



GUNDSEAL

MANUFACTURING QUALITY ASSURANCE MANUAL

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1.0 INTRODUCTION

This manual provides an overview of the GSE Manufacturing Quality Assurance Program for GSE GundSeal geomembrane supported geosynthetic clay liner (GCL) products. It is intended for use by GSE's customers to enhance their understanding of the quality system under which GSE GundSeal geomembrane supported GCL products are manufactured.

2.0 COMMITMENT TO QUALITY

GSE is committed to meeting or exceeding customer's requirements and industry standards. This commitment to quality is established through a documented quality management system, continuous employee training, investment in technology and emphasis on process control. GSE has allocated resources to ensure that this commitment to quality translates into the best products and services for its customers.

3.0 MANUFACTURING QUALITY ASSURANCE

GSE has an on-site quality assurance laboratory at each manufacturing facility worldwide. Each facility has a fully equipped, well staffed, dedicated laboratory with strict guidelines to maintain a high level of quality and up-to-the-minute results on GSE's finished products.

GSE has a rigorous set of minimum standards and an effective test program to assure compliance has been established. These procedures and requirements are frequently reviewed and adjusted to assure compliance with current market demands and/or predetermined project specifications. Also raw materials and process parameters are controlled to provide products complying with GSE's minimum characteristics and regulatory standards.

4.0 MANUFACTURING QUALITY ASSURANCE ORGANIZATION

GSE quality assurance department assures that only products meeting GSE and/or the customer's requirements are released for shipment. The quality assurance personnel are directly responsible for monitoring, testing, and providing feedback to the manufacturing department ensuring the production of the specified product quality. Each member of the quality assurance team must participate in detailed training that includes factory exposure.

The GSE quality assurance team consists of the manufacturing quality assurance laboratories, engineering staff and manufacturing personnel. The combination of expertise and experience from these groups provide GSE with the proper tools to maintain the highest level of product quality and customer service in the industry.

5.0 STAFF & SCHEDULING

The quality assurance laboratories are staffed during any manufacturing run. A continuous communication link is maintained between the laboratory and manufacturing personnel, maximizing production efficiency and product quality.

6.0 PRODUCT IDENTIFICATION & DOCUMENTATION

As the sodium bentonite clay is the primary "active" ingredient for the GSE GundSeal GCL products, the supplier assigns clay lot numbers based upon their processing and delivery constraints. Once the clay is received, GSE maintains the lot designation for tracking and identification purposes.

A. Roll Numbering

Each roll of finished product is assigned a unique roll number. The quality assurance laboratory maintains records, documenting the raw materials and resulting product quality. This information can be associated with any specific roll of geosynthetic clay liner.

B. Approval Procedure

Results for each tested roll of standard GSE product are checked against both GSE and/or customer's

specifications for compliance. Only those materials that meet these requirements are approved for shipment.

C. Non-Conformance

Material that does not meet GSE's minimum standards is given a roll number, but is rejected and separated from the project specific approved material inventory. The rejected material is identified as non-conforming, and may only be used for applications where the material meets all requirements of an alternate project specifications.

Material that meets GSE's minimum standards, but does not meet a stricter customer's specifications will not be allocated to that customer, but will be placed into inventory as a GSE's standard material.

D. Documentation

Quality assurance certificates are generated and supplied for rolls manufactured and supplied for each order or project. The quality assurance documentation includes all information regarding the manufactured GSE GundSeal rolls, the base geomembrane, and the bentonite component of the product.

7.0 RECORDS RETENTION

GSE maintains all necessary reports and/or samples for products produced and sold. Records and/or samples are maintained according to GSE's standard retention policy as outlined below.

A. Geomembranes

ITEMS	YEARS
Resin Supplier Test Reports and Certifications	2
GSE Resin Test Reports	2
Resin Sample Retain (Archive)	2
Geomembrane Sample Retain (Archive; approximately one square foot)	5
Geomembrane Test Data (in computer database)	5
Geomembrane Quality Control Certificates	5

B. Geosynthetic Clay Liner

ITEMS	YEARS
Raw Test Data (in computer database)	5
Quality Control Certificates	5
Sample Retain [1.0 ft ² (300 m ²)]	2

8.0 TESTING CAPABILITIES

GSE maintains modern, state-of-the-art, quality assurance laboratory capable of performing the analysis in Spearfish, South Dakota. Calibration of all laboratory equipment is performed minimally on an annual cycle. The calibration certificates are maintained for review upon request.

A. Routine Testing

GSE has developed a strict quality assurance program, which exceeds all industry's standards and/or customers' specifications. This testing program covers raw materials and finished goods and is adhered to by all GSE's quality assurance laboratories.

B. Other Testing Capabilities

Although the GSE's laboratories are fully equipped of performing most tests routinely specified, there

are a few analysis that are more economically performed by a dedicated testing facility. GSE believes requirements for such testing should be carefully considered, and if found to be necessary specified in terms of a particular design requirements. Some tests that GSE recommends be performed via customer's arrangement with an outside testing facility are: Direct Shear Testing (ASTM D 5321, ASTM D 6243) and Permeability/Index Flux: (ASTM D 5887).

The interface friction characteristics of GCLs, geomembranes and/or other geosynthetic products against adjoining site materials are specific to conditions of the installation. Friction characteristics critical to design parameters are best determined by independent testing incorporating site specific materials and conditions. GSE does not control and cannot warrant specific interface friction characteristics.

