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USACE / NAVFAC / AFCEC **UFGS-02 56 13.13 (February 2025)**

Preparing Activity: USACE **Superseding**
UFGS-02 56 13.13 (February 2021)

UNIFIED FACILITIES GUIDE SPECIFICATIONS

References are in agreement with UMRL dated July 2025
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SECTION 02 56 13.13

GEOMEMBRANE WASTE CONTAINMENT

02/25

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SECTION 02 56 13.13

GEOMEMBRANE WASTE CONTAINMENT
02/25

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NOTE: This guide specification covers the requirements for geomembrane barrier for waste containment applications.

Adhere to UFC 1-300-02 Unified Facilities Guide Specifications (UFGS) Format Standard when editing this guide specification or preparing new project specification sections. Edit this guide specification for project specific requirements by adding, deleting, or revising text. For bracketed items, choose applicable item(s) or insert appropriate information.

Remove information and requirements not required in respective project, whether or not brackets are present.

Comments, suggestions and recommended changes for this guide specification are welcome and should be submitted as a Criteria Change Request (CCR).

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PART 1 GENERAL

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NOTE: This section is intended for geomembrane applications in waste containment applications only. Other UFGS sections should be used for geomembrane applications in other situations. Refer to Section 33 56 19 FUEL IMPERMEABLE LINER SYSTEM (and Standard Design AW 78-24-27). Refer to Section 33 47 13 POND AND RESERVOIR LINERS.

This specification section is referenced in several other UFGS sections as a requirement for lining stockpiles of contaminated and treated materials. For those applications, Designers should consider reducing the overall scope of requirements in this specification section. Some of the requirements in

this specification section may be overly conservative for applications where a geomembrane is used for a short period of time (months to years) and then the contaminated materials and geomembrane are ultimately removed from the site. In those applications, the integrity of the geomembrane may not be as critical compared to using a geomembrane for indefinite storage of contaminated materials in a landfill, for example. Requirements which could be reduced in this specification section include qualifications of the manufacturer/installer and frequency of quality assurance/quality control testing.

This guide specification includes multiple different types of geomembrane materials that may be used depending on the specific application. The Designer must select the appropriate geomembrane material for the specific application; this guide specification is not intended as design recommendation or to endorse specific geomembrane materials. High density polyethylene (HDPE) is the geomembrane material that is almost always used in long-term waste containment applications (i.e. landfill liner and cover systems). Other geomembrane materials which have been used in certain waste containment applications include linear low density polyethylene (LLDPE), polyvinyl chloride (PVC), or polypropylene (PP). Some newer or less-commonly used materials include flexible polypropylene (fPP), ketone ethylene ester/ethylene interpolymer alloy (KEE/EIA), and urethane. These materials can be produced with both smooth and textured surfaces. The need for a textured versus a non-textured material will be based on containment system stability analyses (e.g. veneer stability). The drawings must clearly indicate the limits of placement for textured and non-textured geomembranes.

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1.1 UNIT PRICES

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NOTE: These paragraphs should be edited based on whether the contract will use a single job price or unit prices. If there is a separate Measurement and Payment section, edited versions of these paragraphs should be inserted in that section.

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1.1.1 Measurement

Complete a survey to measure the total surface area in square meters square feet covered by geomembrane. Final quantities will be based on as-built conditions. Allowance will be made for geomembrane in anchor and drainage trenches; however, no allowance will be made for waste, overlap, repairs, or materials used for the convenience of the Contractor.

1.1.2 Payment

Geomembrane installed and accepted by the Contracting Officer will be paid for at the respective contract unit price in the bidding schedule. This unit price will include the costs of materials, equipment, installation, testing, and other costs associated with placement of the geomembrane.

1.2 REFERENCES

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NOTE: This paragraph is used to list the publications cited in the text of the guide specification. The publications are referred to in the text by basic designation only and listed in this paragraph by organization, designation, date, and title.

Use the Reference Wizard's Check Reference feature when you add a Reference Identifier (RID) outside of the Section's Reference Article to automatically place the reference in the Reference Article. Also use the Reference Wizard's Check Reference feature to update the issue dates.

References not used in the text will automatically be deleted from this section of the project specification when you choose to reconcile references in the publish print process.

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The publications listed below form a part of this specification to the extent referenced. The publications are referred to within the text by the basic designation only.

ASTM INTERNATIONAL (ASTM)

ASTM D413	(1998; R 2017) Standard Test Methods for Rubber Property - Adhesion to Flexible Substrate
ASTM D698	(2012; R 2021) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/cu. ft. (600 kN-m/cu. m.))
ASTM D751	(2019) Standard Test Methods for Coated Fabrics
ASTM D1557	(2012; E 2015) Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3) (2700 kN-m/m3)
ASTM D4873/D4873M	(2017) Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples
ASTM D5321/D5321M	(2020) Standard Test Method for Determining the Shear Strength of

	Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
ASTM D5641/D5641M	(2016) Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber
ASTM D5820	(1995; R 2018) Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembranes
ASTM D6392	(2012; R 2018) Standard Test Method for Determining the Integrity of Nonreinforced Geomembrane Seams Produced Using Thermo-Fusion Methods
ASTM D7176	(2006; R 2011) Non-Reinforced Polyvinyl Chloride (PVC) Geomembranes Used in Buried Applications
ASTM D7408	(2012; R 2020) Non Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams

GEOSYNTHETIC INSTITUTE (GSI)

GSI GRI GM7	(1995) Accelerated Curing of Geomembrane Test Strip Seams Made by Chemical Fusion Methods
GSI GRI GM9	(1995; R 2013) Cold Weather Seaming of Geomembranes
GSI GRI GM13	(2016) Test Methods, Test Properties and Testing Frequency for High Density Polyethylene (HDPE) Smooth and Textured Geomembranes
GSI GRI GM17	(2015) Test Methods, Test Properties and Testing Frequency for Linear Low Density Polyethylene (LLDPE) Smooth and Textured Geomembranes
GSI GRI GM18	(2015) Test Methods, Test Properties and Testing Frequencies for Flexible Polypropylene (fPP and fPP-R) Nonreinforced and Reinforced Geomembranes
GSI GRI GM19a	(2002; R 2017) Seam Strength and Related Properties of Thermally Bonded Homogeneous Polyolefin Geomembranes/Barriers
GSI GRI GM34	(2023) Test Methods, Test Properties and Testing Frequency for Ethylene Interpolymer Alloy (EIA=PVC+KEE) Geomembranes

1.3 DEFINITIONS

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NOTE: These definitions are adapted from Waste Containment Facilities, Guidance for Construction Quality Assurance and Construction Quality Control of Liner and Cover Systems, Daniel and Koerner, 2nd Edition.

