APPENDIX F
LINER SYSTEM MATERIAL DATA

Golder Associates	Kettleman Hills Facility – Landfill Unit B-18 LINER SYSTEM MATERIAL DATA	
	Project No.: 083-91887	Made By: RH
	Date: 4-28-2008	Checked By: SS
	Sheet: 1 of 1	Reviewed By: SS

Objective:
To provide data on the existing and proposed geosynthetic liner system materials for Landfill B-18.

Given:
Existing B-18 Liner Systems:
The existing (Phases I and II) B-18 base and sideslope liner systems contain the following geosynthetic components:

- 60-mil textured high-density polyethylene (HDPE) geomembrane;
- 80-mil smooth HDPE geomembrane;
- 8-ounce/square yard (oz/sy) nonwoven geotextile;
- 16-oz/sy nonwoven geotextile; and
- 200-mil geonet.

Product data sheets for the above-listed existing geosynthetic components of the B-18 liner systems were provided by ESI (1990). Copies of these product data sheets are provided in Attachment #1.

Proposed B-18 Liner Systems:
The proposed B-18 expansion area sideslope liner system contains the following geosynthetic components:

- 60-mil textured HDPE geomembrane;
- 16-oz/sy nonwoven geotextile; and
- geocomposite.

The proposed B-18 final closure cover system contains the following geosynthetic components:

- 40-mil textured HDPE geomembrane; and
- 12-oz/sy nonwoven geotextile.

Product data sheets that contain typical specified properties for the above-listed proposed geosynthetic components of the B-18 sideslope liner and cover systems are provided in Attachment #2. The data sheets provided in Attachment #2 were obtained from the Agru America, GSE Lining Technology, Inc. (GSE), Polyflex and Scaps. Inclusion of these data sheets does not imply that these materials will be used exclusively for the proposed B-18 expansion and/or final closure. However, the actual geosynthetics used for the B-18 expansion and final closure are anticipated to have properties that are very similar to or the same as those given in Attachment #2. Attachment #3 provides EPA 9090 test results for products similar to the proposed liner materials. Results of the testing, similar to previous site specific testing, indicate the products are compatible with leachate. No additional EPA 9090 testing is proposed.

Reference:
Environmental Solutions, Inc. (ESI), "Engineering and Design Report, Landfill Unit B-18, Phases I and II and Final Closure, Kettleman Hills Facility, Kings County, California," August 1990.

ATTACHMENT #1
LINER SYSTEM MATERIAL DATA

NSC

NATIONAL SEAL COMPANY

SUGGESTED THICKNESS SPECIFICATIONS

Thickness shall be measured in accordance with ASTM D 1593, paragraph 9.1.3 and ASTM D 751. The minimum average roll thickness shall be as specified with no individual thickness measurement on the sheet falling more than 5% below the specified value.

SPECIFIED THICKNESS	MINIMUM AVERAGE ROLL VALUE	MINIMUM THICKNESS ALLOWED
40 mil	40 mil	38 mil
60 mil	60 mil	57 mil
80 mil	80 mil	76 mil
100 mil	100 mil	95 mil

04/89

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NATIONAL SEAL COMPANY
ROLLSTOCK SPECIFICATIONS

I. RESIN SPECIFICATION:

NSC will use Union Carbide or Soltex resin or the equivalent.

Each lot of resin will be analyzed by National Seal Company's Laboratory as follows:

SPECIFICATION	TEST METHOD
Density	ASTM D 1505
Carbon Black Content	ASTM D 1603
Melt Flow Index	ASTM D 1238
Moisture Content	

II. SHEET SPECIFICATION:

Gauge	±5%
Width	15' Nominal
Carbon Black	2% to 3%
Appearance	smooth surface, minimal haze.

III. QUALITY ASSURANCE and TESTING:

1. Sheet appearance will be monitored continuously by production personnel and at least once per hour by a member of our Laboratory.

2. Sheet thickness will be continuously monitored by automatic gauging equipment located on the extruder.

3. Production will hold sheet thickness to within ±3% whenever possible. ±5% is our advertised tolerance.

4. National Seal Company's Laboratory will perform the following tests every 10,000 pounds of material produced:

SPECIFICATION	TEST METHOD
Tensile Properties	ASTM D 638
Carbon Black Dispersion	ASTM D 3015
Thickness	ASTM D 1593
Dimensional Stability	ASTM D 1204

See National Seal Company's Quality Control Manual for full listing of the tests which our Laboratory can perform. Please contact your sales representative for a pricing.

04/89

HIGH DENSITY POLYETHYLENE HDPE-40 MIL

PHYSICAL PROPERTIES

ALL PROPERTIES MEET OR EXCEED NSF STANDARD 54 SPECIFICATIONS FOR HDPE

PROPERTY	UNITS	TEST METHOD	VALUE
GAUGE OF MATERIAL	MILS	ASTM D 1593	40 (± 5%)
SPECIFIC GRAVITY, MINIMUM		ASTM D 792 A	0.94
MINIMUM TENSILE PROPERTIES		ASTM D 638	
TENSILE STRENGTH AT YIELD	PSI		2200
TENSILE STRENGTH AT BREAK	PSI		3800
ELONGATION AT YIELD	%		13
ELONGATION AT BREAK	%		600
MODULUS OF ELASTICITY	PSI		80,000
TEAR RESISTANCE, MINIMUM	PPI	ASTM D 1004	700
LOW TEMP. BRITTLENESS	DEG C.	ASTM D 746 B	−75° C.
SOIL BURIAL RESISTANCE MAX. CHANGE	%	ASTM D 3083[1]	
TENSILE STRENGTH AT YIELD			10
TENSILE STRENGTH AT BREAK			10
ELONGATION AT YIELD			10
ELONGATION AT BREAK			10
MODULUS OF ELASTICITY			10
ENVIRONMENTAL STRESS CRACK RES.	HRS.	ASTM D 1693[1]	1500
CARBON BLACK CONTENT	%	ASTM D 1603	2-3
CARBON BLACK DISPERSION	RATING	ASTM D 3015	A-2
MELT INDEX, CONDITION E, MAXIMUM	g/10m	ASTM D 1238	1.0
PUNCTURE RESISTANCE	LBS	FTMS 101, 2065	60
WATER VAPOR TRANSMISSION	g/M² hr.	ASTM E 96	0.008
HYDROSTATIC RESISTANCE	PSI	ASTM D 751 A	300

NATIONAL SEAL SEAMING PROPERTIES

BONDED SEAM STRENGTH, MINIMUM	PPI	ASTM D 3083[1]	80 & FTB[2]
SEAM PEEL ADHESION, MINIMUM	PPI	ASTM D 413[1]	60 & FTB[2]
SOIL BURIAL RESISTANCE		ASTM D 3083[1]	
BONDED SEAM STRENGTH, MAX. CHANGE	%		−10
SEAM PEEL ADHESION			FTB[2]

1. AS MODIFIED IN NSF STANDARD NUMBER 54.
2. FILM TEARING BOND.

NSC NATIONAL SEAL COMPANY

1255 MONMOUTH BLVD..
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309/343-1536 FAX

HIGH DENSITY POLYETHYLENE HDPE-60 MIL

PHYSICAL PROPERTIES

ALL PROPERTIES MEET OR EXCEED NSF STANDARD 54 SPECIFICATIONS FOR HDPE

PROPERTY	UNITS	TEST METHOD	VALUE
GAUGE OF MATERIAL	MILS	ASTM D 1593	60 (± 5%)
SPECIFIC GRAVITY, MINIMUM		ASTM D 792 A	0.94
MINIMUM TENSILE PROPERTIES		ASTM D 638	
TENSILE STRENGTH AT YIELD	PSI		2200
TENSILE STRENGTH AT BREAK	PSI		3800
ELONGATION AT YIELD	%		13
ELONGATION AT BREAK	%		600
MODULUS OF ELASTICITY	PSI		80,000
TEAR RESISTANCE, MINIMUM	PPI	ASTM D 1004	700
LOW TEMP. BRITTLENESS	DEG C.	ASTM D 746 B	−75° C.
SOIL BURIAL RESISTANCE MAX. CHANGE	%	ASTM D 3083[1]	
TENSILE STRENGTH AT YIELD			10
TENSILE STRENGTH AT BREAK			10
ELONGATION AT YIELD			10
ELONGATION AT BREAK			10
MODULUS OF ELASTICITY			10
ENVIRONMENTAL STRESS CRACK RES.	HRS.	ASTM D 1693[1]	1500
CARBON BLACK CONTENT	%	ASTM D 1603	2-3
CARBON BLACK DISPERSION	RATING	ASTM D 3015	A-2
MELT INDEX, CONDITION E, MAXIMUM	g/10m	ASTM D 1238	1.0
PUNCTURE RESISTANCE	LBS	FTMS 101, 2065	90
WATER VAPOR TRANSMISSION	g/M^2 hr.	ASTM E 96	0.005
HYDROSTATIC RESISTANCE	PSI	ASTM D 751 A	450

NATIONAL SEAL SEAMING PROPERTIES

BONDED SEAM STRENGTH, MINIMUM	PPI	ASTM D 3083[1]	120 & FTB[2]
SEAM PEEL ADHESION, MINIMUM	PPI	ASTM D 413[1]	90 & FTB[2]
SOIL BURIAL RESISTANCE		ASTM D 3083[1]	
BONDED SEAM STRENGTH, MAX. CHANGE	%		−10
SEAM PEEL ADHESION			FTB[2]

