APPENDIX B
Specifications

Appendix B, Specifications, Section 2.0 – Engineering Standard SC38P, Liner Materials and Installation, Engineering Standard SC1A, General Conditions for Civil, Building, and Plumbing Specifications and Engineering Standard SC5E, Fill-Test Controlled Compaction, have been adopted by INVISTA.

Appendix B, Specifications, Section 5.0 – Engineering Standard SC8E, Seeding, has been adopted by INVISTA.

SPECIFICATIONS

INVISTA SEAFORD POWERHOUSE ASH LANDFILL

FINAL CLOSURE SYSTEM

SEAFORD PLANT

Seaford, Delaware

September 2003

1.0 SUBGRADE PREPARATION

1.1 SCOPE

This portion of the specification describes the materials and methods of preparing the subgrade for the construction of the geomembrane-lined closure system to the lines, grades, and cross-sections shown on the drawings.

1.2 GRADING

Prior to placement of any cap materials on the landfill, all topsoil under the cap footprint shall be stripped and stockpiled as directed by Seaford Plant personnel. The surface shall be graded smooth to the lines, grades, and cross-sections shown on the drawings.

1.3 FINAL ROLLING

After final grading, the entire subgrade shall be proof rolled/compacted using a minimum 10-ton smooth wheel or pneumatic-tired power roller. The compacted surface shall be firm and smooth. Soft or unstable materials that rut or deflect under the roller and do not tighten up with successive passes may require moisture conditioning (i.e. drying) and additional compaction. Materials that do not tighten up after moisture conditioning and additional compaction shall be removed and replaced with test-controlled compacted fill.

Wheeled vehicles shall use care so as not to cause rutting in the completed subgrade. Excessive rutting (determined by the owner) shall be cause for reworking the area prior to placing cap materials. Between acceptance of the subgrade and installation of the geomembrane liner, the dressing of any eroded or otherwise damaged earth surfaces will be the responsibility of the earthwork contractor. Adequate drainage of the subgrade shall be provided and maintained until the geomembrane liner is placed.

2.0 GEOMEMBRANE

The geomembrane liner shall be made of high-density polyethylene (HDPE) textured on both sides with a thickness of 40 mils. The geomembrane material and installation shall meet the requirements of DuPont Engineering Standard SC38P (attached).

Civil Engineering Systems—Civil

SC38P

Section 02778

Liner Materials and Installation: High Density Polyethylene (HDPE) Geomembrane (30 to 120 Mil Thickness)

Table of Contents

Document revised March 2000 / Document reaffirmed March 2000

Contact Valerie.S.Lamison@usa.dupont.com on E-mail for more information.

List of Tables

1. Scope

This specification describes the manufacture and installation of high density polyethylene geomembranes. Both smooth and textured geomembrane surfaces are included. All procedures, operations, and methods shall be in strict accordance with specifications, plans, and engineering drawings.

1.1 Referenced DuPont Engineering Standards

SC1A General Conditions for Civil, Building, and Plumbing

SC5E Fill-Test Controlled Compacted

1.2 Referenced standards

ASTM D 638

ASTM D 792

ASTM D 1004

ASTM D 1238

ASTM D 1248

ASTM D 1505

ASTM D 1603

ASTM D 1765

ASTM D 3895

ASTM D 4437

ASTM D 4833

ASTM D 5199

ASTM D 5397

ASTM D 5596

ASTM D 5721

ASTM D 5820

ASTM D 5885

ASTM D 5994

GRI-GM 6

GRI-GM 13

2. General

DuPont Engineering Standard SC1A (General Conditions) applies to and is a part of this specification.

2.1 Manufacturer quality control (MQC)

2.1.1 Resin manufacturer

The Resin Manufacturer shall supply a first quality resin that has been designed and manufactured specifically for the intended purpose. The Resin Manufacturer shall be capable of supplying and certifying resin that satisfies the requirements of **Table 1**.

2.1.2 Geomembrane manufacturer

The Geomembrane Manufacturer shall have a Quality Control (MQC) plan that has been implemented and followed. The Geomembrane Manufacturer shall have manufactured at least 10,000,000 square feet of HDPE geomembrane and be capable of supplying and certifying HDPE geomembrane that satisfies requirements of **Table 2** and/or **3**.

2.1.2.1 Requirements of the geomembrane MQC plan

2.1.2.1.1 Incoming resin shall be tested prior to geomembrane manufacture at a frequency of one per hopper or batch but not less than one per 200,000 lbs. This testing will verify the properties reported by the Resin Manufacturer and will confirm that meet the properties presented in **Table 1** are satisfied.

2.1.2.1.2 **Table 4** presents the minimum frequency of sampling and testing for MQC.

2.1.2.1.3 The HDPE rod used in extrusion welding shall be tested at least once per formulation and satisfy the requirements of **Table 1**.

2.1.2.1.4 Any resin, geomembrane roll, or extrusion rod formulation that does not meet all of the MQC requirements of the manufacturer or this specification must be rejected.

2.2 Installer

2.2.1 Experience

The Installer shall be approved by the CQA Engineer and must have at least five years' continuous experience in the installation of HDPE geomembrane and/or experience totaling at least 10,000,000 square feet of installed HDPE geomembrane.

2.2.2 Installation supervisor

Installation shall be performed under the direction of an Installation Supervisor who shall remain on-site and be in charge throughout the geomembrane installation, including subgrade acceptance, liner layout, seaming, testing

and repairs. The Installation Supervisor shall have supervised the installation of at least 1,000,000 square feet of HDPE geomembrane.

2.2.3 Master seamer

Actual seaming of the geomembrane shall be performed under the direction of a Master Seamer who may be the same person as the Installation Supervisor and who has experience seaming a minimum of 1,000,000 square feet of HDPE using the same type of seaming apparatus as will be used to satisfy this specification. The Master Seamer must be on-site whenever seaming is being performed. Other seamers shall have experience seaming at least 500,000 square feet of HDPE.

2.2.4 Requirements of the construction quality control (CQC) plan

The Installer must have a Construction Quality Control plan that will be implemented and followed. The Personnel that carry out the CQC plan may be a part of the Installer's personnel or may be hired by the Installer or Contractor.

2.2.4.1 The CQC plan will include provisions for non-destructive and destructive testing of field seams including testing of geosynthetic joints and connections at appurtenances for continuity.

2.2.4.2 The CQC plan will include documentation of all changes, tests, repairs, and re-tests.

2.2.5 Requirements of the installation procedure manual

The Installer shall have an Installation Procedure Manual for HDPE geomembranes that is compatible with the installation guidelines provided by the Geomembrane Manufacturer. The Design Engineer must approve any discrepancies.

2.2.5.1 The Installation Manual shall set forth a minimum and maximum ambient temperature for seaming. Alternately, the temperature can be measured on the sheet.

2.2.5.2 The Installation Manual shall present measures for preventing uplift of the geomembrane due to wind.

2.2.5.3 The Installation Manual shall present guidelines for determining the acceptability of the subgrade surface.

2.2.5.4 The Installation Manual shall provide for inspecting the quality and consistency of the welding material.

2.2.5.5 The Installation Manual shall present guidelines for proper preparation of the geomembrane surface prior to seaming.

2.2.5.6 The Installation Manual shall contain a complete description of the seaming procedure that will be used.

2.3 CQC personnel

The CQC Personnel will carry out the Construction Quality Control plan. A CQC Consultant will be in charge of carrying out the plan, monitoring the other CQC personnel, and documenting and reporting the CQC activities to the CQA Engineer.

2.4 Construction quality assurance (CQA) personnel

The CQA Personnel work for an organization that operates separately from the Owner, Contractors and Installer. The CQA Personnel's organization is hired by the Owner and may not be involved in the manufacture, construction, or installation of the project. The CQA Personnel will implement and follow the approved CQA plan.

2.4.1 CQA engineer

The CQA Engineer will lead the CQA Personnel. The CQA Engineer must be a registered professional engineer and have prior experience on similar projects. The CQA Engineer must be on site for the initiation all major construction activities.

2.5 MQA/CQA geosynthetic laboratory

The Owner or CQA Engineer shall employ an independent GAI-LAP accredited Geosynthetics Laboratory to perform QA testing on the geomembrane and seams as well as interface friction and transmissivity tests, if required. The Lab must have an internal Quality Control plan in effect that monitors conformance with ASTM and other applicable testing standards. The Lab must maintain chain of custody records for samples and be capable of reporting data to the CQA Engineer within the allotted time period. The Lab must be willing to allow observation by the owner, CQA Engineer, permitting agency, Installer, or Design Engineer during testing and recordkeeping for the project, if this is desired.

2.6 Submittals

2.6.1 Resin manufacturer

The Resin Manufacturer will submit certification for each resin batch to the Geomembrane Manufacturer. The Geomembrane Manufacturer shall forward this to the CQA Engineer.

2.6.2 Geomembrane manufacturer

Geomembrane Manufacturer will submit MQC documentation and Field Installation Guidelines to the CQA Engineer. Prior to delivery of the geomembrane to the job site, the Geomembrane Manufacturer shall provide certificates for each roll and extrusion rod batch to the CQA Engineer. No geomembrane should be delivered until the CQA Engineer has such certification and has approved shipment. In the event that shipment does take place prior to approval of the material by the CQA Engineer, the

geomembrane rolls remain the responsibility of the Geomembrane Manufacturer until approved.

2.6.3 Installer

The Installer will submit documentation of personnel qualification, a CQC plan, and an Installation Procedures Manual. The Installer will create approval drawings prior to installation and as-built drawings during installation. The Installer will provide a Warranty good for two years following the date of acceptance by the Owner.

2.6.3.1 Approval drawings

The installer shall produce drawings showing proposed placement of panels and seams. Field seams shall be differentiated from factory seams, if any. Field seams and cross-seams shall be minimized. Slope seams shall be run as straight up and down the slope as possible. There shall be no horizontal seams on slopes. Horizontal seams shall be placed no closer than 3 feet from the toe of the slope. Penetrations and irregular configurations shall be detailed.

2.6.3.2 As-built drawings

The installer shall provide "as-built" layout drawings reflecting any changes from the approval drawings. As-built drawings shall include the dimensions and locations of each panel or roll, the identification and location of all patches and repairs, and the location and identification of areas chosen for destructive seam testing.

2.6.4 CQC consultant

The CQC Consultant shall submit to the CQA Engineer documentation of personnel qualifications, records of all quality control measures, and certification that the CQC plan was followed. (See Sections 2.7 and 5)

2.6.5 CQA engineer

The CQA Engineer shall prepare and submit documentation of personnel qualifications, records of all quality assurance measures, and the final CQA document. (See Sections 2.7 and 5)

2.6.6 CQA geosynthetics lab

The CQA Geosynthetics Lab shall submit documentation of internal Quality Control, chain of custody records, and test results to the CQA Engineer.

2.7 Documentation

A major responsibility of the CQC and CQA Personnel in addition to executing their respective plans is to document that they have done this. This is necessary to prove that the landfill has been constructed correctly.

2.7.1 Daily reports

Daily Reports shall be completed by at least the Installation Supervisor, CQC Consultant, and CQA Engineer. It may be beneficial for additional personnel to complete daily reports as well. These reports describe exactly what was accomplished on a particular day.

2.7.2 Daily summary report

The CQA Engineer will create a Daily Summary Report. The report will include the weather conditions, summaries of meetings, and a synthesis of the Daily Reports. The purpose of the Daily Summary Report is to track the details of each aspect of the construction including personnel, equipment, materials, and inspections.

2.7.3 Inspection and testing reports

All observations, results of field tests, and results of laboratory tests shall be recorded with attention to detail. Test failures and subsequent corrective measures must be documented as well.

2.7.4 Design/construction issues resolution

All issues requiring input or approval by the CQA Engineer shall be fully documented by CQA Engineer.

2.8 Guarantee

Liner installation shall be guaranteed by the Installer in writing for a period of two years after the Owner's acceptance against defective workmanship performed by the installer. This shall not include vandalism, earthquakes, or other unusual acts of God. The guarantee shall be included in the bid submitted by the installer.

3. Products

3.1 Materials

3.1.1 Resin requirements

The polyethylene resin shall meet the requirements set forth in **Table 1**. The resin shall be made from virgin, uncontaminated ingredients.

3.1.2 Geomembrane requirements

3.1.2.1 Formulation

The formulation used for the manufacture of the geomembrane shall be at least 97% polyethylene resin. The HDPE geomembrane formulation can contain no more than 5% rework or regrind. Rework sometimes called regrind or trim is finished geomembrane material that has been cut from the edges or ends of rolls or was off-specification. It is fed as strips or pellets back into the production system. To be acceptable, it must be of the same formulation as the parent material. No reclaimed or recycled materials that

have been used in an application may be added to the formulation. If additives are included in the formulation, the type of additive may be requested of the manufacturer, and the amount of additive shall not exceed 1.0% by weight. Though not required to reveal the exact formulation of the geomembrane, the Geomembrane Manufacturer must be able to certify that the formulation has been successful in similar applications.

