly to test section. Purge all trapped air. Vent high spots as needed. Inspect connections and retighten or otherwise correct any visible leaks.
5. The test consists of an initial expansion and test periods.

### D. Acceptance


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1. Test shall be accepted if the pressure drop over the 20-minute test period is less than five percent of the pressure at the beginning of the test period, or below the amount recommended by the Manufacturer, whichever is less.
2. All visible leaks shall be repaired regardless of test results. Section shall be retested if correcting leaks requires disassembly.

E. Test Pressures

1. Dual containment HDPE leachate forcemain.

   a. Containment piping: 7 psi air for a period of 30 minutes.
   b. Carrier piping: 60 psi water for one hour.

2. In no case shall test pressure exceed maximum allowable pressure for any pipeline component, including valves, fittings, and instruments.
3. If pressure test is not accepted, correct leaks or defects in the pipe and retest. All visible leaks shall be repaired regardless of test results. Section shall be retested if correcting leaks requires disassembly.
4. Remove temporary sectionalizing devices after tests are complete.

3.7 LEAKAGE TESTING FOR HDPE STRUCTURES

A. Perform leakage testing for vaults, wet wells and manholes prior to backfilling by filling the structure with water to the overflow level and observing the water level for the following 24 hours.

B. Make an inspection for leakage of the exterior surface of the structure, especially in areas around construction joints.

C. Leakage will be accepted as within allowable limits for structures from which there are no visible leaks and the leakage rate does not exceed 0.1 gallon per foot of diameter per foot of depth per hour. Method for testing leakage shall be submitted to the ENGINEER prior to testing.

D. If visible leaks appear, repair the structure by removing and replacing the leaking portions of the structure, waterproofing the inside, or by other methods approved.

E. Water for testing will be provided by the CONTRACTOR.

F. ENGINEER must be given 48-hour notice prior to test and must witness all tests.

G. If any deficiencies are revealed during any test, such deficiencies shall be corrected and the tests shall be re-conducted until the results of the tests are within specified allowances, without additional cost to the OWNER.

H. Submit a report describing the manhole description, duration of test, results of testing, and any repairs made.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02741

# PAVING

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. Furnish all labor, materials, and equipment to install the pavement as shown and indicated on the Contract Documents and as specified in this Section.

1.2 RELATED WORK

A. Carefully examine all of the Contract Documents for requirements affecting the work of this section.

B. Other specification sections containing requirements relating to this section include, but are not limited to, the following:

1. Section 01050 – Field Engineering/ Surveying
2. Section 01300 – Submittals
3. Section 02125 – Temporary and Permanent Erosion and Sediment Control
4. Section 02200 – Earthwork
5. Section 03100 – Concrete Formwork
6. Section 03200 – Concrete Reinforcement
7. Section 03300 – Cast in Place Concrete

1.3 REFERENCES

A. Virginia Department of Transportation (VDOT) Road and Bridge Specifications (VDOT Standard Specifications), 2016 edition, including the 2019 Supplement.

1.4 SUBMITTALS

A. Submit the following in accordance with Section 01300 - Submittals.

1. Manufacturer’s product data and certified test results for the geogrid.
2. Mix Design for all pavement materials.
3. As-Built surveys and red-lined drawings for completed work.

1.5 SUBSURFACE CONDITIONS

A. Information on subsurface conditions is referenced under Division 1, General Requirements.

1.6 QUALITY ASSURANCE

A. The CONTRACTOR shall be aware of the activities outlined in the project CQA Plan and shall account for these CQA activities in the installation schedule.


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## PART 2 – PRODUCTS

2.1 MATERIALS

A. General

1. All materials utilized in paving operations shall conform to Sections 210, 211, and 217 of the 2016 edition of the VDOT Road and Bridge Specifications or to the technical specifications contained herein.

2. Equipment utilized in paving operations shall conform to VDOT Section 315.

B. Bituminous Plant Mix Base

1. The specific grading of aggregate to be used will be specified in the Contract Documents. Mineral aggregate, bituminous material and the plant mix will be accepted as provided for in VDOT Section 210.03.

2. Composition of Mixtures.

a. The bituminous base and/or leveling course shall be composed of aggregate and bituminous materials. The hot plant mixes shall comply with the applicable requirements of VDOT Section 211.

C. Bituminous Plant Mix Pavements

1. General: The bituminous mixture shall be composed of a combination of aggregate (coarse, fine, or mixtures thereof), mineral filler if required, anti-strip additive if required, and bituminous material. The several aggregate fractions shall be sized, uniformly graded and combined in such proportions that the resulting mixture will meet the grading and physical properties of the approved Job Mix Formula.

2. Gradation and Bituminous Material Requirement: In all cases, the requested aggregate gradation and bituminous material percentages shown on the Job Mix Formula shall be within the Design Ranges shown in VDOT Standards, respectively. The CONTRACTOR will set recommended asphalt cement content on all mixes with the final optimum asphalt cement content to be determined by the ENGINEER.

3. Job Mix Formula: The CONTRACTOR shall submit a job-mix formula for each mixture planned for use on the project for evaluation and approval. The Job Mix Formula shall be provided in accordance with VDOT Section 211.03, items (a) through (g). Mix designs shall utilize an Equivalent Single Axle Load (ESAL) of 9 x $10^6$ ESALs in consideration of VDOT Section 211.01.

4. PLACEMENT AND LIMITATIONS

a. Asphalt concrete mixtures shall not be placed when weather or surface conditions are such that the material cannot be properly handled, finished, or compacted. The surface upon which asphalt mixtures are to be placed shall be free of standing water, dirt, and mud and the base temperature shall conform to the following:

b. When the base temperature is above 80°F, mixture laydown will be permitted at any temperature conforming to the limits specified in VDOT Section 211.08.

C. When the base temperature is between 40°F and 80°F, the Cold Weather Paving Limitations Nomograph, Table III–2 located in the VDOT Road and Bridge Specifications, Section 315.05 shall be used to determine the minimum laydown


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temperature of the asphalt concrete mixes. At no time should the minimum base and laydown temperatures be less than the following:

| Mix Designation | Percentage of Reclaimed Asphalt Added to Mix | Minimum Base Temperature (ºF) | Minimum Placement Temperature (ºF) |
|---|---|---|---|
| PG 64S-22 (A) | ≤ 25% | 40°F | 250°F |
| PG 64S-22 (A) | > 25% | 50°F | 270°F |
| PG 64H-22 (D) | ≤ 30% | 50°F | 270°F |
| PG 64E-22 (E) | ≤ 15% | 50°F | 290°F |
| PG 64S-22 (S) | ≤ 30% | 50°F | 290°F |

Any additional testing of the mix in a laboratory shall be performed using the laboratory mix and compaction temperatures listed on the approved Job Mix Formula. A tolerance of ± 5°F for each temperature will be allowed.

The Laboratory Design must be prepared and signed by a Certified Laboratory Technician. To be certified, the technician must have completed the Marshall Method of Mix Design School conducted by the Department, including the written and lab performance testing.

5. The approved job mix formula shall remain in effect until a change is authorized in writing by the ENGINEER. The CONTRACTOR, at any time after construction has started, may request that the job mix formula be revised, providing evidence is shown that the revision is necessary, and the revised aggregate gradation will meet all applicable gradation requirements.

6. A revised Job Mix formula shall be necessary if, during the test strip construction and mix design/production verification procedure, changes to the mixture are made to comply with the specified criteria.

7. A new design shall be required for any change in source of materials. All requests for design mix adjustments, redesigns and new design mixes shall be submitted in writing to the ENGINEER for approval.

D. Prime Coat

1. Asphalt may be changed one viscosity grade by the ENGINEER during construction at no change in the contract unit price. Asphalt shall conform to VDOT Section 210 as applicable.

2. Cover material shall conform to VDOT Section 202 or Section 203 as applicable. Lightweight aggregate shall conform to VDOT Section 206. The ENGINEER will not permit cover material to be hauled directly from a washing plant for immediate use in the work.


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E. Tack Coat

1. Tack Coat asphalt tack coat shall be CRS-1, CRS-2, CRS-1h, or CSS-1h conforming to VDOT Section 210. Asphalt emulsion CMS-2 conforming to VDOT Section 210 may be used during the winter months. With the exception of CMS-2, asphalt emulsion for tack coat may be diluted with 50 percent water provided that the resulting material produces uniform tack application.

2. Non-Tracking Tack Coat liquefied asphalt shall be selected from the Materials Division's Approved Products List 50.1A. The CONTRACTOR shall not dilute non-tracking tack coat materials with water.

F. Geogrid

1. Geogrid shall be installed in accordance with Manufacturer specifications. Manufacturer must be listed on VDOT Approved List of Suppliers.

G. Full Depth Reclamation

1. CONTRACTOR shall submit evidence of at least three (3) successfully constructed pavement recycling projects during last three (3) years. On-site supervisor and equipment operators shall have three (3) years total experience.

2. Pre-Construction meeting should be held 15 days prior to start of recycling. Clarify roles and responsibilities, construction requirements and schedule.

3. Pulverized materials shall meet the following gradation:

| Sieve Size | Percent Passing |
|---|---|
| 2-inch | 100% |
| 3/8-inch | 55% minimum |

4. Mix design shall meet a minimum compressive strength by ASTM D1633 (Cement) of Minimum 250 psi at seven (7) days. Mix design shall be submitted to the ENGINEER for approval.

H. Rigid (Concrete) Pavements

1. Concrete pavement materials, mixture designs, and testing should meet the criteria provided in VDOT Section 217. In addition, Section 03100 – Concrete Formwork, Section 03200 – Concrete Reinforcement, and Section 03300 – Cast-In-Place Concrete of these specifications should apply.

## PART 3 – EXECUTION

3.1 SUBGRADE PREPARATION

A. CONTRACTOR to prepare subgrade in accordance with Section 02200 – Earthwork of these specifications and the VDOT Standard Specifications.

B. Full Depth Reclamation depth design to be confirmed in field by measuring each 50 feet of roadway. Compaction to be a minimum of 97% of maximum density from Approved Mix Design.


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3.2 ASPHALT PLACEMENT

A. The Contract Documents shall indicate whether the plant-mixed base is to be constructed on a treated or untreated subgrade or sub-base, on a granular base, or on an existing surface. The surface upon which the plant mix base is to be placed shall meet the requirements of VDOT Sections 210 and 211.

B. Conditioning of surface, when called for in the Contract Documents shall be in accordance with the provisions of VDOT Section 315. Conditioning existing mineral aggregate base shall be in accordance with the provisions of VDOT Section 315.

C. Prime coat or tack coat, when specified in the Contract Documents shall be constructed in accordance with the provisions of VDOT Section 311, respectively.

D. Bituminous plant-mix base mixture shall be placed only upon a surface that is dry and cleaned of loose particles and other undesirable materials.

E. Thickness and Surface Requirement. Thickness shall be controlled during the spreading operation by frequent measurements of the freshly spread mixture to establish relationship between the uncompacted mixture and the completed course. Thickness or spread rate in $lbs/yd^2$ shall be within reasonably close conformity with that specified on the Contract Documents. Each course shall have a thickness after compaction of not more than four (4) inches, unless otherwise authorized by the ENGINEER.

F. The surface of the bases shall meet the requirements specified under VDOT Section 210.

3.3 PRIME COAT

A. The rates of application of materials shall be determined in accordance with the method described in Education Series No. 12 of the Asphalt Institute entitled *Asphalt Surface Treatments Construction Techniques.*

B. The weather limitations of VDOT Section 314.03 shall apply to asphalt prime coat work. When asphalt is to be used as a cover for cement stabilization or as a primer for asphalt concrete, the weather limitations specified for these particular operations shall apply.

C. Equipment for heating and applying asphalt and cover material shall conform to VDOT Section 314.04. The maximum application temperature of the liquid asphalt shall conform to Table III-1 in VDOT Section 310.03.

D. The CONTRACTOR shall shape the surface to be primed to the required grade and section; render it free from ruts, corrugations, segregated material, or other irregularities; and uniformly compact it prior to the application of prime.

E. Delays in priming may necessitate reprocessing or reshaping to provide a smooth, compacted surface.

F. The CONTRACTOR shall apply asphalt by means of a pressure distributor in a uniform continuous spread. When traffic is being maintained, not more than 1/2 the width of the section shall be treated in one (1) application. The CONTRACTOR shall exercise care so that the application of asphalt at junctions of spreads is not in excess of the specified amount. The CONTRACTOR shall remove excess asphalt from the surface by means of a squeegee. Skipped areas or deficiencies shall be corrected.

G. The CONTRACTOR shall exercise care during the application of asphalt to prevent spattering adjacent items. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, the CONTRACTOR shall ensure equipment is parked so that the spray bar or mechanism will not drip asphalt on the surface of the traveled way.


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H. When the CONTRACTOR must maintain traffic through the area of application, the ENGINEER will permit one-way traffic on the untreated portion of the roadbed. When the asphalt has been absorbed by the treated surface and will not pick up, traffic shall be transferred to the treated portion and the remaining width of the section primed.

I. The ENGINEER must approve the quantity, rate of application, temperature, and areas to be treated before application of the prime coat.

J. The CONTRACTOR shall spread cover material at no additional cost to the OWNER in an amount that will prevent pick up of the asphalt if after application of the prime coat the asphalt fails to penetrate within the time specified and the roadway must be used by traffic.

3.4 TACK COAT

A. The existing surface shall be patched, cleaned, and rendered free from irregularities to the extent necessary to provide a reasonably smooth and uniform surface. The CONTRACTOR shall remove and replace unstable corrugated areas with suitable patching materials. The CONTRACTOR shall clean the edges of existing pavements that are to be adjacent to new pavement to permit adhesion of asphalt.

B. The CONTRACTOR shall uniformly apply tack coat or non-tracking tack coat material with a pressure distributor conforming to VDOT Section 314.05(b). Hand spray equipment shall not be used except in areas inaccessible by a pressure distributor.

C. Tack at joints or other appurtenances shall be applied with a hand wand or with spray bar at the rate of 0.2 gallon per square yard. At joints, the tack applied by the hand wand or a spray bar shall be two (2) feet in width with four (4) to six (6) inches protruding beyond the joint for the first pass. Tack for the adjacent pass shall completely cover the vertical face of the pavement mat edge so that slight puddling of asphalt occurs at the joint and extend a minimum of one (1) foot into the lane to be paved.

D. Care shall be taken to prevent splattering adjacent items during the application of tack coat. The distributor shall not be cleaned or discharged into ditches or borrow pits, onto shoulders, or along the right of way. When not in use, the CONTRACTOR shall ensure equipment is parked so that the spray bar or mechanism will not drip asphalt on the surface of the traveled way.

E. The CONTRACTOR shall apply tack coat and non-tracking tack coat in accordance with the weather limitations that apply to the course being placed as well as the manufacturer's recommendations. The ENGINEER shall approve the quantity, rate of application, temperature, and areas to be treated prior to application.

F. The tack coat or non-tracking tack coat shall be applied in a manner to offer the least inconvenience to traffic and to permit one-way traffic without pick up or tracking of the asphalt onto adjacent non-treated areas. All traffic, including construction traffic, shall be excluded from tacked sections until the tack has cured.

3.5 CONCRETE PAVEMENTS

A. Concrete pavement construction should be performed in accordance with VDOT Section 316. In addition, Sections 03290 – Joints in Concrete, 03291 – Joint Fillers, Sealants, and Caulking, 03350 – Concrete Finishes, and 03370 – Concrete Curing of these specifications should apply.

*** * * * * END OF SECTION * * * * ***


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# SECTION 02936

# SEEDING

## PART 1 – GENERAL

1.1 DESCRIPTION

A. Furnish all labor, materials, and equipment required to establish seeding. This work shall include maintenance of established vegetation until final acceptance. The CONTRACTOR shall be expected to provide and place all topsoil necessary to complete the work.

B. CONTRACTOR shall revegetate all areas disturbed by his operations. All areas disturbed or not having sufficient vegetation to prevent erosion shall be revegetated.

1.2 RELATED WORK

A. Section 02126 – Hydraulically Applied Flexible Growth Medium

B. Section 02200 – Earthwork

C. Section 02235 – Vegetative Cover

1.3 REFERENCES AND DEFINITIONS

A. Virginia Department of Environment Quality (DEQ) Erosion and Sediment Control Handbook (VESCH).

1.4 QUALITY ASSURANCE AND QUALITY CONTROL

A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

1.5 MAINTENANCE DATA

A. Submit maintenance data for continuing OWNER maintenance.

1.6 TEMPORARY VEGETATION

A. Reference Std. & Spec. 3.31, Virginia Erosion and Sediment Control Handbook. When earth moving activities are completed more than 15 days prior to installation of permanent control measures, or final grading is completed during a season not favorable for immediate establishment of permanent vegetation, stabilize with rapid growing annual grasses of a seasonally appropriate species. Provide species that allow quick protective cover and are compatible with future permanent measures.

1.7 WARRANTY

A. CONTRACTOR shall provide a two-year warranty on all permanent seeding. If after a two-year period, a mature stand of grass vegetation is not established to the satisfaction of the OWNER, the CONTRACTOR shall be responsible for re-top soiling, fertilizing, seeding, and mulching any denuded areas. At which time, another two-year warranty shall be provided to the OWNER by the CONTRACTOR on the repaired areas. Retainage, withheld on seeding, shall not be released until the warranty period is over and the OWNER is satisfied with the final stand of vegetation.


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## PART 2 – PRODUCTS

2.1 TOPSOIL

A. Vegetative Support Layer: Soils capable of sustaining vegetative growth either excavated from site or imported material and free of weeds as specified in Technical Specification Section 02235 – Vegetative Support Layer.

2.2 ACCESSORIES

A. Mulching material: Seed-free oat or wheat straw, dry, free from weeds and foreign matter detrimental to plant life.

B. Lime: Lime shall comply with applicable Virginia laws and shall be delivered in unopened bags or other convenient standard containers, each fully labeled with the Manufacturer's guaranteed analysis. Lime shall be ground limestone containing not less than 85 percent total carbonates and shall be ground to such fineness that 90 percent by weight will pass through a No. 20 mesh sieve and 50 percent by weight will pass through a No. 100 mesh sieve.

C. Fertilizer: Fertilizer shall comply with applicable Virginia state laws and shall be delivered in unopened bags or other convenient standard container, each fully labeled with the manufacturer's guaranteed analysis. Fertilizer shall contain not less than 10 percent nitrogen, 10 percent available phosphoric acid and 10 percent water soluble potash (N P K, 10-10-10). Any fertilizer which becomes caked or otherwise damaged, making it unsuitable for use, will not be acceptable and shall be immediately removed from the job site.

2.3 SEED

A. Seed shall be brought on site unmixed unless the mixture is certified and stated on the package as to the quality and mixture. Mixing shall be done at the project site from the original unopened packages. Unless otherwise indicated from soil-specific analysis, seed mixtures and application rates for both temporary and permanent seeding shall be as described in Part 3 of this specification.

B. Seed which has become wet, moldy, or damaged in transit or in storage will not be accepted. No seed will be accepted with a test date of more than six months before delivery date to the site.

2.4 FLEXTERRA

A. Flexterra High Performance-Flexible Growth Medium as manufactured by Profile.

B. The application rate for Flexterra as described in Part 3 of this specification.

## PART 3 – EXECUTION

3.1 GENERAL

A. Areas to be seeded include all areas disturbed during construction that are not to be paved.

B. CONTRACTOR shall Verify that prepared soil base is ready to receive the work of this Section.

3.2 SEEDBED PREPARATION

A. Prepare seedbed to a depth of four to six inches.

B. Remove loose rocks, roots, and other obstructions so that they will not interfere with the establishment and maintenance of vegetation.


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3.3 FERTILIZER AND LIME

A. Apply lime and fertilizer according to soil tests, or apply lime at the rate of 90 lbs./1000 ft2, and fertilizer at the rate of 23 lbs./1000 $ft^2$.

B. Mix thoroughly into upper four inches of topsoil.

C. Lightly water to aid the dissipation of fertilizer and lime.

3.4 TEMPORARY SEEDING

A. Provide temporary seeding on any cleared, non-vegetated, or sparsely vegetated soil surface where vegetative cover is needed for less than one year or when seeding dates will prevent the establishment of vegetative cover if permanent seeding is attempted.

B. Seed in accordance with the following schedule and application rates:

| Seeding Dates | Seeding Mixture Species and Application Rate |
|---|---|
| September 1 – February 15 | 50% Annual Ryegrass (*Lolium multi-florum*) and<br>50% Cereal (Winter) Rye (*Secale cereale*) at 100 lbs/acre |
| February 16 – April 30 | Annual Ryegrass at 100 lbs/acre |
| May 1 – August 31 | German Millet at 50 lbs/acre |

C. To amend soil, follow recommendations of soil tests or apply 4000 lbs/acre ground agricultural limestone and 600 lbs./acre 10-20-10 fertilizer.

D. Mulch with three-inch straw applied at the rate of 4000 lbs/acre, and anchor by tacking with netting or a mulch anchoring tool.

E. Refertilize if growth is not fully adequate. Reseed, fertilize, and mulch immediately following erosion or other damage.

F. Water, monitor, but generally do not mow until permanent vegetation is established. Permanent vegetation shall not be considered established until ground cover is achieved that is uniform, mature enough to survive, and will inhibit erosion.

3.5 PERMANENT SEEDING

A. Permanent seeding mixtures shall adhere to the following species and application rates (or to an approved equal):


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| Site Specific | Species | Application Rate |
|---|---|---|
| Slopes shallower than 3:1 | Kentucky 31 Tall Fescue | 128 lbs/ac |
| | Red Top Grass | 2 lbs/ac |
| | Seasonal Nurse Crop* | 20 lbs |
| Slopes steeper than 3:1 or steeper | Kentucky 31 Tall Fescue | 108 lbs/ac |
| | Red Top Grass | 2 lbs/ac |
| | Seasonal Nurse Crop* | 20 lbs/ac |
| | Sericea Lespedeza** | 20 lbs/ac |

| **Seasonal Nurse Crop* | *Species* |
|---|---|
| February 16th through April | Annual Rye |
| May 1st through August 15th | Foxtail Millet |
| August 16th through October | Annual Rye |
| November through February 15th | Winter Rye |

** May through September use hulled Sericea, all other periods, use unhulled Sericea.

B. Fertilizer and lime application rates should be established by the CONTRACTOR based on soil sampling and testing results and coordinated with the OWNER and ENGINEER as needed.