1. AS MODIFIED IN NSF STANDARD NUMBER 54.
2. FILM TEARING BOND.

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HIGH DENSITY POLYETHYLENE HDPE-80 MIL

PHYSICAL PROPERTIES

ALL PROPERTIES MEET OR EXCEED NSF STANDARD 54 SPECIFICATIONS FOR HDPE

PROPERTY	UNITS	TEST METHOD	VALUE
GAUGE OF MATERIAL	MILS	ASTM D 1593	80 (± 5%)
SPECIFIC GRAVITY, MINIMUM		ASTM D 792 A	0.94
MINIMUM TENSILE PROPERTIES		ASTM D 638	
TENSILE STRENGTH AT YIELD	PSI		2200
TENSILE STRENGTH AT BREAK	PSI		3800
ELONGATION AT YIELD	%		13
ELONGATION AT BREAK	%		600
MODULUS OF ELASTICITY	PSI		80,000
TEAR RESISTANCE, MINIMUM	PPI	ASTM D 1004	700
LOW TEMP. BRITTLENESS	DEG C.	ASTM D 746 B	−75° C.
SOIL BURIAL RESISTANCE MAX. CHANGE	%	ASTM D 3083[1]	
TENSILE STRENGTH AT YIELD			10
TENSILE STRENGTH AT BREAK			10
ELONGATION AT YIELD			10
ELONGATION AT BREAK			10
MODULUS OF ELASTICITY			10
ENVIRONMENTAL STRESS CRACK RES.	HRS.	ASTM D 1693[1]	1500
CARBON BLACK CONTENT	%	ASTM D 1603	2-3
CARBON BLACK DISPERSION	RATING	ASTM D 3015	A-2
MELT INDEX, CONDITION E, MAXIMUM	g/10m	ASTM D 1238	1.0
PUNCTURE RESISTANCE	LBS	FTMS 101, 2065	110
WATER VAPOR TRANSMISSION	g/M^2 hr.	ASTM E 96	0.004
HYDROSTATIC RESISTANCE	PSI	ASTM D 751 A	600

NATIONAL SEAL SEAMING PROPERTIES

BONDED SEAM STRENGTH, MINIMUM	PPI	ASTM D 3083[1]	160 & FTB[2]
SEAM PEEL ADHESION, MINIMUM	PPI	ASTM D 413[1]	120 & FTB[2]
SOIL BURIAL RESISTANCE		ASTM D 3083[1]	
BONDED SEAM STRENGTH, MAX. CHANGE	%		−10
SEAM PEEL ADHESION			FTB[2]

1. AS MODIFIED IN NSF STANDARD NUMBER 54.
2. FILM TEARING BOND.

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1255 MONMOUTH BLVD.,
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HIGH DENSITY POLYETHYLENE HDPE-100 MIL

PHYSICAL PROPERTIES

ALL PROPERTIES MEET OR EXCEED NSF STANDARD 54 SPECIFICATIONS FOR HDPE

PROPERTY	UNITS	TEST METHOD	VALUE
GAUGE OF MATERIAL	MILS	ASTM D 1593	100 (± 5%)
SPECIFIC GRAVITY, MINIMUM		ASTM D 792 A	0.94
MINIMUM TENSILE PROPERTIES		ASTM D 638	
TENSILE STRENGTH AT YIELD	PSI		2200
TENSILE STRENGTH AT BREAK	PSI		3800
ELONGATION AT YIELD	%		13
ELONGATION AT BREAK	%		600
MODULUS OF ELASTICITY	PSI		80,000
TEAR RESISTANCE, MINIMUM	PPI	ASTM D 1004	700
LOW TEMP. BRITTLENESS	DEG C.	ASTM D 746 B	−75° C.
SOIL BURIAL RESISTANCE MAX. CHANGE	%	ASTM D 3083[1]	
TENSILE STRENGTH AT YIELD			10
TENSILE STRENGTH AT BREAK			10
ELONGATION AT YIELD			10
ELONGATION AT BREAK			10
MODULUS OF ELASTICITY			10
ENVIRONMENTAL STRESS CRACK RES.	HRS.	ASTM D 1693[1]	1500
CARBON BLACK CONTENT	%	ASTM D 1603	2-3
CARBON BLACK DISPERSION	RATING	ASTM D 3015	A-2
MELT INDEX, CONDITION E, MAXIMUM	g/10m	ASTM D 1238	1.0
PUNCTURE RESISTANCE	LBS	FTMS 101, 2065	130
WATER VAPOR TRANSMISSION	g/M² hr.	ASTM E 96	0.003
HYDROSTATIC RESISTANCE	PSI	ASTM D 751 A	750

NATIONAL SEAL SEAMING PROPERTIES

BONDED SEAM STRENGTH, MINIMUM	PPI	ASTM D 3083[1]	200 & FTB[2]
SEAM PEEL ADHESION, MINIMUM	PPI	ASTM D 413[1]	150 & FTB[2]
SOIL BURIAL RESISTANCE		ASTM D 3083[1]	
BONDED SEAM STRENGTH, MAX. CHANGE	%		−10
SEAM PEEL ADHESION			FTB[2]

1. AS MODIFIED IN NSF STANDARD NUMBER 54.
2. FILM TEARING BOND.

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Trevira® Spunbonds are highly needled nonwoven engineering fabrics with excellent tensile properties, high filtration potential and outstanding permeability.

Trevira® Spunbond Type 11 products are 100% continuous filament polyester nonwoven needlepunched engineering fabrics. They deliver a combination of advantages unmatched by any other spunbonded geotextiles. They're resistant to freeze-thaw, soil chemicals and ultraviolet light exposure.

Trevira® Spunbonds are excellent where the requirement is (1) tensile reinforcement, (2) planar flow, (3) filtration, and (4) separation. For example, in roadways, railbeds, drainage systems, pondliners, retaining walls. And much more. Trevira® Spunbonds are extraordinary engineering fabrics.

TYPICAL PHYSICAL PROPERTIES OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	1112	1114	1120	1125	1135	1145	1155
Fabric Weight	oz/yd²	ASTM D-3776	3.6	4.2	6.0	7.4	10.5	13.5	16.2
Thickness, t	mils	ASTM D-1777	60	65	90	110	150	175	210
Grab Strength (MD/CD)[1]	lbs	ASTM D-4632	110/90	135/110	205/175	270/225	390/330	500/425	625/560
Grab Elongation (MD/CD)	%	ASTM D-4632	70/85	70/85	75/85	75/85	75/85	90/95	90/95
Trapezoid Tear Strength (MD/CD)	lbs	ASTM D-4533	50/40	60/50	80/75	105/95	135/120	175/170	205/200
Puncture Resistance (5/16" hemispherical tip)	lbs	ASTM D-3787	50	60	90	115	155	175	240
Mullen Burst Strength	psi	ASTM D-3786	180	210	315	390	550	625	840
Water Flow Rate (5 cm. hd.)	gpm/ft²	ASTM D-4491	200	200	170	150	110	90	70
Permittivity, Ψ	sec^{-1}	ASTM D-4491	2.72	2.72	2.31	1.77	1.50	1.22	0.95
Permeability, k	cm/sec	$K = \Psi t$	0.41	0.45	0.53	0.49	0.57	0.54	0.51
AOS	Sieve Size mm	ASTM D-4751	70-100 .210-.149	70-100 .210-.149	70-100 .210-.149	70-120 .210-.125	70-120 .210-.125	100-140 .149-.105	100-170 .149-.088
Standard Roll Widths[2]	ft		12.5 and 15.0						
Standard Roll Length[2]	ft		400	400	300	300	300	300	300

[1] MD = Machine Direction, CD = Cross Machine Direction.

[2] Other width and length rolls are available upon request.

MINIMUM AVERAGE ROLL VALUES (WEAKEST PRINCIPAL DIRECTION) OF TREVIRA® TYPE 11 PRODUCTS

Fabric Property	Unit	Test Method	1112	1114	1120	1125	1135	1145	1155
Fabric Weight	oz/yd²	ASTM D-3776	3.4	4.0	5.7	7.1	10.0	13.0	16.0
Thickness, t	mils	ASTM D-1777	50	55	80	100	135	160	200
Grab Strength	lbs	ASTM D-4632	80	100	155	200	290	375	500
Grab Elongation	%	ASTM D-4632	60	60	65	60	65	65	65
Trapezoid Tear Strength	lbs	ASTM D-4533	30	40	60	75	100	140	170
Puncture Resistance (5/16" hemispherical tip)	lbs	ASTM D-3787	35	45	75	95	130	155	200
Mullen Burst Strength	psi	ASTM D-3786	160	190	285	360	500	575	765
Water Flow Rate[3] (5 cm. hd.)	gpm/ft²	ASTM D-4491	170	170	140	100	80	60	40
Permittivity Ψ [3]	sec^{-1}	ASTM D-4491	2.31	2.31	1.90	1.36	1.09	0.82	0.54
Permeability, k[3]	cm/sec	$K = \Psi t$	0.29	0.32	0.39	0.35	0.37	0.33	0.27
AOS[3]	Sieve Size mm	ASTM D-4751	70 .210	70 .210	70 .210	70 .210	70 .210	100 .149	100 .149

[3] AOS "minimum average roll value" is a measure of the *largest* opening size in the fabric.