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a. Construction Quality Assurance (CQA): CQA includes inspections, audits, and evaluations of materials and workmanship to determine and document the quality of the constructed facility. CQA is performed by a party independent from the Contractor.

b. Construction Quality Control (CQC): A planned system of inspections that is used to directly monitor and control the quality of the geomembrane installation project. CQC is normally performed by the geomembrane installation contractor/subcontractor, and is necessary to achieve quality in the geomembrane system. CQC refers to measures taken by the installer or contractor to determine compliance with the requirements for materials and workmanship as stated in the plans and specifications for the project

c. Manufacturing Quality Control (MQC): A planned system of inspections that is used to directly monitor and control the manufacture of a material which is factory originated. MQC is normally performed by the manufacturer of the geomembrane material and is necessary to ensure minimum (or maximum) specified values in the geomembrane. MQC refers to the measures taken by the manufacturer to determine compliance with the requirements for materials and workmanship as stated in certification documents and contract specifications

1.4 SUBMITTALS

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NOTE: Review submittal description (SD) definitions in Section 01 33 00 SUBMITTAL PROCEDURES and edit the following list, and corresponding submittal items in the text, to reflect only the submittals required for the project. The Guide Specification technical editors have classified those items that require Government approval, due to their complexity or criticality, with a "G." Generally, other submittal items can be reviewed by the Contractor's Quality Control System. Only add a "G" to an item, if the submittal is sufficiently important or complex in context of the project.

For Army projects, fill in the empty brackets following the "G" classification, with a code of up to three characters to indicate the approving authority. Codes for Army projects using the Resident Management System (RMS) are: "AE" for Architect-Engineer; "DO" for District Office (Engineering Division or other organization in the District Office); "AO" for Area Office; "RO" for Resident Office; and "PO" for Project Office. Codes following the "G" typically are not used for Navy and Air Force projects.

The "S" classification indicates submittals required

as proof of compliance for sustainability Guiding Principles Validation or Third Party Certification and as described in Section 01 33 00 SUBMITTAL PROCEDURES.

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Government approval is required for submittals with a "G" or "S" classification. Submittals not having a "G" or "S" classification are for Contractor Quality Control approval. Submittals not having a "G" or "S" classification are for information only. When used, a code following the "G" classification identifies the office that will review the submittal for the Government. Submit the following in accordance with Section 01 33 00 SUBMITTAL PROCEDURES:

SD-02 Shop Drawings

Layout And Detail Drawings; G, [_____]

As-Built Drawings; G, [_____]

SD-03 Product Data

Manufacturer's Quality Control Manual

Fabricator's Quality Control Manual

Installer's Quality Control Manual

Materials; G, [_____]

Manufacturer's Warranty

Installer's Warranty

SD-04 Samples

Interface Shear Testing Soil Sample

CQA Product Acceptance Sample

Destructive Field Seam Test Sample

SD-06 Test Reports

Product Acceptance Tests

Trial Seam Logs

Non-Destructive Field Seam Testing

Destructive Field Seam Testing

Destructive Seam Test Repairs

Interface Friction Testing

Manufacturer's Certified Raw And Sheet Material Test Reports

SD-07 Certificates

Certificate Of Subgrade Acceptance

Qualifications; G, [_____]

SD-08 Manufacturer's Instructions

Geomembrane Manufacturer's Installation Instructions

1.5 QUALITY CONTROL

1.5.1 Manufacturer's [and Fabricator's] Quality Control Manual

Submit the Manufacturer's Quality Control Manual[and Fabricator's Quality Control Manual] which describes testing procedures, frequency of testing and [acceptance][rejection] criteria for MQC[and Fabricator Quality Control] testing at least [14][_____] calendar days prior to delivery of the geomembrane.

1.5.2 Installer's Quality Control Manual

Submit the installer's quality control manual a minimum of [seven][_____] calendar days prior to geomembrane placement.

1.5.3 Qualifications

Submit manufacturer[and fabricator] qualification statements a minimum of [seven][_____] calendar days prior to geomembrane shipment. Also submit installer, CQC inspector, [MQC][CQC] laboratory, and Licensed Surveyor qualification statements including resumes of key personnel involved in the project a minimum of [seven][_____] calendar days prior to geomembrane placement.

1.5.3.1 Manufacturer

Manufacturer will have produced the proposed geomembrane sheets for at least five completed projects having a total minimum area of [930,000][_____] square meters [10][_____] million square feet.

1.5.3.2 Fabricator

****

NOTE: Fabricators produce geomembrane products that are combinations of individual manufactured components (e.g. seaming together smaller off-the-shelf geomembrane panels into larger panels). Fabricators are not used on every geomembrane project, so this paragraph can be deleted if a fabricator is not anticipated/allowed on the specific project.

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TThe fabricator is responsible for [seaming geomembrane sheets into panels][_____]. Fabricator will have fabricated the proposed geomembrane panels for at least [five][_____] completed projects having a total minimum area of [186,000][_____] square meters [2][_____] million square feet.

1.5.3.3 Installer

****
NOTE: The International Association of Geosynthetic Installers (IAGI) provides a certification program for installer personnel engaged in seaming (referred to as welding by IAGI). An optional requirement for installer personnel to have IAGI certification is included; the designer should confirm that this requirement does not violate any contracting requirements.
****

The Installer is responsible for field handling, deploying, seaming, and anchoring of the geomembrane. The Installer will have installed the proposed geomembrane material for at least [five][_____] completed projects having a total minimum area of [186,000][_____] square meters [2][_____] million square feet. At least one seamer, designated the Master Seamer, will have experience seaming a minimum of [93,000][_____] square meters [1][_____] million square feet of the proposed geomembrane using the same type of seaming equipment specified for this project.[Installer personnel conducting seaming operations will be Certified Welding Technicians by the International Association of Geosynthetic Installers.]

1.5.3.4 Licensed Surveyor

Perform all survey work under the supervision of a Surveyor licensed in the [applicable jurisdiction][State of [_____]].[Perform surveys in accordance with Section [_____].]