1. Incorporate fertilizer and lime into top 4 to 6 inches of soil by dish harrowing or tilling.

C. Prepare seedbed to comprise well-pulverized, loose and uniform soil. Loosen all disturbed areas to a depth of 3 to 6 inches. In areas where repeated access by heavy equipment or trucks has caused compaction, loosen the soil to a depth of 12 inches. The CONTRACTOR may use agricultural or construction equipment to perform this task.

## 3.6 HYDROSEEDING

A. Establish a smooth, healthy, uniform, close stand of grass from the specified seed. Prior to vegetation, the CONTRACTOR shall adequately test the soils to be vegetated to ensure adequacy of the permanent stabilization and seeding requirements of the VDEQ approved erosion and sediment control plan and provide results to the OWNER. Any modifications to these requirements deemed necessary after the review of soil test results shall be at the CONTRACTOR's expense. The OWNER will perform observations to determine when successful vegetation is achieved.

B. Prepare soils to receive seeding by loosening surface to minimum depth of four (4) inches. Remove stones, roots, sticks, rubbish, and other extraneous matter over 1/2 inches in diameter. Spread lime uniformly over designated areas at the rate specified by soil test results. Grade seeded areas to smooth, even surface with loose, uniformly fine texture. Track finished slopes vertically prior to planting. Limit preparation to areas which will be planted soon after preparation


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C. Mixed sustainable slope seed shall be of the varieties and applied at rates as specified in the stabilization and seeding requirements which shall be determined by the soil test(s) and in accordance with VDEQ approved erosion and sediment control plan.

D. Flexterra flexible high performance – flexible growth medium (HP-FGM) shall be applied at a minimum rate of 4,000 lbs/acre (92 lbs/1000 square feet) or per the manufacturer's recommendations, where shown on the Contract Documents.

E. Equipment shall have a built-in mechanical agitation system with a fan type nozzle and operating capacity sufficient to agitate, suspend, and homogeneously mix a slurry with the required amounts of seed, flexible growth medium, fertilizer, water, and any amendments.

F. Mix the seed, soil amendments, and commercial fertilizer with a small amount of flexible growth medium for visual metering and apply along the areas to be vegetated being sure to apply seed and amendments at the specified rates. Fertilizer and amendments shall be applied at rates specified by soil test results.

G. Mix and apply the flexible growth medium at a rate of 50 lbs. per 150 gallons of water over freshly seeded areas, or per manufacturer's specifications. Hydromulch should be applied in multiple directions so that shadowing does not occur and to ensure uniformity of the application. Confirm the loading rates with equipment manufacturers. Do not leave seeded surfaces unprotected, especially if precipitation is imminent.

H. Exercise special care to prevent any of the slurry from being sprayed onto any hardscape areas including concrete walks, roads, fences, walls, buildings, etc. Remove all slurry sprayed onto these surfaces immediately.

I. The CONTRACTOR shall be responsible for the maintaining all seeded areas through the end of the project. The CONTRACTOR shall provide, at their expense, protection of all seeded areas against damage at all times until acceptance of the work. Maintenance shall include but not be limited to: frequent light irrigation shall be applied to seeded areas if no natural rain events have occurred within one week of hydroseeding. Water shall be applied long enough to moisten the soil thoroughly to the depth of the slurry mulch, taking care not to super saturate or wash away the slurry and seed.

J. After seed germination has occurred and plants are visible the frequency of irrigation shall be cut back with heavier application rates still making sure not to super saturate or wash away the slurry and seed.

K. Repair all seed washings and erosion.

L. Future fertilization shall occur whenever applicable at the recommended rate based on soil analysis.

M. Replant or repair bare areas using same materials specified.

N. Mow seeded areas as needed.

## 3.7 REPLANTING

A. The CONTRACTOR shall be required to replant areas damaged by water, wind, fire, equipment or pedestrian traffic as necessary during phasing or when ordered by the OWNER at no additional cost to the OWNER.

B. All areas and spots that do not show a prompt catch of vegetation shall be reseeded at fifteen-day intervals until a growth of grass is established, defined as Section 3.3 of this Specification. CONTRACTOR shall reseed as required to establish a minimum of 95% vegetation coverage sustained for a period of at least 1 year from establishment of


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vegetation. Remedial seeding, fertilizer and lime will be applied at no additional cost to the OWNER.

3.8 MAINTENANCE OF GRASS AREAS

A. Water and reseed throughout the construction contract or a minimum of one year after the establishment of vegetation, whichever is greater, and/or acceptance by the OWNER after seeding areas are substantially established turf areas.

B. Refertilize in the second year unless growth is fully adequate.

*** * * * * END OF SECTION * * * * ***


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# SECTION 03100

# CONCRETE FORMWORK

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall furnish and install concrete formwork as required to form reinforced concrete as shown and indicated on the Contract Documents, as specified herein, or as otherwise required to complete the Work.

B. The CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, and/or Commonwealth authorities having jurisdiction.

1.2 RELATED SECTIONS

A. Section 01050 – Field Engineering / Surveying

B. Section 03200 - Concrete Reinforcement

C. Section 03300 – Cast-in-place Concrete

1.3 RELATED REFERENCES

The latest edition of the publications listed below are included as a part of these Specifications.

A. American Concrete Institute (ACI) Publications:

1. ACI 318 Building Code Requirements for Reinforced Concrete
2. ACI 347 Recommended Practice for Concrete Formwork

B. US Department of Commerce Product Standard (PS):

1. PS 1 Construction and Industrial Plywood

1.4 FORM DESIGN

A. The design of forms and their performance, as required by this Section, is the CONTRACTOR's responsibility. Formwork shall comply with ANSI A10.9 and OSHA Construction Standards, Part 1926, Subpart Q, Concrete, Concrete Forms, and Shoring.

## PART 2 – PRODUCTS

2.1 FORM MATERIALS

A. Formwork for all concrete, unless otherwise specified, shall not be less than 5/8-inch, 5-ply Douglas fir plywood of exterior structural grade especially processed to resist moisture and conforming to PS 1, B-B Concrete Form Panels. Patented forms may be used, subject to approval by the ENGINEER, provided they are in new, or like-new condition so as to produce a smooth, even surface free from blemishes, defects, and depressions; this approval is for the finish these forms will leave on the contact surfaces and will not relieve the CONTRACTOR of the responsibility for the design and structural soundness of the forms.

2.2 ACCESSORIES

A. Form tie assemblies shall be form clamps with smooth tie rods, with a waterstop at the center, permitting tightening of the forms and be of such type as to leave no metal or other


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material within 1-1/2-inch of the surface after use. The assembly should provide cone-shaped depressions in the cast surface at least one 1-inch in diameter and 1-1/2-inch deep to allow filling and patching.

B. Form releasing agent shall be a non-staining form coating compound such as “Cast-Off” by Sonneborn Products Division (Contech, Inc.), or an equal product as approved by the ENGINEER.

## PART 3 – EXECUTION

### 3.1 FORM CONSTRUCTION

A. Formwork shall be in accordance with ACI 347 and as follows:

1. Forms shall conform to shape, lines and dimensions of members required and shall be sufficiently rigid and tight to prevent leakage of the cement binder. Forms shall be properly braced or tied together so as to maintain position and shape. Construct forms so that they can be removed readily without hammering or prying against the concrete. Forms for exposed concrete shall be carefully made and accurately placed to obtain correct shape and lines.
2. Joints shall be butted tight on solid bearings. Arrangements of panels shall be orderly and symmetrical and use of small pieces shall be avoided. Forms shall be chamfered for external corners of concrete, including top of walls, which will be exposed in the finished work.
3. The CONTRACTOR shall be fully responsible for the adequacy of formwork in its entirety. Forms shall support the anticipated loading while maintaining their dimensional and surface correctness to produce members with the required geometry.
4. Block-outs for slots, chases, recesses or other openings shall be provided by the CONTRACTOR as needed by the work of this and any other trades.
5. Install all the inserts to be supported by the formwork as required by the work of this and other trades as needed.

### 3.2 TOLERANCE FOR FORMED SURFACES

A. Variation from Plumb: Not more than ±1/4 inch in any 10 feet of length with a maximum for the entire length of ±1/2 inch.

B. Variation from the Level or from the Grades Specified in the Contract Documents: Not more than ±1/4 inch in any 10 feet of length with a maximum for the entire length of ± 3/4 inch.

C. Variation in the Sizes and Location of Openings and Thickness of Walls: ±1/4-inch.

### 3.3 INSPECTION

A. CONTRACTOR shall give the Owner’s Representative at least 48 hours notice before any concrete is to be cast. Concrete shall not be cast until the Owner’s Representative has observed and given approval of the Work to be cast including, but not limited to, the placement of all the reinforcing, accessories, forms and the surfaces to be cast against. Such observations are in the nature of assisting the CONTRACTOR to minimize errors and in no case will they serve to relieve the CONTRACTOR of the responsibility to provide the materials and workmanship required by the Contract Documents.

### 3.4 APPLICATION OF FORM COATING

A. Immediately before the placing of reinforcing, faces of all forms in contact with the concrete shall receive a thorough coating of the liquid form-releasing agent specified, applied in compliance with the Manufacturer’s instructions.


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3.5 REMOVAL OF FORMS

A. The CONTRACTOR shall assume full responsibility for removal of formwork and forms shall be removed in such a manner as to ensure complete integrity and safety of the structure. Forms and shoring for mass concrete, walls, columns, and beams shall remain in place a minimum period of 7 days after casting the concrete. Forms for slabs shall remain in-place a minimum of 24 hours after casting.

B. Wood forms shall be completely removed from all concrete cast to avoid termite infestation.

3.6 SURVEYING

A. Prior to pouring concrete, accurately survey and measure the size and location of all structures to be placed in the concrete. Survey and record measurements in accordance with Section 01050 – Field Engineering / Surveying of these Specifications.

B. Provide drawings showing surveyed measurements, dimensions, and locations necessary to locate accurately anchors, pipes, tanks, conduit, and other structures buried in or below concrete.

*** * * * * END OF SECTION * * * * ***


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# SECTION 03200

# CONCRETE REINFORCEMENT

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. CONTRACTOR shall furnish and install the concrete reinforcement as shown and indicated on the Contract Documents, as required by these Specifications, and as specified in this Section.

B. CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, state or federal authorities having jurisdiction.

1.2 RELATED SECTIONS

A. Section 03300 - Cast-In-Place Concrete

1.3 REFERENCED PUBLICATIONS

The latest edition of the publications listed below are included as part of these Specifications.

A. American Concrete Institute (ACI) Publications:

1. ACI 315 Manual of Standard Practice for Detailing Reinforced Concrete Structures
2. ACI 318 Building Code Requirements for Reinforced Concrete

B. American Society for Testing and Materials (ASTM) International:

1. ASTM A82 Specification for Cold Drawn Steel Wire for Concrete Reinforcement
2. ASTM A185 Specification for Welded Steel Wire Fabric for Concrete Reinforcement
3. ASTM A615 Specification for Deformed and Billet-Steel Bars for Concrete Reinforcement
4. ASTM A1064 Specification for Steel Wire and Welded Wire Reinforcement, Plain and Deformed for Concrete

C. American Association of State Highway and Transportation Officials (AASHTO) Publication:

1. AASHTO M284 Epoxy Coating

1.4 SUBMITTALS

A. Shop Drawings to be submitted with the CONTRACTOR's Detailed Design submittal. Shop drawings shall show the required bar sizes, spacing, and splice length for all reinforcement; reinforcement placing plans; and bending details and complete bar lists. Shop drawings will not be reviewed without such information. Wall reinforcing shall be shown in elevation. Location and arrangement of accessories shall be clearly indicated. Placing drawings, detail drawings and bar lists shall be checked by the fabricator and the CONTRACTOR before being submitted to the ENGINEER for review.

B. Mill tests of reinforcing steel shall be submitted prior to use for each 15 tons or less shipped to the Site. Tests shall be conducted in conformance with ASTM A615, and methods prescribed therein.

1. Cost of tests shall be borne by the CONTRACTOR.


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2. Three copies of each test report stating whether the material meets the requirements of the ASTM specifications shall be submitted to the ENGINEER.
3. Certified copies of the mill tests may be considered evidence of compliance provided such tests are regularly conducted by the reinforcement supplier by experienced, competent personnel using appropriate testing equipment. In case of doubt as to the adequacy or accuracy of the mill tests, the ENGINEER may require the CONTRACTOR to furnish, at no additional cost to the OWNER, test results from an independent testing laboratory acceptable to the ENGINEER on mill samples or delivered steel reinforcement.

## PART 2 – PRODUCTS

2.1 REINFORCING BARS

A. Bar reinforcement shall be deformed-type bars conforming to ASTM A615. Reinforcement shall be manufactured from new billet steel of American manufacture, Grade 60, yield strength 60,000 psi minimum.

2.2 WELDED WIRE FABRIC

A. Welded wire fabric shall be in flat sheets conforming to ASTM A185 (A497), with wire conforming to ASTM A82 (A496).

B. Accessories

C. All chairs and bolsters shall have plastic-covered or galvanized steel legs.

D. For slabs on grade, all reinforcing shall be supported on continuous chairs and/or bolsters as required to properly support the reinforcing steel. The chairs and/or bolsters shall be supported on precast concrete pads bearing on the subgrade. The concrete pads shall be at least 6x6 inches and no more than one inch thick. Pads shall be cast from Class "A" concrete or from mortar made up of one-part cement and two parts sand, with tie wires embedded.

## PART 3 – EXECUTION

3.1 STORAGE OF MATERIALS

A. Reinforcing steel delivered to the Site shall be stored on clean well-draining flat surface. All reinforcing steel shall be stored in bundles with tags. Reinforcing steel shall not be exposed to the elements.

3.2 INSPECTION OF STEEL PLACEMENT

A. CONTRACTOR shall give the OWNER at least 48 hours' notice before any concrete is to be cast. Concrete shall not be cast until the ENGINEER has observed and given approval of the work to be cast including, but not limited to, the placement of all the reinforcing, accessories, forms and the surfaces to be cast against. Such observations are in the nature of assisting the CONTRACTOR to minimize errors and in no case will they serve to relieve the CONTRACTOR of the responsibility to provide the materials and workmanship required by the Contract Documents.

3.3 TOLERANCES

A. Allowable tolerances for fabricating steel reinforcement shall be as follows:

1. Sheared length of bars ± 1-inch
2. Location of bends ± 1-inch


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B. Allowable tolerances for placing steel reinforcement shall be as follows:

| | | |
|---|---|---|
| 1. | Concrete cover from outside of bar to finished surface | +1/4-inch |
| 2. | Lateral spacing of bars in plane of reinforcement in slabs and walls | ± 1-inch |
| 3. | Height of bottom bars in slabs | + 1/4-inch |
| 4. | Height of top bars in slabs | + 1/4-inch |

3.4 SHOP FABRICATION

A. Reinforcing steel shall be fabricated to required shapes and dimensions in compliance with applicable provisions of ACI 315 and ACI 318.

B. Bars shall be bent cold. Bars shall be prefabricated to detail and delivered to the site plainly tagged and ready to set.

3.5 EPOXY COATING

A. Reinforcing bars shall be coated after fabrication is complete.

B. Epoxy coating shall be satisfactory repaired by wire brush cleaning and painting with an approved epoxy paint provided by the bar coater, using the manufacturers approved procedure.

C. Bars with more than five percent of the coating damage shall be replaced.

D. Bars shall be fastened by the use of epoxy coated wire only.

3.6 FIELD FABRICATION

A. Field fabrication of reinforcing steel will not be permitted without the approval of the ENGINEER.

B. Field cutting of reinforcing steel shall be performed by shearing or abrasive cutting wheel. Cutting by flame is prohibited.

C. Damaged epoxy coating shall be removed, and coating repaired.

3.7 PLACEMENT AND ANCHORAGE

A. Space metal chairs, bolsters, spacers and hangers in accordance with ACI 315.

B. Reinforcement, at the time concrete is placed, shall be free from any abrasions or damage to the epoxy coating. Repairs shall be made immediately upon discovery.

C. Reinforcement shall be accurately placed in accordance with the shop drawings and shall be adequately secured in position with not less than 16-gauge annealed wire or suitable clips at no less than 50% of the bar intersections. Reinforcement shall be held securely at the required distance from the forms. Nails shall not be driven into outside forms to support reinforcement.

D. Install welded wire fabric reinforcement for concrete sidewalks, equipment pads, and as otherwise indicated. Lap all joints six inches and wire securely. Extend mesh to within two inches of sides and ends of slabs. Unless otherwise specified, place welded wire fabric between the upper third-point and the mid-point of the slab. Sheets that do not lay flat when in their intended position will be rejected. Tags designating the wire size and spacing shall be left on each sheet until ready for use. Tuck ends of welded mesh well down into edge of beams or walls. Do not leave unreinforced border strips. Welded wire fabric shall not contain loose rust.


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3.8 CONCRETE COVER

A. Metal reinforcement shall be protected by concrete cover in accordance with ACI 318.

3.9 SPLICING

A. The location and type of splices desired by the CONTRACTOR must be specifically requested and must meet the approval of the ENGINEER before they can be used.

B. Splices shall not be made at point of maximum stress and shall provide sufficient lap to transfer stress between bars by bond.

C. Mechanical splices may be used instead of lap splices provided that their location and type meet with the approval of the ENGINEER.

D. Splice locations shall be staggered with adjacent bars and bar bundles.

*** * * * * END OF SECTION * * * * ***


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# SECTION 03250

# CONCRETE ACCESSORIES

## PART 1 – GENERAL

### 1.1 THE REQUIREMENT

A. Furnish all materials, labor and equipment required to provide all concrete accessories including expansion joint material, joint sealants, expansion joint seals, contraction joint inserts, and epoxy bonding agent.

### 1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03200 - Concrete Reinforcement

C. Section 03290 - Joints in Concrete

D. Section 03291 - Joint Fillers, Sealants, and Caulking

E. Section 03300 - Cast-in-Place Concrete

F. Section 03350 - Concrete Finishes

G. Section 03370 - Concrete Curing

### 1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

A. American Society for Testing and Materials (ASTM) International:

1. ASTM C881 Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
2. ASTM D412 Standard Test Method for Tension Testing for Rubber and Elastomers
3. ASTM D624 Standard Test Method for Tear Testing for Rubber and Elastomers
4. ASTM D638 Standard Test Method for Tensile Properties of Plastics
5. ASTM D1751 Standard Specifications for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (nonextruding and resilient bituminous types)
6. ASTM D1752 Standard Specification for Preformed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

### 1.4 SUBMITTALS

A. Submit the following in accordance with Section 01300 - Submittals.

1. Manufacturer's literature on all products specified herein including material certifications.
2. Samples of products if requested by the OWNER OR ENGINEER.


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## PART 2 – PRODUCTS

2.1 JOINT SEALANTS

A. Joint sealants shall comply with Section 03291 - Joint Fillers, Sealants, and Caulking.

2.2 EXPANSION JOINT MATERIAL

A. Preformed expansion joint material shall be non-extruding, and shall be of the following types:

1. Type I Sponge rubber, conforming to ASTM D1752, Type I.
2. Type II Cork, conforming to ASTM D1752, Type II.
3. Type III Self-expanding cork, conforming to ASTM D1752, Type III.
4. Type IV Bituminous fiber, conforming to ASTM Designation D1751.

2.3 EXPANSION JOINT SEAL

A. Expansion Joint Seal System shall consist of a preformed neoprene profile, installed using the same dimensions as the joint gap, bonded with a two-component epoxy adhesive and pressurized during the adhesive cure time.

B. The expansion joint system shall be Hydrozo/Jeene Structural Sealing joint system by Hydrozo/Jeene, Inc.

2.4 CONTRACTION JOINT INSERTS

A. Contraction joint inserts shall be Transverse-Control Joints by Greenstreak Plastic Products.

2.5 EPOXY BONDING AGENT

A. Epoxy bonding agent shall conform to ASTM C881 and shall be Sikadur 32 Hi-Mod, Sika Corporation, Lyndhurst, N.J.; Euco #452 Epoxy System, Euclid Chemical Company, Cleveland, OH.

2.6 EPOXY RESIN BINDER

A. Epoxy resin binder shall conform to the requirements of ASTM C-881, Type III, Grade 3, Class B and C for epoxy resin binder and shall be Sikadur 23, Low-Mod-Gel, manufactured by the Sika Corporation, Lyndhurst, N.J., Fleocrete Gel manufactured by Tamms Industries Co.

## PART 3 – EXECUTION

3.1 INSTALLATION OF EXPANSION JOINT MATERIAL AND SEALANTS

A. Type I, II, or III shall be used in all expansion joints in structures and concrete pavements unless specifically shown otherwise on the Contract Documents. Type IV shall be used in sidewalk and curbing, and other locations specifically shown on the Contract Documents.

B. All expansion joints exposed in the finish work, exterior and interior, shall be sealed with the specified joint sealant. Expansion joint material and sealants shall be installed in accordance with manufacturer's recommended procedures and as shown on the Contract Documents.

C. Expansion joint material that will be exposed after removal of forms shall be cut and trimmed to ensure a neat appearance and shall completely fill the joint except for the space required for the sealant. The material shall be held securely in place and no concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.


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D. A bond breaker shall be used between expansion joint material and sealant. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surfaces shall present a clean and even appearance.

E. Type 1 joint sealant shall be used in all expansion and contraction joints in concrete, except where Type 7 or Type 8 is required as stated below, and wherever else specified or shown on the Contract Documents. It shall be furnished in pour grade or gun grade depending on installation requirements. Primers shall be used as required by the manufacturer. The sealant shall be furnished in colors as directed by the OWNER or ENGINEER.

F. Type 8 joint sealant shall be used in all concrete pavements and floors subject to heavy traffic and wherever else specified or shown on the Contract Documents.

G. Type 7 joint sealant shall be used for all joints in chlorine contact tanks and wherever specified or shown on the Contract Documents.

3.2 EXPANSION JOINT SEAL

A. The expansion joint seal system shall be installed as shown on the Contract Documents in strict accordance with the manufacturer's recommendations.

3.3 CONTRACTION JOINT INSERTS

A. For contraction joints in slabs, inserts shall be floated in fresh concrete during finishing.

B. For contraction joints in walls, inserts shall be secured in place prior to casting wall.

C. Inserts shall be installed true to line at the locations of all contraction joints as shown on the Contract Documents.