3.1.2.1.1 Carbon black

The carbon black used in the formulation shall be a Group 3 category, or lower, as defined in ASTM D 1765.

3.1.2.2 Preparation of formulation

The blending, mixing, and extrusion equipment must be clean and completely purged from previously mixed materials of a different formulation. Before the formulation is extruded, it must be completely homogenized. No traces of segregation, agglomeration, streaking, or discoloration shall be visibly apparent in the geomembrane.

3.1.2.3 Physical properties

The polyethylene geomembrane shall meet all requirements of **Table 2** for smooth geomembrane or **Table 3** for textured geomembrane. The width of the geomembrane shall be within 2% of the Geomembrane Manufacturer's specified width.

3.1.2.4 Appearance

The geomembrane shall be free of holes, blisters, undispersed raw materials, or any sign of contamination by foreign matter and shall not have striations, roughness, pinholes, or bubbles on the surface. Textured material shall have a uniform textured appearance and be free from agglomerated texturing material.

3.1.2.5 Certification

Prior to delivery of the geomembrane to the job site, the Geomembrane Manufacturer shall provide certificates for each roll to the CQA Engineer. No geomembrane should be delivered until the CQA Engineer has such certification and has approved shipment.

3.1.2.6 Roll identification

Each roll shall have permanently affixed both inside and outside of the roll the following information: name of manufacturer, product identification, thickness of the material, roll number, roll length, and roll width.

3.1.2.7 Packaging

The cores of the rolls shall have sufficient diameter and be sufficiently strong to ensure that the roll can be lifted without excessively deflecting or buckling.

3.1.2.8 Transportation

Transportation shall be the responsibility of the Geomembrane Manufacturer unless otherwise specified in the contract. Any material that is damaged or unacceptable upon arrival at the job site shall be replaced at the Geomembrane Manufacturer's expense.

3.1.2.9 Storage

3.1.2.9.1 Storage at manufacturing facility

Stacking of rolls shall not cause buckling of the cores or flattening of the rolls.

3.1.2.9.2 On-site storage

Once on site, storage of the geomembrane shall be the responsibility of the Installer, unless otherwise specified in the contract. The geomembrane shall be stored so that deformation of the rolls cannot occur and so that contamination from foreign substances cannot take place. Appropriate handling equipment shall be used when moving rolled goods from one place to another. Any damage caused by the Installer shall be repaired at the Installer's expense.

3.1.3 Extrusion rod

The Extrusion Rod shall meet the properties in **Table 1**. The Extrusion Rod shall be certified by the Geomembrane Manufacturer to be of the same formulation as the HDPE geomembrane. If other types of extrusion are to be used, they must be subjected to rigorous testing, be proven effective in previous similar applications, and be approved by the CQA Engineer prior to their use.

3.2 Equipment

3.2.1 Welding equipment

3.2.1.1 Fusion welding

The Fusion Welding machine shall be automated, vehicular-mounted, equipped with devices giving applicable temperatures and pressures and shall be approved by the CQA Engineer.

3.2.1.2 Extrusion welding

The Extrusion Welding Equipment shall have temperature readout devices that measure the temperature of the extrudate and shall be approved by the CQA Engineer.

3.2.1.3 The installer shall maintain on site at least one spare operable seaming unit.

3.2.2 Field tensiometer

A Field Tensiometer shall be kept on site to perform CQC shear and peel testing on seams. The tensiometer shall be in conformance with the

requirements of ASTM D 638 (Type IV, 2 ipm) and be in good working order. It shall have a current calibration certificate.

3.2.3 Vacuum box

Two Vacuum Boxes shall be kept on site. The boxes shall be capable of producing a vacuum of at least 5-psi and holding it for at least 15 seconds.

3.2.4 Air pressure test equipment

All the equipment necessary to perform the Air Pressure Test as outlined in GRI-GM 6 and ASTM D 5820 shall be on site and in working order. The equipment shall be capable of producing at least 10 psi in excess of the specified values in GRI-GM 6.

3.2.5 Roll handling equipment

Equipment for handling and moving geomembrane rolls around the job site shall be such that no damage is caused to the rolls.

4. Execution

4.1 Pre-construction meeting

4.1.1 Attendees

The Owner's Representative, Design Engineer, representatives of general contractor and sub-contractors, the CQA Engineer, and possibly representatives from the permitting agency should be in attendance.

4.1.2 Timing

The meeting will take place prior to construction on the landfill but after the construction contractor, major subcontractors and material suppliers have been chosen.

4.1.3 Agenda

The different parties should be introduced and their respective responsibilities presented. Any questions about the CQA plan, procedures, or documentation should be asked and answered. Any discrepancies between specifications, the CQC plan, and the CQA plan should be resolved so that all the parties know what procedures to implement. The design, critical aspects of the construction, and scheduling should be covered.

4.2 Safety meeting

Prior to installation, the owner will conduct the safety meeting including safety requirements and site orientation.

4.3 Installation

4.3.1 Subgrade

4.3.1.1 Fill

Where fill is required to bring subgrade surface to grade, fill shall be placed and test control compacted according to DuPont Engineering Standard SC5E.

4.3.1.2 Surface conditions

The surface to be lined shall be smooth and free of all rocks, stones, sticks, roots, sharp objects, or debris of any kind. The surface shall provide a firm, unyielding foundation with no sharp changes or abrupt breaks in grade. Tire or track deformations shall not be greater than 1 inch. No standing water or excessive moisture shall be allowed. In clay substrates, moisture shall be measured within 24 hours of liner placement. Moisture shall be 1 to 3 percent above optimum. In the case of deployment of the geomembrane over other geosynthetic materials, all folds, wrinkles, and other undulations shall be smoothed prior to deployment of the geomembrane.

4.3.1.3 Surface acceptance

The Installer and CQA Engineer shall certify in writing that the surface to be lined is acceptable. No geomembrane shall be placed on surfaces deemed unsuitable by the Installer or CQA Engineer.

4.3.1.4 Anchorage

Anchor trenches shall be excavated no more than 2 or 3 days ahead of the time of the geomembrane deployment.

4.3.2 Weather

4.3.2.1 Temperature for installation

Installation shall not take place if the temperature exceeds 50C or drops below 0C unless the CQA Engineer approves the continuance of installation work. In extreme heat, sticking that leads to tearing or straining of the geomembrane should not be permitted to occur. In extreme cold, cracking, crazing, or distorting should not be permitted to occur to the geomembrane. In either case, damaged rolls shall be inspected by the CQA Engineer and then repaired or rejected at the CQA's discretion. Repairs shall be made in accordance with Section 4.4.6.

4.3.2.2 Slack considerations

The amount of slack left in the geomembrane shall be calculated based on the coldest temperatures envisioned. Tensile stresses shall not be generated in the geomembrane or seams during or just after installation. At no time, shall the geomembrane lift up off the subgrade or substrate in the form of waves or wrinkles. Excessive slack that leads to creases which fold over on themselves shall not be permitted during deployment, seaming, or as

overburden is placed. Any creases that occur shall be repaired in accordance with Section 4.4.6.

4.3.2.3 Wind

Measures shall be taken to prevent uplift of the geomembrane by the wind. Rolls that are damaged by the wind shall be inspected by the CQA Engineer and then repaired or rejected at the CQA's discretion. Repairs shall be made in accordance with Section 4.4.6.

4.3.3 Slope safety

Tag lines may be necessary on slopes to assist personnel.

4.3.4 Deployment

After the subgrade is approved, the geomembrane rolls shall be moved to their intended locations. Rolls shall be placed as close as possible to their final location.

4.3.5 Spotting

Spotting or shifting of the geomembrane prior to seaming shall not result in disturbance to the subgrade or underlying geosynthetics. Dragging of the geomembrane over the subgdrade shall be minimized. Temporary tack welding will be permitted so long as it does not interfere with the primary seaming method or the ability to perform accurate destructive seam tests.

4.3.6 Inspection of geomembrane

Prior to seaming, the entire geomembrane surface shall be examined by the CQA Engineer to confirm that it is free of any defects, holes, blisters, undispersed raw materials, or contamination by foreign matter. Each roll will be approved, rejected, or marked for repair (see Section 4.4.6) by the CQA Engineer.

4.3.7 Approved seaming methods

4.3.7.1 Thermal fusion process (preferred method)

A thermal fusion weld creates a seam by inserting a hot wedge or by blowing hot air between overlapped sheets of geomembrane thus melting them together. See Section 3.2.1.1 for equipment requirements. Dual track welds are necessary if an air pressure is to be performed. Weld temperature and machine speed shall be varied according to ambient conditions to maintain a consistent weld. All welding surfaces shall be kept clean and dry. The Installer's CQC plan shall be followed and referred to for seaming protocol and details.

4.3.7.2 Extrusion process

4.3.7.2.1 An extrusion weld creates a seam by extruding molten resin at the edge of overlapped sheets of geomembrane. Temperature and flow rate shall be varied according to ambient conditions to maintain a consistent

weld. The Installer's CQC plan shall be followed and referred to for seaming protocol and details.

4.3.7.2.2 The extruder shall be purged of all heat degraded or cooled extrudate prior to the commencement of each seaming sequence. Only extrusion rods certified by the Geomembrane Manufacturer shall be used, see Section 3.1.3. See Section 3.2.1.2 for equipment requirements.

4.3.7.2.3 The welding surface shall be prepared by sanding or grinding to a depth no more than 5% of the sheet thickness. The weld surfaces shall be kept clean and dry.

4.3.7.2.4 Extrusion welding shall be primarily used to seam patches, cap strips, poorly accessible areas, and extremely short seam lengths.

4.3.8 Seaming procedures

4.3.8.1 Where conditions warrant, the installer shall be allowed to use a temporary support surface between the geomembrane and the subgrade to achieve proper support during the seaming operation. The temporary support must not cause deformation of the subgrade.

4.3.8.2 Seaming shall be a continuous process with a minimum of interruptions along any given seam.

4.3.8.3 Prior to seaming, the geomembrane shall be overlapped a minimum of 4 inches for fusion welding and a minimum of 3 inches for extrusion welding. Procedures used to temporarily position or bond the rolls shall not result in damage to the geomembrane or interfere with the welding process.

4.3.8.4 Seams shall be aligned so as to create a smooth and wrinkle-free surface in the overlap area.

4.3.8.5 In extrusion welding, grinding is required along a seam, and this shall be done within one hour of the seaming operation and in a way which does not damage the geomembrane.

4.3.8.6 Artificially induced cooling of seams by water or any other means shall not be allowed.

4.3.9 Sumps and penetrations

4.3.9.1 The geomembrane shall be installed around any pipes, concrete structures, or other penetrations in accordance with the details shown on the approval drawings, see Section 2.6.3.1. Prior to the start of the construction, the Installer may request of the CQA Engineer approval of alternate installation methods.

4.3.9.2 All clamps, bolts, nuts, gaskets not shown on the drawings, or other materials used to secure the geomembrane shall be compatible with and have a lifespan at least equal to that of the geomembrane in the waste environment.

4.3.9.3 Soil shall be sufficiently compacted so as to protect the geomembrane from damage due to differential settlement at any soil to concrete transition. Soil compaction shall be in accordance with Section 4.3.1.1.

4.4 Construction quality control (CQC) and construction quality assurance (CQA)

4.4.1 Manufacturer quality assurance

4.4.1.1 Sampling

The CQA Personnel is responsible as part of MQA for verifying that the geomembrane materials satisfy the properties marked for MQA in **Table 4.** This is done by sampling the geomembrane material at the specified frequency in accordance with either Section 4.4.1.1.1 or 4.4.1.1.2.

4.4.1.1.1 In-plant sampling

In-plant Sampling is performed during or after manufacture of the geomembrane but before the CQA Engineer approves the material for shipment. A member of the CQA Personnel, a representative of the MQA/CQA Laboratory or another independent third party representative goes to the manufacturer to cut or observe the cutting of the samples, collect the samples, and ship the samples to the CQA Lab. The sampler must be capable of assuring that the minimum frequency has been met and that the appropriate rolls have been sampled. The CQA will not approve the shipment of the geomembrane until reviewing and approving the test results.

4.4.1.1.2 On-site sampling

The CQA Personnel will take samples from the geomembrane after it has been delivered to the job site. The samples will be sent to the CQA Lab. Installation must not take place until the test results are reviewed and approved by the CQA Engineer.

4.4.2 The Installer's CQC plan shall be followed, see Section 2.2.4. The provisions in this standard are the minimum acceptable measures for Quality Control. Any additional measures included in the Installer's CQC plan should be followed. The CQA Engineer shall witness all the CQC measures as well as implement the CQA plan. The approved CQA plan shall be followed. The CQA provisions in this standard are the minimum acceptable measures for Quality Assurance. Any additional measures included in the approved CQA plan should be followed.