1.5.3.5 CQC Inspector

****
NOTE: A separate third party CQA contract should be considered based on the qualifications of the Government CQA personnel, the size and importance of the project, and impacts of a geomembrane failure. CQC inspectors are still considered necessary even if the Government provides independent third-party CQA inspection.
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The CQC inspector is the person or corporation hired by the Contractor, who is responsible for monitoring and documenting activities related to the CQC of the geomembrane from manufacturing through installation. The CQC inspector will have provided CQC and/or CQA inspection during installation of the proposed geomembrane material for at least [five][_____] completed projects having a total minimum area of [186,000][_____] square meters [2][_____] million square feet.

1.5.3.6 [MQC][CQC] Laboratory

The [MQC][CQC] laboratory will have provided [MQC][CQC] or CQA testing of the proposed geomembrane and geomembrane seams for at least [five][_____] completed projects having a total minimum area of [186,000][_____] square meters [2][_____] million square feet. The [MQC][CQC] laboratory must be accredited by the [Geosynthetic Accreditation Institute's Laboratory Accreditation Program (GAI-LAP)][_____] for the tests the [MQC][CQC] laboratory will be required to perform.

1.5.4 Construction Quality Assurance

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NOTE: Although independent CQA by the Government is strongly recommended, this paragraph should be deleted if CQA will not be performed and only CQC will be performed. If CQA is not performed, references to CQA throughout the specification should be deleted. Note that the specification section uses the term Contracting Officer as a blanket term that would include CQA personnel acting under the Contracting Officer. Activities specified for the CQA personnel acting under the Contracting Officer would also need to be removed.

Depending on the project, the Government may also elect to implement Manufacturing Quality Assurance (MQA) activities, which include manufacturing facility inspections, verifications, audits, and evaluation of the raw materials and finished products (Daniel and Koerner, 2007). MQA is done in addition to MQC. The Contractor does not have an active role in MQA, but must be aware if MQA will occur on a project.

****

All work must be constructed, monitored, and tested in accordance with the requirements of a CQA[and MQA] Plan. Be aware of all activities outlined in the CQA[and MQA] Plan and account for these activities in the construction schedule. If CQA inspections or testing indicate work which does not meet the requirements of the specifications, the Contracting Officer will establish the extent of the nonconforming area. Repair the nonconforming area in accordance with paragraph DEFECTS AND REPAIRS.[If MQA inspections indicate products do not meet the requirements of this specification, applicable portions of the product will be rejected.]

1.6 DELIVERY, STORAGE, AND HANDLING

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NOTE: ASTM D4873/4873M provides guidance on delivery, storage, and handling of geomembrane materials. The designer should be familiar with the requirements of that ASTM standard; in some cases the ASTM standard provides options or suggestions as opposed to strict requirements. The designer can edit this paragraph to include stricter or more specific requirements than allowed in the ASTM.

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Deliver only approved geomembrane materials to the project site. Deliver, store, and handle geomembrane materials in accordance with ASTM D4873/D4873M and this section.[Deliver the geomembrane materials to the project site at least [14][_____] calendar days prior to installation to allow sufficient time for testing in accordance with paragraph PRODUCT ACCEPTANCE.] Deliver and unload the geomembrane with the CQC inspector [and Contracting Officer] present. Confirm the presence of a label on each geomembrane [roll][panel] with the manufacturer's name, product identification number, [roll][panel] number, and roll dimensions. Reject

geomembrane rolls which are not labeled upon delivery to the project site.

1.7 PROJECT/SITE CONDITIONS

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NOTE: To minimize geomembrane contraction stresses, seaming should ideally be carried out in the morning and late evening when the geomembrane is relatively contracted, and during the middle of the day if overcast conditions prevail. If the geomembrane is to be seamed in the middle of a sunny day, the Contractor must ensure that there is sufficient slack in the geomembrane to prevent excessive stresses or trampolining when the geomembrane contracts as cooler temperatures prevail. The required amount of slack must be determined by the Contractor, and it should not be so much so as to cause excessive wrinkling of the geomembrane. Bridging/trampolining is a condition where the geomembrane lifts off the subgrade; this is often observed due to thermal contraction at breaks in grade. If excessive trampolining or wrinkling of the geomembrane is observed, the Contractor will be required to make repairs to eliminate the problem at no additional cost to the Government.

****

Do not deploy or field-seam geomembrane in the presence of excess moisture (i.e., rain, fog, dew), in areas of ponded water, or in the presence of excess wind. Unless authorized by the Contracting Officer, do not place or seam at ambient temperatures below 0 degrees C 32 degrees F or above 40 degrees C 104 degrees F. Measure ambient temperature at a height less than 150 mm 6 inches above the ground or geomembrane surface. If seaming is allowed below 0 degrees C 32 degrees F, follow the procedures outlined in GSI GRI GM9. In marginal conditions, cease seaming unless destructive field seam tests, conducted by the CQC laboratory, confirm that seam properties meet the requirements listed in paragraph PERFORMANCE REQUIREMENTS. Conduct tests in accordance with paragraph DESTRUCTIVE FIELD SEAM TESTING.

1.8 WARRANTY

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NOTE: Several manufacturers should be contacted to determine what length of warranty is available for geomembrane materials and installation. Manufacturers provide prorated material warranties ranging from 1 to 30 years depending on the application. Installation warranties are generally specified as 1 to 2 years in length.

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Provide manufacturer's warranty stating that the geomembrane materials meet all requirements of the Contract documents and that for the intended use, the geomembrane is warranted for [_____] years against deterioration. Provide installer's warranty stating that the geomembrane will not fail due to improper installation within [_____] years.

PART 2 PRODUCTS

2.1 SYSTEM DESCRIPTION

2.1.1 Design Requirements

2.1.1.1 Layout And Detail Drawings

****
NOTE: Minimize the number of penetrations and show their locations on the drawings. Referencing the manufacturer's typical penetration details is generally acceptable. When reviewing submitted penetration details, Designer's and others involved in a project such as CQA personnel may wish to consult ASTM D6497 Standard Guide for Mechanical Attachment of Geomembrane to Penetrations or Structures.
****

Submit geomembrane panel layout and penetration detail drawings a minimum of [seven][_____] calendar days prior to geomembrane placement. Provide geomembrane penetration details [as indicated][as recommended by the geomembrane manufacturer].

2.1.2 Performance Requirements

2.1.2.1 Field Seams

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NOTE: Field seam strength and related property requirements for HDPE, LLDPE, and fPP are defined in GRI-GM19a Seam Strength and Related Properties of Thermally Bonded Homogeneous Polyolefin Geomembranes/Barriers". For PVC, Reference ASTM D7408 Standard Specification for Non-Reinforced PVC (Polyvinyl Chloride) Geomembrane Seams
****

Construct seams in the field conforming to the strength and related property requirements defined in [GSI GRI GM19a][ASTM D7408][_____].