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TREVIRA

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Hoechst

Rev. 8/8

TREVIRA® Spunbond Engineering Fabric Geotextile Selection Guide

INTRODUCTION

Designers, owners, and contractors are now forced to choose from a multitude of geosynthetic products. The December 1987 issue of "Geotechnical Fabrics Report"[1] listed 26 manufacturers or suppliers of geotextiles, and each supplier had several different products listed. When geonets, geogrids, and geocomposites are included, the list becomes very lengthy.

This brochure will only discuss geotextiles and will provide data to assist the specifier or user in selecting the proper fabric(s) for their application. Most data will be presented in a generic format; however, TREVIRA® Spunbond will be used to illustrate some of the presentation.

Polyester or Polypropylene?

Almost all geotextiles available in the United States are manufactured from either polyester or polypropylene. Both polymers are synthetic "man-made" materials, but they display significantly different physical properties. Table 1 lists important characteristics for both polymers expressed as actual test results or as "excellent, good, fair, and poor".

As Table 1 illustrates, polyester and polypropylene display important differences in physical properties. These differences should always be considered when selecting geotextiles for any application.

Woven or Nonwoven?

Woven geotextiles can be placed in two general categories by manufacturing method — Slit Film and Filament. All woven fabrics display high strength/low

Table 1

CHARACTERISTICS

	Polyester	*Polypropylene*
Melting Point	478-490°F	320-350°F
UV Resistance	Excellent	Poor (Unstabilized) Fair-Excellent (Stabilized)
Creep Resistance	Excellent	Fair
Low Temperature (below 32°F) Workability	Excellent	Fair-Poor
Biological Resistance	Excellent	Excellent
Chemical Resistance*	Good	Good
Specific Gravity	1.36	0.9

*Chemical resistance is difficult to generalize. Both polyester and polypropylene are unaffected by most chemicals, particularly in the concentrations commonly found in soil. However, if the fabric is being used in a waste containment facility or tank farm, and will therefore be exposed to higher concentrations, specific compatibility data should be requested from the geoextile manufacturers. If this data is unavailable, which is often the case with leachates, compatibility testing is suggested.

Figure 1

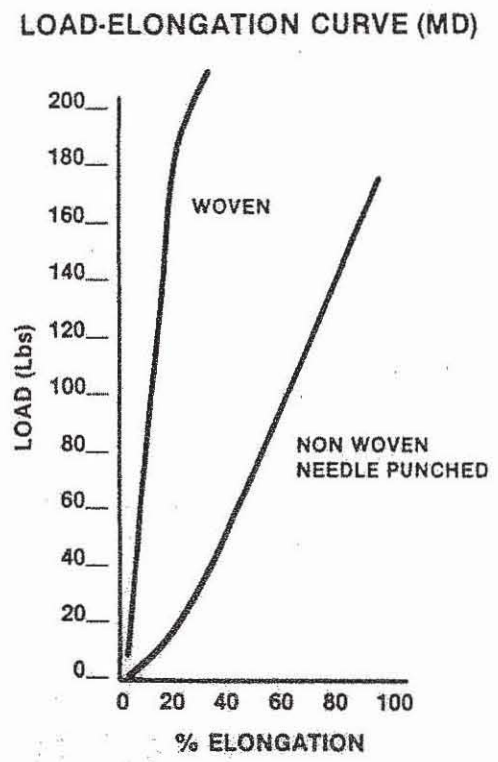

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Table 2

INDEX TESTS

PHYSICAL PROPERTY	TEST PROCEDURE
1) Weight	per ASTM D-3776
2) Thickness	per ASTM D-1777
3) Grab Strength	per ASTM D-4632
4) Grab Elongation	per ASTM D-4632
5) Trapezoid Tear Strength	per ASTM D-4533
6) Puncture Strength (modified) (this test is currently being balloted at ASTM for approval of a 5/16" flat tip with 1/32" x 45° chamfer)	per ASTM D-3787
7) Mullen Burst Strength	per ASTM D-3786
8) Permittivity	per ASTM D-4491
9) Apparent Opening Size (AOS)	per ASTM D-4751

"Typical" and "minimum average roll" results are listed on the TREVIRA® Spunbond sample cards.

Hoechst Celanese Corporation also routinely performs or has independent testing labs perform the following index and design tests:

PHYSICAL PROPERTY	TEST PROCEDURE
1) Ultraviolet Degradation	per ASTM D-4355
2) Transmissivity — fabric and fabric-net or fabric-core (Depending on boundary conditions, this test can be used as an index or design test.)	per ASTM D-4716
3) Abrasion Resistance	ASTM is currently balloting on an Abrasion Testing procedure utilizing the SBS (Sliding Block/Sandpaper Abrasion Test.)
4) Wide Width Tensile Test — This test is actually a design test but can be used for comparing fabrics.	per ASTM-4595
5) Friction Testing per the direct shear method — This test may be used as an index or design test.	This test is currently being balloted at ASTM.
6) Gradient Ratio Test — This test may be used as an index or design test.	This test is currently being balloted at ASTM.
7) Chemical Compatibility — This test may be used as an index or design test.	ASTM is currently working on this testing procedure.
8) Creep — This test may be used as an index or design test.	This test is currently being balloted at ASTM.

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Table 3

PHYSICAL PROPERTIES FOR PERFORMANCE

APPLICATION	FABRIC FUNCTION	IMPORTANT GEOTEXTILE PHYSICAL PROPERTY for PERFORMANCE
1. Drainage • Underdrains • Recharge drains • Structure drains	Filtration Separation	• Permittivity • Coefficient of Permeability • AOS • Resistance to Clogging or Blinding (Gradient Ratio Test or Long-Term Soil-Fabric Filtration Test) • Trapezoid Tear Strength • Puncture Strength
2. Erosion Protection • Rip rap slope protection • Gabion bank protection	Filtration Separation	• Permittivity • Coefficient of Permeability • AOS • Resistance to Clogging or Blinding • Friction Angle (Direct Shear Test) • Puncture Strength • Trapezoid Tear Strength • Mullen Burst Strength
3. Stabilization • Aggregate roads and yards • Paved roads and parking lots • Railroad tracks	Separation Reinforcement Filtration Planar Transport	• Grab Tensile Strength • Mullen Burst Strength • Trapezoid Tear Strength • Puncture Strength • Permittivity • Transmissivity • Abrasion Resistance • Friction Angle (Direct Shear Test)
4. Soil Reinforcement • "Wrap around" walls • Reinforced slopes • Embankments over weak foundations	Reinforcement	• Wide Width Tensile Strength • Secant Modulus (confined) • Direct Shear or Pull Out Friction Angle
5. Lining Systems		
• Gas Relief Layer	Planar transport	• Transmissivity
• Cushion Layer	Separation Reinforcement	• Mullen Burst Strength • Puncture Strength • Trapezoid Tear Strength
• Leachate Collection Systems	Filtration Separation Planar Transport	• Permittivity • Coefficient of Permeability • AOS • Resistance to Clogging and Blinding • Friction Angle (Direct Shear Test) • Transmissivity (if fabric is used as the drain)
6. Asphalt Pavement • Asphalt Overlay • Chip Seal • Full depth asphalt	Waterproofing (after absorbing tack coat) Reinforcement	• Asphalt Retention/Absorption • Shrinkage Temperature

