

Manufacturing Quality Assurance Manual



GSE GundSeal

Geomembrane Supported Geosynthetic Clay Liner Products





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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. Geomembrane

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)]	5

8.0 TESTING CAPABILITIES

GSE maintains modern, state-of-the-art, quality assurance laboratory capable of performing the analysis as shown in Appendixes B-C 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 Materials*

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 as shown in Appendixes F-H.

Each GSE geomembrane production line is equipped with both a thickness gauge and spark testing device. Material property values and test frequencies for the smooth and textured geomembrane backings used in GSE GundSeal are listed in Appendixes B-C. For additional information, please also see the GSE Manufacturing Quality Assurance Manual for geomembrane products.

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. GSE GundSeal material properties and test frequencies are listed in Appendixes B-C.

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 vari-



ables 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 the specified frequencies listed in Appendixes B-C. 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 in Appendixes B-C. 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. A sample GSE GundSeal Manufacturing Quality Assurance document is listed in Appendix H.

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: 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/s
Moisture Content	ASTM D 2216	1/60,000 lb (30,000 kg)	≤ 12%

NOTES:

- ⁽¹⁾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.



Appendix B: GSE GundSeal GCL (Smooth HDPE) Data Sheet

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE VALUE					
			15 mil	20 mil	30 mil	40 mil	60 mil	80 mil
FINISHED GCL PROPERTY								
Bentonite Coating ⁽¹⁾ , lb/ft ² (kg/m ²)	ASTM D 5993	1/40,000 ft ² (1/4000 m ²)	≥ 0.75 (3.66)					
Effective Hydraulic Conductivity, m/s	ASTM D 5887/E96	periodically	≤ 4 x 10 ⁻¹⁴					
Bentonite Moisture Content	ASTM D 2216	1/40,000 ft ² (1/4000 m ²)	25% Typical					
GEOMEMBRANE PROPERTY⁽²⁾								
Thickness, (minimum average) mil (mm)	ASTM D 5199	1/100,000 ft ² (1/10,000 m ²)	15(0.40)	20(0.50)	30(0.75)	40(1.00)	60(1.50)	80(2.00)
Lowest individual reading (-10%)			14(0.34)	18(0.45)	27(0.69)	36(0.91)	54(1.35)	72(1.80)
Density, g/cm ³	ASTM D 1505	1/200,000 ft ² (1/20,000 m ²)	0.94	0.94	0.94	0.94	0.94	0.94
Tensile Properties								
Tensile Break Strength, lb/in (N/mm)	ASTM D 6693	1/200,000 ft ² (1/20,000 m ²)	44(7)	76(12)	114(20)	152(26)	243(42)	327(57)
GCL Tensile Strength ⁽³⁾ , lb/in (N/mm)	ASTM D 6768	1/200,000 ft ² (1/20,000 m ²)	20(3)	42(7)	63(11)	84(15)	130(23)	173 (30)
Elongation at Break, %	ASTM D 6693	1/200,000 ft ² (1/20,000 m ²)	500	500	700	700	700	700
Puncture Resistance, lb (N)	ASTM D 4833	1/200,000 ft ² (1/20,000 m ²)	20(89)	36(158)	54(240)	72(320)	108(480)	144(640)
SODIUM BENTONITE PROPERTY								
Hydraulic Flux: Bentonite, m ³ /m ² /sec	ASTM D 5887	periodically	≤ 1 x 10 ⁻⁸					
Hydraulic Conductivity, m/s	ASTM D 5887	periodically	≤ 5 x 10 ⁻¹¹					
Swell Index, ml/2 g	ASTM D 5890	1/60,000 lb (1/30,000 kg)	≥ 24					
Fluid Loss, ml	ASTM D 5891	1/60,000 lb (1/30,000 kg)	≤ 18					
TYPICAL ROLL DIMENSIONS								
Roll Width ⁽⁴⁾ , ft (m)			17.5(5.3)	17.5(5.3)	17.5(5.3)	17.5(5.3)	17.5(5.3)	17.5(5.3)
Roll Length ⁽⁴⁾ , ft (m)			200(61)	210(64)	180(54)	180(54)	180(54)	150(45)
Roll Area, ft ² (m ²)			3,500 (325)	3,675 (341)	3,150 (286)	3,150 (286)	3,150 (286)	2,625 (244)
Roll Weight, lb (kg)			4,500 (2,050)	4,200 (1,900)	4,200 (1,900)	4,200 (1,900)	4,500 (2,050)	4,300 (1,950)