D. Inserts shall extend into concrete sufficient depth as indicated on the Contract Documents or specified in Section 03290 - Joints in Concrete.

E. Inserts shall not be removed from concrete until concrete has cured sufficiently to prevent chipping or spalling of joint edges due to inadequate concrete strength.

3.4 EPOXY BONDING AGENT

A. The CONTRACTOR shall use an epoxy bonding agent for bonding fresh concrete to existing concrete as shown on the Contract Documents.

B. Bonding surface shall be clean, sound and free of all dust, laitance, grease, form release agents, curing compounds, and any other foreign particles.

C. Application of bonding agent shall be in strict accordance with manufacturer's recommendations.

D. Fresh concrete shall not be placed against existing concrete if epoxy bonding agent has lost its tackiness.

3.5 EPOXY RESIN BINDER

A. Epoxy resin binder shall be used to seal all existing rebar cut and burned off during demolition operations. Exposed rebar shall be burned back 1/2-inch minimum into existing concrete and the resulting void filled with epoxy resin binder.

*** * * * * END OF SECTION * * * * ***


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# SECTION 03290

# JOINTS IN CONCRETE

## PART 1 – GENERAL

1.1 THE REQUIREMENTS

A. Provide all materials, labor and equipment required for the construction of all joints in concrete specified herein and shown on the Contract Documents.

B. Types of joints in concrete shall be as follows:

1. Construction Joints - Joints between adjacent concrete placements continuously connected with reinforcement.
2. Expansion Joints - Joints in concrete which allow thermal expansion and contraction of concrete. Reinforcement terminates within concrete on each side of joint.
3. Contraction Joints - Joints formed in concrete to provide a weakened plane in concrete section to control formation of shrinkage cracks.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03200 - Concrete Reinforcement

C. Section 03250 - Concrete Accessories

D. Section 03291 - Joint Fillers, Sealants and Caulking

E. Section 03300 - Cast-in-Place Concrete

F. Section 03350 - Concrete Finishes

G. Section 03370 - Concrete Curing

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

A. American Concrete Institute (ACI) Publications:

1. ACI 301 Specifications for Structural Concrete for Buildings
2. ACI 318 Building Code Requirements for Structural Concrete
3. ACI 350 Code Requirements for Environmental Engineering Concrete Structures

1.4 SUBMITTALS

A. Submit the following in accordance with Section 01300 - Submittals.

1. Layout drawings showing location and type of all joints to be placed in each structure.

2. Details of proposed joints in each structure.


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## PART 2 – MATERIALS

2.1 MATERIALS

A. All materials required for joint construction shall comply with Section 03250 - Concrete Accessories, and Section 03291 - Joint Fillers, Sealants and Caulking.

## PART 3 – EXECUTION

3.1 CONSTRUCTION JOINTS

A. Construction joints shall be as shown on the Contract Documents. Otherwise, CONTRACTOR shall submit description of the joint and its location to OWNER and ENGINEER for approval.

B. Unless noted otherwise on the Contract Documents, construction joints shall be located near the middle of the spans of slabs. Joints shall be perpendicular to the main reinforcement.

C. Maximum distance between horizontal joints in slabs and vertical joints in walls shall be 45'-0".

D. All corners shall be part of a continuous placement, and should a construction joint be required, the joint shall not be located closer than five (5) feet from a corner.

E. All reinforcing steel and welded wire fabric shall be continued across construction joints. Keys and inclined dowels shall be provided as shown on the Contract Documents or as directed by the OWNER or ENGINEER. Longitudinal keys shall be provided in all joints in walls and between walls and slabs or footings, except as specifically noted otherwise on the Contract Documents. Size of keys shall be as shown on the Contract Documents.

3.2 EXPANSION JOINTS

A. Size and location of expansion joints shall be as shown on the Contract Documents.

3.3 CONTRACTION JOINTS

A. Location of contraction joints shall be as shown on the Contract Documents. If not specifically shown on the Contract Documents, contraction joints shall be at a maximum spacing of 12 feet in any direction and have a spacing length to width ratio of no more than 1.3 to 1.

B. Contraction joints shall be formed with contraction joint inserts as specified in Section 03250 - Concrete Accessories.

C. Sawcutting of contraction joints in lieu of forming will not be allowed unless otherwise noted on the Contract Documents. Where sawcutting is allowed, joints shall be sawed as soon as the concrete can support foot traffic without leaving any impression, normally the same day as concrete is placed and in no case longer than 24 hours after concrete is placed.

D. Unless noted otherwise on Contract Documents, depth of contraction joints shall be 1-1/2 inches in reinforced concrete and 1/3 of concrete thickness in unreinforced concrete.

3.4 JOINT PREPARATION

A. No concrete shall be allowed to enter the joint or the space for the sealant and destroy the proper functions of the joint.

B. The surface of the concrete at all joints shall be thoroughly cleaned and all laitance removed by wire brushing, air or light sand blasting.


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C. The joint shall be thoroughly clean and free from dirt and debris before the primer and the sealant are applied. Where the finished joint will be visible, masking of the adjoining surfaces shall be carried out to avoid their discoloration. The sealant shall be neatly tooled into place and its finished surface shall present a clean and even appearance.

D. All joints shall be sealed as shown on the Contract Documents and specified in Section 03250 - Concrete Accessories.

*** * * * * END OF SECTION * * * * ***


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# SECTION 03291

# JOINT FILLERS, SEALANTS AND CAULKING

## PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Furnish labor, materials, equipment and appliances required for the complete execution of Work shown on the Contract Documents and specified herein.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03200 - Concrete Reinforcement

C. Section 03250 - Concrete Accessories

D. Section 03290 - Joints in Concrete

E. Section 03300 - Cast-in-Place Concrete

F. Section 03350 - Concrete Finishes

G. Section 03370 - Concrete Curing

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

A. American Society for Testing Materials (ASTM) International:

1. ASTM C920 Standard Specification for Elastomeric Joint Sealants
2. ASTM D1056 Standard Specification for Flexible Cellular Materials - Sponge or Expanded Rubber

B. Sealant, Waterproofing, and Restoration Institute (SWR Institute):

1. Sealant and Caulking Guide Specification

C. Federal Specification TT-S-00227-E Sealing Compound

1.4 SUBMITTALS

A. In accordance with the procedures and requirements set forth in Section 01300 - Submittals, submit the following:

1. Manufacturers literature and installation instructions.
2. Color samples of each type of sealant.

1.5 QUALITY ASSURANCE

A. Applicator shall be a company specializing in the installation of sealants with a minimum of five (5) years' experience.

1.6 DELIVERY, STORAGE AND HANDLING

A. Deliver materials in unopened labeled packages.


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B. Store materials in location protected from freezing or damages.

C. Reject and remove from the site materials within broken or damaged packaging.

## PART 2 – PRODUCTS

2.1 MATERIALS

A. Sealants:

1. Type 1: Multi-component, non-sag, low-modulus polyurethane rubber sealant meeting ASTM C-920, Type M, Grade NS, Class 25, use NT, M, A, and O. Capable of withstanding 50% in extension or compression such as Sikaflex-2C NS/SL, Sika Corporation Lyndhurst, NY, or Sonolastic SL-1, Sonneborn, Minneapolis, MN, or DynaTrol II by Pecora Corporation.
2. Type 2: Single component polyurethane sealant meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, A, and O. Capable of withstanding 25% in extension or compression such as Magnum NS-100, Tamms Industries, or Sikaflex 1A, Sika Corporation, Lyndhurst, NY, DynaTrol 1-XL by Pecora Corporation.
3. Type 3: Single component, low-modulus moisture curing silicone meeting ASTM C-920, Type S, Grade NS, Class 25, Use NT, M, G, and A. Capable of withstanding 50% extension and compression. Pecora 890 by Pecora Corporation or equal.
4. Type 4: High grade butyl sealant meeting Federal Specification TT-S-00-1657. BC-158 by Pecora Corporation or equal.
5. Type 5: Multi-component chemical resistant polysulfide sealant conforming to ASTM C-920, Type M, Grade NS, Class 25 such as Sonolastic Two-part, Sonneborn, Minneapolis, MN, Hornflex-L, Tamms, Beltsville, MD, or Cormax PSC, DuPont, Synthacalk GC2+ by Pecora Corporation.
6. Type 6: Nonsag, multi component, traffic grate polyurethane sealant meeting ASTM C920, Type 19, Grate NS, Class 25, use T, M, A, and O. DynaTread by Pecora Corporation.

B. Primer: Non-staining primer recommended by sealant manufacturer for the substrates on this project.

C. Backer Rod: Closed cell foam, nonreactive with caulking materials, non-oily, and approved by the sealant manufacturer. Minimum density shall be 3.24 pounds per cubic foot. Use no asphalt or bitumen-impregnated fiber with sealants.

D. Joint Cleaner: Recommended by sealant or caulking compound manufacturer.

E. Bond breaker: Either polyethylene film or plastic tape as recommended by the sealant manufacturer.

F. Color: Where manufacturer’s standard colors do not closely match materials being sealed, provide a customer color.

## PART 3 – EXECUTION

3.1 QUALITY CONTROL

A. Coordinate work with details shown on approved shop drawings prepared by other trades.

B. Verify conditions in the field.

C. Schedule work to follow closely the installation of other trades.

D. Apply sealants and related items in temperatures and dry conditions recommended by the manufacturers.


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E. Do not paint sealant, unless recommended by sealant and paint manufacturer.

3.2 PREPARATION

A. Protect finished surfaces adjoining by using masking tape or other suitable materials.

B. Clean and prime joints before starting any caulking or sealing work.

C. Thoroughly clean joints and spaces of mortar and other foreign materials. Cleaning agent shall be Xylol or similar non-contaminating solvent to remove any film from metal surfaces. Masonry or concrete surfaces shall be brushed or air jet cleaned.

D. Joint Requirements

1. All joints and spaces to be sealed in exterior work shall be less than 1/2 inch deep and not less than 1/4 inch wide. If joints in masonry are less than that specified herein, the mortar shall be cut out to the required width and depth. All joints and spaces to receive sealant shall be completely prepared and thoroughly dry before installation of sealant.
2. Unless otherwise specified, joints and spaces which are open to a depth of 1/2 inch or greater shall be solidly filled with back-up material to within 1/4 inch of the surface. Back-up material shall be packed tightly and made continuous throughout the length of the joints. Bond breaker shall be applied as required. If joints are less than 1/4 inch deep, the back-up material may be omitted, a bond breaker substituted and the joint completely filled with sealant. The back-up material shall not project beyond the 1/4 inch depth of the open space in any joint. The following width-to-depth ratio table shall be adhered to, unless otherwise recommended by manufacturer.

| Joint Width | Sealant Depth | |
|---|---|---|
| | Minimum | Maximum |
| ¼ inch | 1/4 inch | 1/4 inch |
| Over 1/4 inch to ½ inch | 1/4 inch | Equal to width |
| Over 1/2 inch to 1 inch | 1/2 inch | Equal to width |
| Over 1 inch to 2 inches | 1/2 inch | 1/2 of width |

3.3 APPLICATION

A. Exercise care before, during, and after installation so as not to damage any material by tearing or puncturing. All finished work shall be approved before covering with any other material or construction.

B. Apply sealant by an approved type of gun except where the use of a gun is not practicable, suitable hand tools shall be used. Avoid applying the compound to any surface outside of the joints or spaces to be sealed. Mask areas where required to prevent overlapping of sealant.

C. All joints shall be waterproof and weathertight.

D. Point sealed joints to make a slightly concave joint, the edges of which are flush with the surrounding surfaces. Exposed joints in the interior side of the door and other frames shall be neatly pointed flush or to match adjacent jointing work.

E. Adjacent materials which have been soiled shall be cleaned immediately and the work left in neat and clean condition.


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F. Comply with sealant manufacturer's written instructions except where more stringent requirements are shown or specified and except where manufacturer's technical representative directs otherwise.

3.4 ADJUSTMENT AND CLEANING

A. Remove misplaced sealant compounds promptly using methods and materials recommended by the manufacturer, as the work progresses.

B. Allow sealants to cure and remove protective edging, of doors, louvers, saddles windows etc. as directed by the OWNER or ENGINEER.


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3.5 SCHEDULE

**Schedule of Sealants**

| **Application** | **Sealant** | **Color** |
|---|---|---|
| Vertical and horizontal joints bordered on both sides by concrete, masonry, precast concrete, natural stone or other porous building material. | Type 2 | To closely match adjacent surfaces or mortar and as selected by the Owner. |
| Vertical and horizontal joints bordered on both sides by painted metals, anodized aluminum, mill finished aluminum, PVC, glass or other non-porous building material. | Type 3 | To closely match adjacent surfaces and as selected by the Owner. |
| Masonry expansion and control joints less than 1¼" wide. | Type 2 | To closely match adjacent surfaces and as selected by the Owner. |
| Masonry expansion and control joints equal or greater than 1¼ inches wide. | Type 1 | To closely match adjacent surfaces and as selected by the Owner. |
| Perimeter sealing of doors, windows, louvers, piping, ducts, and electrical conduit. | Type 2 OR Type 3 | To closely match adjacent surfaces and as selected by the Owner. |
| Below thresholds. | Type 4 | Manufacturer's standard |
| **Submerged in liquids. (See Note 2)** | **Type 1** | **Manufacturer's standard** |
| Submerged in liquids with high concentration of chlorine (> 2 ppm). | Type 5 | Manufacturer’s standard |
| Horizontal Joints exposed to vehicular or pedestrian traffic. | Type 6 | To closely match adjacent surfaces. |
| Other joints indicated on the Contract Documents or customarily sealed but not listed. | Type recommended by manufacturer | To closely match adjacent surfaces and as selected by the Owner. |

Note 1: Sealants which will come in contact with potable water shall meet the requirements of NSF 61.
Note 2: Where sealant will be immersed in liquid chemicals verify compatibility prior to installation of sealant.

*** * * * * END OF SECTION * * * * ***


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# SECTION 03300

# CAST-IN-PLACE CONCRETE

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

Furnish and install all cast-in-place concrete as shown and indicated on the Contract Documents and as specified in this Section. This specification does not include structural concrete.

1.2 RELATED SECTIONS

A. Section 03100 – Concrete Formwork

B. Section 03200 – Concrete Reinforcement

1.3 REFERENCES

The latest edition of the publications listed below form a part of these Specifications:

A. American Concrete Institute (ACI) Publications:

| | | |
|---|---|---|
| 1. | ACI 211.1 | Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete |
| 2. | ACI 301 | Specifications for Structural Concrete for Buildings |
| 3. | ACI 302.1R | Guide for Concrete Floor and Slab Construction |
| 4. | ACI 304 | Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete |
| 5. | ACI 305R | Hot Weather Concreting |
| 6. | ACI 306R | Cold Weather Concreting |
| 7. | ACI 318 | Building Code Requirements for Reinforced Concrete |
| 8. | ACI 350 | Requirements for Environmental Engineering Concrete |

B. American Association of State Highway and Transportation Officials (AASHTO) Publication:

1. AASHTO M182 Burlap Cloth Made from Jute or Kenaf

C. American Society for Testing and Materials (ASTM) International:

| | | |
|---|---|---|
| 1. | ASTM C31 | Making and Curing Concrete Test Specimens in the Field |
| 2. | ASTM C33 | Concrete Aggregates |
| 3. | ASTM C39 | Compressive Strength of Cylindrical Concrete Specimens |
| 4. | ASTM C94 | Ready-Mixed Concrete |
| 5. | ASTM C143 | Slump of Portland Cement Concrete |
| 6. | ASTM C150 | Portland Cement |
| 7. | ASTM C171 | Sheet Materials for Curing Concrete |
| 8. | ASTM C172 | Sampling Freshly Mixed Concrete |
| 9. | ASTM C173 | Air Content of Freshly Mixed Concrete by the Volumetric Method |
| 10. | ASTM C231 | Air Content of Freshly Mixed Concrete by the Pressure Method |
| 11. | ASTM C260 | Air-Entraining Admixtures for Concrete |
| 12. | ASTM C309 | Liquid Membrane-Forming Compounds for Curing Concrete |
| 13. | ASTM C494 | Chemical Admixtures for Concrete |
| 14. | ASTM C595 | Blended Hydraulic Cements |
| 15. | ASTM C881 | Epoxy-Resin-Base Bonding Systems for Concrete |

D. U.S. Army Corps of Engineers (COE) Waterways Experiment Station Publication CRD-C-621: Handbook for Concrete and Cement, Specifications for Non-shrink Grout, Volume II.


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E. Virginia Department of Transportation (VDOT) Road and Bridge Specifications, 2007 Edition.

1.4 SUBMITTALS

A. Name and location of concrete suppliers.

B. Concrete mix design indicating amount of all ingredients for each class of concrete to be used in the work.

C. Indicate proposed construction joints required to construct the structure. Location of the construction joints is subject to the approval of the OWNER.

D. Material Certificates: For each of the following, signed by manufacturers:

1. Cementitious materials.
2. Admixtures.
3. Form materials and form-release agents.
4. Steel reinforcement and accessories.
5. Waterstops.
6. Curing compounds.
7. Bonding agents.
8. Adhesives.
9. Semirigid joint filler.
10. Joint-filler strips.
11. Repair materials.

E. Material Test Reports: For the following, from a qualified testing agency:

1. Aggregates

F. Formwork Shop Drawings: Prepared by or under the supervision of a qualified professional engineer, detailing fabrication, assembly, and support of formwork.

**PART 2– PRODUCTS**

2.1 CEMENT

A. Cement shall be standard Portland cement of American manufacture, conforming to ASTM C-150, Type I. Only one brand of commercial Portland cement shall be used in the exposed concrete of the structure. Cement reclaimed by cleaning bags or from leaking containers shall not be used.

2.2 CONCRETE AGGREGATES

A. Fine aggregate shall be sand having clean, hard, durable, uncoated grains and free from deleterious substances and shall conform to ASTM C33.

B. Coarse aggregate shall be crushed stone having clean, hard, durable, uncoated particles conforming to ASTM C33.

2.3 WATER

A. Water used in mixing concrete shall be clean, potable and free from deleterious amounts of acids, alkalis or organic materials.

2.4 WATERSTOPS

Where shown on the Contract Documents in expansion joints and construction joints, waterstops shall be polyvinyl chloride (PVC) and shall incorporate a galvanized steel wire along both edges


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which shall be used to secure the waterstop in position, by tying to reinforcement, during concrete placement. The waterstop shall be of the size noted on the Contract Documents. The waterstop shall be equal to Wirestop CR-9380 or Burke. The waterstop shall extend the entire length of the joint and all splices shall be heat welded and tested in accordance with the manufacturer's instructions.

2.5 NON-SHRINK GROUT

Non-shrink grout shall be a ready-to-use non-metallic aggregate product requiring only the addition of water at the jobsite and shall conform to COE CRD-C-621.

2.6 ADMIXTURES

A. Water reducing admixture shall conform to ASTM C494, Type A.

B. Water reducing, retarding admixture shall conform to ASTM C494, Type D.

C. Non-Corrosive, Non-Chloride Accelerator: The admixture shall conform to ASTM C494, Type C.

D. Air entraining admixture shall conform to ASTM C260.

E. High range water reducer (HRWR) shall conform to ASTM C494, Type F or G.

F. Calcium Chloride: Calcium chloride or admixtures containing more than 0.1 percent chloride ions are not permitted.

G. Fly ash shall not be used as admixture.

2.7 CURING AND SEALING COMPOUNDS

A. Curing compound shall be acrylic based, conforming to ASTM C309.

B. Sealing-hardener compound shall conform to ASTM C309.

2.8 BONDING COMPOUNDS

Bonding Compound shall conform to ASTM C881.

**PART 3 – EXECUTION**

3.1 CONCRETE QUALITY

A. All mix designs shall be proportioned in accordance with ACI 211.1. The proportioning shall be based on the requirements of a well-graded high-density plastic and workable mix within the slump range and strengths required. The following class of concrete is required according to VDOT Road and Bridge Specifications, 2007 edition:

| Mix Number | Compressive Strength @ 28 days | Slump Range | Max Average Size |
|---|---|---|---|
| 3 | 4,000 psi | 2-5 inches | 1 inch |

B. Air Content: All concrete shall have an air content of 6½ percent, +/- 1½ percent.

C. Water-Cement Ratio: All concrete shall have a maximum water-cement ratio of 0.45.


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D. Admixture Usage: All concrete shall contain a water reducing admixture or water reducing-retarding admixture, and an air entraining agent. All concrete placed at air temperatures below 50 degrees F shall contain the specified non-corrosive non-chloride accelerator.

3.2 MIX DESIGNS

A. The testing laboratory shall be paid for by the CONTRACTOR.

B. The CONTRACTOR shall submit samples, in adequate quantities for each mix design and verification, of all concrete materials to be used on the project to the designated testing laboratory. The CONTRACTOR shall not use any concrete in this work without acceptance and verification of design mix by the testing laboratory and the approval of the OWNER.

C. The testing laboratory shall make strength tests from trial batches in the laboratory using materials and mix designs proposed for use by the CONTRACTOR. The testing laboratory shall prepare trial batches in accordance with ACI 211.1.

D. The proposed mix design and supporting data must be submitted, in triplicate, to the testing laboratory for their review and comments at least 21 days prior to the expected start of concreting operations. Within 10 days of receiving this information, the testing laboratory will forward two copies of the submittal to the OWNER with their comments. The OWNER will review the submittal and return one copy to the CONTRACTOR with the OWNER's comments.

E. Compression test specimens made to verify the mixes shall be made in accordance with ASTM C192. Aggregates shall be tested in accordance with ASTM C33. All compression test specimens shall be tested in accordance with ASTM C39.

3.3 PLANT MIXING

A. Proportioning Concrete

1. Proportions shall be in compliance with approved design mix for each class of concrete.
2. The mixing plant shall be provided with adequate equipment and facilities for accurate measurement and control of the quantities of material and water used in the concrete.
3. Concrete materials shall be measured by weight except that admixtures shall be measured by volume.