2.2 FABRICATION

****
NOTE: Polyethylene geomembranes are not usually factory seamed. Delete this paragraph when factory seaming is not applicable.
****

Factory seam geomembrane sheets into maximum sized panels to minimize field seaming. Factory seaming must be by methods approved by the geomembrane manufacturer. Seams must meet the minimum shear and peel strength requirements in paragraph Performance Requirements. Factory seams must extend to the end of the sheet so that no unbonded edges greater than 3.2 mm 0.125 inch wide are present.

2.3 MATERIALS

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NOTE: Non-Government standards are available for the various types of geomembranes considered in this specification section. This specification section is formatted to reference those standards without repeating the requirements from those standards. The designer should be familiar with those standards, and any deviations should be noted in this specification section. For other geomembrane material types not covered by one of the referenced standards, evaluate at least three current manufacturer's property sheets for each acceptable material type before specifying property test values.

****

2.3.1 Raw Material Properties

Use raw materials meeting the requirements of[ASTM D7176][GSI GRI GM13][GSI GRI GM17][GSI GRI GM18][GSI GRI GM34][_____] and this paragraph. All regrind, reworked, or trim materials must be from the same manufacturer and exactly the same formulation as the geomembrane sheet being produced. Submit a copy of the test reports and MQC certificates for materials used in the manufacturing of the geomembrane shipped to the site.

2.3.2 Sheet Material Properties

****

NOTE: USACE practice on landfill cover systems has been to use a minimum nominal geomembrane thickness of 1 mm 40 mils. This criterion is based on survivability. USACE practice for landfill liner systems has been to use a minimum nominal geomembrane thickness of 1.5 mm 60 mils. Site-specific analyses should be conducted to determine the appropriate thickness for both landfill liners and covers. Reinforced geomembranes are generally not recommended where geomembrane elongation properties are critical (i.e., landfill covers) but may be suitable for other applications such as liquid surface impoundments.

****

Provide geomembrane sheets meeting the requirements in Table 1. Provide geomembrane sheets that are uniform in color, thickness, and surface texture. The textured surface features consist of raw materials identical to that of the parent sheet material and are uniform over the entire face of the geomembrane. Provide sheets that are free of and resistant to fungal or bacterial attack and free of cuts, abrasions, holes, blisters, contaminants and other imperfections.

TABLE 1 - GEOMEMBRANE PROPERTIES

Nominal Thickness	[_____] mm [_____] mils

TABLE 1 - GEOMEMBRANE PROPERTIES	
Manufactured in Accordance with	[GSI GRI GM13 for HDPE] [GSI GRI GM17 for LLDPE] [ASTM D7176 for PVC] [GSI GRI GM18 for fPP and fPP-R] [GSI GRI GM34 for EIA] [_____]
Material Type	[HDPE] [LLDPE] [PVC] [fPP] [fPP-R] [EIA] [_____]
Category	[unreinforced] [reinforced]
Surface Finish [for geomembrane on slopes greater than or equal to 1V on [_____] H]	[smooth] [textured one side] [textured both sides]
Minimum Manufactured Sheet Width	[_____] meter[s] [_____] feet
Minimum Manufactured Sheet Length	[_____] meter[s] [_____] feet
[_____]	[_____]

2.3.3 Field Seaming Materials

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NOTE: Requirements for the resin used in extrusion welding are provided below. If welding by other means is allowed/required and that welding involves use of materials such as adhesives or chemicals, provide requirements for those materials here.

****

[Manufacture seaming rods and pellets using materials which are essentially identical to that used in the geomembrane sheet. Test seaming rods and pellets for density, melt index and carbon black content in accordance with the approved Manufacturer's Quality Control manual. Do not use seaming rods and pellets which fail to meet the corresponding property values required for the sheet material for seaming.][_____.]

2.3.4 Interface Shear Testing Soil Sample

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NOTE: This paragraph can be deleted if the geomembrane interface is not against a soil layer, but rather another geosynthetic. An optional requirement is included for the contractor to test the soil that will be used in the interface shear testing, to demonstrate that the soil meets project requirements. This demonstration testing would not be necessary if the borrow source has already been adequately investigated, or if the soil used for interface testing is collected at the same time that other borrow source sampling is conducted.

To reduce the overall risk to the Government, it is strongly advised that the Contractor is required to collect samples for interface shear testing unless the nature of the site prevents the Contractor to do so. Depending on site conditions and project needs

(e.g. site security, access issues, etc.), the Government may provide samples to the Contractor to conduct interface shear testing.

****

[The Contracting Officer will provide][Obtain] soil to be used for interface shear testing from [the proposed borrow source][_____].[Conduct one set of tests and submit testing results demonstrating that the soils to be used for interface shear testing meet the material requirements in accordance with [_____].]

2.4 EQUIPMENT

****

NOTE: Optional requirements are included for the Contractor to provide a spare seaming apparatus and specifying the type of seaming apparatus. These requirements can be deleted if they are considered excessively strict for the particular project.

****

Use the geomembrane manufacturer's recommended equipment to perform the work and maintain equipment in satisfactory working condition.[Maintain at least one spare operable seaming apparatus on site.][Provide seaming apparatuses that are automated vehicular mounted devices equipped with gauges indicating the applicable temperatures and pressures.]

2.5 ACCESSORIES

2.5.1 Geomembrane Fittings

Provide geomembrane fittings (e.g., pipe vents, boots, sleeves, etc.) that are factory prefabricated components [produced by the same manufacturer as the geomembrane][confirmed to be compatible by the geomembrane manufacturer][_____] and having the same fabrication characteristics as the geomembrane.

2.5.2 Fasteners

Provide fasteners (e.g. clamps, slips, bolts, nuts, etc.) to secure the geomembrane to each fitting. Provide fasteners that are factory prefabricated components[produced by the same manufacturer as the geomembrane][confirmed to be compatible by the geomembrane manufacturer][_____].

2.5.3 Temporary Ballast

Provide temporary ballast used during geomembrane installation including sandbags, tires, or other material as recommended by the geomembrane manufacturer. Use non-abrasive material, free of sharp edges or other features that may damage the geomembrane liner.