4.4.3 Test seams

4.4.3.1 The CQA Engineer shall witness all test seams including sampling and field testing.

4.4.3.2 Frequency

Test seams shall be made to verify that under existing conditions successful field seaming can commence and proceed. A test seam shall be produced and approved before seaming commences and once every four hours

thereafter. In addition, when a seaming operation has been suspended for more than 30 minutes, a breakdown of the seaming equipment occurs, or changes in weather, equipment or personnel take place, a test seam shall be produced and approved prior to resumption of seaming operations. The CQA Engineer may request additional test seams at any time.

4.4.3.3 Method

Test seams shall be made in the field on pieces of the approved geomembrane. Each test seam shall be at least 3 ft long by 1 ft wide and with sufficient overlap for peel and shear testing in the field tensiometer. All parameters and conditions of the test seam shall be identical to those of the field seams.

4.4.3.4 Test specimens

Immediately after the seam cools to ambient temperature, cutting and testing of the test specimens will take place. Two specimens each with a width of one inch shall be taken across the seam using an approved template. The CQA Engineer will randomly select the location of the specimens within the test seam. The CQC Personnel will carry out the specimen cutting and testing.

4.4.3.5 Testing

The two specimens shall be tested in the field tensiometer, one in peel and one in shear. To pass, the sample must experience Film Tear Bond (FTB) rupture and satisfy the strength requirements of **Table 5**. A non-FTB rupture with sufficient strength per **Table 5** should be discarded and a new specimen cut and tested. An insufficient strength reading or two non-FTB ruptures with sufficient strength will cause the seam to fail the test. If a failure occurs in shear or peel, field seaming will not commence until another test seam passes in both peel and shear. If both specimens pass, field seaming shall commence immediately.

4.4.3.6 Failures

Seaming should never begin until a successful test seam validates the acceptability of seaming conditions. If a test seam taken during a shift fails, an extra destructive sample must be taken from the length of seam in question. If this fails, the seam should be repaired in accordance with Section 4.4.6. If the destructive test passes, the seam will be accepted if it passes nondestructive testing.

4.4.4 Non-destructive tests (NDTs)

4.4.4.1 General

4.4.4.1.1 The purpose of non-destructive testing is to verify the continuity of the field seams. NDTs do not attempt to measure the seam strength.

4.4.4.1.2 NDTs take place as part of CQC. The CQA Engineer shall observe all NDTs.

4.4.4.1.3 Non-destructive testing shall be performed concurrently with field seaming.

4.4.4.1.4 Some type of NDT shall be performed on 100% of the field seams.

4.4.4.1.5 Location, type of test, test number, name of operator, outcome of test, and any other pertinent information shall be recorded for each NDT.

4.4.4.2 Air pressure test (for dual track fusion welds)

The Air Pressure test shall be conducted in accordance with GRI-GM 6 and ASTM D 5820. The seam to be tested is sealed off at both ends and pressurized. The feed valve is closed and the pressure sustained for a period of not less than 5 minutes. If a pressure loss greater than that allowed by the GRI test method is observed or if the required pressure cannot be reached, then the seam fails the test. Failures will be repaired in accordance with Section 4.4.6. All holes created during air pressure testing shall be sealed with extrudate upon completion of the test and vacuum tested.

4.4.4.3 Vacuum box test

4.4.4.3.1 All extrusion welded seams, single-track fusion welds, and any dual track fusion welds that could not be tested by the Air Pressure test shall be evaluated using Vacuum Box testing.

4.4.4.3.2 A soapy water solution shall be applied to the section of seam to be tested. The vacuum box is placed over the section and used to create a vacuum of at least 3-psi. The test section shall be visually examined under vacuum for a period not less than 15 seconds to determine whether bubbling of the soapy solution is occurring. Bubbling will cause the section of seam to fail the NDT. Failures will be repaired in accordance with Section 4.4.6. Upon completion of the test, the Vacuum Box test is performed on the next adjacent length of seam including an overlap of at least 3 inches with the previously tested section.

4.4.4.4 Spark test

The Spark Test consists of placing a copper wire 1/8-inch under the top sheet overlap of the two sheets prior to extrusion welding. After welding, a spark detector is run along the length of the weld carrying 20,000 volts. The circuit will be completed if there are any holes in the weld. This test method shall only be used when the vacuum test cannot be used and there is no hazard anticipated from a spark. This test should not be performed in water or where there is excessive moisture.

4.4.4.5 Alternate nondestructive procedures shall be submitted for approval prior to the commencement of installation.

4.4.5 Destructive tests

4.4.5.1 Destructive testing of samples of field seams shall be conducted under the direction of the CQA Engineer in order to verify the criteria given in **Table 5**. All sampling and testing shall be done concurrently with field

seaming so that verification of field seam properties is made as the work progresses and corrective action implemented.

4.4.5.2 Seam samples shall be removed from the seam at a rate of one sample per 500 linear feet. Additional samples may be required when the CQA Engineer has reason to suspect excess crystallinity, contamination, faulty seaming equipment or any other adverse seaming condition. The CQA Engineer may require extra sampling at any time.

4.4.5.3 Each seam sample shall measure 12 inches wide by 14 inches long with the seam centered lengthwise along the sample. The Installer under the direction of the CQA Engineer shall cut samples. Each sample shall be indelibly numbered and identified. The CQA Engineer shall record the sample number and location.

4.4.5.4 Two specimens with width of 1 inch shall be cut from one end of the sample using an approved template. The specimens shall be tested by the Installer in the field tensiometer as in Section 4.4.3.5. In the case that both samples pass, the remainder of the sample shall be sent to the CQA laboratory for testing. Five peel tests and five shear tests shall be conducted by the lab on the 12-inch by 12-inch sample.

4.4.5.5 The results of field and laboratory testing shall determine the acceptability of the seam. Laboratory testing shall be performed in accordance with the methods given in ASTM D 4437 to verify the criteria given in **Table 5**. Any specimen that fails field or laboratory testing shall cause the sample to fail.

4.4.5.6 The magnitude of the seam's deficiency must be determined. Two additional destructive seam samples will be taken ten linear feet on either side of the failed sample. If specimens pass both peel and shear in the field tensiometer, the remainder of the sample will be sent to the CQA laboratory. Passing results from the lab will result in only the 20-foot length between the passing samples needing to be repaired in accordance with Section 4.4.6. If failing results occur in the tensiometer or in the lab, this sampling procedure will be continued until the original seam sample failure is bounded on either side by a passing seam sample or the CQA Engineer decides to fail the entire seam and repair its entire length.

4.4.5.7 The area from which the destructive test sample was taken shall be repaired without delay in accordance with the procedures given in Section 4.4.6.

4.4.6 Repairs and re-testing

4.4.6.1 Patches

4.4.6.1.1 Damaged portions of geomembrane that the CQA Engineer has allowed to be repaired and holes left after seam sampling shall be patched.

4.4.6.1.2 All patches shall have rounded corners, shall consist of the approved geomembrane material, and shall extend beyond the edge of any defect a minimum of 4 inches in all directions.

4.4.6.1.3 Patches shall be welded in place. Welding shall be in conformance with the procedures given in Section 4.3.7.2.

4.4.6.1.4 The seams around patches shall be Vacuum Box tested in accordance with Section 4.4.4.3. Any patch seams that cannot be Vacuum Box tested shall be tested by the Spark Test in accordance with Section 4.4.4.4 if approved by the CQA Engineer.

4.4.6.2 Cap strips

4.4.6.2.1 Any seams that fail inspection due to destructive testing shall be re-sealed with a cap strip. The cap strip is a patch that completely covers the failed seam. The cap strip shall extend a minimum of four inches beyond the seam on both sides and beyond the failed section into passing seam on both ends.

4.4.6.2.2 Any seams that fail non-destructive testing and have been sealed or re-sealed with an extrusion weld (see Sections 4.3.7.2 and 4.4.6.3) shall be re-sealed with a cap strip.

4.4.6.2.3 The seams around cap strips shall be Vacuum Box tested in accordance with Section 4.4.4.3. Any cap strip seams that cannot be Vacuum Box tested shall be tested by the Spark Test in accordance with Section 4.4.4.4 if approved by the CQA Engineer.

4.4.6.3 Extrusion weld

4.4.6.3.1 Any seams that fail inspection due to non-destructive testing and were not originally sealed by an extrusion weld shall be repaired with an extrusion weld in accordance with Section 4.3.7.2.

4.4.6.3.2 All extrusion weld repairs shall be Vacuum Box tested in accordance with Section 4.4.4.3. Any extrusion weld repairs that cannot be Vacuum Box tested shall be tested by the Spark Test in accordance with Section 4.4.4.4 if approved by the CQA Engineer.

4.4.7 Overburden

4.4.7.1 The CQA Engineer shall identify any large wrinkles that may have been built into the geomembrane. Any such wrinkle not intentionally formed to accommodate thermal contraction of the geomembrane shall be cut, lain flat, patched, and tested by the Installer prior to placement of the overburden. Any fishmouths created during seaming should be repaired similarly. (See Section 4.4.6)

4.4.7.2 The CQA Engineer shall identify any slope toe, depression, or other surface transitions that might result in bridging of the geomembrane during placement of the overburden. Any such area shall be cut, repaired, and tested by the Installer. Repairs may include splicing in additional geomembrane. (See Section 4.4.6)

4.4.7.3 No vehicle of any kind should at any time be driven directly on the geomembrane without authorization from the CQA Engineer.

4.4.7.4 A minimum thickness of 1 ft of cover shall be maintained between the geomembrane and light earth moving equipment. Such equipment shall have a maximum ground pressure of 9 psi. Equipment shall have no cleats and no abrupt turning shall be allowed on the initial 1 ft of cover.

4.4.7.5 In all cases, the placement of overburden shall be done with caution and in a manner that is least likely to cause wrinkles in, or damage to, the geomembrane.

4.4.7.6 The CQA Personnel shall be on-site during the placement of the overburden to ensure that no damage occurs to the geomembrane.

5. Acceptance

5.1 The Installer and Geomembrane Manufacturer retain ownership and responsibility for the geomembrane until acceptance by the owner.

5.2 Acceptance cannot occur until after the installation is completed and the CQC personnel have submitted the final copy of non-destructive test documentation, repair information, and as-built drawings to the CQA Engineer.

5.3 The CQA Engineer will then complete all documentation of installation and the final CQA report and submit these documents as directed by the owner.

5.4 Acceptance will occur after the CQA Engineer has certified that the installation has proceeded in accordance with the CQA plan and the project specification.

Table 1. HDPE resin and extrusion rod properties

Property	Test Method	Test Value
Resin		
Density, g/cc (range)	ASTM D 1505/ D 792	0.932–0.940 [a]
Melt index, g/10 min. (range)	ASTM D 1238 Condition 190/2.16	<1.0
Extrusion rod [b]		
Density, g/cc (min. average)	ASTM D 1505/ D 792	0.940
Melt index, g/10 min. (range)	ASTM D 1238 Condition 190/2.16	<1.0
Carbon Black Content, % (range)	ASTM D 1603 [c]	2.0–3.0

[a] See ASTM D 1248 for classifications of resins. The raw resin would actually be classified as Type II polyethylene which is medium density. With the addition of carbon black and additives, the density will be above 0.940 g/cc and be classified as high density polyethylene (HDPE). See **Table 2** and **3**.

[b] Minimum testing frequency is per each formulation.

[c] Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

Table 2. Properties of high density polyethylene (HDPE) geomembrane—smooth

Property	Test Method	Test Value						
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Thickness, mil. (average)	ASTM D 5199	30	40	50	60	80	100	120
Thickness, % (min.)	ASTM D 5199	–10	–10	–10	–10	–10	–10	–10
Density, g/cc (min.)	ASTM D 1505/D 792	0.940	0.940	0.940	0.940	0.940	0.940	0.940
Tensile properties[a] (min. average)	ASTM D 638 Type IV							
Yield stress, lb/in.		63	84	105	126	168	210	252
Break stress, lb/in.		114	152	190	228	304	380	456
Yield elongation, %		12	12	12	12	12	12	12
Break elongation, %		700	700	700	700	700	700	700
Tear Resistance, lb. (min. average)	ASTM D 1004	21	28	35	42	56	70	84
Puncture Resistance, lb. (min. average)	ASTM D 4833	54	72	90	108	144	180	216
Stress Crack Resistance, hrs.[b]	ASTM D 5397 (App.)	400	400	400	400	400	400	400
Carbon Black Content, % (range)	ASTM D 1603[c]	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0
Carbon Black Dispersion	ASTM D 5596	note[d]	note[d]	note[d]	note[d]	note[d]	note[d]	note[d]
Oxidation Induction Time (OIT), min. (min. average)[e]								
Standard OIT	ASTM D 3895	100	100	100	100	100	100	100
Or High pressure OIT	ASTM D 5885	400	400	400	400	400	400	400
Oven Aging at 85°C, % retained after 90 days[e,f]	ASTM D 5721							
Standard OIT (min. average)	ASTM D 3895	55	55	55	55	55	55	55
Or High pressure OIT (min. average)	ASTM D 5885	80	80	80	80	80	80	80
UV Resistance,[g,i] (min. average)	GM 11							
Standard OIT	ASTM D 3895	N.R.[h]	N.R.[h]	N.R.[h]	N.R.[h]	N.R.[h]	N.R.[h]	N.R.[h]
Or High pressure OIT, % retained after 1600 hours	ASTM D 5885	50	50	50	50	50	50	50

Source: GRI–GM 13

Note: This Table may be revised to incorporate the latest version of GRI–GM 13.