B. Batching

1. The CONTRACTOR shall provide all necessary equipment to accurately determine and control actual amount of materials entering into the concrete mix. Individual ingredients shall be weighed separately for each batch. Accumulative weighing will be allowed if equipment is in working order as determined by the testing laboratory and approved by the OWNER. Accuracy of all weighing devices shall be such that successive quantities can be measured to within one (1) percent of the desired amount.
2. Completely discharge contents of the mixer before each new batch is loaded. Use of retempered concrete is not permitted.
3. Ready-mixed concrete shall be mixed and delivered in accordance with requirements of ASTM C94 and to the following:

    a. A separate water metering device (not truck tank) shall be used for measuring water added to the original batch.
    b. Use of wash water as a portion of the mixing water is not permitted. Wash water added to empty drums after discharging shall be dumped before a new batch is received.


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c. Centrally mixed concrete shall be mixed for the length of time specified herein, not "shrink-mixed".
d. Mixing drums shall be watertight.
e. Concrete shall be discharged within 1-1/2 hours from the time concrete was mixed, if centrally mixed, or from time the original water was added, if transit-mixed.
f. Furnish delivery ticket with each load of concrete delivered under these Specifications. Delivery ticket shall show clearly the class and strength of concrete, size of coarse aggregate, water per cubic yard, the slump ordered, quantities of all admixtures, and the date and time of departure from the batching plant.

3.4 CONVEYING EQUIPMENT

A. If concrete is to be transported in carts or buggies, the carts or buggies shall be equipped with pneumatic tires.

B. Equipment for chuting or other methods of conveying concrete shall be of such size and design as to insure a practically continuous flow of concrete at delivery without segregation of materials.

3.5 CONVEYING

A. Concrete shall be conveyed from mixer to place of final deposit by methods which will prevent separation or loss of the material.

B. Runway supports shall not bear upon reinforcing steel or fresh concrete.

C. All conveying equipment shall be thoroughly cleaned before each run of concrete is begun.

3.6 DELIVERY AND PROTECTION OF MATERIALS

A. Deliver ready-mixed concrete in compliance with requirements set forth in ASTM C94.

3.7 SEVERE-WEATHER PROVISIONS

A. Hot-Weather Concreting

1. Provide adequate methods of lowering temperature of concrete ingredients so that the temperature of concrete when placed does not exceed 90 degrees F.
2. When the weather is such as to raise concrete temperature, as placed, consistently above 90 degrees F, Pozzolith retarder shall be used.
3. Subgrade and forms shall be wetted with water before placing of concrete. All excess water shall be removed before concrete is placed.
4. Curing shall start as soon as practicable to prevent evaporation of water. Flat work shall be protected from dry winds, direct sun and high temperatures.

B. Cold-Weather Concreting

1. Provide adequate equipment for heating concrete materials and protecting concrete during freezing or near-freezing weather. No frozen materials, or materials containing ice, shall be used.
2. All concrete materials and all reinforcement, forms, fillers and ground with which concrete is to come into contact shall be free from frost.
3. Whenever the temperature of the surrounding air is below 40 degrees F and falling, all concrete placed in the forms shall have a temperature of between 70 and 80 degrees F, and adequate means shall be provided for maintaining a temperature of not less than 70 degrees F for three days, or 50 degrees F for five days, or for as much more time as is necessary to insure proper curing of the concrete. If high


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early strength concrete is used, the requirement for maintenance of 50 degrees F can be reduced to three days.

4. Use only the specified non-chloride accelerator. Calcium chloride or admixtures containing more than 0.1 percent chloride ions are not permitted.
5. Housing, covering or other protection used in connection with curing shall remain in place and intact at least 24 hours after the artificial heat is discontinued.

## 3.8 CONSTRUCTION JOINTS AND EXPANSION JOINTS

A. Construction Joints: Early in the construction program, the CONTRACTOR shall review with the OWNER any construction joints proposed for use which are not indicated on the Contract Documents. The CONTRACTOR shall not use any construction joints which are not approved by the OWNER. In all cases, construction joints shall occur at sections of minimum shear. Where construction joint is to be made, surface of the concrete shall be roughened (construction joints detailed with key ways in slabs and walls, are not required to be roughened) and thoroughly cleaned of foreign matter and laitance. In addition to the foregoing, joints shall be dampened with water and the specified bonding compound applied, or a slush coat of neat cement grout shall be applied. Additional construction joints that are requested by the CONTRACTOR and approved by the OWNER shall be of the type shown and/or noted on the Contract Documents for the specific element(s) being considered (i.e., wall slabs, etc.).

## 3.9 WATERSTOPS

A. Waterstops shall be installed as indicated and noted on Contract Documents.

## 3.10 INSPECTION OF WORK BEFORE PLACING

A. The CONTRACTOR shall inspect the forms to receive concrete for any deficiencies which would prevent proper placing of concrete. Do not proceed with placing concrete until such deficiencies are corrected.

B. Give the Owner's Representative at least 48 hours notice before any concrete is to be cast. Concrete shall not be cast until the OWNER has observed and given approval of the work to be cast including, but not limited to, the placement of all the reinforcing, accessories, forms and the surfaces to be cast against. Such observations are in the nature of assisting the CONTRACTOR to minimize errors and in no case will they serve to relieve the CONTRACTOR of the responsibility to provide the materials and workmanship required by the Contract Documents.

C. Do not place concrete on earth until the fill or excavation has been prepared as set forth under applicable Sections of the Specifications for that work.

D. The CONTRACTOR shall not place in the concrete any item that is not authorized to be placed by the Contract Documents and Specifications. The CONTRACTOR shall insert all the items as required by the other trades and properly position and secure them in their intended location. Openings other than those which are facilitated by sleeves shall be properly formed and positioned as required by the other trades.

E. Do not place concrete in forms until all foreign matter has been removed from forms and the reinforcing steel is in proper condition for placement of concrete.

F. Remove hardened, or partially hardened, concrete on forms or reinforcement before placing concrete.


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3.11 PLACING

A. Deposit concrete as nearly as practicable in its final position to avoid segregation due to rehandling or flowing. Do not deposit concrete on work that has partially hardened or been contaminated by foreign material, and do not use retempered concrete.

B. Concrete shall be placed to avoid the displacement of reinforcing, and coating or spattering the reinforcing steel. The placing of concrete within form work shall be regulated so that the pressure within form work does not exceed the design pressure. In placing concrete each layer shall be placed following the preceding layer to prevent lines of separation or "cold joints" in the work. After the concrete reaches its initial set, jarring the formwork or placing strain or vibration on the ends of projecting reinforcing bars shall be carefully avoided.

C. Once concreting is started, it shall be carried on as a continuous operation until placing of the concrete between construction joints is completed. The top surface will be finished to the required alignment.

D. Concrete shall be placed in layers not over 12 inches deep and each layer shall be compacted with the aid of mechanical internal-vibrating equipment supplemented by hand spading. Vibrators shall in no case be used to transport concrete. Use of form vibrators will not be permitted. Internal vibrators shall maintain a speed of not less than 5,000 impulses per minute when submerged in the concrete. At least one spare vibrator shall be maintained as a relief. Provide backup power source. Duration of vibrator use shall be limited to that necessary to produce satisfactory consolidation without causing objectionable segregation. Vibrator shall not be lowered into courses that have begun to set. Apply vibrator at uniformly spaced points not further apart than the visible effectiveness of the machine.

E. Type and use of vibrators shall be in accordance with ACI 301.

3.12 PROTECTION

A. Protect freshly placed concrete from damage or injury due to water, falling objects, persons or anything that may mar or injure finish surface on concrete. Only light use of any floors shall be permitted for the first seven days after placing of concrete.

3.13 CURING

A. All Concrete. After placement and finishing, concrete shall be maintained in a moist condition for at least seven successive days during which the temperature of the concrete is 50 degrees F or above. For temperatures of 50 degrees F and below, curing period shall be 14 successive days.

Concrete shall be kept moist by any one, or combination, of the following methods:

1. Ponding or Immersion. Continually immerse the concrete in water throughout the curing period. Lowest temperature water shall not be more than 20 degrees F colder than the temperature of the concrete.
2. Fog Spraying or Sprinkling. Provide uniform and continuous application of water throughout the curing period.
3. Impervious Sheeting. Wet the entire exposed surface of the concrete thoroughly with a fine spray of water and cover with impervious sheeting throughout the curing period. Lay sheeting directly on the concrete surface and overlap edges 12 inches minimum. Provide sheeting not less than 18 inches wider than the concrete surface to be cured. Secure edges and transverse laps to form closed joints. Repair torn or damaged sheeting or provide new sheeting. Inspect surface of concrete daily for wetness. The surface shall be kept continuously wet during the curing period.


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B. Concrete in Formed Surfaces. Keep forms and exposed surfaces wet with water during the curing period. If forms are removed before the end of the curing period, apply a curing compound within one hour after form removal.

## 3.14 PATCHING

A. Any concrete which is not formed as shown on the Contract Documents, or for any reason is out of alignment or level or shows a defective surface, or shows defects which reduce the structural adequacy of a member or members, as determined by the Owner's Representative, shall be considered as not conforming with these Specifications and shall be removed from the project by the CONTRACTOR at CONTRACTOR's own expense, unless the Owner's Representative grants permission to patch the defective area, which shall be done in accordance with the following procedure:

1. Permission to patch any such area shall not be considered a waiver of the Owner's Representative right to require complete removal of the defective work if the patching does not, in the Owner's Representative's opinion, satisfactorily restore the quality and appearance of the surface or the structural adequacy of the member or members.

B. After removing the forms, all concrete surfaces shall be inspected and any joints, voids, stone pockets or defective areas permitted by the Owner's Representative to be patched and all tie holes, shall be patched. Defective areas shall be chipped away to a depth not less than one inch with the edges perpendicular to the surface. Remove defective areas to sound concrete with clean, square cuts. Dampen concrete surfaces to be in contact with patching concrete and apply the specified bonding compound. Place patching concrete over the bonding compound as specified by the manufacturer. Place, compact and finish to blend with adjacent finished concrete. Cure in the same manner as adjacent concrete. Before patching mix is applied, the prepared surface shall first be approved by the Owner's Representative.

C. Patching concrete mix (or mortar) shall be subject to the approval of the Owner's Representative. The patching concrete shall be compacted into place and screeded off so as to leave the patch higher than the surrounding surface. It shall then be left undisturbed for a period of one to two (2) hours to permit initial shrinkage before being finished. The patch shall be finished to match the adjoining surface. All patches shall be cured as specified for the original concrete.

D. Tie holes left by withdrawal of rods or the holes left by removal of ends of wall ties shall be filled solid with mortar after first being wetted. For holes passing through the wall, a plunger-type grout gun shall be used to force the mortar through the wall starting at the back face. A piece of burlap or canvas shall be held over the hole on the outside and when the hole is filled, the excess mortar shall be struck off with the cloth flush with the surface. Holes not passing through the walls shall be filled with a small tool that will permit packing the hole solid with mortar. Any excess mortar at the surface of the wall shall be struck off flush with a cloth.

## 3.15 FINISHES ON FORMED SURFACES

Upon completion of patching, surfaces of concrete shall be finished as follows:

A. Rubbed stone finish shall be produced by casting concrete against plywood forms and by rubbing the surfaces with carborundum stone and water, after patching of tie holes and depressions, to a true, even and smooth finish of uniform color and texture. No slush coat of cement grout or cement wash will be permitted at any state of the finishing.

B. Areas to be rubbed shall be finished as soon as forms can be stripped. Strip only those forms on areas which can be finished in the same day as the forms are stripped.


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C. Common finish shall be produced by filling all tie holes, honeycomb and depressions, and knocking off and evening up burrs and form marks. All concrete surfaces not receiving a stone-rubbed or rough finish shall receive a common finish.

D. Rough finish shall be produced by filling all tie holes and honeycomb and in other respects leaving the surface as formed. All concrete surfaces which will be covered by earth and which will not be visible in the completed structure, shall receive a rough finish.

## 3.16 TESTING LABORATORY

A. The testing laboratory shall be paid by the OWNER. The laboratory shall have access to all places where concrete materials and concretes are manufactured, stored, proportioned, mixed, placed and tested. Duties shall include, but not necessarily be limited to the following:

1. Make, store, transport, cure and test compression specimens made during placing of concrete. Compression test specimens shall be tested in accordance with ASTM C39. Test reports shall show all pertinent data, such as class of concrete, exact location of pour, air temperature, date of pour, time of pour, truck number for ready-mixed concrete, date on which specimen was broken, age of specimen, compressive strength of specimen, slump test results, and air content of pour from which the specimen was made. One copy each of all tests shall be sent to the CONTRACTOR and two copies each to the Owner's Representative.
2. For each class of concrete, take five standard test cylinders from each 100 cubic yards or fraction thereof of concrete placed, not less than five cylinders for each 5,000 square feet of surface area placed in any single day. Two of these cylinders shall be designated for the 28-day test and shall comprise a test under the definition of these Specifications. One cylinder will be broken at seven days and will be used as an aid in determining the early strength of the concrete and the 28-day strength, and two cylinders retained in reserve for later testing if required.
3. Periodically inspect the batching plant and file a report with the OWNER stating whether the supplier's equipment and methods meet the requirements of these Specifications.

B. Temperature and Placing Record. Temperature record shall be made each day during the concreting operations. Records shall also include location, quantity and starting and finishing time of placement for all concrete work. Copy distribution shall be as specified above for test reports.

## 3.17 EVALUATION OF COMPRESSION TESTS

A. Evaluation of compression test results shall be as follows:

For each class of concrete, compression-strength tests for laboratory-cured cylinders shall be considered satisfactory if the averages of the results of all sets of three (3) consecutive compression-strength tests equal or exceed the 28-day design compression-strength specified; and, no individual cylinder strength test falls below the required compression strength by more than 500 psi. Strength tests of specimens cured under field conditions may be required by the Owner's Representative to check the adequacy of curing and protecting of the concrete placed. Specimens shall be molded by the field quality-control laboratory at the same time and from the same samples as the laboratory-cured specimens.

B. Faulty Concrete: Failure to meet any of the specified conditions constitutes faulty concrete. Unless otherwise directed by the Owner's Representative, faulty concrete shall be removed and replaced with concrete as specified, at no expense to the Owner's Representative.

C. Additional Testing: If permitted by the Owner's Representative, additional testing shall be subject to the approval of the Owner's Representative and at no expense to the Owner's


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Representative. Load test, if permitted by the Owner's Representative, shall be conducted in accordance with the loading criteria as required by the design of the structure, as determined by the Owner's Representative.

D. Neither the results of laboratory verification tests nor any provision in the Contract Documents shall relieve the CONTRACTOR of the obligation to furnish concrete of the class and strength specified.

*** * * * * END OF SECTION * * * * ***


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# SECTION 03340

# CONCRETE MANHOLES/DROP BOXES/VAULS

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. CONTRACTOR shall furnish all materials, labor, tools, and appurtenances required to complete the precast concrete manholes, concrete valve boxes, and concrete vaults as described herein and/or shown on the Contract Documents.

B. CONTRACTOR shall comply with applicable codes, ordinances, rules, regulations and laws of local, municipal, state, or federal authorities having jurisdiction.

1.2 RELATED SECTIONS

A. Section 03100 – Concrete Formwork

B. Section 03200 – Concrete Reinforcement

C. Section 03300 – Cast-in-Place Concrete

D. Section 02233 – Aggregate

1.3 SUBMITTALS

A. CONTRACTOR shall submit to OWNER shop drawings and engineering data on frames, covers, grates, steps, and precast manholes/drop boxes/vaults sections.

B. CONTRACTOR shall submit to OWNER standard (typical) details showing joints and seals between precast manhole/drop box/vault riser sections and showing joints between pipes and manholes/drop box/vault walls.

1.4 QUALITY ASSURANCE

A. Prior to delivery, all basic materials specified herein shall be tested and inspected by an approved independent commercial testing laboratory or, if approved by OWNER, certified copies of test reports prepared by the manufacturer's testing laboratory will be acceptable. All materials which fail to conform to these Specifications shall be rejected.

B. After delivery to the Site, any materials, which have been damaged in transit or are otherwise unsuitable for use in the Work shall be rejected and removed from the Site, at no additional cost to OWNER.

## PART 2– PRODUCTS

2.1 DESIGN REQUIREMENTS

A. Manholes/drop boxes/vaults shall be constructed of specified materials to the sizes, shapes, and dimensions and at the locations shown on the Contract Documents or as otherwise directed by OWNER. The height or depth of manholes/drop boxes/vaults will vary with the location. The top and bottom elevations of manholes/drop boxes/vaults shall be as shown on the Contract Documents.

2.2 MATERIALS AND CONSTRUCTION

A. Concrete and Reinforcement


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1. Concrete used in manhole, drop box, vault construction shall be 4,000 psi concrete conforming to the requirements of Section 03300 - Cast In Place Concrete of these Specifications.
2. Steel reinforcement shall be epoxy coated and conform to the requirements of Section 03200 - Concrete Reinforcement of these Specifications.

B. Precast Concrete Manholes

1. Precast concrete manholes shall consist of precast reinforced concrete sections, a conical or flat slab top section, and a base slab section conforming to the typical manhole details as shown on the Contract Documents
2. Precast manhole sections shall be manufactured, tested, and marked in accordance with the latest provisions of ASTM C 478.
3. The minimum 28-day compressive strength of the concrete for all sections shall be 4,000 psi.
4. The maximum allowable absorption of the concrete shall not exceed eight percent of the dry weight.

C. Frames, Covers, Attachments, and Steps:

1. Frames and covers shall be cast iron conforming to the minimum requirements of Federal Specifications WW0I 652 or to ASTM A 48 for Class 30 Gray Iron Castings. All castings shall be made accurately to the required dimensions, fully interchangeable, sound, smooth, clean, and free from blisters and/or other defects. Defective castings which have been plugged or otherwise treated shall not be used. All castings shall be thoroughly cleaned and painted or coated with a bituminous paint. Each casting shall have its actual weight in pounds stenciled or painted on it in white paint.
2. Manhole access hatches/doors shall be cast-in-place in concrete top unit and shall be of type and dimension indicated on the Contract Documents
3. Interior concrete anchors, embedment plates, and fall protection system connection eyes shall be stainless steel with stainless steel hardware.
4. The contact surfaces of all manhole covers and hatches and the corresponding supporting frames shall be machined to provide full perimeter contact.
5. Interior manhole steps shall be stainless steel or Epoxy coated and conform to the applicable provisions of ASTM Standard Specification Serial Designation C478.

D. Precast Concrete Drop Boxes and Vaults:

1. Precast concrete drop boxes shall consist of precast reinforced concrete sections, flat slab top section, and a base slab section conforming to the typical drop box details as shown on the Contract Documents
2. Precast drop box sections shall be manufactured, tested, and marked in accordance with the latest provisions of ASTM C 478.
3. The minimum 28-day compressive strength of the concrete for all sections shall be 4,000 psi.
4. The maximum allowable absorption of the concrete shall not exceed eight percent of the dry weight.
5. The reinforcement in the wall sections, top section, and base section shall consist of one line of steel and shall not be less than 0.17 square inch per lineal foot.
6. Each section of the precast drop box shall have not more than two holes for the purpose of handling and laying. These holes shall be tapered and shall be plugged with rubber stoppers or mortar after installation.
7. Joints of the drop box sections, if any, shall be of the tongue and groove type. Sections shall be joined using O-ring rubber gaskets conforming to the applicable provisions of ASTM C443, latest revision, or filled with an approved preformed


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plastic gasket meeting the requirements of Federal Specifications SS-S-00210, "Sealing Compound", Preformed Plastic for Pipe Joints", Type 1, Rope Form.

## PART 3 – EXECUTION

3.1 PLACEMENT OF PRECAST CONCRETE MANHOLES

A. Prior to placing precast manholes, a minimum 9-inch-thick layer of coarse aggregate shall be placed as bedding. After approval of bedding by OWNER, manholes shall be placed and inverts/bottom elevations established and verified.

B. After placing manhole base, inverts shall be constructed using 4,000 psi concrete in accordance with details on the Contract Documents and inverts shall have the same cross section as the invert of the culverts which they connect. The manhole invert shall be carefully formed to the required size and grade by gradual and even changes in sections.

C. After the base section has been set, and inverts formed, the precast manhole sections shall be placed thereon, care being exercised to form the incoming and outgoing pipes into the wall of the manhole at the required elevations.

D. The top unit with cast-in-place access hatch/door for the manhole shall be set at the required elevation and properly anchored to the masonry. Where manholes are constructed in paved areas, the top surface of the frame and cover shall be tilted to conform to the exact slope, crown, and grade of the existing adjacent pavement.

3.2 PLACEMENT OF PRECAST CONCRETE DROP BOXES AND VAULTS

A. Prior to placing precast concrete drop boxes and vaults, a minimum 9-inch-thick layer of coarse aggregate shall be placed as a level bedding for the drop box.

B. After approval of bedding by OWNER, drop boxes and vaults shall be placed, and their inverts shall be established and verified.

C. Covers, grates, hatches as indicated on the Contract Documents shall be set at the required elevation and properly anchored to the drop box, as shown on the Contract Documents.

*** * * * * END OF SECTION * * * * ***


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# SECTION 03350

# CONCRETE FINISHES

## PART 1 – GENERAL

1.1 THE REQUIREMENT

A. Furnish all materials, labor, and equipment required to provide finishes of all concrete surfaces specified herein and shown on the Contract Documents.

1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03200 - Concrete Reinforcement

C. Section 03250 - Concrete Accessories

D. Section 03290 - Joints in Concrete

E. Section 03291 - Joint Fillers, Sealants, and Caulking

F. Section 03300 - Cast-in-Place Concrete

G. Section 03370 - Concrete Curing

1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

A. American Concrete Institute (ACI) Publications:

1. ACI 301 Specifications for Structural Concrete for Buildings
2. ACI 318 Building Code Requirements for Structural Concrete

1.4 SUBMITTALS

A. Submit the following in accordance with Section 01300 - Submittals.

1. Manufacturer's literature on all products specified herein.

## PART 2 – PRODUCTS

NOT USED

## PART 3 – EXECUTION

3.1 FINISHES ON FORMED CONCRETE SURFACES

A. After removal of forms, the finishes described below shall be applied in accordance with Paragraph 3.3 - Concrete Finish Schedule. Unless the finish schedule specifies otherwise, all surfaces shall receive at least a Type I finish. The OWNER shall be the sole judge of acceptability of all concrete finish work.

