APPENDIX F

ACTION LEAKAGE RATES

APPENDIX F

ACTION LEAKAGE RATE CALCULATION

This appendix (Appendix F-1) presents a calculation of the Action Leakage Rates (ALR) for the tailings cells proposed for construction at the Piñon Ridge Project. As per the U.S. EPA, the ALR is defined as "*the maximum design flow rate that the leak detection system (LDS) can remove without the fluid head on the bottom liner exceeding 1 foot.*"

The ALR was calculated for Tailings Cells A1 and A2, both with lined areas of 15.4 acres, and for Tailings Cells B and C, both with lined areas of 30.5 acres. The ALR was calculated to be 4,705 gallons per acre per day (gpad) for the Leak Collection and Recovery System (LCRS) sumps contained within Tailings Cells A1 and A2, and 2,376 gpad for the LCRS sumps contained within Tailings Cells B and C. If leakage rates in exceedance of these values are measured, action must be taken as per Title 40 CFR, Section 264.223.

REFERENCES

40 CFR Part 264 – "*Standards for Owners and Operators of Hazardous Waste Treatment, Storage, and Disposal Facilities*", Subpart K (Surface Impoundments).

U.S. Environmental Protection Agency (U.S. EPA). 1992. "Action leakage rates for detection systems (supplemental background document for the final double liners and leak detection systems rule for hazardous waste landfills, waste piles, and surface impoundments)."

APPENDIX F-1

ALR CALCULATIONS

OBJECTIVE:

The objective is to determine the Action Leakage Rate (ALR) for the Piñon Ridge tailings cells. The ALR is defined as "*the maximum design flow rate that the leak detection system (LDS) can remove without the fluid head on the bottom liner exceeding 1 foot*" (U.S. EPA 1992; United States Government Printing Office 2002) .

GIVEN:

- Leak detection system (LDS) configuration.
- Tailings cells configuration.
- Drainage material properties.

GEOMETRY:

- The tailings cells configuration diagram is shown in Figure 1.
- A typical liner system detail is shown in Figure 2.
- Sump top dimensions of 40 feet by 40 feet for all tailings cells.

MATERIAL PROPERTIES:

Table 1 summarizes the material properties considered in the analysis for the drainage geocomposite in the slopes of the cells and drainage geonet on the floor of the cells.

Table 1. Geonet properties

Manufacturer	*Model*	*Transmissitivity gal/min/ ft (m^2/sec)*	*Thickness mil*
GSE	HyperNet HS Geonet	28.98 (6 x 10^{-3})[1]	275
GSE	FabriNet TRx Drainage geocomposite	12.1 (2.5 x 10^{-3})[1]	275

[1] see Attachment 1

METHOD:

- The ALR calculation is based on the U.S. EPA guidelines published in U.S. EPA (1992).

ASSUMPTIONS:

- Darcy's law is valid;
- The gradient of the floor of the tailings cells is approximately 1 percent. The gradient of the side slopes for the cells is approximately 33.3%;
- One foot of water head is developed on the bottom liner.

CALCULATIONS:

The maximum flow rate within the LDS geonet and geocomposite are calculated using Darcy's equation :

$$Q = K\,i\,A$$

where :

Q = flow through unit width of the LDS drainage layer [ft^3/sec];
K= hydraulic conductivity of the LDS drainage layer [ft/sec];
i = hydraulic gradient; and
A= area of the flow per unit width [ft^2/ft].

For a geonet or drainage geocomposite, the flow through the layer is calculated by using the following equation:

$$q = i\,\theta\,W$$

where:

q = flow through the geosynthetic layer [ft^3/sec/ft];
i = hydraulic gradient;
θ = transmissivity [ft/sec]; and
W= width of the drain [ft].