9.0 MATERIAL QUALITY ASSURANCE

GSE has established strict specifications for all raw materials and finished products. The results from every test performed must fall within the acceptable limits of these specifications.

A. Raw Material

GSE utilizes three primary types of raw materials in the production of GSE GundSeal GCL: geomembrane sheet, water based non-toxic adhesives and sodium bentonite. All geomembrane backings utilized arrive in finished roll form. Both adhesive and bentonite are supplied in bulk. The water based non-toxic adhesive formulation is considered to be proprietary information and is not disclosed. Upon receipt of the raw materials, GSE begins the quality assurance process.

1. HDPE Geomembrane Backings

a. Conformance Sampling & Reporting

Geomembrane sheet is manufactured by GSE at its corporate headquarters in Houston, Texas, and supplied in roll form. Quality control testing occurs at the specific manufacturing facility. A quality certification is issued for each roll of geomembrane sheet detailing the conformance and physical property test results.

Each GSE geomembrane production line is equipped with both a thickness gauge and spark testing device.

2. Sodium Bentonite

a. Conformance Sampling & Reporting

Upon the arrival of each bulk shipment [approximately 60,000 lb (30,000 kg)], a bag is filled with a representative sample of the lot and labeled with the date, lot number and material type. These bags are then delivered to the laboratory for testing. Sodium bentonite for GSE GundSeal manufacture is normally received in bulk truck shipments. If the bentonite is received by other transport means and/or in other quantities, an equivalent suitable sampling procedure is provided on a per lot basis. Material property values and test frequencies for the base bentonite are listed in Appendix A.

b. Evaluation of Results

A certificate of conformance from the mineral processor is required with each bentonite shipment sample. All test data is verified for accuracy, consistency and compliance with GSE's specifications

B. Finished GCL Products

GSE has implemented a strict and thorough manufacturing quality assurance process for all GCL products.

1. On-Line Manufacturing Quality Assurance

The quality assurance program for the finished GCL products begin during the manufacturing process.

a. Application Measurement

As each roll is being produced, application rate readings are taken throughout the production of the roll. These readings are utilized to establish the average bentonite and adhesive application values for each roll and are verified by roll weight testing upon completion of the finished goods.

b. Statistical Process Control

Variables such as line rate and bentonite application rates have established process parameters, which vary with the particular grade of material being produced. Finished roll weight, length and width are measured and used to assure conformance to finished product specification. Process variables are adjusted in response to the minimum average roll data.

2. Post Production Quality Assurance

The finished GCL is sampled across the roll width within each lot. This sample is immediately sent to the quality assurance laboratory for finished product testing.

a. Sampling

A 1.0 ft (300 mm) by roll width [17.5 ft (5.3 m)] sample is cut for quality assurance testing at specified frequencies listed on the data specifications sheet. The laboratory sample is labeled with the roll number, and production date. Test specimens are taken from positions across the width of the roll. The five specimen positions are defined as a constantly repeating set of locations determined by the roll number. A 1.0 ft by 1.0 ft (300 mm by 300 mm) is labeled and retained for 5 years for future reference or testing.

b. Evaluation of Results

Samples are tested using the frequencies and procedures listed on the data specifications sheet. All data are recorded and compared to established order specifications. If materials do not meet the required GSE's minimum average values and/or the customer specifications, the manufacturing personnel are immediately notified to make the appropriate adjustments. Only products meeting GSE's minimum average values and customer's specifications will be approved for shipment to the corresponding project.

c. Reporting

All rolls supplied for a specific project or order will be provided a manufacturing quality assurance document. This document identifies the standards on which the GSE's approval is based along with the actual test results demonstrated by the material. Each report is reviewed by quality assurance personnel, stamped, and initiated by the GSE's laboratory technician.

3. Product Shipping

It is the GSE's policy to ship only products that have been tested and approved. All shipments are packaged according to industry's standards practices and/or customer's specifications. Only approved handling methods are used to move rolls into and out of shipping containers, please see the GSE Installation Quality Assurance Manual for more details.

Appendix A: Minimum Testing Frequencies & Properties

Testing Frequencies and Properties of the Delivered Bentonite

Property	Test Method ⁽¹⁾	Frequency	Minimum Average Value
Swell Index	ASTM D 5890	1/60,000 lb (30,000 kg)	≥ 24 ml
Fluid Loss	ASTM D 5891	1/60,000 lb (30,000 kg)	≤ 18 ml
Hydraulic Flux: Bentonite Coating	ASTM D 5887	Periodically	≤ 1 x 10 ⁻⁸ m ³ /m ² •sec
Hydraulic Conductivity	ASTM D 5887	Periodically	≤ 5 x 10 ⁻¹¹ m/sec
Moisture Content	ASTM D 2216	1/60,000 lb (30,000 kg)	≤ 12%

Notes:

- GSE utilizes test equipment and procedures that enable effective and economical confirmation that the product will conform to specifications based on the noted procedures. Some test procedures have been modified for application to geosynthetics. All procedures and values are subject to change without prior notification.

GSE is a leading manufacturer and marketer of geosynthetic lining products and services. We've built a reputation of reliability through our dedication to providing consistency of product, price and protection to our global customers.

Our commitment to innovation, our focus on quality and our industry expertise allow us the flexibility to collaborate with our clients to develop a custom, purpose-fit solution.

For more information on this product and others, please visit us at GSEworld.com, call 800.435.2008 or contact your local sales office.

[DURABILITY RUNS DEEP]