1. Type I - Rough: All fins, burrs, offsets, marks and all other projections left by the forms shall be removed. Projections, depressions, etc. below finished grade required to be removed will only be those greater than ¼-inch. All holes left by removal of ends of ties, and all other holes, depressions, bugholes, air/blow holes


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or voids shall be filled solid with cement grout after first being thoroughly wetted and then struck off flush. The only holes below grade to be filled will be tie holes and any other holes larger than ¼-inch in any dimension. Honeycombs shall be chipped back to solid concrete and repaired as directed by the OWNER OR ENGINEER. All holes shall be filled with tools, such as sponge floats and trowels, that will permit packing the hole solidly with cement grout. Cement grout shall consist of one (1) part cement to three (3) parts sand, epoxy bonding agent (for tie holes only) and the amount of mixing water shall be as little as consistent with the requirements of handling and placing. Color of cement grout shall match the adjacent wall surface.

2. Type II - Grout Cleaned: Where this finish is required, it shall be applied after completion of Type I finish. After the concrete has been predampened, a slurry consisting of one (1) part cement (including an appropriate quantity of white cement in order to produce a color matching the surrounding concrete) and 1-1/2 parts sand passing the No. 16 sieve, by damp loose volume, shall be spread over the surface with clean burlap pads or sponge rubber floats. Mix proportions shall be submitted to the OWNER and ENGINEER after a sample of the work is established and accepted. Any surplus shall be removed by scraping and then rubbing with clean burlap.
3. Type III - Smooth Rubbed: Where this finish is required, it shall be applied after the completion of the Type I finish. No rubbing shall be done before the concrete is thoroughly hardened and the mortar used for patching is firmly set. A smooth, uniform surface shall be obtained by wetting the surface and rubbing it with a carborundum stone to eliminate irregularities. Unless the nature of the irregularities require it, the general surface of the concrete shall not be cut into. Corners and edges shall be slightly rounded by the use of the carborundum stone. Brush finishing or painting with grout or neat cement will not be permitted. A 100 square foot example shall be established at the beginning of the project to establish acceptability.

## 3.2 SLAB AND FLOOR FINISHES

A. The finishes described below shall be applied to floors, slabs, flow channels and top of walls in accordance with Paragraph 3.3 - Concrete Finish Schedule. The OWNER shall be the sole judge of acceptability of all such finish work.

1. Type "A" - Screeded: This finish shall be obtained by placing screeds at frequent intervals and striking off to the surface elevation required. When a Type "F" finish is subsequently to be applied, the surface of the screeded concrete shall be roughened with a stiff brush, jitter bug or rake prior to final set.
2. Type "B" - Wood or Magnesium Floated: This finish shall be obtained after completion of a Type "A" finish by working a previously screeded surface with a wood or magnesium float or until the desired texture is reached. Floating shall begin when the water sheen has disappeared and when the concrete has sufficiently hardened so that a person's foot leaves only a slight imprint. If wet spots occur, water shall be removed with a squeegee. Care shall be taken to prevent the formation of laitance and excess water on the finished surface. All edges shall be edged with an 1/8-inch tool as directed by the OWNER or ENGINEER. The finished surface shall be true, even, and free from blemishes and any other irregularities.
3. Type "C" - Cork Floated: This finish shall be similar to Type "B" but slightly smoother than that obtained with a wood float. It shall be obtained by power or band floating with cork floats.
4. Type "D" - Steel Troweled: This finish shall be obtained after completion of a Type "B" finish. When the concrete has hardened sufficiently to prevent excess fine material from working to the surface, the surface shall be compacted and smoothed with not less than two (2) thorough and complete steel troweling operations. In areas which are to receive a floor covering such as tile, resilient


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flooring, or carpeting, the applicable Specification Sections and Contract Documents shall be reviewed for the required finishes and degree of flatness. In areas that are intermittently wet such as pump rooms, only one (1) troweling operation is required to provide some trowel marks for slip resistance. All edges shall be edged with an 1/8-inch tool as directed by the OWNER or ENGINEER. The finish shall be brought to a smooth, dense surface, free from defects and blemishes.

5. Type "E" - Broom or Belt: This finish shall provide the surface with a transverse scored texture by drawing a broom or burlap belt across the surface immediately after completion of a Type "B" finish. All edges shall be edged with an 1/8-inch tool as directed by the OWNER or ENGINEER.
6. Type "F" - Swept in Grout Topping: This finish shall be applied after a completion of a Type "A" finish. The concrete surface shall be properly cleaned, washed, and coated with a mixture of water and Portland Cement. Cement grout, in accordance with Section 03300 – Cast-in-Place Concrete, shall then be plowed and swept into neat conformance with the blades or arms of the apparatus by turning or rotating the previously positioned mechanical equipment. Special attention shall be paid to true grades, shapes and tolerances as specified by the manufacturer of the equipment. Before beginning this finish, the CONTRACTOR shall notify the OWNER and ENGINEER and the equipment manufacturer of the details of the operation and obtain approval and recommendations.
7. Type "G" - Hardened Finish: Either a liquid hardened finish or an aggregate hardened finish shall be provided at the CONTRACTOR'S option.

    a. Liquid hardened finish shall be provided by application of a liquid floor hardener. Floors to receive this finish shall have previously received a Type "D" finish. Liquid hardener shall be applied between 30 to 60 days after concrete placement. Surface to be treated shall be dry, clean and free of all loose dust, dirt, oil, wax, sealers and curing compounds. Application procedure shall be in accordance with manufacturer's instructions and shall consist of a three-coat treatment.
    b. Aggregate hardened finish shall be provided by applying an aggregate floor hardener concurrently with the application of a Type "D" finish. Application procedure shall be in accordance with manufacturer's instructions.

8. Type "H" - Non-Slip Finish: This finish shall be provided by applying a non-slip shake-on aggregate concurrently with the application of a Type "D" finish. Application procedure shall be in accordance with manufacturer's instructions.

    a. Type "J" - Raked Finish: This finish shall be provided by raking the surface as soon as the condition of the concrete permits by making depressions of ±1/4 inch. shall be given a color selection from the full range of colors offered from the manufacturer.

## 3.3 CONCRETE FINISH SCHEDULE

| Item | Type of Finish |
|---|---|
| Concrete surfaces indicated to receive textured coating (as noted on Contract Documents) | I |
| Inner face of walls of tanks, flow channels, wet wells, perimeter walls, and miscellaneous concrete structures: | |
| From one (1) foot below water surface to bottom of wall | II |
| From top of wall to one(1) foot below water surface | II |
| Exterior concrete walls below grade | I |


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| Item | Type of Finish |
|---|---|
| Exterior exposed concrete walls, ceilings, beams, manholes, hand holes, miscellaneous structures and columns (including top of wall) to one (1) foot below grade. All other exposed concrete surfaces not specified elsewhere | II |
| All interior exposed concrete walls and vertical surfaces | III |
| Interior exposed ceiling, including beams | III |
| **Floors of flow channels (stormwater conveyance ditches)** | **B** |
| All interior finish floors of buildings and structures and walking surfaces which will be continuously or intermittently wet | D |
| All interior finish floors of buildings and structures which are not continuously or intermittently wet | D |
| Floors to receive tile, resilient flooring, or carpeting | D |
| Exterior concrete sidewalks, steps, ramps, decks, slabs on grade and landings exposed to weather | E |
| Floors of process equipment tanks indicated on Contract Documents to receive grout topping | F |
| Garage and storage area floors | G |
| Precast concrete form panels, hollow core planks, double tees | J |

*** * * * * END OF SECTION * * * * ***


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# SECTION 03370

# CONCRETE CURING

## PART 1 – GENERAL

### 1.1 THE REQUIREMENT

A. Protect all freshly deposited concrete from premature drying and from the weather elements. The concrete shall be maintained with minimal moisture loss at a relatively constant temperature for a period of time necessary for the hydration of the cement and proper hardening of the concrete in accordance with the requirements specified herein.

### 1.2 RELATED WORK SPECIFIED ELSEWHERE

A. Section 03100 - Concrete Formwork

B. Section 03200 - Concrete Reinforcement

C. Section 03250 - Concrete Accessories

D. Section 03290 - Joints in Concrete

E. Section 03291 - Joint Fillers, Sealants, and Caulking

F. Section 03300 - Cast-in-Place Concrete

G. Section 03350 - Concrete Finishes

### 1.3 REFERENCE SPECIFICATIONS, CODES AND STANDARDS

Without limiting the generality of the other requirements of the specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

A. American Society for Testing and Materials (ASTM) International:

1. ASTM C171 Standard Specifications for Sheet Materials for Curing Concrete
2. ASTM C309 Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete

B. American Concrete Institute (ACI) Publications:

1. ACI 301 Specifications for Structural Concrete for Buildings
2. ACI 304 Guide for Measuring, Mixing, Transporting, and Placing Concrete
3. ACI 305 Hot Weather Concreting
4. ACI 306 Cold Weather Concreting
5. ACI 308 Standard Practice for Curing Concrete

### 1.4 SUBMITTALS

A. Submit the following in accordance with Section 01300 - Submittals.

1. Proposed procedures for protection of concrete under wet weather placement conditions.
2. Proposed normal procedures for protection and curing of concrete.
3. Proposed special procedures for protection and curing of concrete under hot and cold weather conditions.
4. Proposed method of measuring concrete surface temperature changes.


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5. Manufacturer's literature and material certification for proposed curing compounds.

## PART 2 – PRODUCTS

### 2.1 LIQUID MEMBRANE-FORMING CURING COMPOUND

A. Curing compound shall comply with ASTM C309 Type I, Class B.

B. Minimum solids content of curing compound shall be 30%.

C. Moisture loss from concrete surface receiving compound shall not exceed 0.03 grams per square centimeter when applied at 300 square feet per gallon.

D. The curing compound shall be an emulsion which is freeze-thaw stable and displays a white color that disappears when dry.

E. Curing compound shall be SureCure 30 by Kaufman Products, Inc., CA D.O.T. Acrylic Cure by Symons Corporation, or Sealtight CS-309-30 by W. R. Meadows.

### 2.2 EVAPORATION REDUCER

A. Evaporation reducer shall be Master Builders, "Confilm", or Euclid Chemical "Euco-Bar".

## PART 3 – EXECUTION

### 3.1 PROTECTION AND CURING

A. All freshly placed concrete shall be protected from the elements, flowing water and from defacement of any nature during construction operations.

B. As soon as the concrete has been placed and horizontal top surfaces have received their required finish, provision shall be made for maintaining the concrete in a moist condition for at least a five day period thereafter except for high early strength concrete, for which the period shall be at least the first three days after placement. Horizontal surfaces shall be kept covered, and intermittent, localized drying will not be permitted.

C. Walls that will be exposed on one side with either fluid or earth backfill on the opposite side shall be continuously wet cured for a minimum of five days. Use of a curing compound will not be acceptable for applications of this type.

D. The CONTRACTOR shall use one of the following methods to ensure that the concrete remains in a moist condition for the minimum period stated above.

1. Ponding or continuous fogging or sprinkling.
2. Application of mats or fabric kept continuously wet.
3. Continuous application of steam (under 150°F).
4. Application of sheet materials conforming to ASTM C171.
5. If approved by the OWNER and ENGINEER, application of a curing compound in accordance with Paragraph 3.4.

E. The CONTRACTOR shall keep absorbent wood forms wet until they are removed. After form removal, the concrete shall be cured by one of the methods in paragraph D.

F. Any of the curing procedures used in Paragraph 3.1D may be replaced by one of the other curing procedures listed in Paragraph 3.1D after the concrete is one day old. However, the concrete surface shall not be permitted to become dry at any time.


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## 3.2 CURING CONCRETE UNDER COLD WEATHER CONDITIONS

A. Suitable means shall be provided for a minimum of 72 hours after placing concrete to maintain it at or above the minimum as placed temperatures specified in Section 03300 - Cast-In-Place Concrete, for concrete work in cold weather. During the 72-hour period, the concrete surface shall not be exposed to air more than 20°F above the minimum as placed temperatures.

B. Stripping time for forms and supports shall be increased as necessary to allow for retardation in concrete strength caused by colder temperatures. This retardation is magnified when using concrete made with blended cements or containing fly ash or ground granulated blast furnace slag. Therefore, curing times and stripping times shall be further increased as necessary when using these types of concrete.

C. The methods of protecting the concrete shall be approved by the OWNER and ENGINEER and shall be such as will prevent local drying. Equipment and materials approved for this purpose shall be on the site in sufficient quantity before the work begins. The CONTRACTOR shall assist the ENGINEER by providing holes in the forms and the concrete in which thermometers can be placed to determine the adequacy of heating and protection. All such thermometers shall be furnished by the CONTRACTOR in quantity and type which the OWNER or ENGINEER directs.

D. Curing procedures during cold weather conditions shall conform to the requirements of ACI 306.

## 3.3 CURING CONCRETE UNDER HOT WEATHER CONDITIONS

A. When air temperatures exceed 85°F, the CONTRACTOR shall take extra care in placing and finishing techniques to avoid formation of cold joints and plastic shrinkage cracking. If ordered by the OWNER or ENGINEER, temporary sun shades and/or windbreakers shall be erected to guard against such developments, including generous use of wet burlap coverings and fog sprays to prevent drying out of the exposed concrete surfaces.

B. Immediately after screeding, horizontal surfaces shall receive an application of evaporation reducer. Apply in accordance with manufacturer's instructions. Final finish work shall begin as soon as the mix has stiffened sufficiently to support the workmen.

C. Curing and protection of the concrete shall begin immediately after completion of the finishing operation. Continuous moist-curing consisting of Method 1 or 2 listed in paragraph 3.1D is mandatory for at least the first 24 hours. Method 2 may be used only if the finished surface is not marred or blemished during contact with the coverings.

D. At the end of the initial 24 hour period, curing and protection of the concrete shall continue for at least four additional days using one of the methods listed in Paragraph 3.1D.

E. Curing procedures during hot weather conditions shall conform to the requirements of ACI 305.

## 3.4 USE OF CURING COMPOUND

A. Curing compound shall be used only where specifically approved by the OWNER and ENGINEER. Curing compound shall not be used on surfaces to receive subsequent coatings. Curing compound shall never be used for curing exposed walls with fluid or earth backfill on the opposite side. A continuous wet cure for a minimum of five days is required for these applications. Curing compound shall not be used on surfaces exposed to water in potable water storage tanks and treatment plants unless curing compound is certified in accordance with ANSI/NSF Standard 61.


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B. When permitted, the curing compound shall maintain the concrete in a moist condition for the required time period, and the subsequent appearance of the concrete surface shall not be affected.

C. The compound shall be applied in accordance with the manufacturer's recommendations after water sheen has disappeared from the concrete surface and after finishing operations. The rate of application shall not exceed 300 square feet per gallon. For rough surfaces, apply in two directions at right angles to each other.

## 3.5 EARLY TERMINATION OF CURING

A. Moisture retention measures may be terminated earlier than the specified times only when at least one of the following conditions is met:

1. The strength of the concrete reaches 85 percent of the specified 28-day compressive strength in laboratory-cured cylinders representative of the concrete in place, and the temperature of the in-place concrete has been constantly maintained at 50 degrees Fahrenheit or higher.
2. The strength of concrete reaches the specified 28-day compressive strength as determined by accepted nondestructive methods or laboratory-cured cylinder test results.

*** * * * * END OF SECTION * * * * ***


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# SECTION 03600

# GROUT

## PART 1 – GENERAL

1.1 SUMMARY

A. The CONTRACTOR shall furnish all materials, labor, and equipment required to abandon by grouting conduits and related structures, in accordance with the Contract Documents.

B. Grout shall flow freely to completely fill conduit to be abandoned in a single continuous operation. Construct one or more bulkheads as required, use multiple air vents, and grout injection pipes to minimize trapping air voids within the grouted pipe.

C. Flowable Fill (Controlled Low Strength Material) shall be used for backfill where shown on the Contract Documents. Material and installation shall be in accordance with VDOT requirements.

1.2 REFERENCES

A. Without limiting the generality of the other requirements of the Specifications, all work herein shall conform to the applicable requirements of the following documents. All referenced specifications, codes, and standards refer to the most current issue available at the time of Bid.

1. CRD- C621 Corps of Engineers Specification for Non-shrink Grout
2. Virginia Department of Transportation (VDOT) Road and Bridge Specifications (latest version)
3. American Society for Testing and Materials (ASTM) International:
   a. ASTM C144 Standard Specification for Aggregate for Masonry Mortar
   b. ASTM C150 Standard Specification for Portland Cement
   c. ASTM C109 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2 inch or 50 mm Cube Specimens)
   d. ASTM C494 Standard Specification for Chemical Admixture for Concrete
   e. ASTM C531 Standard Test Method for Linear Shrinkage and Coefficient of Thermal Expansion of Chemical-Resistant Mortars, Grouts, and Monolithic Surfacings, and Polymer Concretes
   f. ASTM C579 Standard Test Methods for Compressive Strength of Chemical-Resistant Mortars, Grouts, Monolithic Surfacings, and Polymer Concretes
   g. ASTM C827 Standard Test Method for Early Volume Change of Cementiitious Mixtures
   h. ASTM C937 Standard Specification for Grout Fluidifier for Preplaced-Aggregate Concrete
   i. ASTM C939 Standard Test Method for Flow of Grout for Preplaced-Aggregate Concrete (Flow Cone Method)
   j. ASTM C1017 Standard Specification for Chemical Admixtures for Use in Producing Flowing Concrete
   k. ASTM C1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Nonshrink)


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1.3 SUBMITTALS

A. CONTRACTOR shall submit the following in accordance with Section 01300 - Submittals.

1. Grouting Work Plan shall be prepared by the CONTRACTOR and submitted to the ENGINEER for review and approval a minimum of 20 days prior to the planned start of grouting operations. The plan shall include detailed descriptions of equipment, procedures, and materials proposed for the Work. The plan shall include grouting schedule; grout mix design including admixtures and manufacturer's recommendations for usage; proposed grout plant with mixer and agitator details; grout pump equipment details including photographs or cut sheets from the plant manufacturer and pump rating curves; power system for the pump, mixer, and agitator; piping and accessory layout diagram; pressure gage, valve, and flowmeter details; proposed grouting pressure and measuring location; and shop drawings for all bulkhead configurations to be used for containing grout pressures at the conduit openings. Include qualifying experience of individual responsible for supervising and directing grouting effort.

   a. At the direction of the ENGINEER, a trial mix shall be completed and tested prior to the start of production grouting.

2. Certified test results verifying the 24-hour and 28-day grout compressive strength, initial set time, and shrinkage and expansion requirements specified herein.

3. Manufacturer's literature containing instructions and recommendations on the mixing, handling, placement, and appropriate uses for each type of grout used in the Work.

1.4 QUALITY ASSURANCE AND QUALITY CONTROL

A. Field tests:

1. Compression test specimens will be taken during trial mix verification or during construction from the first placement of each type of grout and at intervals thereafter as selected by the ENGINEER to ensure continued compliance with these Specifications. The specimens will be taken by the Owner's Representative.

   a. Compression tests and fabrication of specimens for cement grout and non-shrink grout will be performed as specified in ASTM C109 at intervals during construction as selected by the ENGINEER. A set of three (3) specimens will be made for testing at seven (7) days, 28 days, and any additional time period as appropriate.

   b. Compression tests and fabrication of specimens for epoxy grout will be performed as specified in ASTM C579, Method B, at intervals during construction as selected by the ENGINEER. A set of three (3) specimens will be made for testing at seven (7) days and any other time period as appropriate.

2. The cost of all laboratory tests on grout will be borne by the OWNER, but the CONTRACTOR shall assist the Owner's Representative in obtaining specimens for testing. The CONTRACTOR shall be charged for the cost of any additional tests and investigation on work performed which does not meet the Specifications. The CONTRACTOR shall supply all grout materials necessary for fabricating the test specimens, at no additional cost to the OWNER.

3. All grout, already placed, which fails to meet the requirements of these Specifications, is subject to removal and replacement at no additional cost to the OWNER.


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B. Grouting Personnel

1. Grouting Supervisor: Minimum of five (5) years of experience in responsible charge of grouting project similar in nature to that required by these specifications.
2. Other grouting personnel: Minimum of two (2) years of experience in grouting.
3. Maintain sufficient qualified personnel onsite to perform the required work.

## PART 2 – PRODUCTS

2.1 MATERIALS

A. Cement Grout

1. Cement grout shall be composed of Portland cement meeting the requirements of ASTM C150, Type II and potable water with approved admixtures to enhance or control flowability, water use, or shrinkage in the proportion specified in the Contract Documents and the minimum amount of water necessary to obtain the desired consistency and minimize settlement and formation of bleed water. Water amount shall be as required to achieve desired consistency without compromising strength requirements.

2. The minimum compressive strength at 28 days shall be 2,000 psi.

3. Grout shrinkage shall be limited to 0.5-percent by in-place volume at 28 days. Use of a grout fluidifier meeting the requirements of ASTM C937 with shrinkage compensating characteristics is required. Use Intrusion-Aid type FG+ or Intrusion-Aid type R for neat cement grouts manufactured by Specrete-IPP, 10703 Quebec Ave., Cleveland, OH 44106, or approved equal.

4. No fly ash shall be used in grout mix.

5. Water cement ratio: grout mix shall have a water/cement ratio of 0.5 to 0.6 by weight (about 0.7 to 0.9 by volume), subject to approval by the ENGINEER.

B. Non-Shrink Grout

1. Non-shrink grout shall conform to CRD- C621 and ASTM C1107, Grade B or C when tested at a maximum fluid consistency of 30 seconds per CDC 611/ASTM C939 at temperature extremes of 45°F and 90°F and an extended working time of 15 minutes. Grout shall have a minimum 28- day strength of 7,000 psi. Non-shrink grout shall be "Euco N-S" by the Euclid Chemical Company, "Sikagrout 212" by Sika Corporation, or Conspec 100 Non-Shrink Non-Metallic Grout by Conspec.

C. Epoxy Grout

1. Epoxy grout shall be “Sikadur 32 Hi-Mod” by Sika Corporation, “Duralcrete LV” by Tamms Industries, or “Euco #452” by Euclid Chemical.

2. Epoxy Adhesive shall be Hilti HIT-HY200 Adhesive or approved equal.

3. Epoxy grout shall be modified as required for each particular application with aggregate per manufacturer's instructions.

D. Flowable Fill

1. The Contractor shall provide the appropriate mix design for the flowable backfill application. Flowable fill for pipe backfill applications where shown on the Contract Documents shall have a design compressive strength of 150 to 200 pounds per square inch. Flowable fill for anchor trench backfill applications as


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shown on the Contract Documents shall have design compressive strength of 80 to 100 pounds per square inch.