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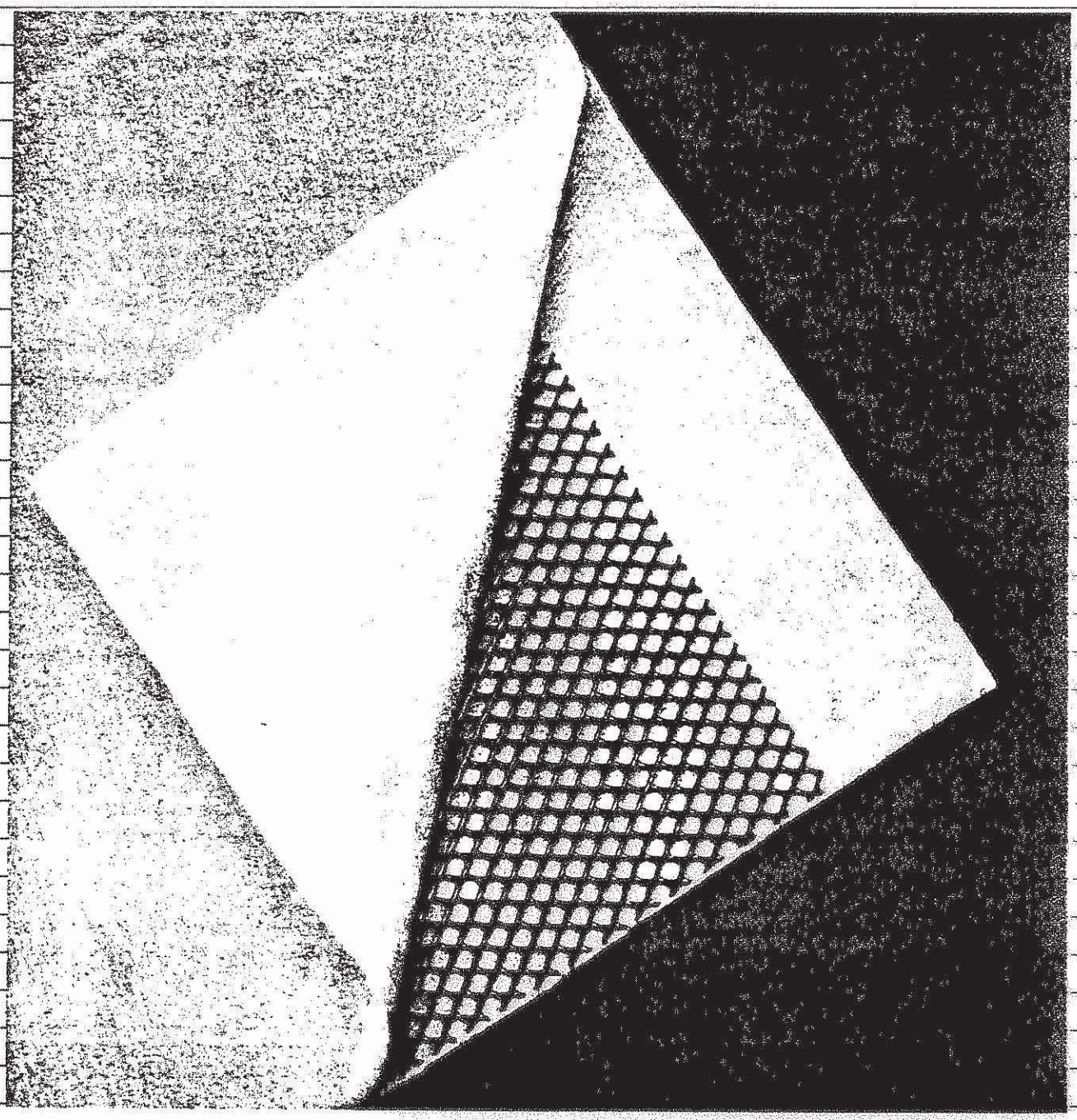
TEX-NET™

The Composite Drainage System



Solid and Hazardous Waste Containment Drainage

Primary Leachate Collection

TEX-NET, a composite of a drainage net and one or two layers of geotextile fabric, can provide a desired planar flow of liquids down the steep slopes of the walls and across the floor of waste containments to collection standpipes. The fabric acts as a filter to keep soil or fines from inhibiting any planar flow of leachate through the drainage net. It also acts as a cushion protecting the liner from damage. By having the fabric heat-laminated to the net, superior frictional resistance is achieved. Shear tests of TEX-NET with clayey soils indicate realistic friction angles in excess of 30°.

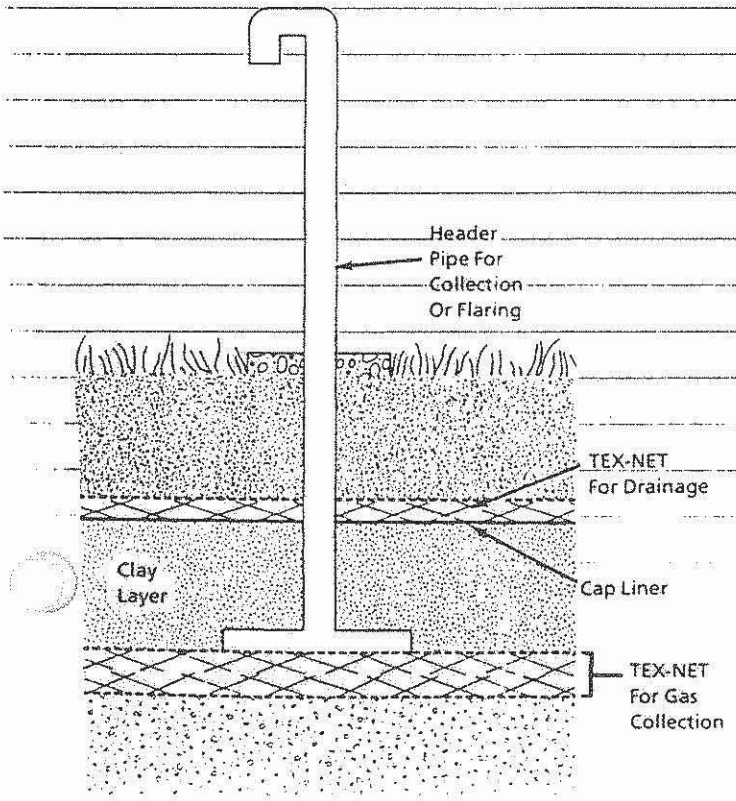
Landfill Cap

There are two applications of TEX-NET in a typical landfill cap. One, as the medium to drain surface water off the geomembrane cap...and two, under the landfill cap as a gas collector. TEX-NET with a geotextile on one side only is ideal for installation over the cap. TEX-NET with fabric on both sides is suggested for under the cap to reduce generated gas buildup. Gases will flow along the grid as freely as fluids.

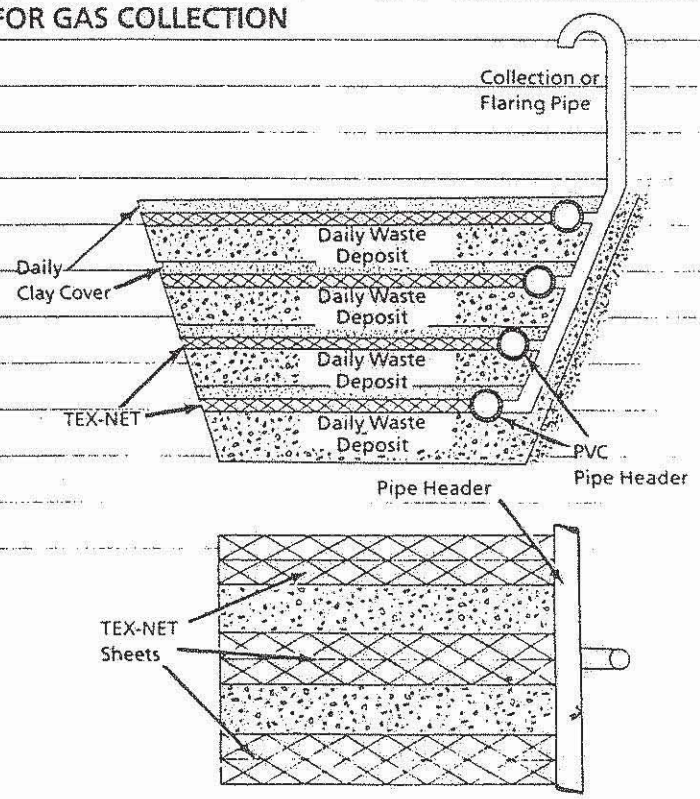
Gas Collection Within The Landfill

TEX-NET works very well in the collection and release of methane and other gases commonly generated in solid waste landfills. Strips of double-faced TEX-NET, if appropriately positioned throughout the refuse, will collect generated gas and direct its flow toward manifold pipes and onto the surface for collection and use, or flaring.

TEX-NET IN A LANDFILL CAP



TEX-NET WITHIN LANDFILL FOR GAS COLLECTION



FSI
FLUID SYSTEMS, INC.

POLY-NET®

TRANSMISSIVITY – CHARTS

513/771-5656
800/346-9107
FAX - 513/771-4844

32 Triangle Park Drive
Suite 3201
Cincinnati, Ohio 45246

FLUID SYSTEMS, INC.

POLY-NET™

PN-4000 FOR CLAY LINED FACILITIES
PN-3000 CN — "CAP-NET"

SPECIFICATION	PN-4000	PN-3000 CN
ROLL LENGTH (MAXIMUM) (FT.)	300	300
ROLL WIDTH (+ 1 in.—0 in.) (FT.)	6.9	6.9
THICKNESS (IN.)	.300	.200
S.F. IN ROLL	2025	2025
WEIGHT PER ROLL (LBS.)	500	233
WEIGHT PER S.F.	.245	.115

*Available to Lengths of 400 Feet

PROPERTY	PN-4000	PN-3000 CN
RAW MATERIAL (ALL DOMESTIC)	POLYETHYLENE (VIRGIN MATERIAL)	POLYETHYLENE (VIRGIN MATERIAL)
MANUFACTURING	FOAMED + EXTRUDED	FOAMED + EXTRUDED
COLOR	BLACK	BLACK
CARBON BLACK	2%	2%
DENSITY & POLYMER (g/cm^3)	.936	.936
MELT INDEX (g/10 MIN)	1.10	1.10
TENSILE STRENGTH (LBS./IN.) (MACH. DIRECTION)	58	24
TENSILE STRENGTH (LBS./IN.) (TRANS. DIRECTION)	33	11
ELONGATION TO BREAK (MACH. DIRECTION)	175%	180%
ELONGATION TO BREAK (TRANS. DIRECTION	165%	150%
POROSITY	.81-.84	.81-.84
U.V. RESISTANCE	STABLE	STABLE
TRANSMISSIVITY	—SEE TABLES—	—SEE TABLES—

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POLY-NET IS PROUDLY MANUFACTURED IN THE U.S.