2.6 TESTS, INSPECTIONS, AND VERIFICATIONS

2.6.1 Interface Friction Testing

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NOTE: Interface friction testing should be conducted on all potential slip interfaces. The

rate of displacement and normal stresses used for interface friction testing are dependent on the materials being tested and anticipated site conditions. Normal stresses specified should cover the range of anticipated field loads. Selection of peak versus residual values should be based on anticipated interface displacements taking into account seismic activities and long term conditions. Table 2 is from ASTM D5321/5321M; the Designer should verify that the table is current if ASTM D5321/53231M is updated.

The number of interface friction tests must be determined on a site specific basis considering regulator input and the potential for damage due to a shear failure. This testing should be completed during design or by the Contractor prior to the start of construction.

A method sometimes used to model saturated conditions at the shear interface is to wet these surfaces prior to shearing.

Note that if an interface surface for the geomembrane is a geosynthetic clay liner (GCL), interface friction/shear testing should be a requirement of the specification for that GCL and should follow ASTM D6243/D6243M Standard Test Method for Determining the Internal and Interface Shear Strength of Geosynthetic Clay Liner by the Direct Shear Method.

****

The frequency of testing for each interface is [1 per [_____] hectares [_____] acres of geomembrane placed][[_____] per project]. Conduct tests in accordance with ASTM D5321/D5321M using the conditions specified in Table 2. Use the same soil components that are used for full scale construction. Provide geosynthetics that are the same materials as those proposed for use during full scale construction. A minimum [peak][residual] interface friction angle of [_____] degrees is required for all interfaces. Submit certified laboratory interface friction test results including description of equipment and test method, a minimum of [seven][_____] calendar days prior to geomembrane shipment.[For interfaces between a geomembrane and geosynthetic clay liner, perform interface [friction][shear] testing in accordance with [Section 02 56 13.16 GEOSYNTHETIC CLAY LINER WASTE CONTAINMENT][_____].]

TABLE 2 - INTERFACE FRICTION TESTING PROPERTIES	
Type of test	[Procedure A - Geosynthetic on Geosynthetic Interface Friction] [Procedure B - Soil on Geosynthetic Interface Friction]
Material(s) for which shear will be tested	1 - [_____] 2 - [_____]

TABLE 2 - INTERFACE FRICTION TESTING PROPERTIES	
Side or characteristics for the side of material to be tested at the interface	1 - [_____] 2 - [_____]
Orientation of material	1 - [Machine Direction][Cross Direction][N/A] 2 - [Machine Direction][Cross Direction][N/A]
Soil Interface Compaction Density and Moisture Content (MC) (Note 1)	[Lightly Compacted] [Specified Density = [_____] kN/m3 [_____] lb/ft3] [As-received MC] [Specified MC = [_____] percent] [Based on ASTM D698 test results: Maximum Dry Density = [_____] kN/m3 [_____] lb/ft3, Optimum MC = [_____] percent] [Based on ASTM D1557 test results: Maximum Dry Density = [_____] kN/m3 [_____] lb/ft3, Optimum MC = [_____] percent] If compaction unit weight and moisture content for soil placement based on ASTM D698 or D1557 test results, compaction [_____] percent of maximum dry unit weight and Moisture Content [optimum water content] [plus [_____] percent relative to optimum] [minus [_____] percent relative to optimum]
Conditioning of Geosynthetic Materials	[Wetted by pouring water over entire specimen][Wetted by spraying water over entire specimen][As-received]
Shear Test Normal Loads (Note 2)	[_____], [_____],[_____], [_____], [_____] kPa [_____], [_____],[_____], [_____], [_____] psi
List if there is a specified Normal Load Application Sequency to be applied:	[_____]
Interface saturation condition	[Inundated with Water - Interface is submerged in water prior to consolidation and through duration of shear][Spray Wetted - The interface is wetted using a spray bottle during placement of specimens, but not submerged in water][Dry - No addition of water during placement of specimens or shear]
Settling/Consolidation time under test normal load prior to shearing	[_____] hours
Shear displacement rate	[1.0][5.0][_____] mm [0.04][0.2][_____] inches per minute

TABLE 2 - INTERFACE FRICTION TESTING PROPERTIES	
Other test instructions	[_____]
Note 1 - Over-sized corrected test values from ASTM D698 and ASTM D1557 are typically not applied in calculating compaction density and moisture content as gradations minus 19.5 mm 0.75 inch sieve of soil sample are used due to dimensions of most shear boxes. If requesting use of rock correction values to be applied, indicate so. Note 2 - The normal loads selected should bracket the design normal loads being evaluated.	

2.6.2 Manufacturing, Sampling, and Testing

****
NOTE: The testing required in this paragraph and subparagraphs occurs at the manufacturing facility. Additional testing is required once materials are delivered to the site, as defined in paragraph PRODUCT ACCEPTANCE.
****

Submit manufacturer's certified raw and sheet material test reports and a copy of the MQC certificates, a minimum of [seven][_____] calendar days prior to shipment of geomembrane to the site.

2.6.2.1 Raw Material Testing

Test raw materials in accordance with the approved Manufacturer's Quality Control Manual and[ASTM D7176][GSI GRI GM13][GSI GRI GM17][GSI GRI GM18][GSI GRI GM34][_____]; test according to the stricter standard if there are deviations. Do not use any raw material which fails to meet the requirements of paragraph RAW MATERIAL PROPERTIES.

2.6.2.2 Sheet Material Testing

Test geomembrane sheets in accordance with the approved Manufacturer's Quality Control Manual and[ASTM D7176][GSI GRI GM13][GSI GRI GM17][GSI GRI GM18][GSI GRI GM34][_____]; test according to the stricter standard if there are deviations. Do not send sheets not meeting the minimum requirements specified in paragraph SHEET MATERIAL PROPERTIES to the site.

2.6.3 Product Acceptance

****
NOTE: The testing required in this paragraph and subparagraphs occurs at project site.
****

2.6.3.1 Product Acceptance Samples

Obtain one CQC sample, 500 mm 18 inches in length, for the entire width of a roll, for every 9,000 square meters 100,000 square feet of material delivered to the site. Do not obtain samples from the first three feet of

the roll. For accordion folded geomembranes, collect samples of equivalent size from approved locations. Identify the samples by manufacturer's name, product identification, lot and roll/panel number. Also, note the date, a unique sample number, and the machine direction. In addition, collect and label a [305 by 305 mm][_____] [12 inch by 12 inch][_____] CQA Product Acceptance Sample, and submit to the Contracting Officer each time CQC samples are collected.[Collect all CQC and CQA samples for product acceptance with the [Contracting Officer][_____] present.]