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

[b] The yield stress used to calculate the applied load for the SP–NCTL test should be the manufacturer's mean value via MQC testing.

[c] Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

[d] Carbon black dispersion for 10 different views: all 10 in Categories 1 or 2

[e] The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

[f] It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

[g] The condition of the test should be 20 hour UV cycle at 75°C followed by 4 hour condensation at 60°C.

[h] Not recommended since the high temperature of the Standard OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

[i] UV resistance is based on the percent retained value regardless of the original High Pressure OIT value.

Table 3. Properties of high density polyethylene (HDPE) geomembrane—textured

Property	Test Method	Test Value						
		30 mils	40 mils	50 mils	60 mils	80 mils	100 mils	120 mils
Thickness, mil. (nom.)	ASTM D 5994	30	40	50	60	80	100	120
Lowest individual for 8 out of 10 values (min. average)		–10	–10	–10	–10	–10	–10	–10
Lowest individual for any of the 10 values (min. average)		–15	–15	–15	–15	–15	–15	–15
Asperity Height, mil. (min. average)[a,b]	GM 12	10	10	10	10	10	10	10
Density, g/cc (min.average)	ASTM D 1505/D 792	0.940	0.940	0.940	0.940	0.940	0.940	0.940
Tensile properties[c] (min. average)	ASTM D 638 Type IV							
Yield stress, lb/in.		63	84	105	126	168	210	252
Break stress, lb/in.		45	60	75	90	120	150	180
Yield elongation, %		12	12	12	12	12	12	12
Break elongation, %		100	100	100	100	100	100	100
Tear Resistance, lb. (min. average)	ASTM D 1004	21	28	35	42	56	70	84
Puncture Resistance, lb. (min. average)	ASTM D 4833	45	60	75	90	120	150	180
Stress Crack Resistance, hr.[d]	ASTM D 5397 (App.)	400	400	400	400	400	400	400
Carbon Black Content, % (range)	ASTM D 1603[e]	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0	2.0–3.0
Carbon Black Dispersion	ASTM D 5596	note[f]	note[f]	note[f]	note[f]	note[f]	note[f]	note[f]
Oxidation Induction Time (OIT), min. (min. average)[g]								
Standard OIT	ASTM D 3895	100	100	100	100	100	100	100
High pressure OIT	ASTM D 5885	400	400	400	400	400	400	400

Source: GRI–GM 13

Note: This Table may be revised to incorporate the latest version of GRI–GM 13.

[a] Of 10 readings; 8 out of 10 must be greater than or equal to 7 mils, and the lowest individual reading must be greater than or equal to 5 mils.

[b] Alternate the measurement side for double sided textured sheet.

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

[d] The SP–NCTL test in 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.

[e] Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

[f] Carbon black dispersion for 10 different views: all 10 in Categories 1 or 2

[g] The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

[h] It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

[i] The condition of the test should be 20 hour UV cycle at 75°C followed by 4 hour condensation at 60°C.

[j] Not recommended since the high temperature of the Standard OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

[k] UV resistance is based on the percent retained value regardless of the original High Pressure OIT value.

Table 3. Properties of high density polyethylene (HDPE) geomembrane—textured *(continued)*

Property	Test Method	Test Value						
Oven Aging at 85°C, % retained after 90 days [g,h]	ASTM D 5721							
Standard OIT (min. average)	ASTM D 3895	55	55	55	55	55	55	55
High pressure OIT (min. average)	ASTM D 5885	80	80	80	80	80	80	80
UV Resistance,[i] (min. average)	GM 11							
Standard OIT	ASTM D 3895	N.R.[j]	N.R.[j]	N.R.[j]	N.R.[j]	N.R.[j]	N.R.[j]	N.R.[j]
High pressure OIT, % retained after 1600 hours[k]	ASTM D 5885	50	50	50	50	50	50	50

Source: GRI–GM 13

Note: This Table may be revised to incorporate the latest version of GRI–GM 13.

[a] Of 10 readings; 8 out of 10 must be greater than or equal to 7 mils, and the lowest individual reading must be greater than or equal to 5 mils.

[b] Alternate the measurement side for double sided textured sheet.

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

[d] The SP–NCTL test in 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.

[e] Other methods such as D 4218 (muffle furnace) or microwave methods are acceptable if an appropriate correlation to D 1603 (tube furnace) can be established.

[f] Carbon black dispersion for 10 different views: all 10 in Categories 1 or 2

[g] The manufacturer has the option to select either one of the OIT methods listed to evaluate the antioxidant content in the geomembrane.

[h] It is also recommended to evaluate samples at 30 and 60 days to compare with the 90 day response.

[i] The condition of the test should be 20 hour UV cycle at 75°C followed by 4 hour condensation at 60°C.

[j] Not recommended since the high temperature of the Standard OIT test produces an unrealistic result for some of the antioxidants in the UV exposed samples.

[k] UV resistance is based on the percent retained value regardless of the original High Pressure OIT value.

Table 4. MQC and MQA testing frequency

Property	Testing Frequency (minimum)	
	MQC	MQA
Thickness	per roll	1/100,000 sf
Asperity Height (textured only)	every 2nd roll	1/100,000 sf
Density	1/200,000 lbs.	1/100,000 sf
Tensile Properties	1/45,000 lbs.	1/100,000 sf
Tear Resistance	1/45,000 lbs.	1/200,000 sf
Puncture Resistance	1/45,000 lbs.	1/200,000 sf
Stress Crack Resistance	per each formulation	per each formulation
Carbon Black Content	1/20,000 lbs.	1/100,000
Carbon Black Dispersion	1/45,000 lbs.	1/100,000
Oxidative Induction Time	1/200,000 lbs.	N/a
Oven Aging	per each formulation	N/a
UV Resistance	per each formulation	N/a

N/a—No MQA testing is required for the property.

Table 5. Factory and field seam properties

Property	Test Method	Test Result
Shear Test on Seams	ASTM D 4437 2 ipm	FTB and 95% of spec. min. yield strength
Peel Test on Seams	ASTM D 4437 2 ipm	FTB and 62% of spec. min. yield strength

FTB (Film Tear Bond)—Seam does not delaminate, but fails in adjacent sheet material.

Civil Engineering Systems

SC1A
General Conditions for Civil, Building, and Plumbing Specifications

Table of Contents

Document reaffirmed September 1997 / Document revised September 1997
Contact Valerie.S.Lamison@usa.dupont.com on E-mail for more information.

1. Scope

This specification includes general conditions of the contract for performance of the work, definition of terms, requirements involved in the use of alternate materials or methods, references to DuPont standards as well as a list of initiating sources of national codes and standards and national associations that are referenced in the civil, architectural, concrete, steel, and plumbing specifications.

2. General

2.1 Contract is the written agreement covering the performance by other than DuPont forces, of all or a part of the work under these specifications. In the performance of such work by others, the "General Conditions—Lump Sum or Unit Price On-Site Contracting Services (Form EM-6681)" applies to and is made a part thereof.

2.2 The intent of these specifications is to describe the materials and methods of construction required for the performance of the work. In general, it is intended that the drawings will delineate the detailed scope of the work.

3. Alternate materials and methods

3.1 Manufacturers' products are named for the purpose of describing the type and quality of material required. The naming shall not be construed as preventing the use of other materials providing such materials have received the prior approval of DuPont before incorporation of such materials in the work. Samples or complete specifications (or both) of the proposed alternate material shall be submitted when requested by DuPont.

3.2 Alternate methods of installation and erection, which will result in similar finished quality, may be substituted for the methods specified only upon prior written approval by DuPont.

4. References

4.1 DuPont

4.1.1 DuPont refers to the authorized representative of E. I. du Pont de Nemours & Company, Inc.

4.1.2 Reference to Standard Engineering Specifications and to Engineering Standards shall be considered as referring to E. I. du Pont de Nemours & Company Standard Engineering Specifications and Engineering Standards respectively.

4.2 **Bureaus, Associations, Institutes, and Societies** that publish specifications and standards referenced in DuPont specifications are listed

herein. In all cases, the referenced specification or standard shall be of the most recent publication date.

4.2.1 Abbreviations

The letters in parentheses are the approved abbreviations of the various organizations and such abbreviated references are used throughout the specifications.

5. Governing codes

Work performed under this specification shall be in compliance with applicable codes, laws, and ordinances of the municipal, state, and federal departments concerned, including the Occupational Safety and Health Act of 1970. Materials and workmanship required by such regulations shall be provided by the contractor whether or not specifically noted herein or shown on the drawings.

1. (AASHTO) American Association of State Highway and Transportation Officials
   444 N. Capitol Street NW, Suite 249
   Washington, DC 20001
2. (ACI) American Concrete Institute
   P.O. Box 19150
   Detroit, MI 48219
3. (AISC) American Institute of Steel Construction
   1 E. Wacker Drive, Suite 3100
   Chicago, IL 60601-2001
4. (AISI) American Iron and Steel Institute
   1101 17th Street, NW
   Washington, DC 20036-4700
5. (ANSI) American National Standards Institute
   11 W. 42nd Street, 13th Floor
   New York, NY 10036
6. (APA) American Plywood Association
   P.O. Box 11700
   Tacoma, WA 98411
7. (AREA) American Railway
   Engineering Association
   50 F Street NW
   Washington, DC 20001
8. (ASME) American Society of
   Mechanical Engineers
   345 E. 47th Street
   New York, NY 10017

9. (ASSE) American Society of
   Sanitary Engineering
   28901 Clemens Road, Suite 100
   Cleveland, OH 44145-1166

10. (ASTM) American Society for
    Testing and Materials
    1916 Race Street
    Philadelphia, PA 19103-1187

11. (AWI) Architectural Woodwork Institute
    13924 Braddock Road, No. 100
    Centreville, VA 22020

12. (AWPA) American Wood Preservers' Association
    P.O. Box 286
    Woodstock, MD 21163-0286

13. (AWS) American Welding Society
    550 LeJeune Road NW
    Miami, FL 33126

14. (AWWA) American Water Works Association
    6666 W. Quincy Avenue
    Denver, CO 80235

15. (BOCA) Building Officials and
    Code Administrators Intl.
    4051 W. Flossmoor Road
    Country Club Hills, IL 60478-5795

16. (CISPI) Cast Iron Soil Pipe Institute
    5959 Shallowford Road, Suite 419
    Chattanooga, TN 37421

17. (CRSI) Concrete Reinforcing Steel Institute
    933 Plum Grove Road
    Schaumberg, IL 60173

18. (CS) Commercial Specification
    Government Printing Office
    Superintendent of Documents
    Washington, DC 20401

19. (FS) Federal Specifications Division
    (GSA) General Services Administration
    Government Printing Office
    Superintendent of Documents
    Washington, DC 20401

20. (FTMS) Federal Test Materials Standard
Government Printing Office
Superintendent of Documents
Washington, DC 20401

21. (MIL) Military Specification
Government Printing Office
Superintendent of Documents
Washington, DC 20401

22. (NBS) National Bureau of Standards
U.S. Department of Commerce
Washington, DC 20230

23. (NCPI) National Clay Pipe Institute
P.O. Box 759
Lake Geneva, WI 53147

24. (NEMA) National Electrical
Manufacturers Association
1300 North 17th Street, Suite 1847
Rosslyn, VA 22209

25. (NFPA) National Fire Protection Association
1 Battery March Park, P.O. Box 9101
Quincy, MA 02269-9101

26. (NWMA) National Woodwork
Manufacturers Association
1400 E. Touhy Avenue, No. G54
Des Plaines, IL 60018

27. (OSHA) Occupational Safety and
Health Administration
Government Printing Office
Superintendent of Documents
Washington, DC 20401

28. (PCA) Portland Cement Association
5420 Old Orchard Road
Skokie, IL 60077

29. (PDI) Plumbing and Drainage Institute
1106 W. 77th Street, South Drive
Indianapolis, IN 46260

30. (PS) Product Standard
Government Printing Office
Superintendent of Documents
Washington, DC 20401

31. (SDI) Steel Deck Institute
    P.O. Box 9506
    Canton, OH 44711

32. (SPIB) Southern Pine Inspection Bureau
    4709 Scenic Highway
    Pensacola, FL 32504

33. (SSPC) Steel Structures Painting Council
    40 24th Street, 6th Floor
    Pittsburgh, PA 15222-4643

34. (TCA) Tile Council of America
    P.O. Box 1787
    Clemson, SC 29633

35. (WCLIB) West Coast Lumber Inspection Bureau
    P.O. Box 23145
    Portland, OR 97281

36. (WWPA) Western Wood Products Association
    Yeon Building, 522 SW 5th Avenue
    Portland, OR 97204-2122

DUPONT

Civil

SC5E
Fill, Test-Controlled Compaction

1. Scope

This specification describes the materials and methods of placing and compacting fills with test-controlled compaction.