32 Triangle Park Drive
Suite 3201
Cincinnati, Ohio 45246

NSC

POLYNET PN-3000

PRODUCT DESCRIPTION

PN-3000 is a profiled geonet manufactured by extruding two sets of polyethylene strands to form a diamond shape. The resulting net provides superior planar water flow, is inert to biological and naturally encountered chemicals, alkalies, and acids and is resistant to UV light exposure. Polynet PN-3000 conforms to the property values listed below.

PROPERTY	METHOD	UNITS	QUALIFIER	VALUE
Roll Length	-	ft	Normal	300
Roll Width	-	ft	Normal	7.54
Thickness	ASTM D1777	inches	Range	0.220±0.022
Area per Roll	-	ft^2	Normal	2262
Weight per Roll	-	lbs	Normal	407
Weight per Square Foot	ASTM D3776 (option C)	lbs/ft^2	Range	0.180±0.018
Carbon Black Content	ASTM D1603	percent	Range	2.5±0.5
Polymer Density	ASTM D1505	g/cm^3	Range	0.937±0.002
Melt Flow Index	ASTM D1238 (condition E)	g/10 min.	Maximum	1.0
Tensile Strength (Machine Direction)	ASTM D1682 (modified)	ppi	Range	50±10
Transmissivity[1] (gradient = 1.0 at 15,000 psf)	ASTM D4716	M^2/sec	Minimum	1×10^{-3}

1 Measured between two steel plates one hour after application of the confining pressure. Values may vary based on transmissivity specimen dimensions and specific laboratory.

9/27/88

NSC

POLYNET PN-3000-CN

PRODUCT DESCRIPTION

PN-3000 CN is a foamed profiled geonet manufactured by extruding two sets of polyethylene strands to form a diamond shape. The resulting net provides superior planar water flow, is inert to biological and naturally encountered chemicals, alkalies, and acids and is resistant to UV light exposure. Polynet PN-3000-CN conforms to the property values listed below.

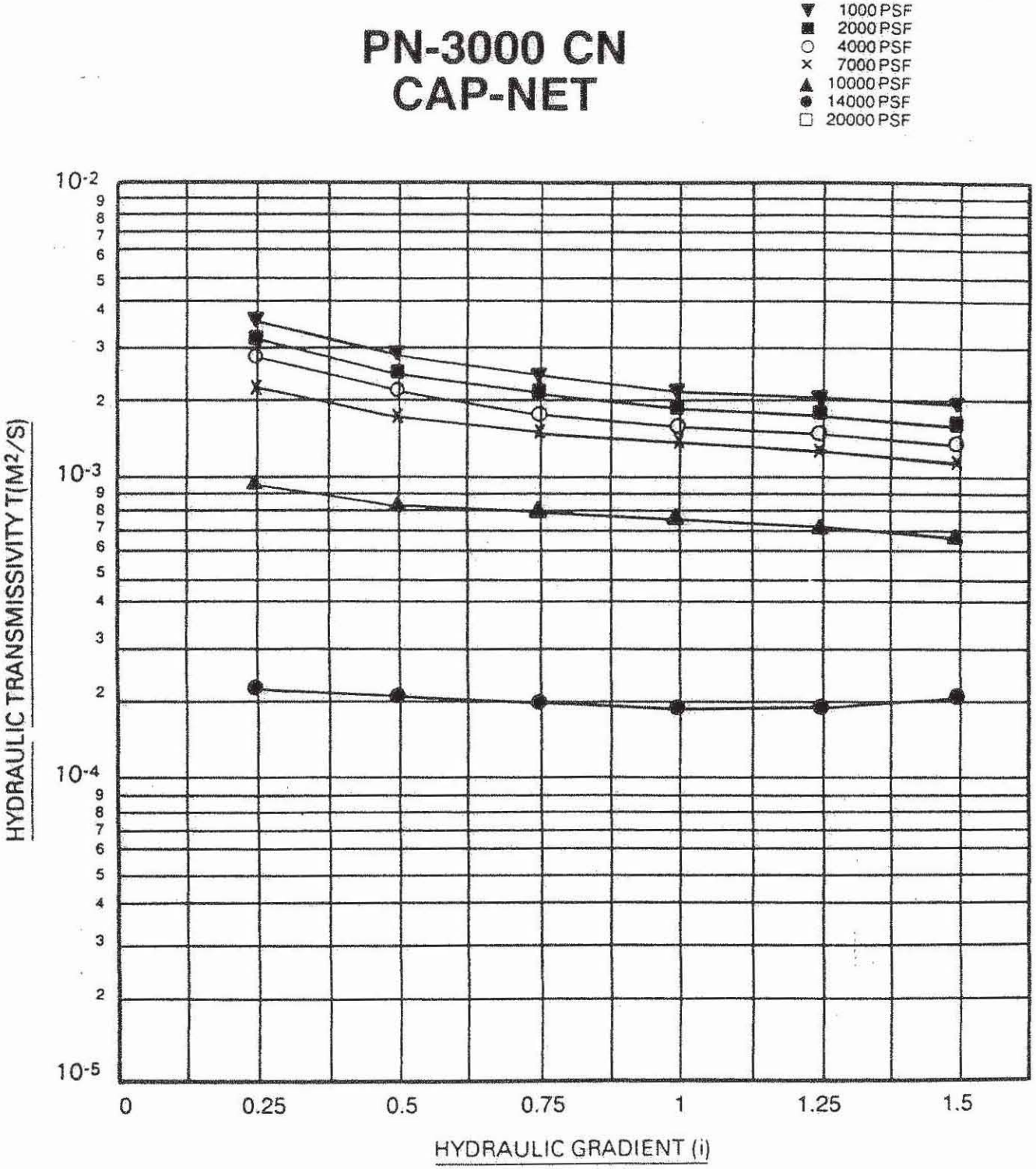
PROPERTY	METHOD	UNITS	QUALIFIER	VALUE
Roll Length	-	ft	Normal	300
Roll Width	-	ft	Normal	7.54
Thickness	ASTM D1777	inches	Range	0.220±0.022
Area per Roll	-	ft^2	Normal	2262
Weight per Roll	-	lbs	Normal	260
Weight per Square Foot	ASTM D3776 (option C)	lbs/ft^2	Range	0.115±0.011
Carbon Black Content	ASTM D1603	percent	Range	2.5±0.5
Polymer Density	ASTM D1505	g/cm^3	Range	0.937±0.002
Melt Flow Index	ASTM D1238 (condition E)	g/10 min.	Maximum	1.0
Tensile Strength (Machine Direction)	ASTM D1682 (modified)	ppi	Range	28±10
Transmissivity[1] (gradient = 1.0 at 4,000 psf)	ASTM D4716	M^2/sec	Minimum	1×10^{-3}

1 Measured between two steel plates one hour after application of the confining pressure. Values may vary based on transmissivity specimen dimensions and specific laboratory.

9/27/88

POLY-NET™ TRANSMISSIVITY	INSTALLATION METHOD LEAK DETECTION HDPE LINER/POLY-NET/HDPE LINER	HYDRAULIC PRESSURE

PN-3000 CN
CAP-NET



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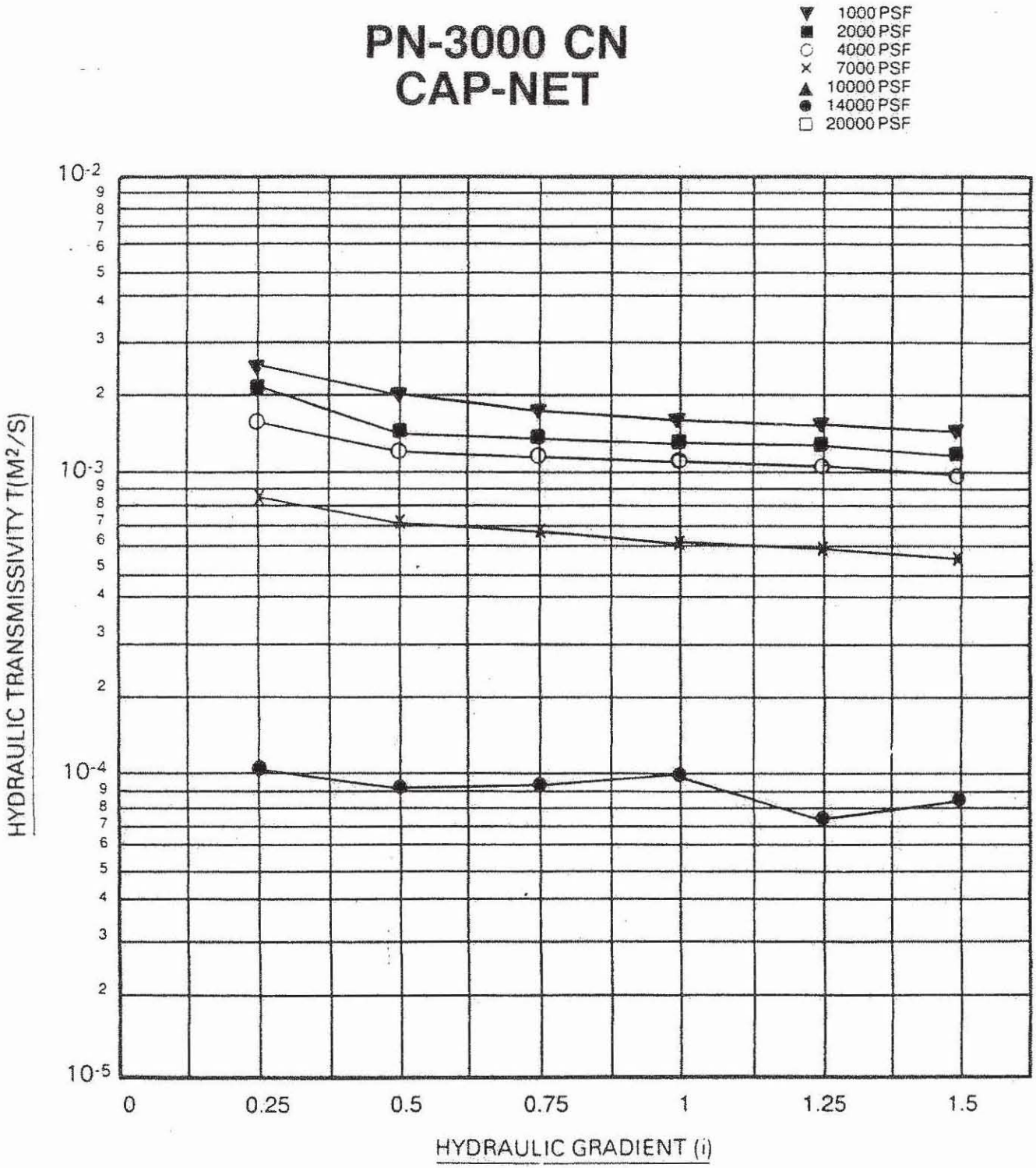
POLY-NET™ TRANSMISSIVITY	INSTALLATION METHOD LEACHATE COLLECTION CLAY SUBGRADE · GEOTEXTILE POLY-NET/HDPE LINER	HYDRAULIC PRESSURE