A factor of safety should be applied to consider the reduction in flow capacity of the geonet due to deformations, intrusions, clogging, or precipitation of chemicals (Koerner 1998) :

$$q_{allow} = q_{ult}\left[\frac{1}{RF_{IN} + RF_{CR} + RF_{CC} + RF_{BC}}\right]$$

where:

q_{ult} = flow rate of the geosynthetic drain;
q_{allow} = allowable flow rate;
RF_{IN} = reduction factor for elastic deformation or intrusion;
RF_{CR} = reduction factor for creep deformation;
RF_{CC} = reduction factor for chemical clogging; and
RF_{BC} = reduction factor for biological clogging.

Table 2 shows the adopted reduction factors for a secondary leachate collection system according to Table 4.2 in Koerner (1998) :

Table 2. Reduction factors for determining allowable flow rate of geonets

Factor	Recommend value range	Use value for geonet	Use value for geocomposite
RF_{IN}	1.5 – 2.0	1.5 (possible elastic deformation)	2.0 (possible elastic deformation and geotextile intrusion)
RF_{CR}	1.4 – 2.0	1.4 (low normal stress)	1.4 (low normal stress)
RF_{CC}	1.5 – 2.0	2.0 (low pH liquids)	2.0 (low pH liquids)
RF_{BC}	1.5 -2.0	1.5 (low pH should preclude biological activity)	1.5 (low pH should preclude biological activity)

A water head equal to 1 foot is assumed to be acting over the bottom liner so the hydraulic gradient can be assumed to be equal to the slope of the geonet or geocomposite . For the bottom of the tailing cells:

$$i = 1\%$$

For the slopes of the tailings cells (3H:1V):

$$i = 33.3\%$$

The flow in the geonet per unit width for the bottom of the tailing cells is:

$$\frac{q_{ult}}{W} = 0.01 * 28.98\, gal/\min ft = 0.29\, gal/\min ft$$

And for the sideslopes the flow per unit width of the drainage geocomposite is:

$$\frac{q_{ult}}{W} = 0.3333 * 12.1\, gal/\min ft = 4.03\, gal/\min ft$$

The allowable flow rates per unit width for the bottom of the cell and the sideslopes are:

$$\frac{q_{allow}}{W} = \frac{q_{ult}}{W} * \frac{1}{\prod RF}$$

$$\prod RF = 1.5 + 1.4 + 2.0 + 1.5 = 6.4 \quad \text{for geonet}$$

$$\prod RF = 2.0 + 1.4 + 2.0 + 1.5 = 6.9 \quad \text{for drainage geocomposite}$$

Flow rate per unit length from cell bottom:

$$q_{1\%} = \frac{0.29\ gal/\min ft}{6.4} = 0.045\ gal/\min ft$$

Flow rate per unit length from cell sides slopes:

$$q_{33.3\%} = \frac{4.03\ gal/\min ft}{6.9} = 0.584\ gal/\min ft$$

Flow access to the sump is a function of the perimeter length of the crest of the sump. The sump is located at the low point of each cell and adjacent to two sideslopes. As shown in Figure 1, the sump will receive leachate from the cell bottom on two sides and from the sideslope on two sides. The flow rate to a sump is:

> $q_{1\%}$ * perimeter length of sump in that flow direction (2 sides) + $q_{33.3\%}$ * perimeter length of Sump in that flow direction (2 sides)

The ALR expressed in gallons per acre per day (gpad) for each cell is summarized in Table 3:

Table 3. Action leakage rates for different cells expressed in gpad

Sump	Perimeter Length of Sumps		Cell Area (Acres)	ALR (gpd)	ALR (gpad)
	1% slope (ft)	33.3% slope (ft)			
Cell A1	80	80	15.4	72,461	4,705
Cell A2	80	80	15.4	72,461	4,705
Cell B	80	80	30.5	72,461	2,376
Cell C	80	80	30.5	72,461	2,376

CONCLUSIONS:

Per EPA guidance, the Action Leakage Rate (ALR) was calculated assuming one foot of water head on the bottom geomembrane liner of the tailings cells double composite liner system. The ALR was calculated to be 4,705 gpad for cells A1 and A2 and 2,376 gpad for cells B and C.