2. General

Specification SC1A applies to and is a part of this specification.

3. Materials

3.1 Materials shall be approved by Du Pont and shall be free of rock or gravel over 3 inches in greatest dimension, organic substances, sludge, rubbish, brush, limbs, frozen soil, and other objectionable substances which will prevent satisfactory compaction.

3.2 Prior to submission for approval, the following ASTM tests shall be completed for each sample:

a. Grain size analysis per ASTM D 422

b. Modified Proctor moisture-density test per ASTM D 1557.

c. Liquid limit, plastic limit, and plasticity index per ASTM D 4318.

3.3 Prior to starting fill operations, a minimum of 3 tests per ASTM D 1557 will be required for approved material.

4. Preparation

4.1 Clearing, grubbing, demolition, excavation, and removal of topsoil shall be completed in accordance with SC1E, SC2E, and SC3E, before placing fill.

4.2 If subgrade is a cohesive material, the surface shall be scarified to a minimum depth of 3 inches. If a granular material, the surface is not required to be scarified.

Document reaffirmed August 1987

5. Placing

The material shall be placed in successive uniform loose layers and to a depth at which uniform densities specified in section 6 can be obtained with the compacting equipment to be used. In no case shall any layer of loose material placed for compaction exceed 12 inches.

6. Compaction

6.1 Each layer of fill shall be compacted to a dry density not less than 95 percent of maximum dry density as determined by ASTM D 1557.

6.2 For tank farm containment dikes and dikes or berms for retention basins, the fill shall be placed on the wet side of optimum moisture content and compacted to 92 percent of maximum dry density per ASTM D 1557.

6.3 If a cohesive material is used, the surface of each compacted layer shall be scarified to a minimum depth of 3 inches before placing the next layer. If a granular material is used, the surface of each compacted layer is not required to be scarified.

6.4 All scarifying is to be done with a weighted disk harrow.

7. Inspection

7.1 Inspection of densities and moisture contents during construction will be performed by Du Pont.

7.2 Moisture-density tests such as rubber-balloon ASTM D 2167, sand-cone ASTM D 1556, nuclear density ASTM D 2922, or others will be made in accordance with the following minimum daily schedule:

Once every layer of fill, or
Once every 100 cubic yards of fill, or
Once every 3500 square feet of fill

whichever requires the greatest number of tests.

7.3 Samples will be taken at the bottom one-third of each compacted layer.

7.4 Fill sections failing to meet these specifications shall be removed and replaced or reworked until satisfactory to Du Pont.

8. Drainage

Drainage, both temporary and permanent, shall be constructed and maintained during the performance of the work. The surface of unfinished fills shall be bladed smooth to a crown or grade at the conclusion of the day's work, or before shutdown for any cause, to permit runoff of water. Fill that has become saturated with water shall be removed to a depth determined by Du Pont. Such saturated fill shall be disposed of as directed by Du Pont or reconditioned to conform with this specification.

9. Borrow

Borrow, when required to complete fill material requirements, shall conform to SC6E.

10. Measurement

10.1 Method of measurement for pay quantities under unit prices shall be on a cubic-yard basis. If fill is being accomplished by cut-and-fill method or from borrow pits, on which sections may be taken, unit prices paid for excavation shall cover payment for fill.

10.2 If fill is furnished from sources which have not been measured by Du Pont, quantities will be determined from compacted material in place by cross sections made by Du Pont of the original and final surfaces.

3.0 COVER SOIL

3.1 MATERIAL

Purchased cover soil will be pre-approved by the owner. Suitable cover soil shall be free from organic or other perishable material, roots, frozen material, stones or other materials larger than 2 inches in any dimension, debris, contaminants and any other objectionable material, unless otherwise specified or approved by the owner. Material that is gap graded or segregated will not be permitted unless otherwise specified. Excessively wet materials will not be permitted for placement if they appear too wet to effectively compact.

The contractor shall provide documentation of the quality of the fill, including a certification stating that it is virgin material from a commercial or non commercial source, documentation of the location where the fill was obtained (including the street, town, lot and block, country, state, and a brief history of the borrow source site) and a written statement from the borrow source owner.

3.2 ANALYSIS

The cover soil shall meet the following requirements, in addition to the requirements stated above:

- The cover soil must meet the gradation requirement shown below in accordance with the Unified Soil Classification System. One grain size analysis test (ASTM D422), representative of each 3,000 cy of cover soil for each borrow source shall be provided. If the CQA inspector believes the borrow material has changed enough to suspect it no longer meets the requirements, additional testing will be required.

Sieve Size	Percent Passing
2-inch	100%
#4	90-100%
#200	15-40%

- Contain no hazardous constituents. The contractor shall sample and analyze imported cover soil for the full Target Compound List and Target Analyte List (TCL/TAL) parameters in accordance with USEPA method SW 846. One TCL/TAL analysis representative of each 3,000 cy of cover soil for each borrow source shall be provided.

3.3 PLACEMENT

The geomembrane shall be held in place using sand bags or other approved materials prior to spreading and compacting cover soil over the geomembrane. Compaction of the cover soil shall be accomplished by tracking in the soil with a low ground pressure bulldozer (maximum 5 psi).

The geomembrane must not be damaged or allowed to move while cover soil is spread in place. The minimum cover thickness of the first lift shall not be less than 12 inches prior to operating equipment over the geomembrane. Cover soil shall be spread in lifts not exceeding 12 inches in loose thickness prior to compaction.

4.0 TOPSOIL

4.1 MATERIAL

Stockpiled on-site topsoil is suitable material.

If additional material is required, any purchased topsoil will be pre-approved by the owner. Suitable topsoil is defined as selectively excavated natural, friable, loamy soil that is representative of soils (topsoil) in the vicinity of the site that produce heavy growths of crops, grass, or other vegetation and is reasonably free from underlying subsoil, clay lumps, objectionable weeds, rocks, litter, brush, matted roots, toxic substances or any material that might be harmful to plant growth or be a hindrance to grading and planting.

4.2 ANALYSIS

The purchased topsoil shall meet the following requirements:

- The topsoil must meet the gradation requirement shown below in accordance with the Unified Soil Classification System. One grain size analysis test (ASTM D422), representative of each 3,000 cy of topsoil for each borrow source shall be provided. If the CQA inspector believes the borrow material has changed enough to suspect it no longer meets the requirements, additional testing will be required.

Sieve Size	Percent Passing
1-inch	100%
#10	80-100%
#40	30-50%
#200	5-30%

- Contain between 3 and 20 percent organic matter by weight as determined by test method ASTM D2974. One organic content test representative of each 3,000 cy of topsoil for each borrow source shall be provided.

- Have a pH of 6.0 to 7.5 (amended if required). One pH test (ASTM D4972) representative of each 3,000 cy of topsoil for each borrow source shall be provided.

- Contain no hazardous constituents. The contractor shall sample and analyze imported topsoil for the full Target Compound List and Target Analyte List (TCL/TAL) parameters in accordance with USEPA method SW 846. One TCL/TAL analysis representative of each 3,000 cy of topsoil for each borrow source shall be provided.

In addition, the general contractor shall take a representative sample from each proposed topsoil borrow source and send to the local agricultural authorities for analysis. From this analysis, required quantities of lime and fertilizer will be established. The results of the analysis shall be provided to the owner for evaluation prior to borrow source approval.

4.3 GRADING

4.3.1 Subsoil and Grade Preparation

The area to be seeded shall be smoothed and evened to attain a consistent cross-section throughout the length of the area.

4.3.2 Placing Topsoil

Topsoil shall be spread uniformly over areas to be seeded to a minimum depth of six inches on the prepared subgrade. The finished level shall be the required finished grade. Soil shall not be handled when it is frozen or too wet for proper cultivation and pulverization. It shall be handled only when in a friable and tillable condition. Minimum wetting of the soil before applying it to a slope will prevent excessive loss of topsoil at the bottom of the slope.

5.0 SEED

Seeding materials and application shall be in accordance with DuPont Engineering Standard SC8E (attached).

DUPONT

Civil

SC8E
Section 02931
Seeding

1. Section 02931—seeding

1.1 General

1.1.1 Scope

This portion of the specification describes the materials and methods of seeding, including application of mulch where necessary to protect slopes from erosion. Mechanical seeding and hydroseeding, as specified herein, are each acceptable seeding methods.

1.1.2 Recommended seeding periods

Seed shall be sown during the periods recommended by local agricultural authorities.

1.1.3 Analysis of topsoil

The contractor shall send four representative samples of the topsoil to the local agricultural authorities for analysis. From this analysis, proper quantities of lime and fertilizer will be established.

1.2 Products

1.2.1 Topsoil

Use the topsoil stripped from the site and stockpiled. Before use, remove sticks, roots, branches, and all other foreign material. After spreading, the surface shall be cleared of all stones larger than 1 inch.

Purchased topsoil shall be approved by Du Pont and shall be free of sticks, roots, branches, and all other foreign materials.

The Section Number in the title block is the Construction Specifications Institute designation for this information.

1.2.2 Lime

Lime shall be pulverized limestone, finely ground to permit a minimum of 70 percent to pass a 200-mesh screen and 95 percent to pass a 100-mesh screen. The chemical analysis shall show a total calcium and magnesium carbonate content of not less than 85 percent. Application rate shall be determined by soil analysis.

1.2.3 Fertilizer

Fertilizer shall be nitrogen, phosphoric acid, and potash, commercially mixed and furnished in bags. Percentages of each shall be as recommended by local agricultural authorities, based upon soil analysis.

1.2.4 Mesh reinforcing

If the use of mesh reinforcement is proposed by the contractor, Du Pont will select the grade of material for the mesh size and/or the degradation rate.

The mesh shall be held in place with low-carbon steel staples (11 gage by 6 inches).

1.2.5 Seed

The seed shall consist of the varieties and proportions by weight as recommended by local agricultural authorities for the intended purpose.

Seed shall be guaranteed for 90 percent germination and shall be free of weeds. Seed shall be delivered premixed in sealed standard-size, tagged bags. The tag shall show weight, seed analysis, percent germination, and vendor's name. For seeding rate, see item titled "Sowing Seed".

1.2.6 Mulch for mechanical application

Emulsified asphalt shall conform to the requirements of ASTM D 977 for slow setting SS-1.

Straw mulch shall consist of thoroughly threshed wheat, rye, or oat straw and shall be free of all foreign material.

Hay shall consist of native grasses or other plant material as approved by Du Pont. Hay shall be free of weed seeds and shall not be undercured, hot, musty, moldy, caked, decayed, or otherwise distinctly low quality.

Salt hay or other saline grasses may not be used for mulch.

1.2.7 Mulch for hydroseeding application

Natural wood cellulose fiber shall be readily dispersible in water and shall have no toxic effect when combined with seed or other materials. The mixture shall be applicable with power spray equipment. A green-colored dye which is noninjurious to plant growth shall be required. Wood cellulose fiber shall be packaged in new, labeled containers in an air-dry condition and shall have a pH of 4.5 to 10.0 in distilled water. The fibers shall conform to the following:

Moisture Content	12% ± 3%

Organic Matter (Oven Dried Basis)	98.6% ± 0.2%
Ash Content	1.4% ± 0.2%
Water-Holding Capacity	1000% minimum

Chemical mulch binder shall be a 55 percent solids in water emulsion. The solids content shall be a mixture of a polyvinyl resin.

The mulch binder shall be miscible with all normally available water, with resistance to water hardness and sea water. After adequate drying (2–6 hours), the binder shall no longer be soluble or dispersible in water. It shall dry transparent without affecting the aesthetic appearance of the environment. It shall be physiologically harmless, shall not inhibit seed germination and shall be entirely safe for existing vegetation and wildlife.

1.3 Execution

1.3.1 Establishing seedbed

1.3.1.1 Subsoil and grade preparation

The area to be seeded shall be smoothed and evened to attain a consistent cross section throughout the area to be treated.

1.3.1.2 Placing topsoil

Topsoil shall be spread uniformly to a minimum depth of 4 inches on the prepared subgrade. The finished level of topsoil shall be the required finished grade. Soil shall not be handled when it is frozen or too wet for proper cultivation and pulverization. It shall be handled only when in a friable and tillable condition. Minimum wetting of the topsoil before applying it to a slope will prevent excessive loss of topsoil at the bottom of the slope. After even cross sections have been attained, all ditches shall be cleaned of excessive silt or topsoil. Finished grade shall be 1-1/2 inches below top of sidewalks and roadways.