2.6.3.2 Product Acceptance Tests

****

NOTE: The testing methods listed below are those recommended by Daniel and Koerner 2007. Note that puncture is not a test specified by ASTM D7167 for PVC geomembranes, and ply adhesion only applies for reinforced geomembranes.

****

Provide all CQC samples to the CQC laboratory to determine[thickness,] [tensile strength at break,][elongation at break,][puncture,][tear,][and][ply adhesion]. Test the samples in accordance with the methods specified in [ASTM D7176][GSI GRI GM13][GSI GRI GM17][GSI GRI GM18][GSI GRI GM34][_____]. Samples not meeting the specified requirements will result in the rejection of applicable [rolls][panels]. As a minimum, test [rolls][panels] produced immediately prior to and immediately after the failed [roll][panel] for the same failed parameter. Continue testing until a minimum of three successive [rolls][panels] on both sides of the original failing [roll][panel] pass the failed parameter.

PART 3 EXECUTION

3.1 EXAMINATION

3.1.1 Certificate of Subgrade Acceptance

****

NOTE: An example Certificate of Subgrade Acceptance can be found in the USACE Engineering Manual EM 1110-1-4011. Depending on the specific design of the geomembrane and subgrade, the examination items specified below should be revised.

****

Each day during placement of geomembrane, the CQC Inspector [and Contracting Officer] and installer must inspect the surface on which geomembrane is to be placed and certify in writing on a Certificate of Subgrade Acceptance that the surface is acceptable. Examine the subgrade for compliance with the items in the list below. Perform repairs to the subgrade in accordance with paragraph PREPARATION, and at no additional cost to the Government.

a. A project-qualified land surveyor has verified the lines and grades of the subgrade meet project design;

b. All CQC and CQA of the underlying soils or geosynthetics has been completed and results have been accepted by the Contracting Officer;

c. The subgrade is free of irregularities, protrusions, loose soil, and abrupt changes in grade;

d. The subgrade is not excessively deformed or rutted by construction equipment used to deploy geomembrane rolls. Ruts of the underlying soil should not exceed [25][_____] mm [1][_____] inch in depth.

e. The underlying soil surface (if present) does not contain stones, litter, or organic matter which may be damaging to the geomembrane. Rocks larger than [13][_____] mm [0.5][_____] inch in diameter and any other material which could damage the geomembrane must be removed from the surface to be covered with the geomembrane;

f. If installed on soil, no area of the underlying soil surface is excessively softened by high water content; and

g. If installed on soil, no area of the underlying soil surface contains desiccation cracks which may damage the geomembrane.

3.2 PREPARATION

****
NOTE: Ensure other sections of the specification package adequately address compaction requirements for soil subgrade layers. If the geomembrane is placed directly on top of a compacted clay layer, reference Section 02 56 13.16 CLAY WASTE CONTAINMENT for repairs/preparation.
****

3.2.1 Subgrade Repair

For any subgrade found deficient in accordance with paragraph EXAMINATION, perform repairs in accordance with [Section 31 00 00 EARTHWORK][Section 02 56 13.16 CLAY WASTE CONTAINMENT][_____].

3.2.2 Anchor Trenches

****
NOTE: Anchor trench dimensions are often site-specific and are therefore defined in the project drawings. If that is the case, replace the dimensioning sentences with a reference to the project drawings/plans. Dimensions for a 90 degree anchor trench are included in the paragraph; if other standard anchor trench designs such as a "V" trench or horizontal runout are used instead, replace the dimensions as appropriate.
****

Where an anchor trench is required, place it [610][_____] mm [24][_____] inches back from the edge of the slope to be covered. Provide an anchor trench [610][_____] mm [24][_____] inches deep and [460][_____] mm [18][_____] inches wide. If the anchor trench is excavated in cohesive soil susceptible to desiccation, excavate only the quantity of anchor trench required for placement of geomembrane in a single day. Remove ponded water from the anchor trench while the trench is open. Slightly round trench corners to avoid sharp bends in the geomembrane. Remove loose soil, rocks larger than [13][_____] mm [0.5][_____] inch in

diameter, and any other material which could damage the geomembrane from the surfaces of the trench. Extend the geomembrane down the front wall and across the bottom of the anchor trench. Perform backfilling and compaction of the anchor trench in accordance with [Section 31 00 00 EARTHWORK][_____].

3.3 GEOMEMBRANE INSTALLATION

3.3.1 Geomembrane Placement

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NOTE: An optional requirement is provided for using a rub/slip sheet when placing the geomembrane. Rub sheets are thin sheets of plastic placed between the geomembrane and another surface. Rub sheets facilitate movement/placement of the geomembrane, particularly when the geomembrane is textured.

****

At least [seven][_____] calendar days prior to placement, submit geomembrane manufacturer's installation instructions. Complete geomembrane placement in accordance with the geomembrane manufacturer's installation instructions and this paragraph. Do not elongate, wrinkle, scratch, or otherwise damage the geomembrane, other geosynthetic layers, or the underlying subgrade. Replace or repair geomembrane damaged during installation at the [CQC inspector's][and][Contracting Officer's] discretion. Only deploy geomembrane panels that can be anchored and seamed together the same day.[Deploy a [rub][slip] sheet (e.g. 0.50 mm 20 mil smooth HDPE) when placing the geomembrane and carefully remove the rub sheet to avoid shifting the geomembrane once the geomembrane is in place.] Place adequate ballast on the geomembrane, without damaging the geomembrane, to prevent uplift by wind. On side slopes, anchor the geomembrane at the top and deploy down the slope to minimize wrinkles. Minimize dragging of geomembrane panels over the ground surface. Do not operate equipment on the top surface of the geomembrane without permission from the Contracting Officer. Orient seams parallel to the line of maximum slope. Where seams can only be oriented across the slope, lap the upper panel over the lower panel. Minimize wrinkles and tensile stresses in the geomembrane. Provide adequate slack to prevent the creation of tensile stress. Wrinkle height to width ratio for installed geomembrane exceeding 0.5 is unacceptable. In addition, geomembrane wrinkles exceeding 150 mm 6 inches in height is prohibited. Cut out and repair wrinkles that do not meet the above criteria in accordance with the installer's approved CQC manual.