REFERENCES:

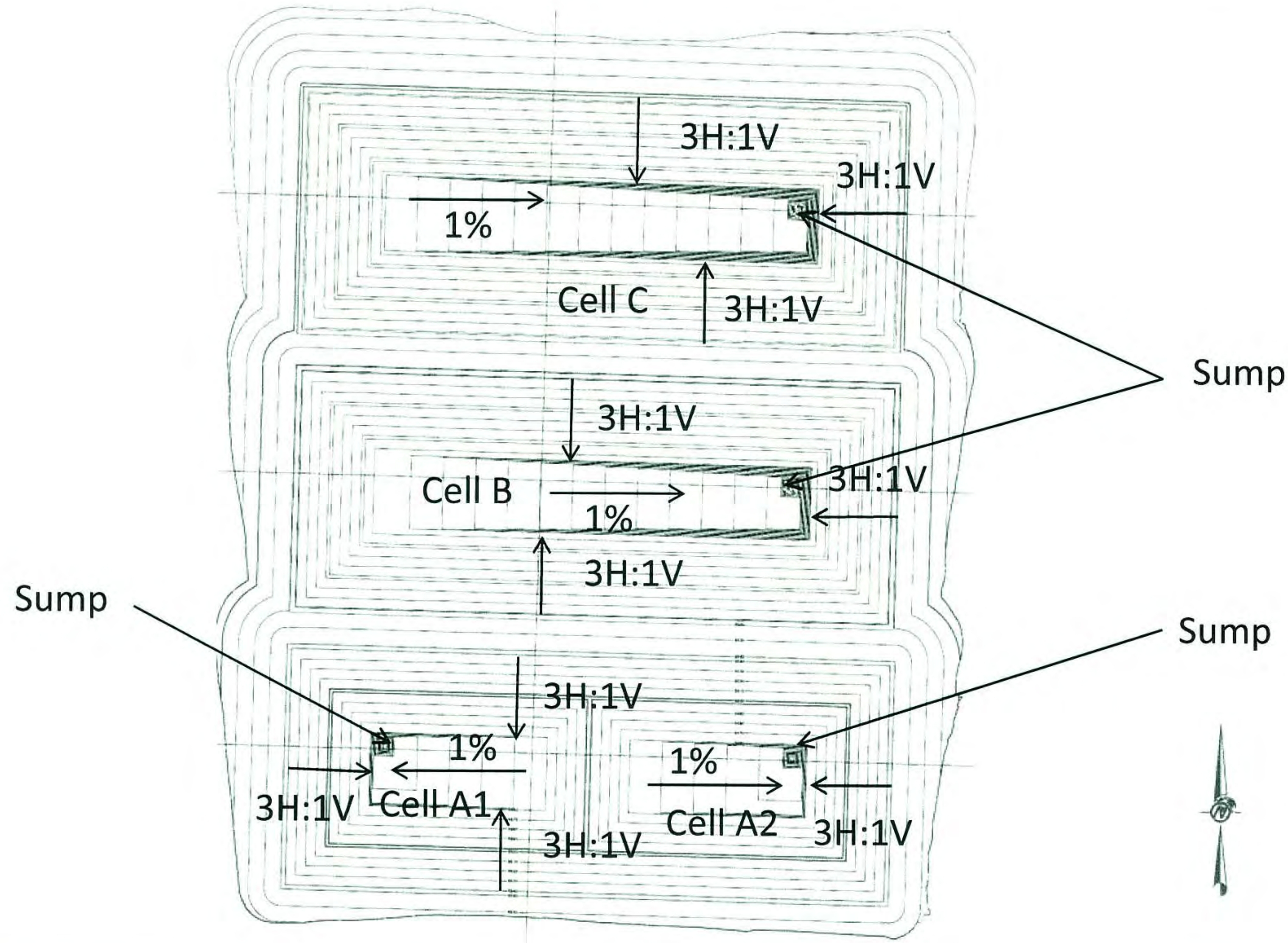
Colorado Department of Public Health and the Environment (CDPHE), Hazardous Waste Regulations 6 CCR 1007-1, Parts 3 and 18.