PN-3000 CN
CAP-NET



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POLY-NET™ TRANSMISSIVITY	INSTALLATION METHOD CLAYSUBGRADE/GEOTEXTILE/ POLY-NET/GEOTEXTILE/CLAY SUBGRADE	HYDRAULIC PRESSURE

LEACHATE COLLECTION FOR CLAY LINED FACILITY

PN-4000

SANDWICHED BETWEEN GEOTEXTILES

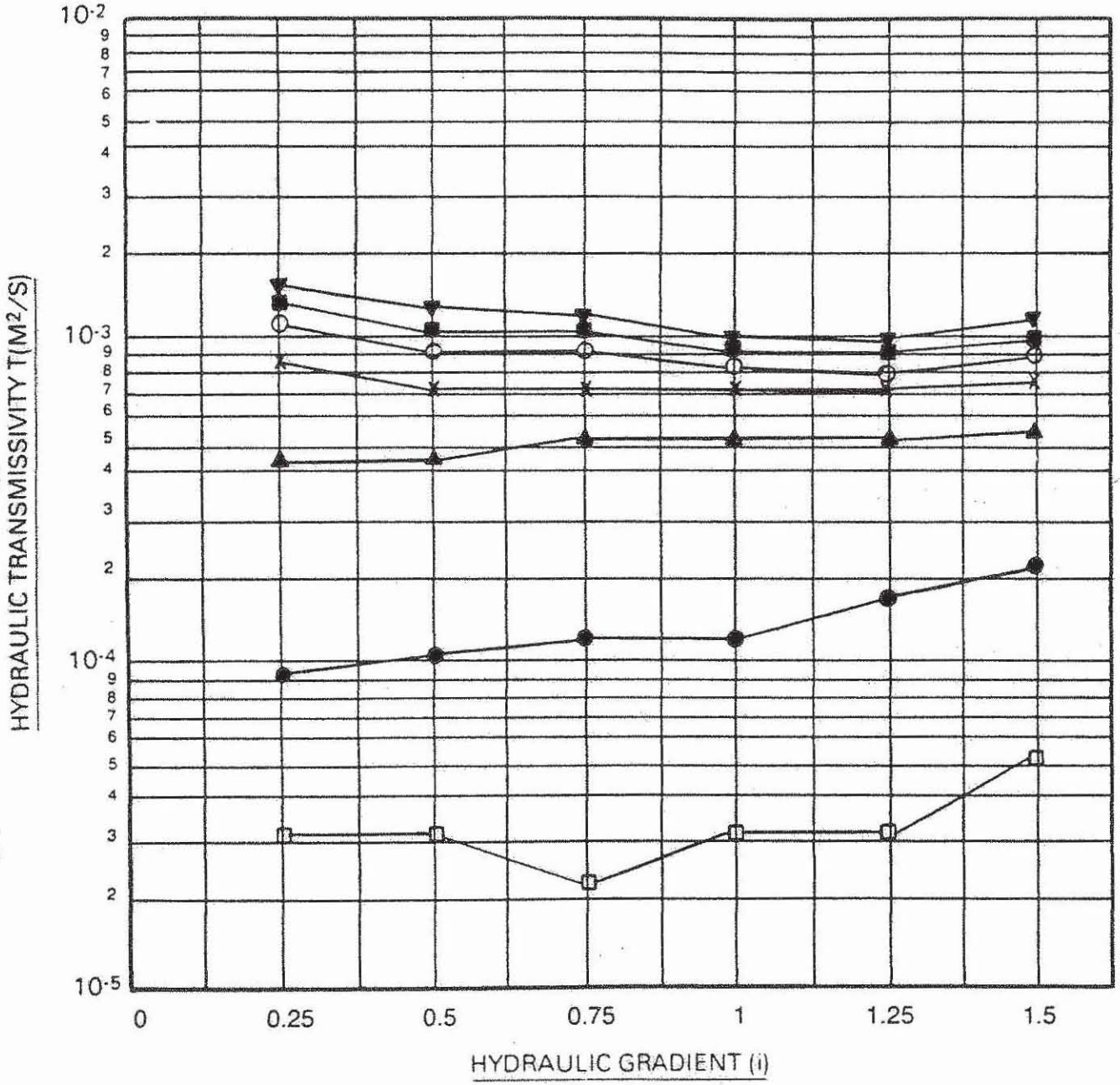

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TABLE 5. HYDRAULIC TRANSMISSIVITY ($M^2/SEC \times 10^{-4}$)
PN4000 GEONET

GRADIENT = 0.25

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	3.67	2.16	1.07	0.43	0.17
2.	4.54	3.02	1.27	0.58	0.19
3.	4.54	3.07	1.34	0.63	0.18
Avg:	4.25	2.75	1.23	0.55	0.18
SD:	0.50	0.51	0.14	0.10	0.01

GRADIENT = 0.50

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.56	1.65	0.78	0.30	0.13
2.	3.05	2.09	1.04	0.46	0.17
3.	2.94	2.05	1.08	0.46	0.18
Avg:	2.85	1.93	0.97	0.41	0.16
SD:	0.26	0.24	0.16	0.09	0.03

GRADIENT = 0.75

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.01	1.36	0.67	0.25	0.11
2.	2.69	1.74	0.85	0.37	0.13
3.	2.66	1.78	0.86	0.38	0.14
Avg:	2.45	1.63	0.79	0.33	0.13
SD:	0.38	0.23	0.11	0.07	0.02

2×10^{-2}

GRADIENT = 1.0

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	1.83	1.22	0.57	0.22	0.10
2.	2.23	1.56	0.75	0.34	0.13
3.	2.26	1.49	0.76	0.34	0.13
Avg:	2.11	1.42	0.69	0.30	0.12
SD:	0.24	0.18	0.11	0.07	0.02

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TABLE 3. HYDRAULIC TRANSMISSIVITY (M^2/SEC X 10^{-3})
PN3000 GEONET

GRADIENT = 0.25

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.85	2.19	1.84	1.37	0.31
2.	2.13	2.81	2.29	1.45	0.80
3.	3.04	2.46	2.08	1.03	0.52
Avg:	2.67	2.49	2.07	1.28	0.54
SD:	0.48	0.31	0.23	0.22	0.25

GRADIENT = 0.50

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.21	1.84	1.44	0.92	0.26
2.	1.78	2.09	1.72	1.20	0.59
3.	2.23	1.97	1.45	0.78	0.38
Avg:	2.07	1.97	1.54	0.97	0.41
SD:	0.25	0.13	0.16	0.21	0.17

GRADIENT = 0.75

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	2.02	1.47	1.11	0.88	0.23
2.	1.61	1.72	1.44	1.04	0.54
3.	1.81	1.68	1.24	0.64	0.33
Avg:	1.81	1.62	1.26	0.85	0.37
SD:	0.21	0.13	0.17	0.20	0.15

GRADIENT = 1.0

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	1.75	1.46	1.20	0.81	0.22
2.	1.35	1.51	1.26	0.94	0.49
3.	1.56	1.47	1.10	0.58	0.30
Avg:	1.55	1.48	1.19	0.78	0.34
SD:	0.20	0.03	0.08	0.18	0.14

TABLE 3. HYDRAULIC TRANSMISSIVITY (M^2/Sec X 10^{-3})
SOIL/TREVIRA 1120/PN3000 GEONET/TREVIRA 1120/SOIL

GRADIENT = 0.25

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.41	0.16	0.07	0.04	0.02
2.	0.42	0.17	0.08	0.05	0.04
3.	0.48	0.23	0.14	0.11	0.09
Avg:	0.44	0.19	0.10	0.07	0.05
SD:	0.04	0.04	0.04	0.04	0.04