1.3.1.3 Placing mesh reinforcing

Mesh reinforcing shall be unrolled over the topsoil (slopes, ditches, and swales only) and fastened to the topsoil with staples, driven flush with the surface on 5-foot centers.

1.3.1.4 Top berm

To ensure against erosion caused by water runoff over the top of a slope, a berm shall be constructed on the top, draining away from the edge of the slope to a swale. This berm shall be treated in the same manner as the slope area.

1.3.2 Seeding application

Either of the following methods may be used for applying seed.

1.3.2.1 Mechanical seeding application

1.3.2.1.1 Application of fertilizer and lime

After preparation of the seedbed, commercial fertilizer or lime, or both, shall be evenly applied at the rates determined by soil analysis, and shall be thoroughly incorporated to a depth of 2 inches. Following application of the fertilizer or lime, or both, the seedbed shall be uniformly smoothed.

1.3.2.1.2 Sowing seed

The seed shall be evenly sown with an approved mechanical seeder at the rate recommended by local agricultural authorities. One half of the quantity shall be sown in one direction, followed immediately by the remaining half sown at right angles to the first operation. Seeding shall be done only on a calm day when wind does not exceed five miles per hour. Seeding will not be permitted after a rain until the soil is workable and the surface has been loosened and reraked to a fine seedbed. The seeded area shall be rolled with a roller not exceeding 1000 pounds. Care shall be taken during seeding to ensure that no change will occur in the finished grade.

1.3.2.1.3 Watering

After seeding has been completed, the entire area shall be gently sprinkled with water, attaining maximum absorption without causing excessive runoff resulting in washes or the loss of seed.

1.3.2.1.4 Application of straw or hay mulch

Straw or hay mulch may be used in lieu of asphalt mulch. Mulch shall be applied at the rate of 90 pounds of straw or hay per 1000 square feet.

1.3.2.2 Hydroseeding application

1.3.2.2.1 Application without chemical binder

The contractor shall mix the seed, lime, fertilizer, and mulch in an aqueous solution. The solution shall then be sprayed on the previously prepared seedbed.

The lime, fertilizer, and seed shall be added to the seeding applicator after the unit has been completely filled with water. A minimum of 1000 gallons of water shall be required per acre. The mulch shall be applied over the seeded areas at the rate of 1800 pounds per acre. The mulch may be applied as an integral part of the lime, fertilizer, and seed slurry, or separately. When the mulch is applied with the seed slurry, the mulch shall be added after the seed, fertilizer, and lime are thoroughly mixed in the spraying applicator.

1.3.2.2.2 Application with chemical binder

The contractor may (at his option) use a chemical binder to reduce the amount of mulch required. When chemical binder is used, it shall conform to the following:

The lime, fertilizer, seed, wood cellulose fiber, and chemical binder shall comprise the seeding slurry to be applied with the hydroseeding equipment. The undiluted chemical binder shall be applied at a minimum rate of 45 gallons per acre, or as determined by DuPont. The wood cellulose fiber shall be applied at the rate of 600 pounds per acre. The chemical binder shall be diluted in a minimum of 1500 gallons of water per acre when applied on rain-wet soil, and in a minimum of 2500 gallons when applied on dry soil. Both the application rate of the chemical binder and the dilution rate may be varied by Du Pont, in accordance with the particular soil requirements.

1.3.2.2.3 Application rates and restrictions

The quantities of lime, seed, and fertilizer shall be applied at the rates recommended by local agricultural authorities. The seeding slurry shall not be applied during heavy rainfall or high wind (as determined by Du Pont), or at temperatures below 34°F (1°C).

1.3.2.2.4 Protection

Following the final application, all surfaces consolidated shall not be disturbed in any manner by vehicular, pedestrian, or other traffic until acceptance by Du Pont.

1.3.3 Maintenance prior to acceptance

All seeded areas shall be maintained until accepted by Du Pont. Maintenance shall include all necessary watering, weeding, mowing, and rolling, also repairing and reseeding areas where erosion or settlement occurs and areas where the catch of grass is unsatisfactory. All areas shall receive at least three mowings before acceptance. Mowings may be by power mowers with the blades set higher than for established areas. Any seeded areas damaged by mowing shall be replaced at no cost to Du Pont.

1.3.4 Acceptance

Inspection of the seeded area will be made throughout the season. In order to qualify for acceptance, all areas shall have a good clean stand of grass satisfactory to Du Pont in color, quality, and density. Areas that fail to meet these requirements shall be repaired or reseeded as necessary to produce an acceptable lawn.

6.0 CRUSHED STONE ROAD

This portion of the specification describes the materials and methods of constructing a crushed stone surface course upon a prepared subgrade to the lines and grades shown on the drawings.

6.1 MATERIALS

6.1.1 Geotextile

The geotextile shall be a nonwoven, needlepunched, pervious sheet of plastic yarn, consisting of a long-chain geosynthetic polymer composed of at least 85 percent by weight of propylene, ethylene, ester, amide, or vinylidene-chloride. The geotextile shall contain stabilizers and/or inhibitors added to the base plastic, if necessary, to make the filaments resistant to deterioration due to ultra-violet and heat exposure. The geotextile shall meet the following physical requirements:

Property	Test Method	Criteria
Mass per Unit Area	ASTM D3776	8 oz/sy (min)
Permittivity	ASTM D4491	0.2 sec^{-1}(min.)
Grab Tensile Strength	ASTM D4632	90 lb (min.)
Grab Tensile Elongation	ASTM D4632	50% (min.)
Trapezoidal Tear	ASTM D4533	45 lb (min.)
Puncture Resistance	ASTM D4833	50 lb (min.)
Mullen Burst	ASTM D3786	140 psi (min.)
Apparent Opening Size	ASTM D4751	2.0 mm (max.)

6.1.2 Stone

Graded aggregate shall conform to the Delaware Department of Transportation Standard Specifications, "Specifications for Road and Bridge Construction", January 1998, Section 821 – Graded Aggregates. The gradation shall meet the requirements of Type B, Crusher Run.

6.2 PLACING AND SPREADING

6.2.1 Geotextile

All geotextiles shall be handled in a manner to ensure they are not damaged. In the presence of wind, all geotextiles shall be weighted with sandbags or the equivalent. Geotextiles shall be cut using an approved cutter.

The geotextile shall be rolled out in the direction of the road. All overlaps shall be a minimum of 12 inches.

Any holes or tears in the geotextile shall be repaired by making a patch from the same geotextile and spot-seaming in-place with a minimum of 12 inches overlap in all directions.

6.2.2 Stone

The material shall be deposited and spread upon the completed and approved subgrade or subbase, in uniform, nearly horizontal layers, without segregation of size, to such loose depth that, when compacted, the total course will have the required thickness. In the event that the material does become segregated, the material shall be mixed by a method acceptable to the owner.

6.3 COMPACTION

The aggregate shall be rolled with a self-propelled 3-wheel roller weighing not less than 10 tons or approved vibratory equipment may be used. The rolling shall begin at the edges of the courses and on the final course the outside wheel of the roller shall cover equal parts of the material and the shoulder. The roller shall run forward and backward along the edge until the shoulder and coarse material are bound together firmly. When the sides have been firmly rolled, the rolling shall progress gradually toward the center, parallel with the centerline of roadway, uniformly lapping each preceding track at least 18 inches and covering thoroughly the entire surface with the rear wheel, and continuing until the entire surface is well keyed and does not creep or wave ahead of the roller.

The completed surface shall be firm, even, and true to line and grade. Inaccessible areas shall be compacted with smaller mechanical equipment or hand tampers.

The development of a soft or spongy condition in the rolling process will justify either a discontinuance of the rolling for a period of time sufficient to permit the drying of the subgrade, or the complete removal of the course and a treatment of the subgrade, all of which will be done under the direction of the owner. If any irregularity exceeding 1/2" develops during the rolling, the coarse materials shall be loosened, backfilled with new material, and again rolled as specified above.

7.0 SILT FENCE

Silt fence shall be installed as shown on the project drawings.

7.1 MATERIALS

7.1.1 Geotextile

The silt fence geotextile shall be composed of strong synthetic fibers formed into a woven fabric. The fabric shall contain stabilizer and/or inhibitors to make the filaments resistant to deterioration resulting from exposure to sunlight and/or heat. The edges of the geotextile shall be fabricated to prevent the outer yard from pulling away from the fabric. Minimum height of the geotextile shall be 24 inches (after burial). The silt fence geotextile shall meet the following physical requirements:

Property	Test Standard	Criteria
Grab Tensile Strength	ASTM D 4632	200 pounds, minimum
Grab Tensile Elongation	ASTM D4632	15 percent, minimum
Apparent Opening Size (AOS)	ASTM D4751	No. 100 Sieve
Permittivity	ASTM D4491	0.20 sec^{-1}, minimum
Ultraviolet Stability	ASTM D4355	70 percent, minimum (after 500 hours exposure)

7.1.2 Fence Posts

Posts shall be either wood or steel having a minimum length of 24 inches plus burial depth. Posts shall be of sufficient strength to resist damage during installation and to support applied loads.

7.1.3 Support Fences

Wire or other support fence, if used, shall be at least 18 inches high and strong enough to support applied loads.

For wooden posts, fasteners shall be either wire staples or nails. Steel or synthetic post fasteners shall be approved by the owner

7.2 INSTALLATION

The contractor shall install temporary silt fence according to this specification and as shown on the project drawings.

A trench 4 to 6 inches in depth shall be excavated with equipment such as a trenching machine or motor grader; or, if equipment cannot be operated on the site, by hand.

The geotextile shall be securely attached to the post by wire, cord, pockets, staples, or other acceptable means. The geotextile shall be installed in such a manner that 8 inches of fabric is left at the bottom to be buried and a minimum overlap 18 inches is provided at all splice joints.

When wire support fence is used, the wire mesh shall be fastened securely to the upslope side of the post behind the geotextile. The wire shall extend into the trench a minimum of 2 inches and extend a maximum of 3 feet above the original ground surface.

At the time of installation, the geotextile shall be rejected if it has defects, rips, holes, flaws, deterioration, or damage incurred during manufacture, transportation, or storage.

7.3 MAINTENANCE

The contractor shall maintain the integrity of silt fences as long as they are necessary to contain sediment runoff associated with the work shown on the project drawings. The contractor shall inspect all temporary silt fences immediately after each rainfall and at least daily during prolonged rainfall. Any deficiencies shall be immediately corrected by the contractor. In addition, the contractor shall make a daily review of the location of silt fences in areas where construction activities have changed the natural contour and drainage runoff to ensure that the silt fences are properly located for effectiveness. Where deficiencies exist, additional silt fences shall be installed as directed by the owner. Should the silt fence become damaged or otherwise ineffective while the barrier is still necessary, it shall be repaired promptly.

APPENDIX C
CQA/QC Plan

CONSTRUCTION QUALITY ASSURANCE/QUALITY CONTROL (CQA/QC) PLAN

INVISTA SEAFORD POWERHOUSE ASH LANDFILL

FINAL CLOSURE SYSTEM

SEAFORD PLANT

Seaford, Delaware

September 2003

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1.0 PURPOSE AND SCOPE

This document presents the Construction Quality Assurance/Quality Control (CQA/QC) Plan for the closure of the Seaford Ash Landfill, Seaford Plant, Seaford, Delaware. This document will be considered part of the contract documents for this project. The purpose of this document is to specify in detail the methods, procedures, and frequency of inspection and testing activities implemented to document the closure of the Seaford Ash Landfill in accordance with the approved engineering drawings and specifications. The data and information collected during this program will be used as part of the basis for the closure certification by a Professional Engineer registered in the State of Delaware.

The activities addressed in this document consist of the construction of the final cover system (cap). The construction of the closure system will require verification of types and compositions of materials being delivered to the site, placement of material, and field and laboratory testing of the in-place materials to verify compliance with project specifications, design drawings, and good workmanship.

2.0 PROJECT ORGANIZATION

2.1 PROJECT CONTACTS

The following checklist for project contacts will be completed and specific contacts identified during the final closure design process.

Function	Firm	Contact	Phone No.
Owner/Operator	T.B.D.	T.B.D.	T.B.D.
Permitting	T.B.D.	T.B.D.	T.B.D.
Project Manager	T.B.D.	T.B.D.	T.B.D.
Contract Administrator	T.B.D.	T.B.D.	T.B.D.
Civil Engineer	T.B.D.	T.B.D.	T.B.D.
Geotechnical Engineer	T.B.D.	T.B.D.	T.B.D.
CQA/QC Officer	T.B.D.	T.B.D.	T.B.D.
QA/QC Laboratory	T.B.D.	T.B.D.	T.B.D.
General Contractor	T.B.D.	T.B.D.	T.B.D.