Koerner, R. M. (1998). *Designing with geosynthetics*, Prentice Hall, Upper Saddle River, N.J.

U.S. EPA. (1992). "Action leakage rates for detection systems (supplemental background document for the final double liners and leak detection systems rule for hazardous waste landfills, waste piles, and surface impoundments)." U.S. Enviromental Protection Agency.

United States Government Printing Office. (2002). *Title 40, CFR*, U.S. G.P.O., Washington, D.C.

FIGURES

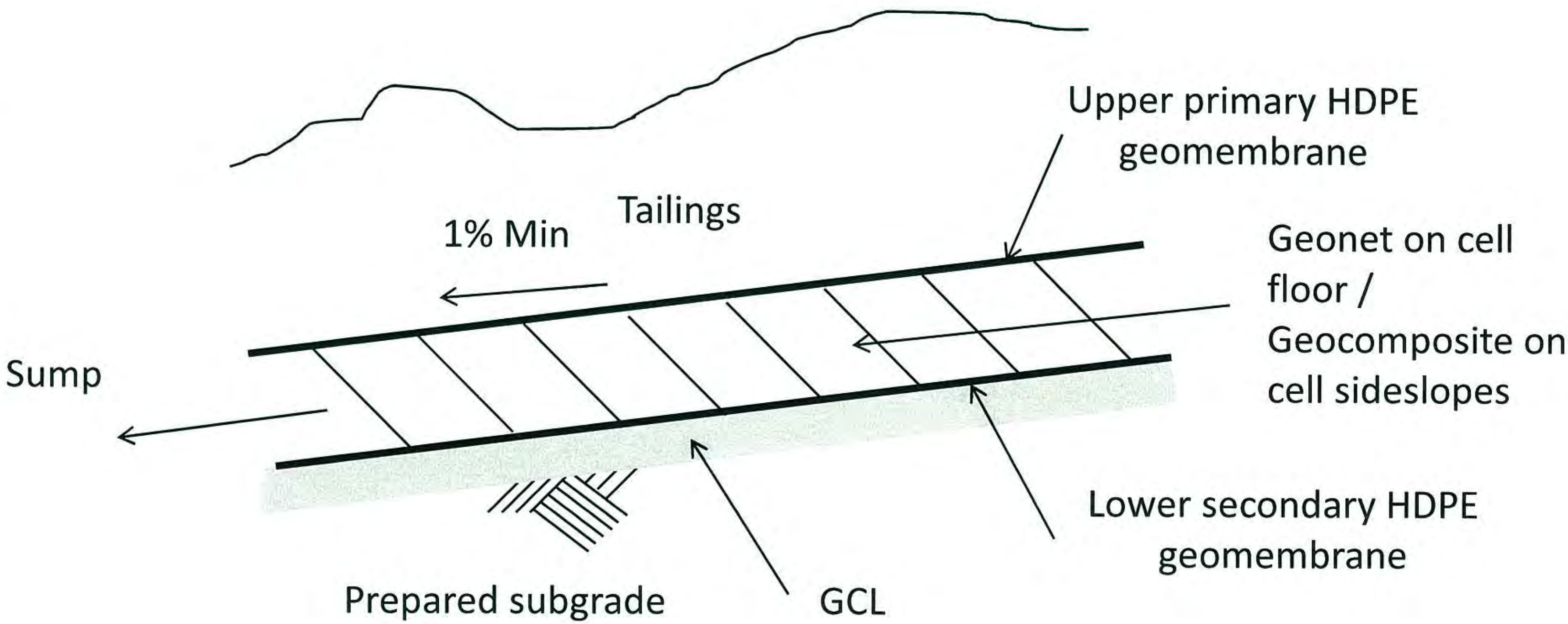


Golder Associates
Denver, Colorado

TITLE

TAILINGS CELLS CONFIGURATION

CLIENT/PROJECT ENERGY FUELS RESOURCES CORPORATION PIÑON RIDGE PROJECT – TAILINGS CELLS DESIGN MONTROSE COUNTY, COLORADO	DRAWN EF	DATE FEBRUARY 5 2008	JOB NO. 073-81694
	CHECKED KAM	SCALE N.T.S.	DWG. NO.
	REVIEWED KAM	FILE NO.	FIGURE NO. 1