3.3.2 Field Seaming

3.3.2.1 Trial Seams

Make trial seams under field conditions on strips of excess geomembrane. Make trial seams each day prior to production seaming, whenever there is a change in seaming personnel or seaming equipment and at least once every four hours, by each seamer and each piece of seaming equipment used that day. Collect and test trial seam samples in accordance with ASTM D6392. Obtain one sample from each trial seam. This sample must be at least 920 mm long by 305 mm wide 36 inches long by 12 inches wide with the seam centered lengthwise. Where necessary, conduct accelerated curing of trial seams made by chemical methods in accordance with GSI GRI GM7. To be acceptable, four out of five replicate test specimens must meet seam

strength requirements specified in paragraph PERFORMANCE REQUIREMENTS. If the field tests fail to meet these requirements, repeat the entire operation. If the additional trial seam fails, do not use the seaming apparatus or seamer until the deficiencies are corrected by the installer and two consecutive successful trial seams are achieved. Submit trial seam logs following the completion of installation.

3.3.2.2 Field Seams

****

NOTE: Additional requirements for geomembrane seaming apparatuses may be considered on a project-specific basis. As discussed in GSI GRI GM 32 Geomembrane Seaming Data Using Data Acquisition Hot Wedge Welding Devices, welding/seaming devices which continuously record and display temperature, pressure, and speed data can be used. These devices provide information that can be used by both the geomembrane installer during installation and CQC/CQA personnel during inspection and testing. Furthermore, automatic feedback welders (aka "smart welding devices") exist which can be used to maintain operations within a seaming window for temperature, speed, and pressure.

****

Completely unroll and layout adjacent geomembrane panels/sheets before performing field seaming. Seam panels in accordance with the geomembrane manufacturer's recommendations and the requirements listed in this paragraph. Perform seaming with an automated seaming device [equipped with gauges for measuring [temperature][pressure][speed]][_____]. Where the geomembrane manufacturer's recommendations disagree with the requirements of this specification [follow the more stringent requirement][notify the Contracting Officer].

a. Complete seaming only when the Master Seamer is present.

b. In sumps, corners and odd-shaped geometric locations, minimize the number of field seams.

c. Overlap geomembrane panels a minimum of [75][_____] mm [3][_____] inches and a maximum of [150][_____] mm [6][_____] inches.

d. Only use temporary bonding procedures that [are approved by the geomembrane manufacturer][will not damage the geomembrane].

e. Extend seaming to the outside edge of panels.

f. Clean the seam area to provide an area that is free of moisture, dust, dirt, and foreign material at the time of seaming. Do not use solvent for cleaning.

g. If grinding is required, follow a grinding process approved by the geomembrane manufacturer. Complete grinding in a manner that does not damage the geomembrane.

h. Repair fish mouths (half-cylinder openings/voids caused by wrinkling/shifting) in seam.

i. Provide adequate illumination when seaming at night.

j. Protect exposed geomembrane edges at the end of each day or whenever an installation activity is temporarily suspended during the day.

3.3.2.3 Polyethylene Seams

Seam polyethylene geomembranes by thermal fusion methods. Only use extrusion welding for patching and seaming in locations where thermal fusion methods are not feasible. Ground seam overlaps that are to be attached using extrusion welds prior to welding. Orient grinding marks perpendicular to the seam direction and do not extend marks beyond the extrudate after placement. Begin extrusion welding within 10 minutes after grinding. Where extrusion welds are temporarily terminated long enough to cool, ground prior to applying new extrudate over the existing seam. The total depth of the grinding marks greater than 10 percent of the sheet thickness is unacceptable.

3.3.2.4 Non-Polyethylene Seams

Seam non-polyethylene geomembranes by methods as recommended by the geomembrane manufacturer. Store seaming adhesives, solvents, or chemical cleaning agents away from the geomembrane and only use spill-resistant containers while working on the geomembrane. If low temperatures slow the curing process of chemically fused seams and delay seam testing, use the procedures in GSI GRI GM7 to accelerate sample curing.

3.3.3 Penetrations

Install geomembrane fittings (e.g., pipe vents, boots, sleeves, etc.) as shown on the drawings and in accordance with any manufacturer's recommendations.

3.3.4 Defects and Repairs

3.3.4.1 Destructive Seam Test Repairs

Seams that fail destructive seam testing may be overlaid with a strip of new material and seamed (cap stripped). Alternatively, retrace the seaming path to an intermediate location a minimum of 3 meters 10 feet on each side of the failed seam location. At each location, take a 305 by 460 mm 12 by 18 inch minimum size seam sample for two additional shear strength and two additional peel adhesion tests using an approved quantitative field tensiometer. If these tests pass, send the remaining seam sample portion to the CQC laboratory for five shear strength and five peel adhesion tests in accordance with the CQC laboratory's approved procedures. To be acceptable, four out of five replicate test specimens must meet specified seam strength requirements. If these laboratory tests pass, cap strip or repair the seam using other approved methods between that location and the original failed location. If field or laboratory tests fail, repeat the process. After repairs are completed, non-destructively test the repaired seam in accordance with paragraph NON-DESTRUCTIVE FIELD SEAM TESTING. Submit CQC inspector certified test results on all repaired seams.

3.3.4.2 Patches

Repair tears, holes, blisters and other defects with patches. Provide patches that have rounded corners, are made of the same geomembrane, and

extend a minimum of 150 mm 6 inches beyond the edge of defects. Repair minor localized flaws by spot welding or seaming as determined by the CQC inspector. Non-destructively test repairs. The Contracting Officer or the CQC inspector may also elect to perform destructive seam tests on suspect areas.

3.4 FIELD QUALITY CONTROL

3.4.1 Visual Inspection of Field Seams

Visually inspect each field seam to confirm that the seams are tightly bonded. Perform the inspection of a seam within 30 hours after the manufacturer's suggested application, curing, and cooling time. Repair and re-inspect seams found to be defective in accordance with manufacturer's recommendations.

3.4.2 Non-Destructive Field Seam Testing

****

NOTE: Multiple non-destructive field seam testing methods are included below. Not all testing methods are applicable to all types of geomembranes. The pressurized air channel test is only applicable when a dual track hot wedge seaming method is employed. The pressurized air channel test method is considered a preferred method when applicable. Because the pressurized air channel method is not applicable for testing extrusion welds, at least one other non-destructive testing method should be required such as the vacuum box test.

****

Perform non-destructive testing on all field seams over the full seam length and on any other areas showing damage or other distresses. Allowable methods are stated below. Alternate methods approved by the geomembrane manufacturer may be submitted for approval by the Contracting Officer. Submit non-destructive field seam test reports following the completion of installation and prior to covering the geomembrane liner. Non-destructively test field seams for penetrations in accordance with the installer's approved CQC manual. Repair seams that fail non-destructive testing in accordance with the installer's approved CQC manual and non-destructively test prior to acceptance.