NOTES:

- ⁽¹⁾0% moisture content.
- ⁽²⁾See specific GSE HD geomembrane product data sheet for additional information.
- ⁽³⁾4 in (101 mm) wide sample, 12 in/min (305 mm/min). Values are representative of the geomembrane tensile yield strength.
- ⁽⁴⁾Roll lengths and widths have a tolerance of ± 1%.



Appendix C: GSE GundSeal GCL (Textured HDPE) Data Sheet

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE VALUE				
			20 mil	30 mil	40 mil	60 mil	80 mil
FINISHED GCL PROPERTY							
Bentonite Coating ⁽¹⁾ , lb/ft ² (kg/m ²)	ASTM D 5993	1/40,000 ft ² (1/4000 m ²)	≥ 0.75 (3.66)				
Effective Hydraulic Conductivity, m/s	ASTM D 5887/E 96	periodically	≤ 4 x 10 ⁻¹⁴				
Bentonite Moisture Content	ASTM D 2216	1/40,000 ft ² (1/4000 m ²)	25% Typical				
GEOMEMBRANE PROPERTY⁽²⁾							
Thickness, (minimum average) mil (mm)	ASTM D 5994	1/100,000 ft ² (1/10,000 m ²)	18 (0.45)	30 (0.75)	40 (1.00)	60 (1.50)	80 (2.00)
Lowest individual reading (-10%)			18 (0.45)	27 (0.69)	36 (0.91)	54 (1.40)	72 (1.80)
Density, g/cm ³	ASTM D 1505	1/200,000 ft ² (1/20,000 m ²)	0.94	0.94	0.94	0.94	0.94
Tensile Properties							
Tensile Break Strength, lb/in (N/mm)	ASTM D 6693	1/200,000 ft ² (1/20,000 m ²)	30 (5)	66 (11)	75 (13)	115 (20)	155 (27)
GCL Tensile Strength ⁽³⁾ , lb/in (N/mm)	ASTM D 6768	1/200,000 ft ² (1/20,000 m ²)	40 (7)	63 (11)	84 (15)	130 (23)	173 (30)
Elongation at Break, %	ASTM D 6693	1/200,000 ft ² (1/20,000 m ²)	100	100	100	100	100
Puncture Resistance, lb (N)	ASTM D 4833	1/200,000 ft ² (1/20,000 m ²)	30 (133)	65 (289)	95 (422)	130 (578)	160 (711)
SODIUM BENTONITE PROPERTY							
Hydraulic Flux: Bentonite, m ³ /m ² /sec	ASTM D 5887	periodically	≤ 1 x 10 ⁻⁸				
Hydraulic Conductivity, m/s	ASTM D 5887	periodically	≤ 5 x 10 ⁻¹¹				
Swell Index, ml/2 g	ASTM D 5890	1/60,000 lb (1/30,000 kg)	≥ 24				
Fluid Loss, ml	ASTM D 5891	1/60,000 lb (1/30,000 kg)	≤ 18				
TYPICAL ROLL DIMENSIONS							
Roll Width ⁽⁴⁾ , ft (m)			17.5 (5.3)	17.5 (5.3)	17.5 (5.3)	17.5 (5.3)	17.5 (5.3)
Roll Length ⁽⁴⁾ , ft (m)			180 (54)	180 (54)	170 (51)	170 (51)	150 (45)
Roll Area, ft ² (m ²)			3,150 (286)	3,150 (286)	2,975 (276)	2,975 (276)	2,625 (244)
Roll Weight, lb (kg)			3,900 (1,770)	4,100 (1,870)	4,300 (1,940)	4,600 (2,090)	4,400 (2,000)

NOTES:

- ⁽¹⁾0% moisture content.
- ⁽²⁾See specific GSE HD Textured geomembrane product data sheet for additional information.
- ⁽³⁾4 in (101 mm) wide sample, 12 in/min (305 mm/min). Values are representative of the geomembrane tensile yield strength.
- ⁽⁴⁾Roll lengths and widths have a tolerance of ± 1%.