E. Pipe

1. Grout pipes and vent pipes: PVC pipe conforming to ASTM D1785, Schedule 40, 1.5-inch diameter with solvent welded coupler connections.
2. Tees, connectors, and other fittings: As recommended and supplied by pipe manufacturer.

F. Bulkhead

1. The downstream bulkhead shall be cast-in-place concrete or shall be formed by dry packing quick set non-shrink grout in the end of the pipe around the grout and vent pipes as approved by the ENGINEER.

2.2 ADMIXTURES

A. Other admixtures shall be required at the ENGINEER's discretion or, if not required, may be added upon approval of the ENGINEER at the CONTRACTOR's option to control the set, effect water reduction, and increase workability. Admixtures permitted shall conform to the requirements of ASTM C494. Admixtures shall be non-toxic after 30 days and shall be compatible with and made by the same manufacturer as other admixtures. Use all admixtures in strict accordance with manufacturer's recommendations.

B. Admixtures shall be identified in the Grouting Work Plan and approved by the ENGINEER. Admixtures proposed by the CONTRACTOR shall be included in a trial mix where directed by the ENGINEER. Upon approval of the CONTRACTOR's trial mix and Grouting Work Plan, admixtures shall be included in the Grout mix in accordance with manufacturer's recommendations.

C. Set controlling admixture shall be either with or without water-reducing properties. Where the air temperature at the time of placement is expected to be consistently over 90°F, a water-reducing retarder may be used. Where the air temperature at the time of placement is expected to be consistently less than 40°F., a non-corrosive, non-chloride accelerator may be used.

D. Low range water reducing admixture shall be in conformance with ASTM C494 Type A or D. The admixtures shall be used in strict accordance with manufacturer's recommendations.

E. High range water reducer shall conform to ASTM C494, Type A or Type F. The high range water-reducing admixture shall be accurately measured and pressure injected into the mixer as a single dose by an experienced technician. Grout shall be mixed at mixing speed for a minimum of 100 mixer revolutions after the addition of the high range water reducer.

F. Admixtures containing calcium chloride, thiocyanate or more than 0.05 percent chloride ions are not permitted. The addition of admixtures to prevent freezing is not permitted.

1. The CONTRACTOR shall submit manufacturer's data including the chloride ion content of each admixture and certification from the admixture manufacturer that all admixtures utilized in the design mix are compatible with one another and properly proportioned prior to mix design review by the ENGINEER.

2.3 GROUT PLANT AND EQUIPMENT

A. Mixing Plant:

1. A minimum of two (2) mixing plants is required.


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2. Furnish suitable equipment for mixing and placing grout including circulating lines and fittings.

3. Equipment shall be capable of effectively mixing and stirring the grout and forcing it into the grout pipes in a continuous, uninterrupted flow at the specified pressure.

4. System shall supply adequate quantity of water to the mixer at all times to provide the required pumping rate.

5. Cylindrical mixing tank:

    a. Mounted vertically.

    b. Volume: 17 cubic feet minimum.

    c. High-speed colloidal type.

    d. Equipped with high-speed, diffuser-type centrifugal mixing pump operating at 1,500 to 2,000 revolutions per minute during mixing.

    e. Furnish with water meter:

        1) Meter shall be capable of reading cubic feet to tenths of a cubic foot for controlling amount of mixing water used in grout.

        2) Meter shall be capable of being reset to zero.

        3) Calibrate meter in presence of ENGINEER at times directed by the ENGINEER.

            a) When calibration is off, calibrate before continuing to grout.

            b) Calibration equipment and supplies: Furnish adequate water supply, calibrated container capable of holding 55 gallons of water, and scales to weigh water container.

            c) Keep calibration equipment and supplies on site for duration of grouting operations.

            d) Immediately replace defective water meters.

            e) Demonstrate testing and calibration procedures to Engineer, for approval, prior to grouting startup.

            f) Keep at jobsite one (1) extra calibrated and working water meter for immediate replacement of defective units.

    f. Direct return flow from centrifugal mixing pump tangentially into cylindrical tank near the top to create a vortex.

6. Provide a holdover mechanical agitator tank similar in volume to the mixer.

7. Use configuration of agitator tub as shown on the Contract Documents.

8. Pass grout through a U.S. Standard No. 16 screen as it is discharged from the mixer to the agitator. Grout mixed offsite shall also be discharged through screen into agitator tank before pumping into circulating lines.


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a. Locate screen so that flows from return line of circulating grout system shall be passed over the screen.

b. Keep screen clean and free of grout scale and buildup.

c. Make screen readily accessible for cleaning and replacement.

9. ENGINEER has right to require changes to be made in the equipment which ENGINEER determines necessary to make equipment perform satisfactorily during grouting operations.

B. Communication Facilities:

1. Provide radio communication from grout plant to grout manifold.

a. Furnish four (4) units with two (2) chargers and two (2) spare batteries or as otherwise approved by the ENGINEER.

C. Grout Pump:

1. Helical-screw, progressive cavity rotor-type pumps that produce a uniform flow without pulsation.

a. Variable speed.

b. Pump minimum capacity of 35 gallons per minute at pressure of 150 pounds per square inch.

c. Power units for grout pumps shall have variable speed capabilities.

d. Grout pumps with open-throat design including holding hoppers will not be allowed.

2. Include one (1) standby grout pump, capable of being placed in operation with no more than 15-minute notice.

3. Maintain grouting equipment in a manner satisfactory to ENGINEER so it is capable of continuous and efficient performance during any grouting operation.

4. Arrange grouting equipment to provide a supply line and a return line from the grout pump to the grout hole or the agitator tank.

a. Pass grout through a U.S. Standard No. 16 screen as it is discharged from the return line to the agitator tank.

D. Manifold:

1. Install manifold at collars of grout pipes.

2. Locate manifold in the grout line at the injection pipe to permit continuous circulation, accurate control, and monitoring of grouting pressure, bleeding, and regulation of flow into grout pipes.

3. Manifold shall consist of a system of valves and a pressure gauge.

4. Quick shutoff type steel valves with 6-inch lever handles shall be furnished for the manifold.


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5. Minimum size of supply lines and manifolds including valves and fittings: 1.5-inch inside diameter.

E. Pressure Gauges:

1. Manufactured by Marsh Instrument Co., a unit of General Signal, PO Box 1011, Skokie IL 60076; Ashcroft, 250 East Main Street, Stratford CT 06614-5145; or equal with the following essential characteristics:

   a. Glycerin filled.

   b. Plain case.

   c. Pressure indicated in pounds per square inch.

   d. 2.5-inch diameter minimum dial-face size.

   e. Rating of each pressure gauge not more than three (3) times the pressure rating at which the grout is anticipated to be pumped.

   f. Gauges accurate to no more than two (2) percent error over the full range of gauge.

2. Equip pressure gauges with approved pressure sensors.

   a. Furnish Series 42 pressure sensor, manufactured by Red Valve Co., Inc., Carnegie PA 15106; or equal with the following essential characteristics:

      1) Flow-through type suitable for installation in the manifold in the flow pattern behind pressure control valve and ahead of bleed-off valve in accordance with the approved Grouting Work Plan.

      2) Threaded ends with standard NPT threads.

      3) Capable of measuring pressure for full circumference around sensor sleeve.

3. Check pressure gauges prior to commencement of backfill grouting.

   a. Immediately replace defective gauges or gauges with broken glass faces.

   b. Provide an accurately calibrated, high precision master gauge for checking of the accuracy of gauges used in the grouting operations.

      1) Master Gauge: Calibrated and certified by gauge manufacturer to be accurate to not more than one (1) percent error over the full range of gauge.

   c. Provide accurate and reliable gauge tester and keep at grout plant at all times.

F. Flowmeter:

1. Provide ultrasonic or magnetic flowmeter to measure the flow of grout being pumped into grout manifold.

2. Locate flowmeter between the manifold and the grout pipe.

3. Calibrate flowmeter prior to initiating grouting operations.


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4. Keep calibration material and equipment onsite throughout the job.

5. Immediately replace defective flowmeter.

6. Use grout hose attachments to magnetic flowmeter with standard manufactured quick disconnect couplers of appropriate sizes so grout hoses can be rapidly disconnected.

G. Air Circulation Equipment:

1. Furnish air compressor, supply lines, pressure gauges, fittings, valves, and any other equipment needed to circulate air through the vent pipes and grout pipes during backfill grouting.

2. Method of air circulation: As directed by ENGINEER.

3. Air pressure: As directed by the ENGINEER, not exceeding 10 pounds per square inch.

H. Water Flushing Equipment:

1. Furnish independent water flushing equipment for flushing out unwanted grout, such as blockage or partial grout encapsulation due to an equipment breakdown.

2. Equipment shall be immediately available if the need arises.

3. Equipment shall be capable of developing 35 pounds per square inch pressure.

4. Equipment shall have sufficient flow and duration to flush out unwanted grout.

5. Equipment shall have a different power supply than the grouting equipment.

## PART 3 – EXECUTION

3.1 GENERAL

A. No grout shall be placed prior to approval of the grout mix design and Grouting Work Plan. All formwork, bulkheads, sleeves, piping, openings, ties, etc. shall be in place prior to commencement of grouting operations.

1. The number and length of grout feed pipes and vent pipes shall be accordance with the approved Grouting Work Plan. Recommended length between grout pipe ends is about 40 feet.

2. Staging of grout feed piping shall be in accordance with the approved Grouting Work Plan.

B. Grout mixing and pumping equipment shall be capable of continuously supplying, mixing, and pumping the required quantities of grout and to the specified consistency without interruption due to inadequate batching or mechanical limitations. Backfill grouting shall be completed in one working day without interruptions. The grout mixing system shall be capable of precisely proportioning the mix constituents and blending them into a homogeneous grout of uniform consistency.

1. Batch type mixers may be used subject to provision of an accurate means of proportioning the individual grout constituents. Batch type mixers shall thoroughly and uniformly mix the grout components to be free of lumps or variations in mix


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consistency before discharging into the mixing or holdover tanks on the grout plant. Grout mixed in batch type mixers shall be discharged into the grout plant through a U.S. Standard No. 16 screen before it enters the pump intake.

2. The pump shall be in good operating condition and capable of complete filling of the grout cylinders on each stroke.

3. A remote off-on control for the pump shall be provided at the grout injection point. An accurate system to measure the quantity of grout pumped at any time interval shall be provided. The grout volume measuring system shall be calibrated by the CONTRACTOR each day of pumping at the beginning of work and at any other time that short stroking or a change of the grout pumping rate is suspected.

4. The grout delivery line shall consist of high-pressure flexible hose or a combination of hose and rigid pipeline and be watertight under pressure. All components of the delivery line including coupling clamps shall be in good condition and capable of handling the pumping pressures to be use with a minimum safety factor of two (2). A pressure test of the delivery line to confirm its conformance herewith shall be performed as required by the ENGINEER.

5. Pressure gauges in quantity and type approved by the ENGINEER shall be installed at the grout pump and at the grout header. All gauges shall be accurate and in good working order. They shall be protected from grout intrusion by suitable gauge protectors. Gauges shall have a minimum dial diameter of three (3) inches, and the maximum pressure range shall be not greater than 150% of the anticipated maximum grout pressure. Gauges shall be capable of performing under the pressures and grout consistencies used and shall measure volumes to a tenth (0.1) of a cubic foot, and pressures to five (5) psig. A sufficient number of spare pressure gauges shall be maintained on the job site and any gauge of questionable accuracy shall be promptly replaced.

C. Cleaning of the conduit shall be completed prior to the commencement of grouting operations to remove sediment in the pipe invert or excessive deposits inside the pipe. Video inspection of the entire conduit length to be grouted is required after cleaning to demonstrate cleaning was effective. ENGINEER may require changes to the approved grouting program based on conditions observed in the video inspection.

D. Measures to contain grout and to provide environmental protection shall be in place and approved by the ENGINEER prior to commencement of grouting operations.

E. Grouting equipment shall be staged such that the approved grout mix can be delivered to the conduit at the approved rates and maintained until the conduit is completely grouted in one continuous operation. Grout shall be conveyed as rapidly as practicable to the point of deposit by methods which prevent the separation or loss of the ingredients.

F. Vent piping shall be kept free from grout to allow displacement of trapped air.

G. Circulate low-pressure air through all grout and vent pipes to ensure there are no obstructions in the pipes. Valves on the end of each vent and grout pipe shall be left open until grouting is completed through each pipe.

H. Start grouting at downstream end to discharge grout as close as possible to the bulkhead, working progressively to push grout from the lowest point in the conduit to the highest point. Switch to other grout pipes that discharge further upstream only when first pipe becomes clogged or injection pressure exceeds allowable values. Confirm grout is beyond subsequent discharge points before grouting through them by observing grout exiting through opened valve. Close valves only to prevent loss of grout from outlet conduit. Grouting through multiple pipes at the same time is not allowed.


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I. Maintain grout and vent pipes in correct position and alignment during grouting. Prevent pipes from floating during grouting.

J. Grouting pressures shall not exceed 35-psi. The monitoring location for grouting pressures shall be at the manifold or otherwise in accordance with the approved Grouting Work Plan and approved by the ENGINEER.

K. Remove grout pipes by cutting as close to flush as practicable with bulkhead no sooner than 24 hours after backfill grouting is complete.

L. Spilled grout shall be promptly picked up and moved to an appropriate waste storage area. Hoses, delivery lines, and other items that are not in immediate use shall be neatly stored in a manner that will not impede the ongoing work. All trash, used cement bags, etc. shall be collected and neatly stored for disposal. As soon as a reasonable quantity of such waste material has gathered, it shall be promptly removed from the site at CONTRACTOR expense. Water and waste grout resulting from cleaning of the mixer and/or pump shall be promptly collected and disposed of.

M. Where directed by the ENGINEER, a hold pressure of five (5) psi shall be required until the grout sets to ensure complete filling.

N. Bulkheads, formwork and vent piping shall remain in place until grout has set in accordance with the approved Grouting Work Plan

*** * * * * END OF SECTION * * * * ***


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# SECTION 13200

# LEACHATE TANK

## PART 1 – GENERAL

### 1.1 DESCRIPTION OF WORK

A. Furnish and erect a glass-fused-to-steel bolted leachate storage tank, including foundation, tank structure and tank appurtenances as shown on the submittal drawings and described herein. Leachate tank shall incorporate secondary containment.

B. All required labor, materials and equipment shall be included.

### 1.2 REFERENCES

A. SSPC SP-10 - Surface Preparation Standard – Near-White Metal Blast Cleaning

B. ASTM C633-79 - Standard Test Method for Adhesion or Cohesive Strength of Flame-Sprayed Coatings

C. ISO 28706-1:2008 - Vitreous and Porcelain Enamels -- Determination of Resistance to Chemical Corrosion

D. ISO 2859 – Sampling Procedures for Inspection by Attributes

E. EN 14430:2004 – Vitreous and Porcelain Enamels – High Voltage Test

F. ISO 6370-2 – Vitreous and Porcelain Enamels – Determination of Resistance to Abrasion

### 1.3 QUALIFICATIONS OF TANK SUPPLIER

A. The Engineer's selection of factory applied glass-fused-to-steel bolted tank construction for this facility has been predicated upon specific criteria, construction methods, and an optimum coating for resistance to internal and external tank corrosion. Deviations from the specified design, construction or coating details, will not be permitted.

B. The bidder shall offer a new tank structure as supplied from a manufacturer specializing in the design, fabrication and erection of factory applied glass-fused-to-steel bolted tanks. The manufacturer shall employ a staff of full-time design engineers and shall own and operate its steel fabrication facilities and glass coating facilities.

C. The tank shown on the submittal drawings and specified herein is an Aquastore® Tank as manufactured by CST Storage.

D. Alternate glass-fused-to-steel bolted tank products, as provided by other manufacturers, will be considered for prior approval by the Engineer. If other manufacturers are approved, they must provide a list of 10 glass fused to steel tanks in service for more than 5 years in good working order.

E. Strict adherence to the standards of design, fabrication, erection, product quality, and long-term performance established in this Specification will be required by the Owner and Engineer.

F. Tank suppliers wishing to pre-qualify shall submit the following to the Engineer/Owner for consideration:

1. Typical structure and foundation drawing(s).
2. List of tank materials, appurtenances, and tank coating specifications.


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3. List of 10 glass fused to steel tanks presently in water service designed to AWWA D 103 Standard, of equal or greater size and character specified herein, operating satisfactorily for a minimum of 5 years in leachate storage, including the name and telephone number of Owner and Engineer.

G. Only bids from tank suppliers who have successfully pre-qualified will be considered.

H. The Engineer reserves the right to evaluate all bids based on long term, 50-year minimum operation, coating and maintenance costs. Values to be used in this evaluation will be at the discretion of the Engineer, as detailed in this specification and bid tabulation form. The Engineer will add such costs, dependent upon the type of tank offered, to the bidder's price to determine the effective low bid for purposes of making the award.

1.4 SUBMITTALS

A. Construction shall be governed by the Owner's drawings and specifications showing general dimensions and construction details, after written approval by the Engineer of detailed erection drawings prepared by the tank bidder. There shall be no deviation from the Owner's drawings and specifications, except upon written order from the Engineer.

B. The bidder is required to furnish, for the approval of the Engineer and at no increase in contract price, complete specifications and construction drawings for all work not shown in complete detail on the submittal drawings. Structural calculations shall be provided for the tank structure and foundation. All such submissions shall be stamped by a Licensed Professional Engineer licensed in the state of project location, as well as, designed by a Licensed Professional Engineer employed by the tank manufacturer's engineering staff.

C. When approved, an electronic copy of the submittal information will be returned to the bidder marked "APPROVED FOR CONSTRUCTION" and these drawings will then govern the work detailed thereon. The approval by the Engineer of the tank supplier's drawings shall be an approval relating only to their general conformity with the bidding drawings and specifications and shall not guarantee detail dimensions and quantities, which remains the bidder's responsibility.

D. The tank manufacturer's standard published warranty shall be included with submittal information.

E. The bidder shall include the tank manufacturer's standard Operation and Maintenance Manual upon receipt of approved drawings.

## PART 2 – PRODUCTS

A. TANK

1. The factory coated glass-fused-to-steel bolted primary tank shall have a nominal diameter of approximately 53 feet, with a height of approximately 33 feet. Primary tank shall have an aluminum dome roof.
2. The factory-coated glass-fused-to-steel secondary tank shall be open top with an approximately 69 feet diameter and approximately 19 feet in height.
3. CONTRACTOR may submit alternate tank design and/or manufacturer for review by OWNER and ENGINEER.
4. Tank Capacity:

    a. Tank capacity shall be approximately 500,000 gallons per tank (minimum) (nominal, U.S. gallons) liquid depth, with 1 foot of freeboard.

5. Tank Design Standards:


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a. The materials, design, fabrication and erection of the bolted steel tank shall conform to the AWWA Standard for "Factory-Coated Bolted Steel Tanks" - ANSI/AWWA D103, latest revision.
b. Tank foundation design shall be provided by the manufacturer.
c. The tank coating system shall conform solely to Section 12.4 of ANSI/AWWA D103 latest revision.
d. All materials furnished by the tank manufacturer, which are in contact with the stored liquid shall be certified and listed by the National Sanitation Foundation (NSF) to meet ANSI/NSF Additives Standard No. 61. Certification of a coating type alone will not be sufficient to meet this requirement.

B. PLATES AND SHEETS

1. All steel shall be smelted and produced in the United States of America.
2. Steel plates and sheets used in the construction of the tank shell, tank floor (when supplied) and tank roof, shall comply with the minimum standards of AWWA D103, latest edition.
3. Design requirements for mild strength steel shall be ASTM A1011 Grade 30 with a maximum allowable tensile stress of 14,566 psi.
4. Design requirements for high strength steel shall be ASTM A1011 Grade 50 with a maximum allowable tensile stress of 26,000 psi.
5. The annealing effect created from the glass coated firing process shall be considered in determining ultimate steel strength. In no event shall a yield strength greater than 50,000 psi be utilized for calculations detailed in AWWA D103, Sections 3.4 and 3.5.
6. When multiple vertical bolt line sheets and plates of ASTM A1011 Grade 50 are used, the effective net section area shall not be taken as greater than 85% of the gross area.

C. ROLLED STRUCTURAL SHAPES

1. Material shall conform to minimum standards of ASTM A36 or ASTM A992.

D. HORIZONTAL WIND STIFFENERS

1. Design requirements for intermediate horizontal wind stiffeners shall be of the "web truss" type with an extended tail creating multiple layers of stiffener, permitting wind loads to be distributed around the tank.
2. Web truss stiffeners shall be of steel with hot dipped galvanized coating.
3. Rolled steel angle stiffeners are not permitted for use as intermediate horizontal wind stiffeners.

E. BOLT FASTENERS

1. Bolts used in tank lap joints shall be ½" - 13 UNC- 2A rolled thread, and shall meet the minimum requirements of AWWA D103, Section 2.2.
2. Bolt Material

a. SAE J429 Grade 2 (1inch bolt length)

1) Tensile Strength - 74,000 psi Min.
2) Proof Load - 55,000 psi Min.
3) Allowable shear stress with threads excluded from the shear plane - 18,163 psi Min.

b. SAE J429 Grade 5 (1 ¼ inch bolt length)

1) Tensile Strength - 120,000 psi Min.
2) Proof Load - 85,000 psi Min.


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3) Allowable shear stress with threads excluded from the shear plane – 29,454 psi Min.

c. SAE J429 Grade 8 (>1 ¼ inch bolt length)

1) Tensile Strength - 150,000 psi Min.
2) Proof Load - 120,000 psi Min.
3) Allowable shear stress with threads excluded from the shear plane – 36,818 psi Min.

d. Bolt Finish - Zinc, mechanically deposited.

1) 2.0 mils (0.002 inches) Min. - under bolt head, on shank and threads.

e. Bolt Head Encapsulation

1) High impact polypropylene copolymer encapsulation of entire bolt head up to the splines on the shank.
2) Resin shall be stabilized with an ultraviolet light resistant material such that the color shall appear black.
3) The bolt head encapsulation shall be certified to meet the ANSI/NSF Standard 61 for indirect additives.

f. All bolts on the vertical tank wall shall be installed such that the head portion is located inside the tank, and the washer and nut are on the exterior.

g. All lap joint bolts shall be properly selected such that threaded portions of the bolts will not be exposed to the "shear plane" between tank sheets.

h. Bolt lengths shall be sized to achieve a neat and uniform appearance. Excessive threads extending beyond the nut after torquing will not be permitted.