3.4.2.1 Liner Pressurized Air Channel Test

Perform air pressure testing in accordance with ASTM D5820. Upon completion of the test, relieve pressure from the opposite end of the seam being tested to verify continuity of the seam.

3.4.2.2 Liner Vacuum Box Test

Perform a vacuum box test in accordance with ASTM D5641/D5641M on each field seam, the area around the seams, and each liner surface showing injury due to scuffing, penetration by foreign objects, or distress from rough subgrade. If the vacuum box test indicates a continuous stream of bubbles on repeated testing at the same location, then the area being tested is considered damaged and must be repaired and retested. Perform repairs in accordance with manufacturer's recommendations.

3.4.3 Destructive Field Seam Testing

****

NOTE: Destructively testing field seams at a fixed frequency (the method described in this paragraph) is a fairly standard approach for testing geomembrane seams. However, it is also a somewhat dated approach that was established prior to development of additional concepts that improve quality of geomembrane installations (e.g. taped edges, automatic welders, advanced non-destructive testing methods, certification of geomembrane installers). Destructive seam testing creates holes in a geomembrane where the samples are collected. These holes are patched/repaired using an extrusion seaming method which may be challenging to execute correctly. See Geosynthetic Institute's GRI Test Method GM29, December 2013 for additional discussion. The designer may wish to specify a different frequency of destructive field seam testing based on their own experience, the concepts discussed in GM29, and the application of some of the improved quality concepts mentioned above. However if doing so, the designer should be aware of any specific regulatory requirements on destructive field seam testing (i.e. a destructive testing method that is not acceptable to regulators should not be specified).

****

Obtain a minimum of one test sample per [230][_____] meter[s] [750][_____] feet of field seam. Recommended locations include the ends of seams or anchor trenches, so as to minimize the impact of required repairs to the geomembrane; however, final sample locations will be determined by the [CQC inspector][Contracting Officer]. Do not identify sample locations prior to seaming. Provide samples that are a minimum of 305 mm 12 inches by 1.1 meter[s] 42 inches long with the seam centered lengthwise. Cut each sample into three equal pieces, with one piece retained by the installer, one piece given to the CQC laboratory, and the remaining destructive field seam test sample submitted to the Contracting Officer for CQA testing and/or permanent record. Number and cross reference each sample to a field log which identifies: (1) panel number; (2) seam number; (3) date and time cut; (4) ambient temperature within 150 mm 6 inches above the geomembrane; (5) seaming unit designation; (6) name of seamer; and (7) seaming apparatus temperature and pressures (where applicable). Cut ten 25 mm 1 inch wide replicate specimens from the installer's sample. Field test in accordance with [ASTM D6392 for non-reinforced liner][or][ASTM D751 and ASTM D413 for fabric-reinforced liner]. Jaw separation speed must be in accordance with the approved CQC manual. To be acceptable, four out of five replicate test specimens must meet the seam strength requirements specified in paragraph PERFORMANCE REQUIREMENTS. If the field tests pass, test five specimens at the CQC laboratory for shear strength and five for peel adhesion in accordance with the CQC laboratory's approved procedures. To be acceptable, four out of five replicate test specimens must meet the seam strength requirements specified in paragraph PERFORMANCE REQUIREMENTS. If the field or laboratory tests fail, repair the seam in accordance with paragraph DESTRUCTIVE SEAM TEST REPAIRS. Repair holes for destructive seam samples the same day they are cut. Submit Installer and certified CQC laboratory

test results on all destructively tested field seams.

[3.4.4 Electrical Leak Location

****
NOTE: Electrical leak location is strongly encouraged by some organizations as a means of investigating and improving installed geomembranes. The designer should have a good understanding of electrical leak location methods, availability of testing firms to perform the work, and scheduling of electrical leak location testing to align with completion of placement of the geomembrane and covering/protection of the geomembrane. Refer to ASTM D6747 Standard Guide for Selection of Techniques for Electrical Leak Location of Leaks in Geomembranes to determine the appropriate location technique. If electrical leak location is used, the frequency of destructive testing of geomembrane seams can potentially be reduced (for more information see the note for paragraph DESTRUCTIVE FIELD SEAM TESTING). If electrical leak location is retained, the specification and references must indicate how leaks will be identified and how repairs will be made.
****

Perform electrical leak location in accordance with [_____].

]3.4.5 Visual Inspection And Evaluation

Immediately prior to covering, the CQC inspector [and Contracting Officer] will visually inspect the geomembrane, seams, and non-seam areas for defects, holes, or damage due to weather conditions or construction activities. At the Contracting Officer's or the CQC inspector's discretion, the surface of the geomembrane must be brushed, blown, or washed by the Installer if the quantity of dust, mud, or foreign material inhibits inspection or functioning of the overlying material. Non-destructively test each suspect location in accordance with paragraph NON-DESTRUCTIVE FIELD SEAM TESTING. Repair each location that fails non-destructive testing in accordance with paragraph PATCHES, and non-destructively retest.

[3.5 PROTECTION AND BACKFILLING

Do not leave any tools or equipment on the geomembrane after active work ceases in the area. Do not cover the geomembrane until the Contracting Officer approves the geomembrane liner installation. Cover the deployed and seamed geomembrane with the specified material within [five][14][_____] calendar days of acceptance. Prevent wrinkles in the geomembrane from folding over during placement of cover materials. Do not drop cover soil onto the geomembrane or overlying geosynthetics from a height greater than 1 meter 3 feet. Push the soil out over the geomembrane or overlying geosynthetics in an upward tumbling motion. Place soil from the bottom of the slope upward. Provide an initial loose soil lift thickness of [350][_____] mm [12][_____] inches. Do not operate equipment directly on the geomembrane. Use equipment with ground pressures less than 50 kPa 7 psi to place the first lift over the geomembrane. Maintain a minimum of [460][610][915][_____] mm

[18][24][36][_____] inches of soil between construction equipment with ground pressures greater than 50 kPa 7 psi and the geomembrane. Cover soil compaction and testing requirements are described in [Section 31 00 00 EARTHWORK][_____]. While placing cover soil do not operate equipment by stopping abruptly, making sharp turns, spinning their wheels, or traveling at speeds exceeding [2.2][_____] m/s [5][_____] mph.

]3.6 As-Built drawings

Submit final as-built drawings of the geomembrane installation. Include panel numbers with a unique identifier that can be linked to the [resin][roll] [number][factory] panel number, seam numbers, location of repairs, destructive seam samples, and penetrations in these drawings.

-- End of Section --