GRADIENT = 0.50

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.36	0.14	0.08	0.03	0.02
2.	0.37	0.14	0.08	0.04	0.03
3.	0.40	0.18	0.11	0.07	0.06
Avg:	0.38	0.15	0.09	0.05	0.04
SD:	0.02	0.02	0.02	0.02	0.02

GRADIENT = 0.75

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.32	0.14	0.06	0.04	0.03
2.	0.32	0.14	0.06	0.05	0.03
3.	0.35	0.16	0.08	0.06	0.05
Avg:	0.33	0.15	0.07	0.05	0.04
SD:	0.02	0.01	0.01	0.01	0.01

GRADIENT = 1.0

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.26	0.12	0.05	0.03	0.03
2.	0.26	0.12	0.06	0.04	0.03
3.	0.29	0.14	0.07	0.05	0.04
Avg:	0.27	0.13	0.06	0.04	0.03
SD:	0.02	0.01	0.01	0.01	0.01

TABLE 5. HYDRAULIC TRANSMISSIVITY (M^2/Sec X 10^{-3})
SOIL/TREVIRA 1120/PN4000 GEONET/TREVIRA 1120/SOIL

GRADIENT = 0.25

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.63	0.17	0.03	0.00	0.00
2.	0.66	0.19	0.05	0.02	0.02
3.	0.76	0.29	0.15	0.11	0.11
Avg:	0.68	0.22	0.08	0.04	0.04
SD:	0.07	0.06	0.06	0.06	0.06

GRADIENT = 0.50

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.62	0.18	0.02	0.00	0.00
2.	0.64	0.19	0.03	0.01	0.01
3.	0.71	0.24	0.08	0.06	0.05
Avg:	0.66	0.20	0.04	0.02	0.02
SD:	0.05	0.03	0.03	0.03	0.03

GRADIENT = 0.75

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.51	0.15	0.02	0.00	0.00
2.	0.53	0.16	0.03	0.01	0.01
3.	0.59	0.20	0.06	0.04	0.04
Avg:	0.54	0.17	0.04	0.02	0.02
SD:	0.04	0.03	0.02	0.02	0.02

GRADIENT = 1.0

Specimen	5,000 psf	10,000 psf	15,000 psf	20,000 psf	25,000 psf
1.	0.46	0.13	0.02	0.01	0.00
2.	0.47	0.13	0.03	0.02	0.01
3.	0.53	0.16	0.05	0.04	0.03
Avg:	0.49	0.14	0.03	0.02	0.01
SD:	0.04	0.02	0.02	0.02	0.02

ATTACHMENT #2
LINER SYSTEM MATERIAL DATA

High Density Polyethylene Micro Spike® Liner

Product Data

Property	Test Method	Values				
Thickness, nominal (mm)		30 (.75)	40 (1.0)	60 (1.5)	80 (2.0)	100 (2.5)
Thickness (min. ave.), mil (mm)	ASTM D5994*	29 (.71)	38 (.95)	57 (1.43)	76 (1.90)	95 (2.38)
Thickness (lowest indiv. for 8 of 10 spec.), mil (mm)	ASTM D5994*	27 (.68)	36 (.90)	54 (1.35)	72 (1.80)	90 (2.25)
Thickness (lowest indiv. for 1 of 10 spec.), mil (mm)	ASTM D5994*	26 (.64)	34 (.85)	51 (1.28)	68 (1.70)	85 (2.13)
*The thickness values may be changed due to project specifications (i.e., absolute minimum thickness)						
Asperity Height (min. ave.), mil (mm)	GRI GM12	16 (.41)	16 (.41)	16 (.41)	16 (.41)	16 (.41)
Density, g/cc, minimum	ASTM D792, Method B	0.94	0.94	0.94	0.94	0.94
Tensile Properties (ave. both directions)	ASTM D6693, Type IV					
Strength @ Yield (min. ave.), lb/in width (N/mm)	2 in/minute	66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Yield (min. ave.), % (GL=1.3in)	5 specimens in each direction	13	13	13	13	13
Strength @ Break (min. ave.), lb/in width (N/mm)		66 (11.6)	88 (15.4)	132 (23.1)	176 (30.8)	220 (38.5)
Elongation @ Break (min. ave.), % (GL=2.0in)		350	350	350	350	350
Tear Resistance (min. ave.), lbs. (N)	ASTM D1004	23 (102)	30 (133)	45 (200)	60 (267)	72 (320)
Puncture Resistance (min. ave.), lbs. (N)	ASTM D4833	60 (267)	90 (400)	120 (534)	150 (667)	180 (801)
Carbon Black Content (range in %)	ASTM D4218	2 - 3	2 - 3	2 - 3	2 - 3	2 - 3
Carbon Black Dispersion (Category)	ASTM D5596	Only near spherical agglomerates for 10 views: 9 views in Cat. 1 or 2, and 1 view in Cat. 3				
Stress Crack Resistance (Single Point NCTL), hours	ASTM D5397, Appendix	300	300	300	300	300
Oxidative Induction Time, minutes	ASTM D3895, 200°C, 1 atm O_2	≥100	≥100	≥100	≥100	≥100
Melt Flow Index, g/10 minutes	ASTM D1238, 190°C, 2.16kg	≤1.0	≤1.0	≤1.0	≤1.0	≤1.0
Oven Aging	ASTM D5721	80	80	80	80	80
with HP OIT, (% retained after 90 days)	ASTM D5885, 150°C, 500psi O_2					
UV Resistance	GRI GM11	20hr. Cycle @ 75°C/4 hr. dark condensation @ 60°C				
with HP OIT, (% retained after 1600 hours)	ASTM D5885, 150°C, 500psi O_2	50	50	50	50	50

These product specifications meet or exceed GRI's GM13

Supply Information (Standard Roll Dimensions)

Thickness		Width		Length		Area (approx.)		Weight (average)	
mil	mm	ft	m	ft	m	ft^2	m^2	lbs	kg
30	.75	23	7	600.1	182.9	13,782	1,280	3,325	1,510
40	1.0	23	7	600.1	182.9	13,782	1,280	3,325	1,510
60	1.5	23	7	410.1	125	9,419	875	3,356	1,522
80	2.0	23	7	328.1	100	7,535	700	3,306	1,500
100	2.5	23	7	246.1	75	5,651	525	3,167	1,436

Notes:

All rolls are supplied with two slings. All rolls are wound on a 6 inch core. Special roll lengths are available on request.

All information, recommendations and suggestions appearing in this literature concerning the use of our products are based upon tests and data believed to be reliable; however, it is the users responsibility to determine the suitability for their own use of the products described herein. Since the actual use by others is beyond our control, no guarantee or warranty of any kind, expressed or implied, is made by Agru/America as to the effects of such use or the results to be obtained, nor does Agru/America assume any liability in connection herewith. Any statement made herein may not be absolutely complete since additional information may be necessary or desirable when particular or exceptional conditions or circumstances exist or because of applicable laws or government regulations. Nothing herein is to be construed as permission or as a recommendation to infringe any patent.

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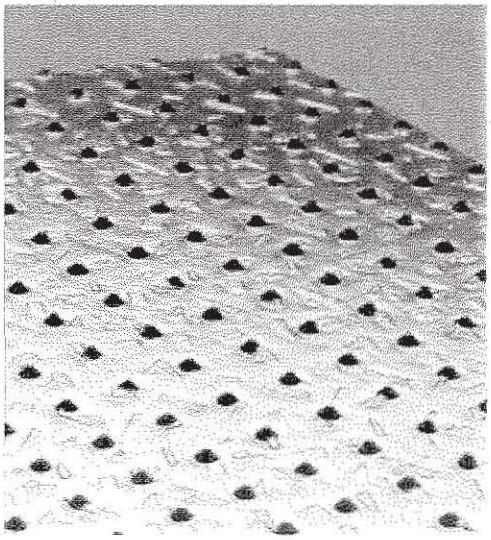
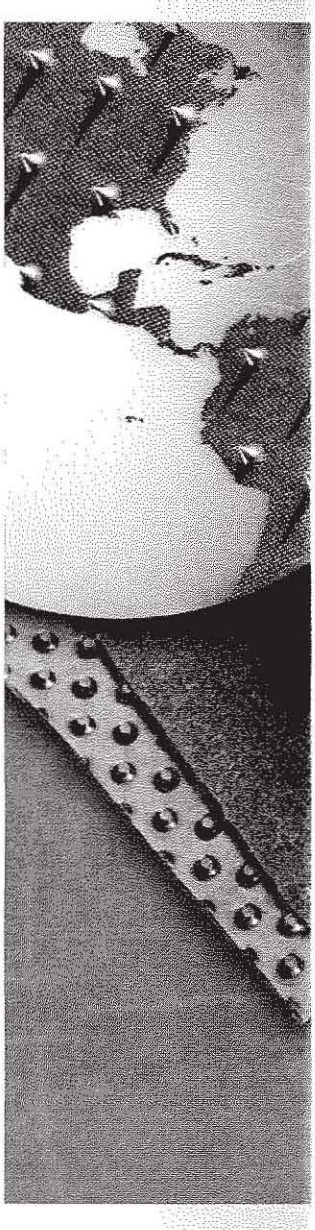
Micro Spike® Textured Geomembrane

Applications for HDPE and LLDPE Micro Spike®, textured geomembranes include projects where slope stability is critical. Micro Spike® is the only HDPE or LLDPE geomembrane that exhibits reproducible texture and friction angle values with the highest interface surface friction values in the industry.