2.2 PROJECT MEETINGS

2.2.1 Preconstruction Meeting

Prior to commencement of the Seaford Ash Landfill closure construction, an Initial Meeting shall be held with at least the following parties: Owner/Operator, Contract Administrator, CQA/QC Officer (QAO), and General Contractor. The purpose of the meeting is to:

- Communicate relevant documents to all parties
- Review project specifications
- Review critical design details
- Review CQA/QC Plan
- Assign responsibilities to each party
- Establish lines of authority and communication
- Transmit project schedule

The meeting should be documented by a Seaford Plant Representative, with the minutes subsequently transmitted to all parties.

2.2.2 Weekly Meetings

Weekly meetings shall be held and shall be attended by a Seaford Plant Representative, the General Contractor, the lead field QAO, and Subcontractors when applicable.

During the weekly meeting, coordination activities, work planned, current work progress, problem resolution, safety issues, and the projected work schedule will be reviewed.

2.3 CQA/QC PERSONNEL QUALIFICATIONS

QA personnel will be retained by the Seaford Plant to perform the CQA functions associated with the construction of the Seaford Ash Landfill closure system and will be responsible for reporting on the implementation of this Plan. The retained QA personnel will be qualified to perform said activities by formal academic training, professional practice, managerial experience, and communication skills.

The QA personnel will have at his/her disposal access to qualified field staff. The field staff will include a lead field QAO experienced in construction field testing and quality assurance/control procedures. The QAO will be assisted in the field, as required by the Contractor's level of effort, by other technical staff familiar with field testing procedures and construction activities documentation.

3.0 FIELD INSPECTION ACTIVITIES

Field Inspection Activities associated with the Seaford Ash Landfill construction consist of the evaluation of construction procedures and the assessment of construction material properties, composition and performance within the limits established by the project plans and specifications. Material requirements are discussed in detail in the following sections.

3.1 SITE PREPARATION

Topsoil will be stripped and stockpiled in an area designated by the Seaford Plant. The QAO will observe proof-rolling of the subgrade. Any loose or soft areas identified during proof-rolling will be compacted in place to provide a firm subgrade capable of supporting the cap.

3.2 FINAL COVER SYSTEM

The Contractor shall be responsible for installing the final cover system according to the project specifications and to the lines and grades on the design drawings.

3.2.1 Geomembrane Barrier

3.2.1.1 Materials

The materials referenced herein are specified in the project specifications and plans. In instances where the project specifications are not clear, the owner will clarify the information.

3.2.1.2 Geomembrane Manufacturing

Prior to the installation of any geomembrane material, the Manufacturer/Installer shall provide the owner with the items specified in the project specifications.

3.2.1.3 Shipment, Handling and Storage

Shipment of the geomembrane is the responsibility of the Manufacturer, the Geomembrane Installer, or other party as decided at the Initial Meeting. All handling on site is the responsibility of the Geomembrane Installer. The QAO will verify the following:

- The handling equipment used on the site is adequate and does not pose any risk of damage to the geomembrane;
- The Geomembrane Installer's personnel handle the geomembrane with care.

- Upon delivery at the site, the Geomembrane Installer and the QAO will conduct a surface inspection of all geomembrane rolls for defects and/or damage. This inspection will be conducted without unrolling the geomembrane rolls, unless defects or damages are found on the surface or otherwise suspected. The QAO will indicate/document to the owner:

  - That the all geomembrane rolls are tagged with the proper identification;

  - Geomembrane rolls or portions thereof, which should be rejected and removed from the site because they have severe flaws; and

  - Geomembrane rolls that include repairable minor flaws.

The owner's representative will provide the QAO with the tags or copies of the tags, which have been attached to all rolls. The Contractor shall ensure and the QAO will verify that storage of the geomembrane provides adequate protection against puncture and other sources of damage.

The QAO will verify that the geomembrane rolls are marked or tagged with the following information:

- Manufacturer's Name;
- Product Identification;
- Lot Number;
- Roll Number; and
- Roll Dimensions.

Selected samples of the stored geomembrane, at the frequency presented on Table 1, may be obtained by the QAO for laboratory testing to determine if the geomembrane material received on site satisfies the minimum material property requirements established in the project specifications.

3.2.1.4 Geomembrane Installation

3.2.1.4.1 Surface Preparation

The General Contractor will be responsible for preparing the subgrade according to the project specifications. The QAO will verify that:

- A qualified Land Surveyor has determined that all lines and grades are in accordance with project plans;

- The surfaces to be lined have been rolled and compacted so as to be free of irregularities, protrusions, loose soil, and abrupt changes in grade;

- The surface of the subgrade does not contain stones which may be damaging to the geomembrane;

- There are no areas excessively softened by high water content;

- The subgrade areas which are unstable under the loading of the compaction equipment have been corrected by recompaction or removal and replacement with appropriate material; and

The Geomembrane Installer shall certify in writing that the surface on which each geomembrane roll will be installed is acceptable. This written acceptance will be documented and will be given by the Geomembrane Installer to the owner's representative daily, prior to commencement of geomembrane installation. The QAO will document this acceptance in the daily inspection report, using a subgrade surface acceptance form provided by the Geomembrane Installer or the QAO.

After the soil subgrade has been accepted by the Geomembrane Installer, it will be the Geomembrane Installer's responsibility to indicate to the owner and the QAO any change in the soil subgrade conditions that may require repair work. If the QAO concurs with the Geomembrane Installer, then the QAO will document the repair work performed by the Contractor.

At any time prior to or during the geomembrane installation, the QAO will indicate to the owner and the Contractor locations which may not provide adequate support for the geomembrane and which will require corrective action prior to geomembrane installation.

3.2.1.4.2 Crest Anchorage System

The anchor system will be excavated to the lines and grades shown on the project plans, prior to geomembrane placement. The QAO will verify that the anchor system has been constructed according to the project plans.

3.2.1.4.3 Geomembrane Panel Identification

A panel is the unit area of geomembrane that is seamed in the field.

Prior to or during the Initial Meeting, the Geomembrane Installer shall provide the owner and the QAO with a plan of the cell to be lined showing the orientation of the geomembrane panels. The QAO will review the panel layout and verify that it is consistent with the accepted state of practice.

Each panel will be given an "identification code" (number or letter-number) consistent with the layout plan. This identification code shall be agreed upon by the Geomembrane Installer and the QAO. This identification code should be as simple and logical as

possible. (Note that panel numbers established in the manufacturing plant are usually cumbersome and are not related to location in the field.)

The QAO will establish a table or chart showing correspondence between panel numbers and panel identification codes. The identification codes will be used for all quality assurance records.

3.2.1.4.4 Geomembrane Panel Placement

3.2.1.4.4.1 Location

The QAO will verify that panels are installed at the locations indicated in the Geomembrane Installer's layout plan, as approved or modified at the Initial Meeting.

3.2.1.4.4.2 Installation Schedule

Only those geomembrane panels that can be reasonably expected to be anchored or seamed together in one day are to be installed. Panels may be installed using any one of the following schedules:

- All panels placed prior to field seaming;
- Panels placed one at a time and each panel seamed immediately after its placement; and
- Any combination of the above.

The QAO will evaluate changes in the schedule proposed by the Geomembrane Installer and advise the owner on the acceptability of that change. The QAO will also verify that the condition of the soil subgrade has not changed detrimentally during installation.

The QAO will record on the project plans the identification code, location, and date of installation of each panel.

3.2.1.4.4.3 Weather Conditions

Geomembrane panel placement shall be performed in accordance with the project specifications.

The QAO will verify and document that geomembrane placement is performed in consideration of weather conditions. The QAO will verify and document that the soil subgrade has not been damaged by weather conditions.

The QAO will inform the owner if the weather conditions are not acceptable or if the soil subgrade has been damaged by weather conditions.

3.2.1.4.4.4 Method of Placement

The Contractor shall ensure and the QAO will verify and document the following:

- The equipment used does not damage the geomembrane by handling, trafficking, leakage of hydrocarbons or other means.
- All personnel working on the geomembrane do not smoke, wear damaging shoes, or engage in other activities that could damage the geomembrane.
- The method used to unroll the panels does not cause scratches, crease marks, or crimps in the geomembrane and does not damage the soil subgrade.
- Sufficient slack shall be placed in the geomembrane to compensate for the coldest temperatures envisioned so that no tensile stresses are generated in the geomembrane or in its seams either during installation or subsequently after the geomembrane is covered.
- The geomembrane shall have adequate slack such that it does not lift up off of the subgrade or substrate material at any location within the facility, i.e., no "trampolining" of the geomembrane shall be allowed to occur at any time.
- The geomembrane shall not have excessive slack to the point where creases fold over upon themselves either during placement and seaming.
- Permanent (fold-over type) creases in the covered geomembrane should not be permitted at any time.
- Adequate loading (e.g., sand bags, tires), not likely to damage the geomembrane, has been placed to reduce uplift by wind (in case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind flow under panels).
- Direct contact with the geomembrane is minimized; i.e., the geomembrane in traffic areas is protected by geotextiles, extra geomembrane, or other suitable materials approved by the owner's representative.

The QAO will inform the owner if the above conditions are not fulfilled.

3.2.1.4.4.5 Damage

The QAO will inspect each panel, after placement and prior to seaming, for damage. The QAO will advise the Geomembrane Installer and the owner 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 QAO. The damaged materials are the property of the Geomembrane Installer and will be removed from the site at the expense of the Geomembrane Installer. Repairs shall be made according to procedures described in the project specifications.

3.2.1.4.5 Geomembrane Thickness

The QAO will verify that geomembrane thickness is in conformance with the project specifications. Readings will be taken across the width at any point where the panel has been cut. Any non-conformance will be reported to the Geomembrane Installer and the owner.

3.2.1.4.6 Field Seams

3.2.1.4.6.1 Field Seam Layout

Prior to or during the Initial Meeting, the Geomembrane Installer shall provide the owner and the QAO with plans of the cell to be lined. The QAO will review the seam layouts. A seam numbering system compatible with the panel numbering system should be agreed upon at the Initial Meeting.

3.2.1.4.6.2 Personnel Requirements

The Geomembrane Installer shall provide the Owner with a list of proposed seaming personnel and their professional records. This document will be reviewed by the owner and the QAO.

3.2.1.4.6.3 Seam Preparation

The QAO will verify that:

- Panels of geomembrane are overlapped for field seams in accordance with the project specifications;
- Prior to seaming, the seam area is clean and free of moisture, dust, dirt, debris of any kind, and foreign material; and
- Seams are aligned with the fewest possible number of wrinkles and "fish mouths".

3.2.1.4.6.4 Seaming Equipment and Products

The QAO will verify that equipment used for seaming is not likely to damage the geomembrane.

3.2.1.4.6.5 Weather Conditions for Seaming

The weather conditions for seaming shall comply with the geomembrane manufacturers guidelines.

The QAO will document ambient air/panel temperatures at appropriate intervals. The QAO will verify that the Installer observes the required weather conditions and will inform the owner if the Installer deviates from the required practice. The owner will decide if the installation should be stopped or postponed.

3.2.1.4.6.6 Test Seams

Test seams shall be made in accordance with the project specifications.

The QAO will observe all test seam procedures and maintain documentation recording the date, time, operator, ambient and operating temperatures, speed setting, strength values (i.e., peel and shear), and pass/fail designation.

3.2.1.4.6.7 General Seaming Procedure

The QAO will verify that the seaming procedures in the project specifications (or any other procedures agreed upon) are followed, and will inform the owner if they are not.

3.2.1.4.7 Non-Destructive Seam Continuity Testing

The Geomembrane Installer will non-destructively test all field seams in accordance with the project specifications. The QAO will:

- Observe all continuity testing;
- Record location, date, test unit number, name of tester, and results of all testing; and
- Inform the Geomembrane Installer and the owner of any required repairs.

The Geomembrane Installer shall complete any required repairs in accordance with the project specifications. If repairs are required, the QAO will:

- Observe the repair and the re-testing of the repair;
- Mark on the geomembrane that the repair has been made;
- Document the results.

The seaming operation will be observed by the QAO and the seam number, date of observation, name of tester, and outcome of the test or observation will be recorded by the QAO.

3.2.1.4.8 Destructive Seam Strength Testing

3.2.1.4.8.1 Locations and Frequency

The QAO will submit to the owner a list of locations where seam samples have been cut out for laboratory testing. The sampling list will be established as follows:

- A minimum frequency of one every 500 lineal feet.
- A maximum frequency will be agreed upon by the Geomembrane Installer, the owner and QAO at the Initial Meeting.
- Additional test locations will be determined during seaming at the QAO's discretion.

3.2.1.4.8.2 Sampling Procedure

Samples shall be cut by the Geomembrane Installer as the seaming progresses in order to have laboratory test results before completion of geomembrane installation. The QAO will:

- Observe sample cutting;
- Assign a number to each sample, and mark it accordingly;
- Record the sample, date, time, seam number, ambient temperature, name of master seamer, identification of seaming unit, location on a layout drawing and test results; and
- Record the reason for taking the sample at this location (e.g., statistical routine, change in sheet temperature, suspicious feature of the geomembrane).