Appendix D: Product Certification Letter



GSE LINING TECHNOLOGY, LLC
3150 1st Avenue
Spearfish, SD 57783
Ph: (605) 642-8531
Fax: (605) 642-8539

Date: _____
To: _____

From: _____

Attached are your Quality Control Assurance documents for your recent order of Gundseal.

These documents cover roll numbers:

Item 1) Pages _____ Are the Bentonite Certificate of Analysis from the Bentonite Supplier.

Item 2) Pages _____ Gundseal Roll Test Data Report, Physical Properties.

Item 3) Pages _____ is the Gundseal Traceability Report.

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Item 4) Pages _____ Geomembrane Roll Test Data Report.

Thank you for choosing Gundseal for your project. Quality is important to us at GSE Lining Technology, LLC. If you have questions regarding this order please call.

Robert Stadler

Date: _____

Plant Manager
GSE Lining Technology, LLC

MQA GS-801/18/10



Appendix E: Bentonite Certificate of Analysis

GSE Lining Technology, LLC

CERTIFICATE OF ANALYSIS 2009
PRODUCT : BARA-KADE@LD-16
ATTN: MR. Bob Stadler

SHIPPED FROM:
BENTONITE PERFORMANCE MINERALS LLC
554 US HWY 212
COLONY PLANT
BELLE FOURCHE, S.D. 57717

BOL #	LOAD DATE	LOT No.	% MOIST 12 MAX	FL 18 MAX	MBC MEQ 70 MIN	SWELL INDEX 25 MIN	PWA 750 MIN	% MOIST 12 MAX	FL 18 MAX	MBC meq 70 MIN	SWELL INDEX 25 MIN	PWA 750 MIN
B0001340145	04-13-09	BULK	10.3	12.8	120	32	1018	9.77	13.27	119.00	31.33	998.33
B0001340147	04-16-09	BULK	8.4	13.2	122	34	1046	0.98	0.50	1.91	1.37	26.04
B0001340148	04-16-09	BULK	8.7	12.8	120	31	989					
B0001340149	04-17-09	BULK	10.3	13.6	118	30	989					
B0001340150	04-19-09	BULK	11.3	13.0	118	30	979					
B0001340151	04-21-09	BULK	9.6	14.2	116	31	969					
M AVG												
STD DEV												
YTD No. of TRUCKS												
M AVG			9.80	12.85	120.92	33.38	1062.50					
STD DEV			0.84	0.52	4.34	2.40	61.26					

SOLD TO: GSE Lining Technology, LLC
3150 FIRST AVENUE
SPEARFISH, SD 57783

Attn: Bob Stadler (rstadler@gseworld.com)
Lynn Crumbley (lcrumbley@gseworld.com)



Appendix F: Roll Test Data Report

Roll Test Data Report



GSE Lining Technology, LLC

Roll No. 21042440

ROLL IDENTIFICATION

Roll Number 21042440
Product Name SEH060A000
10/7/2002

CLAY INFORMATION

Lot Number 114939
Type National Granular LD 16
Supplier Bentonite Performance Minerals

Length \pm (+/-1%) 194 feet
59.1 meters
Width (Nominal) 17.5 feet
5.3 meters
Sheet Area 3,395 sq. feet
315 sq. meters
Weight 4,620 pounds
2,096 kilograms

GSE CLAY TEST DATA

Property	Test Method	Results
Moisture Content	ASTM D2216	10.0% %
Free Swell	ASTM D 5890	33.5 mL
Fluid Loss	ASTM D 5891	15.6 mL