1) All lap joint bolts shall include a minimum of 4 splines on the underside of the bolt head at the shank in order to resist rotation during torquing.

F. SEALANTS

1. The lap joint sealant shall be a one component, moisture cured, polyurethane compound. The sealant shall be suitable for contact with liquid and shall be certified to meet ANSI/NSF Additives Standard 61 for indirect additives.
2. The sealant shall be used to seal lap joints and bolt connections and edge fillets for sheet notches and starter sheets. The sealant shall cure to a rubber-like consistency, have excellent adhesion to the glass coating, low shrinkage, and be suitable for interior and exterior use.
3. Sealant curing rate at 73°F (23°F ) and 50% RH.

a. Tack-free time: 6 to 8 hours.
b. Final cure time: 10 to 12 days.

4. Neoprene gaskets and tape type sealer shall not be used.

## PART 3 – EXECUTION

3.1 GLASS COATING

A. SURFACE PREPARATION


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1. Sheets shall be steel grit-blasted on both sides to the equivalent of SSPC SP-10 (Near–White Metal Blast Cleaning).
2. The surface anchor pattern shall be not less than 1.0 mil (0.001 inches).

B. SHEET EDGES

1. The process shall be equal in all respects to Edge Coat II by CST Storage. Sealer or glass overspray as edge coating shall not be an acceptable alternative and nozzle spray must be directionally oriented toward the edges to ensure consistency of coverage. Prior to sheet glassing all four (4) edges, including starter sheets, for each specific radii shall be mechanically rounded in profile resulting in an optimized radius to adhere to The Porcelain Enameling Institute's Technical Manual PEI-101. The sheet surface next to the edge must remain flat, post process, to prevent 'bulging" to less than 0.030 inches (.79 mm) relative to the flat while being formed. All (4) exposed sheet edges will then be directionally sprayed by nozzles and coated with the same vitreous enamel glass coating as the sheet surface. Sheet edge encapsulation will have an enamel coating minimum DFT (dry film thickness) of 5 mils (127 microns). Coating adhesion shall be tested in accordance with ISO 28765 Class 2 or better. Rounded sheet edge encapsulation will have zero exposed uncoated steel.

C. CLEANING

1. After fabrication and prior to application of the coating system, all sheets shall be thoroughly cleaned by a caustic wash and hot rinse process followed immediately by hot air drying.
2. Inspection of the sheets shall be made for traces of foreign matter, soil particles, grease or rust.

D. COATING

1. A base coat of glass frit containing nickel oxide shall be applied to both side of the sheet.
2. A second coat of milled cobalt blue glass shall be applied to both sides of the sheets.
3. A third coat of glass shall be applied to all interior sidewall and floor sheet surfaces which must be a titanium dioxide reinforced mixture, white glass. The specified coating shall be Aquastore Vitrium. An acceptable alternate three coat system must be submitted for approval prior to the bid.
4. The same glass coating as applied to the exterior sheet surfaces shall be applied to the exposed edges.
5. The sheets shall then be fired at a minimum temperature of 1500° F (816° C) in strict accordance with the manufacturer's ISO 9001 quality control procedures, including firing time, furnace humidity, temperature control, etc.
6. The interior coating process for sidewall sheets and floor must be a 3 coat process. The interior color shall be white. The exterior color shall be cobalt blue.
7. The dry film interior coating thickness shall be 10.0 to 18.0 mils (0.010 to 0.018 inches) minimum.
8. The dry film exterior coating thickness shall be 7.0 to 15.0 mils (0.007 to 0.015 inches) minimum.

E. FACTORY INSPECTION

1. The manufacturer's quality system shall be ISO 9001 certified and refer to ISO (International Organization for Standardization) for the following testing and procedures.
2. Chemical Resistance of Glass Coating

    a. Frits shall be individually tested in accordance with pertinent sections of ISO 28706-1:2008.


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3. Factory Holiday Test

    a. A dry volt test using a minimum of 1100 volts is required.
    b. Frequency of the test shall be every sheet. Any sheet registering a discontinuity on the interior surface or floor shall be rejected.

4. Measurement of Glass Thickness

    a. Glass thickness shall be measured using an electronic dry film thickness gage (magnetic induction type) approved by CST Storage. The thickness gage shall have a valid calibration record.
    b. The thickness of the glass shall be between 10.0 and 18.0 mils (0.010 and 0.018 inches).

5. Measurement of Color

    a. The exterior color of the sheets shall be measured using a colorimeter approved by CST Storage. The colorimeter shall have a valid calibration record.
    b. The color must fall within the tolerance specified by CST Storage, else the panel shall be rejected.

6. Impact Adherence Test

    a. The adherence of the glass coating to the steel shall be tested in accordance with ISO standards. Any sheet that has poor adherence shall be rejected.

7. Fishscale Test

    a. The glass coating shall be tested in-house for fishscale by placing the full size production sheets in an oven at 400º F (204º C) for one hour. The sheets will then be examined for signs of fishscale. Any sheet exhibiting fishscale shall be rejected and all sheets from that gage lot will be similarly tested.

F. PACKAGING

1. All sheets that pass Factory Inspection and Quality Control checks shall be protected from damage prior to packing for shipment.
2. Heavy paper or plastic foam sheets shall be placed between each panel to eliminate sheet-to-sheet abrasion during shipment.
3. Individual stacks of panels will be wrapped in heavy mil plastic and steel banded to special wood pallets built to maintain the roll-radius of the tank panels and minimize contact or movement of finished panels during shipment.
4. Shipment from the factory will be by truck, hauling the tank components exclusively.

## 3.2 FOUNDATION

A. The tank foundation is a part of this contract and shall be installed by the tank bidder.

B. The tank foundation shall be designed by the manufacturer to safely sustain the structure and its live loads.

C. Tank foundation design shall be based on the soil bearing capacity determined by geotechnical analysis performed by a licensed soils engineer. The cost of this investigation and analysis is not to be included in the bid price. Copies of the soil report are to be provided to the bidder prior to bid date by the Owner or Engineer.


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D. Foundation designs for soil bearing strengths less than that specified, and those designs deviating from tank manufacturers' standard shall be the responsibility of the Owner and his Engineer based on tank live and dead loading data provided by the tank manufacturer.

E. Embedded starter shall be 19" or 25" as determined by manufacturer.

F. Slot Mount concrete footing is not acceptable.

3.3 TANK FLOOR

A. Concrete Floor

1. The floor design is of reinforced concrete with an embedded glass coated steel starter sheet per the manufacturer's design and in accordance with AWWA D103 latest edition, Sec 11.4. Slot Mount style foundation is not acceptable.
2. Leveling of the starter ring shall be required and the maximum differential elevation within the ring shall not exceed 1/8 inch (3 mm) , nor exceed 1/16 inch (2 mm) within any 10 feet (3048 mm) of length.
3. A leveling plate assembly consisting of two anchor rods and a slotted plate shall be used to secure the starter ring, prior to encasement in concrete. Installation of the starter ring on concrete blocks or bricks, using shims for adjustment, is not permitted.
4. Place one butyl rubber elastomer waterstop seal on the inside surface of the starter ring below concrete floor line. Place one bentonite impregnated water seal below the butyl rubber seal. The materials shall be installed in accordance with tank manufacturer's instructions.

3.4 SIDEWALL STRUCTURE

A. Field erection of the glass-coated, bolted-steel tank shall be in strict accordance with the procedures outlined in the manufacturer's erection manual, and performed by an authorized dealer of the tank manufacturer, regularly engaged in erection of these tanks, using factory trained erectors.

B. Specialized erection jacks and building equipment developed and manufactured by the tank manufacturer shall be used to erect the tanks.

C. Particular care shall be taken in handling and bolting of the tank panels, structural members, and appurtenances to avoid abrasion of the coating system. Prior to a liquid test, all surface areas shall be visually inspected by the Engineer.

D. An electrical leak test shall be performed during erection using a wet sponge 9 volt leak detection device. All electrical leak points found on the inside surface shall be repaired in accordance with manufacturer's published touch up procedure.

E. No backfill shall be placed against the tank sidewall without prior written approval of the tank manufacturer. Any backfill allowed shall be placed according to the strict instructions of the tank manufacturer.

3.5 ROOF

A. Tanks with diameters of 14 to 31 feet (4267 to 9449 mm) shall include a radially sectioned roof fabricated from glass - coated, bolted steel panels, as produced by the tank manufacturer, and shall be assembled in a similar manner as the sidewall panels utilizing the same sealant and bolting techniques, to assure a weather tight assembly. The roof shall be clear - span and self-supporting. Both live and dead loads shall be carried by the tank walls. The roof shall be of a rolled knuckle design, with no rolled angle connection between sidewall and roof panels. The manufacturer shall furnish a roof opening which shall be placed near the outside tank ladder and which shall be provided with a hinged cover and a hasp for locking. The opening shall have a clear dimension of at least 24 inches (610 mm) in one


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direction and 15 inches (381 mm) in the other direction. The opening shall have a curb at least 4 inches (102 mm) in height, and the cover shall have a downward overlap of at least 2 inches (51 mm), or a gasketed weather-tight cover in lieu of the 4 inch (102 mm) curb and 2 inch (51 mm) overlap.

B. Roofs for tanks greater than 31 feet (9449 mm) in diameter shall be constructed of non-corrugated triangular aluminum panels which are sealed and firmly clamped in an interlocking manner to a fully triangulated aluminum space truss system of wide flange extrusions, thus forming a dome structure.

1. The dome shall be clear span and designed to be self-supporting from the periphery structure with primary horizontal thrust contained by an integral tension ring.
2. The dome and tank shall be designed to act as an integral unit. The tank shall be designed to support an aluminum dome roof including all specified live loads.
3. Materials:

    a. Triangulated dome frame struts: AA6005A-T6 aluminum.
    b. Structural frame node plates: 0.375 inch (10 mm) nominal thickness, AA6061-T6 aluminum,
    c. Triangular dome panels: 0.050 inch (1 mm) nominal thickness, AA3003-H16 aluminum Sheet.
    d. Triangular skylight panels, (if specified): nominal thickness of ¼ inch (6 mm) thick clear acrylic or polycarbonate.
    e. Perimeter tension/compression ring: AA6005A-T6 aluminum.
    f. Fasteners: AA2024-T4 aluminum or austenitic series 300 stainless steel as required by the manufacturers design.
    g. Sealant: Silicone, conforming to Federal Specification TT-S-00230.
    h. Gaskets: Silicone, conforming to Federal Specification ZZ-R-765, Class 2, Grade 50 or equal, or Neoprene conforming to ASTM C509-00.
    i. Dormers, doors, and hatches: AA6061-T6, AA6005A-T6, AA5086-H34 or AA5052-H36 aluminum, 0.090inch (2 mm) nominal thickness.

C. Roof Vent

1. A properly sized vent assembly in accordance with AWWA D103 shall be furnished and installed above the maximum water level of sufficient capacity so that at maximum design rate of water fill or withdrawal, the resulting interior pressure or vacuum will not exceed ½ inch (13 mm) water column.
2. The overflow pipe shall not be considered to be a tank vent.
3. The vent shall be constructed of aluminum such that the hood can be unbolted and used as a secondary roof access.
4. The vent shall be so designed in construction as to prevent the entrance of birds and/or animals by including an expanded aluminum screen (½ inch [13 mm]) opening. An insect screen of 23 to 25 mesh polyester monofilament shall be provided and designed to open should the screen become plugged by ice formation.

## 3.6 APPURTENANCES

A. Pipe Connections

1. Where pipe connections are shown to pass through tank panels, they shall be field located, saw cut, (acetylene torch cutting or welding is not permitted), and utilize an interior and exterior flange assembly. Tank shell reinforcing shall comply with AWWA D103 latest edition. A single component urethane sealer shall be applied on any cut panel edges or bolt connections.
2. Overflow piping shall be 10 inches diameter schedule 40 PVC, seamless aluminum tubing, or FRP.

B. Outside Tank Ladder


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1. An outside tank ladder shall be furnished and installed as shown on the submittal drawings.
2. Ladders shall be fabricated of aluminum and utilize grooved, skid-resistant rungs.
3. Safety cage and step-off platforms shall be fabricated of galvanized steel. Ladders shall be equipped with a hinged lockable entry device.

C. Access Doors

1. One bottom access door shall be provided as shown on the submittal drawings in accordance with AWWA D103.
2. The manhole opening shall be a minimum of 24 inches (610 mm) in diameter. The access door (shell manhole) and the tank shell reinforcing shall comply with AWWA D103 latest edition, Sec. 5.1.

D. Identification Plate: A manufacturer's nameplate shall list the tank serial number, tank diameter and height, and maximum design capacity. The nameplate shall be affixed to the tank exterior sidewall at a location approximately 5 feet (1524 mm) from grade elevation in a position of unobstructed view.

E. Cathodic Protection

1. A passive cathodic protection system shall be designed and supplied by the tank manufacturer based upon information supplied by the Engineer or Owner.

## 3.7 FIELD TESTING

A. Hydrostatic

1. Following completion of erection and cleaning of the tank, the structure shall be tested for liquid tightness by filling tank to its overflow elevation.
2. Any leaks disclosed by this test shall be corrected by the authorized dealer in accordance with the manufacturer's recommendations.
3. Water required for testing shall be furnished by the Owner at the time of tank erection completion, and at no charge to the tank erector. Disposal of test water shall be the responsibility of the Owner.

    a. Labor and equipment necessary for hydrostatic tank testing is to be included in the price of the tank.

## 3.8 DISINFECTION (NOT REQUIRED)

## 3.9 TANK MANUFACTURER’S WARRANTY

A. The tank manufacturer shall include a warranty for the tank materials and coating. As a minimum, this warranty shall provide assurance against defects in material or workmanship for the period of 1 year and corrosion of the glass coated surface for the period of 1 year.

*** * * * * END OF SECTION * * * * ***


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# SECTION 15240

# SELF-PRIMING CENTRIFUGAL PUMPS

## PART 1 – GENERAL

1.1 WORK INCLUDED

A. This section defines the requirements for performance, design, fabrication, inspection, testing, coating, delivery, installation supervision, start-up supervision, and documentation of self-priming centrifugal pumps for process service.

B. This section is not intended to cover all specific requirements of the equipment design in complete detail. This section is intended to provide minimum acceptable requirements to be met or exceeded and to establish a standard of design and quality.

C. It shall be the CONTRACTOR's responsibility to ensure that all subcontractors of equipment, materials, or services comply with the requirements.

D. The performance requirements for the pumps are detailed in the pump data sheet(s). Equipment supplier and/or CONTRACTOR is to complete the indicated sections on the data sheet(s).

E. Provide each pump unit with all required components and accessories for continuous and reliable operation, including but not limited to the following items:

1. Pump
2. Electric Motor Drive
3. Mechanical Seal
4. V-belt drive
5. Coupling (as applicable)
6. Baseplate/Skid and Soleplates (as applicable), including all lifting lugs required for safe lift of fully assembled pump skid
7. Special features and accessories as specified

1.2 REFERENCES

A. ASME, American Society of Mechanical Engineers

1. ASME B16.5 - Pipe Flanges and Flanged Fittings

B. ASTM, American Society for Testing and Materials

1. ASTM A532 - Standard Specification for Abrasion-Resistant Cast Irons

C. NEMA, National Electrical Manufacturers Association

D. OSHA, Occupational Safety and Health Administration

1.3 SUBMITTALS

A. Submittals shall be provided as specified in Section 01300.

## PART 2 – PRODUCTS

2.1 DESIGN CRITERIA

A. General

1. Each pump shall be heavy-duty, centrifugal, self-priming type pump with a vertical top discharge.


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2. Equipment supplier's standard or usual products and construction of products shall be furnished unless inconsistent with the requirements of this section. If any provision of this section departs sufficiently from the manufacturer's standard or usual construction so as to increase the cost without providing a corresponding increase in quality; or, if the supplier's standard or usual construction would provide better quality than that specified, then this fact shall be brought to the attention of OWNER and ENGINEER.
3. The equipment and all components shall be of proven and dependable design, constructed of high-quality materials (new, of recent manufacture, and unused), and with quality workmanship.
4. Design all wetted parts to handle temperature minimum of 50ºF above maximum operating temperature.
5. All moving parts shall be readily accessible for inspection, lubrication, repair, and when applicable be protected from the flow of conveyed materials. All exposed rotating drive components shall be enclosed with easily removable guards in compliance with OSHA standards.
6. All major heavy components and assemblies shall have lifting lugs or design points for lifting slings for handling and bracing.

B. Operating Requirements

1. Provide each pump rated and designed in accordance with the operating conditions specified on the data sheet(s). The design and selection of all pump components shall be based on the results of laboratory tests or from previous experience of similar applications.
2. Pumps shall provide a flow of 2500 gallons per minute (GPM) at a discharge pressure of 310 feet of total dynamic head when operating with a single pump.
3. For a given pump speed, the total dynamic head (TDH) of the pumps shall be as follows:

    a. Shut-off head shall not be less than 115% of TDH at the design point.
    b. Shut-off head shall not be more than 150% of TDH at the design point.

4. Provide pumps that operate at or near its Best Efficiency Point (BEP) and with a normal capacity operating point that falls within the preferred operating range for centrifugal pumps.
5. Supplier shall identify the minimum operating flow for each pump on the pump data sheet(s).
6. Each pump shall be provided with an impeller that most closely matches the performance requirements specified on the pump data sheet(s).
7. Pump shall be capable of at least a 5% head increase at rated conditions by replacement of the impeller with impeller of larger diameter or different hydraulic design, or an increase in the impeller speed.
8. The net positive suction head required (NPSHR) for each pump at operating point shall be no greater than 50% of net positive suction head available (NPSHA) or 2.0 ft below (whatever is greater). Here, the term NPSHR is equivalent to NPSH3 which refers to the net positive suction head that will cause the total head to be reduced by 3%.
9. Vibration Related Design Criteria

    a. The first critical speed of each pump and motor shall not be within 125% of maximum operating speed.

C. Casing

1. Provide pump with through-bolt construction, split on the vertical centerline or with bolted suction and drive end plates.


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2. Provide a pump casing design that allows for disassembly and removal of pump internals, rotor, and seal with the pump in place.

D. Impeller

1. Provide an impeller with repelling vanes as a standard.
2. If impeller-to-shaft connection is threaded, the impeller shall thread onto the shaft in a direction opposite to the shaft rotation. Machined threads are to be integral with the impeller hub. The threads shall be sealed for protection from corrosion or erosion.
3. Provide impellers that are single (static) and two-plane (dynamically) balanced.
4. The impeller tip speed shall not exceed the supplier's normal design standards.

E. Shaft

1. Provide ground heavy-duty type shaft with adequate fillets for all changes in diameter, so as to reduce stress concentration. The pump shaft shall be of adequate size to withstand the full output of the drive motor with suitable safety margin.
2. Provide shaft with fully replaceable shaft sleeve. The shaft shall be completely encased along its entire wetted length by the impeller and shaft sleeve to protect shaft.
3. Shaft rotation shall be in same direction for sets of similar pumps furnished.

F. Bearings

1. Provide heavy duty grease or oil lubricated bearings with a minimum L-10 life of 60,000 hours in the specified service with continuous operation and considering maximum radial and axial loads.
2. Bearing shall be spherical or tapered roller type, mounted in a lubricant-filled housing.
3. Provide at least two bearings for support of overhung shafts.
4. Provide the bearing cartridge assembly with labyrinth type seals and deflectors to prevent leakage of lubricant to the outside environment and the entry of dust, water, and other foreign matter to the inside of the pump bearing assembly.
5. Provide a shaft and bearing cartridge assembly that permits axial adjustment of impeller/casing clearance without readjustment of the individual bearings. Provide means to allow adjustment by external adjustment of the bearing cartridge assembly with external screws and locknuts.
6. For pumps with oil lubricated bearings, provide the bearing cartridge assembly with a constant-level oiler, a drain connection, clear sight glass (with clearly visible indication of recommended oil level) and breather vent. Designs requiring field measurements (i.e. the use of a dipstick) to determine oil level are not acceptable. Include oil sampling point with isolation valves for in-service oil sampling.

G. Seals

1. Provide pumps with packing or mechanical seals as indicated on the data sheets.
2. Seals shall be designed for long-term reliable operation with the seal water quality as identified by supplier.

H. Motor Rating

1. Provide motor nameplate horsepower a minimum of 115% of the horsepower requirement of the driven equipment when operating at the design capacity and pressure indicated on the data sheets, and at the design pump speed.
2. Provide motor nameplate horsepower exceeding the required horsepower of the driven equipment at all points on the pump curve, from shutoff to run out.


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I. Baseplate/Skid & Soleplates

1. Provide a common or individual structural baseplate/skid with individual soleplates for each pump and motor with belt drive or gear driver. Provide complete design of the baseplate/skid including design of bolting of equipment components to the baseplate/skid and design of alignment, shimming, and leveling of components.
2. Provide a minimum of four lifting lugs per skid frame. Lugs shall be shop-welded to skid frame.
3. Each pump baseplate shall be provided with a drip edge with a pipe coupling for plumbing to a collection point.
4. Mount the pump, motor, belt driver on fully-machined flat surfaces. Completely weld the skid base prior to machining the pump and driver mounting surfaces. Continuously seal weld (100%) all structural steel joints to prevent corrosion. Do not weld on any machined surfaces.
5. Design the baseplate/skid pump and driver supports with enough stiffness to limit coupling angular misalignment caused by maximum allowable nozzle loads and to limit shaft misalignment and axial displacements or vibration in the as-installed operating condition.
6. Provide proper structural design of the complete baseplate/skid to eliminate unacceptable characteristics such as harmonic vibration in the baseplate/skid. Provide baseplate/skid with natural frequencies that do not coincide with frequencies related to running speed, electrical supply frequencies or any relevant harmonic which would result in the baseplate/skid resonance.

J. Fasteners

1. Provide technical specifications for all anchor bolts, mounting bolts, nuts, washers, and sleeves required to mount all equipment to the foundation or structural steel supports.
2. Provide all required fasteners and bolting hardware for blanked-off or unused flanged nozzles and connection points.