All holes in the geomembrane resulting from destructive seam sampling will be immediately repaired by the Geomembrane Installer in accordance with repair procedures described in the project specifications. The continuity of the new seams in the repaired area will be tested according to the project specifications.

3.2.1.4.8.3 Size of Samples

The samples will be a minimum 12 inches wide by approximately 42 inches long with the seam centered lengthwise. One, 1-inch wide specimen will be cut from each end of the

sample and tested in the field by tensiometer for peel strength. If the results are acceptable, specimens from the remaining samples will be cut into three parts and distributed as follows:

- a 12-inch wide by 18-inch long sample for off-site laboratory testing;
- a 12-inch wide by 12-inch long sample to the Geomembrane Installer's for archives; and
- a 12-inch wide by 12-inch long sample to the owner for archive storage.

The QAO will witness all field tests and mark all samples and portion with their sample number.

3.2.1.4.8.4 Sample Shipping

Destructive test samples will be packaged and shipped under the responsibility of the QAO in a manner that will not damage the test sample. The QAO will transmit all the archive samples to the owner following acceptance of the geomembrane materials and installation. Procedure for sample packaging and shipping will be outlined at the Initial Meeting.

Each day, test samples will be forwarded to a laboratory selected by the QAO with the concurrence of the owner. Testing will include "Shear Strengths and "Peel Adhesions (ASTM D4437). The minimum acceptable values to be obtained in these tests are those indicated in the project specifications.

The QAO will review laboratory test results as soon as they become available, and make appropriate recommendations to the owner.

3.2.1.4.9 Retest Procedures for Seam Test Failure

The following procedures will apply whenever a sample fails the field destructive seam test. Two new locations approximately 10 feet on either side of the failed specimen(s) shall be selected and tested. Continue with this procedure until acceptable seams are located. If the seam failure is near the beginning or end of a seam, the additional testing is performed only on the side distant from that beginning or end.

All acceptable reconstructed seams must be bounded by two passed field test locations, and one laboratory test must be taken within the reconstructed area if the failed length exceeds 150 feet.

In the event that a sample fails a laboratory destructive test, the above procedures should also be followed, using laboratory tests exclusively. Since the final seam must be bounded by two passed test locations, it will be necessary to take one or more new

samples for laboratory testing in addition to the one required in the reconstructed seam area.

The QAO will document all actions taken in conjunction with destructive test failures.

3.2.1.4.10 Defects Identification and Repairs

All seams and non-seam areas of the geomembrane will be inspected by the QAO for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. Because light reflected by the geomembrane aids in the detection of defects, the surface of the geomembrane should be clean at the time of inspection. The geomembrane surface should be broomed or washed by the Geomembrane Installer if the amount of dust or mud inhibits inspection. Any suspect location, both in seam and non-seam areas, will be nondestructively tested using the methods described in the project specifications, as appropriate. Any location which fails the non-destructive testing will be marked by the QAO and shall be repaired by the Geomembrane Installer. Repair procedures will be in accordance with the project specifications. The QAO shall document all suspect, defective, and repaired areas.

3.2.1.4.11 Backfilling of Anchor System

The anchor system shall be backfilled and compacted to the project specifications by the Contractor, as outlined in the project specifications and at the Initial Meeting.

The QAO will observe the backfilling operation and advise the owner of any problems, such as liner damage or insufficient burial depth, etc.

3.2.1.4.12 Geomembrane Acceptance

The Geomembrane Installer and the Manufacturer will retain ownership and responsibility for the geomembranes until acceptance by the owner. Acceptance criteria shall be in accordance with the project specifications.

The QAO will certify to the owner that installation has proceeded in accordance with this CQA/QC Plan, except as noted.

3.2.2 Cover Soil

3.2.2.1 Material Properties and Testing

Prior to the acceptance of any cover soil material, the Contractor shall make arrangements for the Seaford Plant Representative and the QAO to visit the proposed borrow areas to visually inspect the material. Upon visual inspection by the owner, samples of each proposed cover soil material from each borrow source will be transported to the approved

soil testing laboratory. Each source of offsite borrow shall be tested for natural water content, grain-size analysis, standard Proctor density, and Atterberg Limits, and shall be made in accordance with the schedule presented in Table 2.

The laboratory data will be transmitted to the QAO who will verify that all cover soil materials shall be free of rock or gravel larger than 3 inches, organic substances, sludge, rubbish, brush, limbs, spongy or frozen soil and other objectionable substances which will preclude satisfactory compaction.

3.2.2.2 Placement and Compaction

The cover soil shall be placed and compacted in accordance with the project specifications.

3.2.2.3 Testing and Monitoring

Monitoring of density and moisture contents during construction will be performed by the QAO. In-place density and moisture tests shall be made in accordance with Table 2.

3.2.3 Vegetative Layer

3.2.3.1 Material Properties and Testing

Test results shall be submitted to the QAO to verify compliance with the project specifications.

3.2.3.2 Seeding

The Contractor shall ensure and the QAO will verify that:

- The area to be seeded shall be smoothed and evened to attain a consistent cross section throughout the length of the area.

- Vegetative support soil shall be spread uniformly over areas to be seeded on the prepared subgrade in accordance with the project specifications. The finished level of vegetative support soil shall be the required finished grade.

- Soil shall not be handled when it is frozen or too wet for proper cultivation and pulverization. It shall be handled only when in a friable and tillable condition. Minimum wetting of the soil before applying it to a slope will prevent excessive loss of material at the bottom of the slope.

3.2.3.2.1 Delivery, Storage, and Handling

Products shall be delivered to the site to support the progress of Work.

The Contractor shall ensure and the QAO will verify that:

- Products shall be stored and protected from deleterious conditions.
- Grass seed mixture shall be delivered in sealed containers.
- Seed in damaged packaging is not acceptable. Fertilizer shall be delivered in waterproof bags showing weight, chemical analysis, and name of manufacturer.

3.2.3.2.2 Hydroseeding Application

The QAO shall verify that hydroseeding application is performed in accordance with the project specifications.

3.2.3.2.3 Maintenance Prior to Acceptance

All seeding shall be maintained in accordance with the project specifications until its acceptance by the owner.

3.2.3.3 Testing and Monitoring

The QAO will visually inspect the vegetative support layer for conformance with the specifications.

3.2.3.4 Acceptance

Acceptance shall be in accordance with the project specifications.

4.0 LABORATORY QUALITY CONTROL

4.1 FIELD SAMPLES

All geosynthetic and soil samples will be transported to the laboratory retained by the Seaford Plant on a timely basis. These samples will consist of geomembrane destructive testing samples and representative soil samples from the borrow areas, on-site materials, and materials delivered to the site.

4.2 LABORATORY TESTING

The laboratory testing program will be performed according to the standards and frequency listed on Tables 1 and 2.

4.3 REPORTING

A verbal report of the laboratory tests will be made to the QAO's site representative as soon as possible after the results have been tabulated. A brief written report with the appropriate test results will follow within five days of the verbal report.

5.0 DOCUMENTATION

The ultimate value of a CQA/QC plan depends, to a large extent, on the QAO's experience with the construction activities that will be inspected and the assignment of responsibilities to inspection personnel for the inspection of each activity. This is most effectively accomplished by requiring appropriate documentation of all CQA/QC activities. The CQA/QC personnel will note, through required descriptive remarks, data sheets, and checklists signed by them, that the inspection activities have been accomplished in accordance with the requirements contained herein.

5.1 DAILY RECORD KEEPING

Standard daily reporting procedures will include preparation of a summary report with supporting inspection data sheets and, when appropriate, problem identification and corrective measures reports.

5.1.1 Daily Summary Report

A summary report will be prepared daily by each inspection crew. This report provides the chronological framework for identifying and recording all other reports. At a minimum, the summary report will include the following information:

- Unique identifying sheet number for cross-referencing and document control. The identifying sheet numbering system will be based on the date of the daily summary report;
- Date, project name, location, and other identification;
- Data on weather conditions;
- Reports of any meetings held and their results;
- Descriptions and locations of construction underway during the time frame of the daily summary report;
- Equipment and number of personnel working on site, including subcontractors;
- Descriptions of areas of work being inspected and documented;
- Description of off-site materials received, including any quality verification documentation;
- Calibrations, or recalibrations, of test equipment, including actions taken as a result of recalibration;
- Decisions made regarding approval of units of material or of work, and/or corrective actions to be taken in instances of substandard quality;
- Unique identifying sheet numbers of inspection data sheets and/or problem reporting and correcting measures reports used to substantiate the decisions described in the preceding item.
- Signature of the QAO.

5.1.2 Inspection Data Sheet

All observations, and field and/or laboratory tests will be recorded on an inspection data sheet. Required data to be included for most of the standardized test methods are noted in the pertinent ASTM Standards or equivalent. At a minimum, the inspection data sheets will include the following information:

- Unique identifying sheet number for cross-referencing and document control;
- Description or title of the inspection activity;
- Location of the inspection activity or location from which the sample was obtained;
- Type of inspection activity and procedure used (reference to standard method when appropriate);
- Recorded observation or test data, with all necessary calculations;
- Results of the inspection activity; comparison with specification requirements;
- Personnel involved in the inspection activity;
- Signature of the QAO.

5.2 PROBLEM IDENTIFICATION AND CORRECTIVE MEASURES

A problem is defined herein as material or workmanship that does not meet the design criteria, plans, and/or project specifications. Problem identification and corrective measures should be cross-referenced to specific inspection data sheets where the problem was first identified. At a minimum, they should include the following information, when applicable:

- Unique identifying sheet number for cross-referencing and document control;
- Detailed description of the problem;
- Location of the problem;
- Probable cause;
- How and when the problem was located (reference to inspection data sheets);
- Estimation of how long problem has existed;
- Suggested corrective measures;
- Documentation of correction (reference to inspection data sheets);
- Final results;
- Suggested methods to prevent similar problems;
- Signature of the QAO.

In some cases, not all of the above information will be available or obtainable. However, when available, such efforts to document problems could help to avoid similar problems in the future.

The QAO should be aware of any significant recurring nonconformances, evaluate the cause of the nonconformance, and recommend appropriate changes to prevent recurrence. When this type of evaluation is made, the results should be documented in a brief report to the Engineer containing the supporting problem identification and corrective measures.

5.3 FINAL DOCUMENTATION

At the completion of the project, the QAO will submit a final summary certification report to the Seaford Plant. This report should include all of the daily inspection summary reports, inspection data sheets, problem identification and corrective measures, deviations from design material and construction project specifications (with justifying documentation). This document will include as a minimum the following information:

- Personnel involved with the project;
- Scope of work;
- Inspection methods;
- Test results;
- Certification signed and sealed by a Professional Engineer, registered in the State of Delaware.
- Record drawing(s), signed and sealed by a Professional Land Surveyor registered in the State of Delaware

Table 1

CQA Field Inspection Test and Observation Frequency
HDPE Geomembrane

Parameter	Test Method	Minimum Testing Frequency
Thickness	ASTM D751	1 per 50,000 ft^2
Density	ASTM D792 or D1505	1 per 50,000 ft^2
Tensile Strength at Yield	ASTM D638, Type IV	1 per 50,000 ft^2
Tensile Strength at Break	ASTM D638, Type IV	1 per 50,000 ft^2
Elongation at Yield	ASTM D638, Type IV	1 per 50,000 ft^2
Elongation at Break	ASTM D638, Type IV	1 per 50,000 ft^2
Tear Strength	ASTM D1004	1 per 50,000 ft^2
Puncture Resistance	ASTM D4833	1 per 50,000 ft^2
Seam Shear Strength	ASTM D4437	1 per 500 linear feet
Seam Peel Adhesion	ASTM D4437	1 per 500 linear feet
Field Seam Continuity	Air Pressure Test and Vacuum Box	Continuous

Table 2

CQA Field Inspection Test and Observation Frequency
Cover Soil

Parameter	Test Method	Minimum Frequency
Borrow Material		
Water Content	ASTM D-2216	1 per 2,600 cy or each change in material
Grain Size Analysis	ASTM D-422	1 per 6,500 cy or each change in material
Atterberg Limits	ASTM D-4318	1 per 6,500 cy or each change in material
Compaction Curve	ASTM D-698	1 per 6,500 cy or each change in material
Compacted Fill		
Water Content -Rapid (1)	ASTM D-3017	5 per acre per lift
Water Content -Check (2)	ASTM D-2216	1 per 10 rapid tests
Total Density - Rapid (1)	ASTM D-2922	5 per acre per lift
Total Density – Check (3)	ASTM D-1556 or ASTM D-2167	1 per 20 rapid tests

Notes:

(1) In addition at least one test should be performed each day soil is compacted and additional tests should be performed in areas for which CQA personnel have reason to suspect inadequate compaction.
(2) Direct oven drying will aid in identifying significant, systematic calibration errors with ASTM D-3017.
(3) Sand cone or rubber balloon method will aid in identifying significant, systematic calibration errors with ASTM D-2922.