Physical Properties	Test Method	Test Frequency	GSE Minimum		Test Results	
			English	Metric	English	Metric
Bentonite Loading (mass/area)	ASTM D 5993	1/40,000 sf	>.75		0.87 (lbs/sf)	4.25 (kg/sm)
Moisture Content (%)	ASTM D 2216	1/40,000 sf	25%	typical	25.4%	

* The test results listed above on roll number : 21042440
which covers rolls from 21042440 to 21042447

Order No. SG# 27221
Customer Name ADM
Location Columbus, NE

Senior Supervisor Robert Stadler

Date 10/7/2002

Robert Stadler



Appendix G: Traceability Report



GSE Lining Technology, LLC
3150 1st Avenue
Spearfish, SD 57783
Phone: (605)642-8531
Fax: (605)642-8539

To: River Birch Landfill
2000 South Kenner Road
Avondale, LA 70094
SG# 56285

B.O.L NUMBER	GUNDSEAL ROLL NUMBER	GEOMEMBRANE ROLL NUMBER	TESTED ROLL NUMBER	BENTONITE LOT NUMBER
	140111235	"		"
	140111236	"		"
	140111237	"		"
	140111238	102137263		1287585
	140111239	"		"
	140111240	"		"
	140111241	"	X	"
	140111242	102137244		"
	140111243	"		"
	140111244	"		"
	140111245	"		"
	140111246	102137258		"
	140111247	"		"
	140111248	"		"
	140111249	"		"
	140111250	102137266		"
	140111251	"		"
	140111252	"		"
	140111253	"		"
	140111254	102137274	X	"
	140111255	"		"
	140111256	"		"
	140111257	"		"
	140111258	102137273		"
	140111259	"		"
	140111260	"		1305010
	140111261	"		"
	140111262	102137254		"
	140111263	"		"
	140111264	"		"
	140111265	"		"
	140111266	102137260		"
	140111267	"	X	"



Appendix H: Geomembrane Roll Test Data Report

Roll Test Data Report

GSE Lining Technology, LLC

Sales Order No.
53665

Project Number
524353

Customer Name
River Birch Landfill

Project Location
Avondale, LA

Product Name
HDT040A002

Report Date
2/25/2008

Roll No.	ASTM D 594			ASTM D 1545 (Type IV / DMRS)			ASTM D 1584			ASTM D 1585			ASTM D 1586			ASTM D 1587			ASTM D 1588			GRI GM 11		
	Average Thickness (mil)	Thickness (mil)	Standard Deviation (mil)	TD Strength (psi)	MD Strength (psi)	TD Elongation (%)	MD Elongation (%)	TD Tear Resistance (psi)	MD Tear Resistance (psi)	Density (g/cc)	Permeability (cm/s)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)	Carbon Black (phr)
103143094	42	37	116	107	134	152	15	16	543	609	35	38	114	0.946	2.53	10	22	21						
103143096	42	37	116	107	134	152	15	16	543	609	35	38	114	0.946	2.53	10	22	21						
103143097	41	37	113	104	130	148	14	15	533	589	36	37	115	0.946	2.52	10	22	22						
103143100	41	38	113	109	121	151	13	15	434	572	34	39	117	0.946	2.52	10	22	23						
103143101	41	38	113	109	121	151	13	15	434	572	34	39	117	0.946	2.52	10	22	23						
104139114	42	37	113	105	126	162	15	17	568	629	35	39	103	0.945	2.45	10	17	21						
104139116	41	38	112	108	141	167	16	17	556	607	36	40	112	0.945	2.32	10	23	22						
104139117	41	38	112	108	141	167	16	17	556	607	36	40	112	0.945	2.32	10	22	22						
104139118	41	38	112	108	141	167	16	17	556	607	36	40	112	0.945	2.32	10	22	22						
104139120	41	38	107	103	136	151	15	17	548	543	35	38	111	0.945	2.56	10	27	27						
104139122	43	40	107	102	136	158	15	22	543	589	36	38	108	0.945	2.60	10	28	25						

Laboratory Manager:

This test report shall not be reproduced, except in full, without written approval of the laboratory.

19103 Gundlie Road - Houston, Texas 77073



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