Golder Associates — Denver, Colorado

TITLE: LINER SYSTEM TYPICAL DETAIL

DRAWN EF	DATE FEBRUARY 5 2008	JOB NO. 073-81694
CHECKED KHM	SCALE N.T.S.	DWG. NO.
REVIEWED KHM	FILE NO.	FIGURE NO. 2

CLIENT/PROJECT
ENERGY FUELS RESOURCES CORPORATION
PIÑON RIDGE PROJECT – TAILINGS CELLS DESIGN
MONTROSE COUNTY, COLORADO

ATTACHMENT 1

T/// Rx

GSE Drainage Performance Series

Product Data Sheet

GSE FabriNet TRx Geocomposites (Double-Sided)

GSE FabriNet TRx high flow geocomposites are produced with a unique one step process that coextrudes creep resistant columns to an intrusion resistant roof. The resulting tri-axial geonet is then laminated to a nonwoven geotextile filtration media. GSE FabriNet TRx achieves high in-situ transmissivity from optimally oriented flow channels that maintain porosity because of the intrusion and creep resistant nature of the tri-axial structure. GSE FabriNet TRx provides continuous performance over a broad range of conditions. It is also well suited for use in surface water collection and removal systems, gas venting, and landfill liner system drainage applications.

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE ROLL VALUE		
Geocomposite - GSE FabriNet TRx			4 oz/yd²	6 oz/yd²	8 oz/yd²
Product Code			**FS82040040T**	**FS82060060T**	**FS82080080T**
Transmissivity[b], gal/min/ft (m²/sec)	ASTM D 4716	1/540,000 ft²	12.1 (2.5x10⁻³)	12.1 (2.5x10⁻³)	10.1 (2.2x10⁻³)
Ply Adhesion, lb/in (g/cm)	ASTM D 7005	1/50,000 ft²	1.0 (178)	1.0 (178)	1.0 (178)
Roll Width[a], ft (m)			15 (4.5)	15 (4.5)	15 (4.5)
Roll Length[a], ft (m)			140 (42)	130 (39)	130 (39)
Roll Area, ft² (m²)			2,100 (195)	1,950 (181)	1,950 (181)
Geonet Core - GSE HyperNet TRx					
Transmissivity[c], gal/min/ft (m²/sec)	ASTM D 4716	1/540,000 ft²	43.5 (9.0 x10⁻³)		
Density, g/cm³	ASTM D 1505	1/50,000 ft²	> 0.94		
Tensile Strength[e], lb/in (N/mm)	ASTM D 5035	1/50,000 ft²	75 (13.3)		
Carbon Black Content (%)	ASTM D 1603*/4218	1/50,000 ft²	> 2.0		
Geotextile - (Prior to lamination)					
Mass per Unit Area	ASTM D 5261	1/90,000 ft²	4	6	8
Grab Tensile, lb (N)	ASTM D 4632	1/90,000 ft²	120 (530)	170 (755)	220 (975)
Puncture Strength, lb (N)	ASTM D 4833	1/90,000 ft²	60 (265)	90 (395)	120 (525)
AOS, US Sieve (mm)	ASTM D 4751	1/540,000 ft²	70	70	80
Permittivity, sec⁻¹	ASTM D 4491	1/540,000 ft²	1.5	1.5	1.5
Flow Rate, gpm/ft² (lpm/m²)	ASTM D 4491	1/540,000 ft²	120 (4,885)	110 (4,480)	110 (4,480)
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	once per formulation	70	70	70

NOTES:

- [a] Roll widths and lengths have a tolerance of ±1%.
- [b] This is an index transmissivity value measured at stress = 1,000 psf; gradient = 0.1; time = 15 minutes; boundary conditions = plate/geocomposite/plate. Contact GSE for performance transmissivity value for use in design.
- [c] This is an index transmissivity value measured at stress = 1,000 psf; gradient = 0.1; time = 15 minutes; boundary conditions = plate/geonet/plate. Contact GSE for performance transmissivity value for use in design.
- [d] All properties are minimum average roll values based on the cumulative results of specimens tested and determined by GSE except AOS (mm) which is a maximum average roll value (MaxARV); and UV resistance which is a typical value.
- [e] Tested in machine direction (MD).
- *Modified.

DS026 Fabrinet TRX R01/07/08

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North America	GSE Lining Technology, Inc.	Houston, Texas	800.435.2008	281.443.8564	Fax: 281.230.6739
South America	GSE Lining Technology Chile S.A.	Santiago, Chile		56.2.595.4200	Fax: 56.2.595.4290
Asia Pacific	GSE Lining Technology Company Limited	Bangkok, Thailand		66.2.937.0091	Fax: 66.2.937.0097
Europe & Africa	GSE Lining Technology GmbH	Hamburg, Germany		49.40.767420	Fax: 49.40.7674234
Middle East	GSE Lining Technology-Egypt	The 6th of October City, Egypt		20.2.828.8888	Fax: 20.2.828.8889

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GSE STANDARD PRODUCTS

Product Data Sheet

GSE HyperNet Geonets

GSE HyperNet geonets are synthetic drainage materials manufactured from a premium grade high density polyethylene (HDPE) resin. The structure of the HyperNet geonet is formed specifically to transmit fluids uniformly under a variety of field conditions. HDPE resins are inert to chemicals encountered in most of the civil and environmental applications where these materials are used. GSE geonets are formulated to be resistant to ultraviolet light for time periods necessary to complete installation. GSE HyperNet geonets are available in standard, HF, HS, and UF varieties.

The table below provides index physical, mechanical and hydraulic characteristics of GSE geonets. Contact GSE for information regarding performance of these products under site-specific load, gradient, and boundary conditions.

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE ROLL VALUE[c]			
			HyperNet	HyperNet HF	HyperNet HS	HyperNet UF
Product Code			XL4000N004	XL5000N004	XL7000N004	XL8000N004
Transmissivity[a], gal/min/ft (m^2/sec)	ASTM D 4716-00	1/540,000 ft^2	9.66 (2×10^{-3})	14.49 (3×10^{-3})	28.98 (6×10^{-3})	38.64 (8×10^{-3})
Thickness, mil (mm)	ASTM D 5199	1/50,000 ft^2	200 (5)	250 (6.3)	275 (7)	300 (7.6)
Density, g/cm^3	ASTM D 1505	1/50,000 ft^2	0.94	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	1/50,000 ft^2	45 (7.9)	55 (9.6)	65 (11.5)	75 (13.3)
Carbon Black Content, %	ASTM D 1603, modified	1/50,000 ft^2	2.0	2.0	2.0	2.0
Roll Width, ft (m)			15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)
Roll Length, ft (m)[b]			300 (91)	250 (76)	220 (67)	200 (60)
Roll Area, ft^2 (m^2)			4,500 (418)	3,750 (348)	3,300 (305)	3,000 (278)

NOTES:

- [a]Gradient of 0.1, normal load of 10,000 psf, water at 70° F (20° C), between steel plates for 15 minutes.
- [b]Please check with GSE for other available roll lengths.
- [c]These are MARV values that are based on the cumulative results of specimens tested by GSE.

DS017 R07/07/03

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Europe/Middle East/Africa	GSE Lining Technology GmbH	Hamburg, Germany		49-40-767420	Fax: 49-40-7674233
Asia/Pacific	GSE Lining Technology Company Ltd.	Bangkok, Thailand		66-2-937-0091	Fax: 66-2-937-0097