K. Lubrication

1. Select the proper lubricant required to maintain the equipment warranty. Indicate the proper lubricant designation and required quantity for each lubricant in the manuals with a list of acceptable alternate lubricants.
2. For oil lubrication systems, provide constant-level oilers and/or oil level sight gauges. Provide oil drains with bronze or stainless steel valves and/or fill plugs that are easily accessible from normal operating areas. Locate oil drains to allow convenient collection of oil during oil changes without removing equipment from its installed position.
3. For grease type bearings which are not easily accessible, provide stainless steel tubing to allow lubrication from operating level. Protect and extend the tubing to a convenient location with a suitable grease fitting.

## 2.2 MATERIALS AND FABRICATION

A. Provide equipment manufactured from material(s) as specified or supplier recommended equals submitted to ENGINEER and OWNER for approval. For supplier recommended equals, provide the details of the materials, with specific attention to the anti-corrosion and anti-erosion properties.

B. Provide materials suitable for the service conditions indicated in this section and on the attached data sheets. Confirm the suitability of all materials specified for use in the specified application.


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C. Impellers: Provide material that as a minimum meets the requirements of ASTM A532 high chromium white iron suitable for the process conditions described in the data sheet, with suitable corrosion/erosion resistance, or better.

D. Shaft Sleeves: CD4MCu or higher grade alloy.

E. Shaft: AISI 4140 steel or higher grade alloy.

F. Spare Parts & Special Tools

1. Provide spare parts and special tools required for initial startup and testing until final acceptance of the installed product.
2. Provide pricing and lead times for each recommended operating spare required for one year of operation and maintenance.
3. The OWNER will determine what spare parts to purchase after review of the submittal.

2.3 TESTING AND INSPECTION

A. The tests to be conducted are as follows:

1. Hydrostatic Tests (Required)

a. Hydrostatically pressure test each pump at 1.5 times the design pressure.
b. Hold test pressures for a minimum of ½ hour.
c. Perform a hydrostatic test of all pumps.

2.4 CLEANING AND PAINTING

A. All equipment and materials supplied shall be prepared, shop primed, and finish painted with coatings of manufacturer's standard paint system for a duty and environmental conditions typically found in a power station or industrial outdoor environment.

2.5 TAGGING AND MARKING

A. Provide appropriate markings, nameplates, labels, etc. for all equipment.

B. Provide all equipment with a rotation arrow at an easily visible location. Arrows cast into the body of the equipment or a 316 SS stainless steel plate with inscribed/stamped arrow securely affixed to the equipment using 316L SS screws or rivets are acceptable.

**PART 3– EXECUTION**

3.1 FIELD TECHNICAL SERVICES

A. The pump supplier shall furnish experienced start-up/service personnel to inspect the final installation and supervise the field start-up tests of the equipment.

*** * * * * END OF SECTION * * * * ***


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# SECTION 15250

# LEACHATE PUMPS

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. The CONTRACTOR shall provide all labor, materials, tools and services to install and test the leachate pumping systems in accordance with the Contract Documents.

B. Provide all supplementary or miscellaneous items and devices incidental or necessary for proper and complete installation.

1.2 RELATED SECTIONS

A. Section 02650 – Leachate Collection and Conveyance Pipe

B. Section 02651 – HDPE Pipe and Appurtenances

C. Section 260000 – Basic Electrical Requirements

1.3 SUBMITTALS

A. Product Data

1. The CONTRACTOR shall submit product data for the pump and motor to the ENGINEER, including, but not limited to, characteristic curves, dimensional drawings, materials of construction for all wetted parts, mechanical seals, packings, and shafts. Pump curves shall indicate efficiency, horsepower, proposed number of impeller stages, and electrical characteristics of the motor. The motor data shall include motor manufacturer, motor horsepower, rated speed, service factors, voltage, maximum amperage draw, and phase.
2. Submittals shall include assembly drawings, electrical schematics, key components, cut sheets, fittings installation details, and warranty statements.

B. Operation and Maintenance Data

The CONTRACTOR shall provide 3 sets of operation and maintenance (O&M) manuals for the leachate sump pumping system. The O&M manuals shall include at a minimum, all drawings, equipment lists with manufacturer's name and model number, equipment manuals, recommended spare parts inventory, detailed description of controls sequence of operation, and troubleshooting guide.

## PART 2– PRODUCTS

2.1 MANUFACTURER

A. Pumping system shall comply to specifications and drawings and shall not take exceptions.

2.2 PUMP

A. Pumps shall be constructed of 300 series stainless steel including housing, impellers, bowls, check valve disc, shaft, coupling, and strainer. Bearings and seal rings shall be constructed of non-corrosive material.

B. Pumps shall provide a flow of approximately 200 gallons per minute (GPM) at a discharge pressure of 225 feet of total dynamic head when operating with a single pump.


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2.3 MOTOR

A. The motors shall be non-overloading and suitable for operation based on the site's power supply.

B. Motors shall be suitable for leachate applications, be permanently lubricated, and constructed of stainless-steel wetted parts with stainless steel clad or corrosion resistant end housings.

C. Power cables shall be heavy duty submersible type, jacketed, continuous length, and sized per U.S. NEC standards. The cable shall be equal to the riser sump length plus enough additional length for proper installation from the control panel and/or power supply.

2.4 WHEELED CARRIER

A. Pumps and motors shall be mounted in a wheeled carrier constructed of stainless steel with non-corrosive and self-lubricating wheels.

B. The pump assembly shall be designed for use in a 24-inch SDR 11 HDPE riser pipe with a maximum pump riser length of 147 feet (distance from the pump operating location to the entry of the pipe). The carrier shall allow the pump to travel up and down the riser over welding beads to allow for stable operation of the pump. Wheels shall be constructed of a self-lubricating non-metallic material.

C. The carrier shall be equipped with a stainless-steel welded ring with a suitable retrieval cable equal to the total riser pump length plus an additional 25 feet of cable. The cable shall be provided with U-bolt type clamps, snap hook, and anchor. The cable shall be removable from the pump carrier without removal of cable U-bolt clamps.

2.5 DISCHARGE ASSEMBLY

A. A 2-inch discharge assembly shall be provided. Pipe shall be HDPE and a minimum working pressure rating of 126 pounds per square inch (PSI).

B. Pump discharge shall have stainless steel cam lock connector and positive locking companion fitting to allow for quick connect/disconnect of the pump and discharge piping.

2.6 CONTROLS

A. The control panel shall provide automatic pump operation, protection, and level indication for each pump operating in sump. Enclosure shall be rated NEMA 4 Steel or NEMA 4X Stainless Steel.

B. Control system shall be configured for the ability to operate a single pump, alternating pumps, or dual pumps.

C. An indicating control with digital level readout shall be installed for each pump. The controller shall be adjustable for pump and alarm set and reset points. Display and an alarm light shall flash during a high-level condition.

D. Control system shall be configured for the following conditions:

1. Low-Level Condition (Pump OFF) set 10-inches above bottom of sump elevation.
2. High-Level Condition (Pump ON) set 36-inches above bottom of sump elevation.
3. High-High Level Condition (Both Pumps ON) set 48-inches above bottom of sump elevation
4. High-High Level Condition (Audio Alarm) set 54-inches above bottom sump elevation.


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E. All components shall be labeled, and all wires shall be numbered. Schematic drawing shall include wire and terminal numbers for each component.

F. The panel shall be equipped with a properly sized main disconnect circuit breaker. Additional breakers shall include Motor Breaker, Control Circuit Breaker, Receptacle/Accessories Circuit Breakers, where applicable, and two spares. All breakers shall be selected for the required trip characteristics of the components protected.

G. Lights/Indicators

1. The control panel shall include:

a. Pump “running” light (Red).
b. Pump “fault” light (Amber).
c. Pump “leakage’ light (Amber).
d. Pump “OFF” light (Green).
e. Leachate level indicator.
f. Resettable elapsed pump run time meter.
g. NEMA 4 amber flashing alarm light mounted on top of the control panel (100 Watts) shall illuminate on “High-High Leachate Level.”
h. Audio alarm for “High-High Leachate Level.”

2.7 INSTRUMENTATION

A. Each pump shall be equipped with a submersible pressure transducer of stainless-steel construction compatible with control panel and with a static accuracy of no more than 1% of range shall be provided. Range shall be 0-5 psi and the unit shall provide a 4-20mA signal and be equipped with an integral surge suppressor.

B. The transducers shall be equipped with a shielded cable suitable for the application and of continuous length. Cable shall be equal to pump power cable length.

2.8 JUNCTION BOXES

A. Junction boxes shall be selected and designed for easy recovery and replacement of the pump and transducer cables.

B. All boxes shall be NEMA 4X rated [non-metallic] [stainless steel] with hinged door and locking hasp.

## PART 3– EXECUTION

3.1 INSTALLATION

A. Equipment shall be properly installed by the manufacturer, or an approved manufacture installer based upon the contract documents and manufacturer’s instructions.

B. All piping outside the riser (pipe, pipe supports, required pipe fittings, check valves, and isolation valves) shall be supplied and installed by the CONTRACTOR.

3.2 CONTRACTOR’S RESPONSIBILITIES

A. CONTRACTOR shall ensure that all collection piping and riser pipe should be free of shavings, debris, sand, silt, and/or mud at the time of pump installation.

B. CONTRACTOR shall ensure there is sufficient liquid in the risers at the time of start-up and testing.

C. CONTRACTOR shall ensure an accurate “as-built” sketch is recorded of the riser pipe fabrication and dimensions at the time of installation of the pumps.


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D. CONTRACTOR shall ensure a record of total length of materials “as installed” used in each riser pipe is recorded and provided to the manufacturer at the time of start-up along with a copy of the original “as-built” sketch.

E. CONTRACTOR shall install the system package per the manufacturer’s instructions including but not limited to the pump, discharge piping, control panel, junction boxes, wiring between junction boxes and control panel, controls, and seal-offs.

*** * * * * END OF SECTION * * * * ***


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# SECTION 15260

# HORIZONTAL CENTRIFUGAL PUMPS

## PART 1 – GENERAL

1.1 WORK INCLUDED

A. This section defines the requirements for performance, design, fabrication, inspection, testing, coating, delivery, installation supervision, start-up supervision, and documentation of centrifugal, axial flow, single stage pumps for process service.

B. This section is not intended to cover all specific requirements of the equipment design in complete detail. This section is intended to provide minimum acceptable requirements to be met or exceeded and to establish a standard of design and quality.

C. It shall be the CONTRACTOR's responsibility to ensure that all subcontractors of equipment, materials, or services comply with the requirements.

D. The performance requirements for the pumps are detailed in the pump data sheet(s). Equipment supplier and/or CONTRACTOR is to complete the indicated sections on the data sheet(s).

E. Provide each pump unit with all required components and accessories for continuous and reliable operation, including but not limited to the following items:

1. Pump
2. Electric Motor Drive
3. Mechanical Seal or Packing (as applicable)
4. V-belt drive or Gearbox (as applicable)
5. Coupling (as applicable)
6. Baseplate/Skid and Soleplates (as applicable), including all lifting lugs required for safe lift of fully assembled pump skid
7. Special features and accessories as specified

1.2 REFERENCES

A. ASME, American Society of Mechanical Engineers

1. ASME B16.5 - Pipe Flanges and Flanged Fittings
2. ASME B73.1 – Horizontal End Suction Centrifugal Pumps for Chemical Process

B. ASTM, American Society for Testing and Materials

1. ASTM A532 - Standard Specification for Abrasion-Resistant Cast Irons
2.

C. NEMA, National Electrical Manufacturers Association

D. OSHA, Occupational Safety and Health Administration

1.3 SUBMITTALS

A. Submittals shall be provided as specified in Section 01300.

## PART 2 – PRODUCTS

2.1 DESIGN CRITERIA

A. General


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1. Each pump shall be heavy-duty, centrifugal, single stage, horizontal type pump with a vertical top discharge.
2. Equipment supplier's standard or usual products and construction of products shall be furnished unless inconsistent with the requirements of this section. If any provision of this section departs sufficiently from the manufacturer's standard or usual construction so as to increase the cost without providing a corresponding increase in quality; or, if the supplier's standard or usual construction would provide better quality than that specified, then this fact shall be brought to the attention of OWNER and ENGINEER.
3. The equipment and all components shall be of proven and dependable design, constructed of high quality materials (new, of recent manufacture, and unused), and with quality workmanship.
4. Design all wetted parts to handle temperature minimum of 50ºF above maximum operating temperature.
5. All moving parts shall be readily accessible for inspection, lubrication, repair, and when applicable be protected from the flow of conveyed materials. All exposed rotating drive components shall be enclosed with easily removable guards in compliance with OSHA standards.
6. All major heavy components and assemblies shall have lifting lugs or design points for lifting slings for handling and bracing.

B. Operating Requirements

1. Provide each pump rated and designed in accordance with the operating conditions specified on the data sheet(s). The design and selection of all pump components shall be based on the results of laboratory tests or from previous experience of similar applications.
2. Pumps shall provide a flow of 750 gallons per minute (GPM) at a discharge pressure of 216 feet of total dynamic head when operating with a single pump.
3. For a given pump speed, the total dynamic head (TDH) of the pumps shall be as follows:

    a. Shut-off head shall not be less than 115% of TDH at the design point.
    b. Shut-off head shall not be more than 150% of TDH at the design point.

4. Provide pumps that operate at or very near its Best Efficiency Point (BEP) and with a normal capacity operating point that falls within the preferred operating range for centrifugal pumps.
5. Supplier shall identify the minimum operating flow for each pump on the pump data sheet(s).
6. Each pump shall be provided with an impeller that most closely matches the performance requirements specified on the pump data sheet(s).
7. Pump shall be capable of at least a 5% head increase at rated conditions by replacement of the impeller with impeller of larger diameter or different hydraulic design, , or an increase in the impeller speed.
8. The net positive suction head required (NPSHR) for each pump at operating point shall be no greater than 50% of net positive suction head available (NPSHA) or 2.0 ft below (whatever is greater). Here, the term NPSHR is equivalent to NPSH3 which refers to the net positive suction head that will cause the total head to be reduced by 3%.
9. Vibration Related Design Criteria

    a. The first critical speed of each pump and motor shall not be within 125% of maximum operating speed.


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C. Casing

1. Provide pump with through-bolt construction, split on the vertical centerline or with bolted suction and drive end plates.
2. Provide a pump casing design that allows for disassembly and removal of pump internals, rotor, and seal with the pump in place.

D. Impeller

1. Provide a closed type impeller with repelling vanes as a standard.
2. If impeller-to-shaft connection is threaded, the impeller shall thread onto the shaft in a direction opposite to the shaft rotation. Machined threads are to be integral with the impeller hub. The threads shall be sealed for protection from corrosion or erosion.
3. Provide impellers that are single (static) and two-plane (dynamically) balanced.
4. The impeller tip speed shall not exceed the supplier's normal design standards.

E. Shaft

1. Provide ground heavy-duty type shaft with adequate fillets for all changes in diameter, so as to reduce stress concentration. The pump shaft shall be of adequate size to withstand the full output of the drive motor with suitable safety margin.
2. Provide shaft with fully replaceable shaft sleeve. The shaft shall be completely encased along its entire wetted length by the impeller and shaft sleeve to protect shaft.
3. Shaft rotation shall be in same direction for sets of similar pumps furnished.

F. Bearings

1. Provide heavy duty grease or oil lubricated bearings with a minimum L-10 life of 60,000 hours in the specified service with continuous operation and considering maximum radial and axial loads.
2. Bearing shall be spherical or tapered roller type, mounted in a lubricant-filled housing.
3. Provide at least two bearings for support of overhung shafts.
4. Provide the bearing cartridge assembly with labyrinth type seals and deflectors to prevent leakage of lubricant to the outside environment and the entry of dust, water, and other foreign matter to the inside of the pump bearing assembly.
5. Provide a shaft and bearing cartridge assembly that permits axial adjustment of impeller/casing clearance without readjustment of the individual bearings. Provide means to allow adjustment by external adjustment of the bearing cartridge assembly with external screws and locknuts.
6. For pumps with oil lubricated bearings, provide the bearing cartridge assembly with a constant-level oiler, a drain connection, clear sight glass (with clearly visible indication of recommended oil level) and breather vent. Designs requiring field measurements (i.e. the use of a dipstick) to determine oil level are not acceptable. Include oil sampling point with isolation valves for in-service oil sampling.

G. Seals

1. Provide pumps with packing or mechanical seals as indicated on the data sheets.
2. Seals shall be designed for long-term reliable operation with the seal water quality as identified by supplier.

H. Motor Rating


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1. Provide motor nameplate horsepower a minimum of 115% of the horsepower requirement of the driven equipment when operating at the design capacity and pressure indicated on the data sheets, and at the design pump speed.
2. Provide motor nameplate horsepower exceeding the required horsepower of the driven equipment at all points on the pump curve, from shutoff to run out.

I. Baseplate/Skid & Soleplates

1. Provide a common or individual structural baseplate/skid with individual soleplates for each pump and motor with belt drive or gear driver. Provide complete design of the baseplate/skid including design of bolting of equipment components to the baseplate/skid and design of alignment, shimming, and leveling of components.
2. Provide a minimum of four lifting lugs per skid frame. Lugs shall be shop-welded to skid frame.
3. Each pump baseplate shall be provided with a drip edge with a pipe coupling for plumbing to a collection point.
4. Mount the pump, motor, belt driver on fully-machined flat surfaces. Completely weld the skid base prior to machining the pump and driver mounting surfaces. Continuously seal weld (100%) all structural steel joints to prevent corrosion. Do not weld on any machined surfaces.
5. Design the baseplate/skid pump and driver supports with enough stiffness to limit coupling angular misalignment caused by maximum allowable nozzle loads and to limit shaft misalignment and axial displacements or vibration in the as-installed operating condition.
6. Provide proper structural design of the complete baseplate/skid to eliminate unacceptable characteristics such as harmonic vibration in the baseplate/skid. Provide baseplate/skid with natural frequencies that do not coincide with frequencies related to running speed, electrical supply frequencies or any relevant harmonic which would result in the baseplate/skid resonance.

J. Fasteners

1. Provide technical specifications for all anchor bolts, mounting bolts, nuts, washers, and sleeves required to mount all equipment to the foundation or structural steel supports.
2. Provide all required fasteners and bolting hardware for blanked-off or unused flanged nozzles and connection points.

K. Lubrication

1. Select the proper lubricant required to maintain the equipment warranty. Indicate the proper lubricant designation and required quantity for each lubricant in the manuals with a list of acceptable alternate lubricants.
2. For oil lubrication systems, provide constant-level oilers and/or oil level sight gauges. Provide oil drains with bronze or stainless steel valves and/or fill plugs that are easily accessible from normal operating areas. Locate oil drains to allow convenient collection of oil during oil changes without removing equipment from its installed position.
3. For grease type bearings which are not easily accessible, provide stainless steel tubing to allow lubrication from operating level. Protect and extend the tubing to a convenient location with a suitable grease fitting.

## 2.2 MATERIALS AND FABRICATION

A. Provide equipment manufactured from material(s) as specified or supplier recommended equals submitted to ENGINEER and OWNER for approval. For supplier recommended equals, provide the details of the materials, with specific attention to the anti-corrosion and anti-erosion properties.


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B. Provide materials suitable for the service conditions indicated in this section and on the attached data sheets. Confirm the suitability of all materials specified for use in the specified application.

C. Impellers: Provide material that as a minimum meets the requirements of ASTM A532 high chromium white iron suitable for the process conditions described in the data sheet, with suitable corrosion/erosion resistance, or better.

D. Shaft Sleeves: CD4MCu or higher grade alloy.

E. Shaft: AISI 4140 steel or higher grade alloy.

F. Spare Parts & Special Tools

1. Provide spare parts and special tools required for initial startup and testing until final acceptance of the installed product.
2. Provide pricing and lead times for each recommended operating spare required for one year of operation and maintenance.
3. The OWNER will determine what spare parts to purchase after review of the submittal.

2.3 TESTING AND INSPECTION

A. The tests to be conducted are as follows:

1. Hydrostatic Tests (Required)

a. Hydrostatically pressure test each pump at 1.5 times the design pressure.
b. Hold test pressures for a minimum of ½ hour.
c. Perform a hydrostatic test of all pumps.

2.4 CLEANING AND PAINTING

A. All equipment and materials supplied shall be prepared, shop primed, and finish painted with coatings of manufacturer's standard paint system for a duty and environmental conditions typically found in a power station or industrial outdoor environment.

2.5 TAGGING AND MARKING

A. Provide appropriate markings, nameplates, labels, etc. for all equipment.

B. Provide all equipment with a rotation arrow at an easily visible location. Arrows cast into the body of the equipment or a 316 SS stainless steel plate with inscribed/stamped arrow securely affixed to the equipment using 316L SS screws or rivets are acceptable.

## PART 3– EXECUTION

3.1 FIELD TECHNICAL SERVICES

A. The pump supplier shall furnish experienced start-up/service personnel to inspect the final installation and supervise the field start-up tests of the equipment.

*** * * * * END OF SECTION * * * * ***


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# SECTION 260000

# BASIC ELECTRICAL WORK

## PART 1 – GENERAL

1.1 DESCRIPTION OF WORK

A. CONTRACTOR shall furnish all labor, material, equipment, tools, and appurtenances required to setup and install all electrical components presented on the Drawings, mentioned herein, or both. The CONTRACTOR shall provide a “Competent Person” to implement, supervise, and inspect all Work.

B. CONTRACTOR shall comply with all applicable codes, ordinances, rules, regulations and laws of local, municipal, State or Federal authorities having jurisdiction. CONTRACTOR shall also comply with all applicable health and safety regulations as required by OSHA and in accordance with the CONTRACTOR’s Health and Safety Plan and basic electrical requirements specifically applicable to Division 26 – Electrical, in addition to General Requirements.

1.2 REGULATORY REQUIREMENTS

A. Comply with the latest editions of following works, including all supplements thereto and any other authority having jurisdiction within requirements of this specification.

1. Local Codes.
2. National Electrical Code as amended (NFPA No. 70).
3. O.S.H.A.
4. International Building Code (IBC 2012).
5. Obtain permit, and request inspections from authority having jurisdiction.

1.3 PROJECT/STATE CONDITIONS

A. Install work in locations shown on the Contract Documents, unless prevented by project conditions.

## PART 2 – PRODUCTS

Install equipment type as specified on the Contract Documents.

## PART 3– EXECUTION

All installations shall be in accordance with manufacturer’s instructions and recommendations.

*** * * * * END OF SECTION * * * * ***


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