Agru America's structured Geomembranes are produced on state-of-the-art equipment using a flat die-cast extrusion manufacturing process as opposed to blown film extrusion. Agru America is the only manufacturer of structured and embossed Geomembranes in North America.

Micro Spike® surface texture





Comparative properties for Design Consideration

Blown film co-extruded textured surfaces vs. Micro Spike® structured surfaces

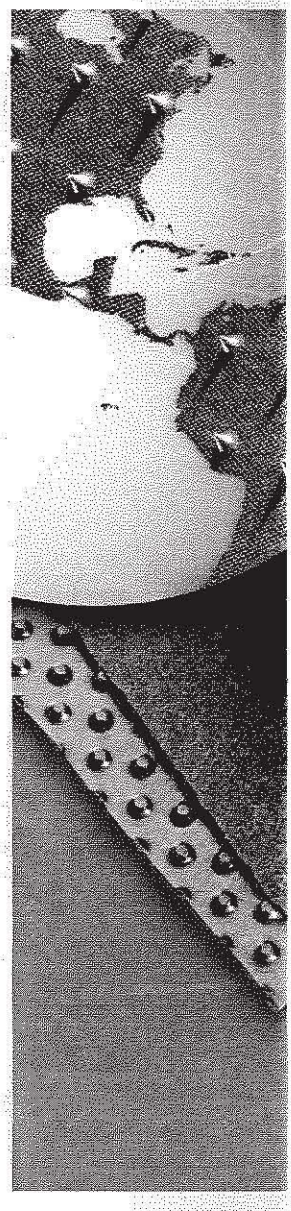
Design Consideration	Blown film co-extruded	Micro Spike® structured
Consistent core thickness	no	yes
Consistent surface texture	no	yes
Consistent asperity height	no	yes
Consistent interface friction	no	yes
Affect on mechanical properties	yes	no
Affect on stress crack potential	yes	no
Affect on multiaxial stress-strain	yes	no
Reduction in CQA program costs (less testing required)	no	yes

The calendared structured liner manufacturing process allows production of the only textured liner with a consistent core thickness, resulting in unchanged mechanical properties from that of smooth sheet. The consistent surface structuring or texture gives Micro Spike® Geomembranes reproducible friction angle values with efficiencies of over 95%.

Representative Large Scale Interface Shear Values
***cap loading conditions** (ASTM 5321)**

Soil/Micro Spike® Surface	P	LD
Coarse Sand	34°	34°
Glacial Till	37°	32°
Silty Sand	32°	28°
Non Woven GT	32°	17°

*SGI Testing Services, Atlanta



Micro Spike® geomembranes are manufactured to meet or exceed current industry standards including GRI GM 13 (HDPE) and GRI GM 17 (LLDPE) test values, frequency of testing and functional requirements. Micro Spike® textured Geomembranes have smooth edges to allow for high quality thermal fusion welding between adjacent sheets. All Agru Geomembrane material is rolled on plastic pipe cores to ensure ease of installation without damage to the roll material.

Micro Spike® textured HDPE and LLDPE geomembrane has a decided advantage over blown film textured geomembrane:

Reliability: Micro Spike's® reproducible friction angles gives the design engineer the confidence that he has designed a system that will be built to meet or exceed the project design requirements.

Cost Savings: Micro Spike® is competitively priced with value added advantages including consistent core thickness and texture which reduces the on-site Quality Control and third party Quality Assurance costs.

Consistent Material: The structured "Micro Spikes" are totally integrated with the Geomembrane.

High Interface shear: Exceptional shear resistance between soil and geotextile components allows flexibility and stability during protective cover material placement. The textured asperity height is not only consistent but higher than competitive textured products.

Why specify or use anything else!

Agru has over 20 years experience with Geomembranes and 50 years experience with Thermoplastic Extrusion Agru offers a wide range of concrete protective liners (Sure Grip), pipe fittings and semi-finished materials.

500 Garrison Road, Georgetown, South Carolina 29440 843-546-0600 800-321-1379 Fax: 843-546-0516
email: salesmkg@agruamerica.com www.agruamerica.com

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GSE®

GSE STANDARD PRODUCTS

Product Data Sheet

GSE HD Textured Geomembranes

GSE HD Textured is the textured version of GSE HD. It is a high quality, high density polyethylene (HDPE) geomembrane with one or two coextruded, textured surfaces, and consisting of approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. The resin used is specially formulated, virgin polyethylene and is designed specifically for flexible geomembrane applications. GSE HD Textured has excellent resistance to UV radiation and is suitable for exposed conditions. This product allows projects with greater slopes to be designed since frictional characteristics are enhanced. *These product specifications meet or exceed GRI GM13.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM VALUE				
Product Code			HDT 030G000	HDT 040G000	HDT 060G000	HDT 080G000	HDT 100G000
Thickness, (minimum average) mil (mm)	ASTM D 5994	every roll	29 (0.73)	38 (0.96)	57 (1.45)	76 (1.93)	95 (2.41)
Lowest individual for 8 out of 10 values			27 (0.69)	36 (0.91)	54 (1.40)	72 (1.80)	90 (2.30)
Lowest individual for any of the 10 values			26 (0.66)	34 (0.86)	51 (1.30)	68 (1.73)	85 (2.16)
Density, g/cm³	ASTM D 1505	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)[1]	ASTM D 6693, Type IV	20,000 lb					
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm		45 (8)	60 (11)	90 (16)	120(21)	150 (27)
Strength at Yield, lb/in-width (N/mm)			63 (11)	84 (15)	126 (22)	168 (29)	210 (37)
Elongation at Break, %	G.L. = 2.0 in (51 mm)		100	100	100	100	100
Elongation at Yield, %	G.L. = 1.3 in (33 mm)		12	12	12	12	12
Tear Resistance, lb (N)	ASTM D 1004	45,000 lb	21 (93)	28 (125)	42 (187)	56 (249)	70 (311)
Puncture Resistance, lb (N)	ASTM D 4833	45,000 lb	45 (200)	60 (267)	90 (400)	120 (534)	150 (667)
Carbon Black Content, %	ASTM D 1603*/4218	20,000 lb	2.0	2.0	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1
Asperity Height	GRI GM 12	second roll	+Note 2	+Note 2	+Note 2	+Note 2	+Note 2
Notched Constant Tensile Load[2], hr	ASTM D 5397, Appendix	200,000 lb	300	300	300	300	300
REFERENCE PROPERTY	**TEST METHOD**	**FREQUENCY**	**NOMINAL VALUE**				
Oxidative Induction Time, min	ASTM D 3895, 200° C; O_2, 1 atm	200,000 lb	>100	>100	>100	>100	>100
Roll Length[3] (approximate), ft (m)	Standard Textured		830 (253)	700 (213)	520 (158)	400 (122)	330 (101)
Roll Width[3], ft (m)			22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)
Roll Area, ft² (m²)			18,674 (1,735)	15,750 (1,463)	11,700 (1,087)	9,000 (836)	7,425 (690)

NOTES:

- +Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- +Note 2: 10 mil average. 8 of 10 readings ≥7 mils. Lowest individual ≥ 5 mils.
- GSE HD Standard Textured is available in rolls weighing about 4,000 lb (1,800 kg).
- [1]The combination of stress concentrations due to coextrusion texture geometry and the small specimen size results in large variation of test results. Therefore, these tensile properties are minimum average values.
- [2]NCTL for HD Textured is conducted on representative smooth membrane samples.
- All GSE geomembranes have dimensional stability of ±2% when tested with ASTM D 1204 and LTB of <-77° C when tested with ASTM D 746.
- [3]Roll lengths and widths have a tolerance of ± 1%.
- *Modified.

DS006 HDtext R01/08/08

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GSE STANDARD PRODUCTS

Product Data Sheet

GSE HD Geomembranes

GSE HD is a smooth, high quality, high density polyethylene (HDPE) geomembrane produced from specially formulated, virgin polyethylene resin. This polyethylene resin is designed specifically for flexible geomembrane applications. It contains approximately 97.5% polyethylene, 2.5% carbon black and trace amounts of antioxidants and heat stabilizers; no other additives, fillers or extenders are used. GSE HD has outstanding chemical resistance, mechanical properties, environmental stress crack resistance, dimensional stability and thermal aging characteristics. GSE HD has excellent resistance to UV radiation and is suitable for exposed conditions. *These product specifications meet or exceed GRI GM13.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM VALUE				
Product Code			HDE 030A000	HDE 040A000	HDE 060A000	HDE 080A000	HDE 100A000
Thickness, (minimum average) mil (mm)	ASTM D 5199	every roll	30 (0.75)	40 (1.00)	60 (1.50)	80 (2.00)	100 (2.50)
Lowest individual reading (-10%)			27 (0.69)	36 (0.91)	54 (1.40)	72 (1.80)	90 (2.30)
Density, g/cm³	ASTM D 1505	200,000 lb	0.94	0.94	0.94	0.94	0.94
Tensile Properties (each direction)	ASTM D 6693, Type IV	20,000 lb					
Strength at Break, lb/in-width (N/mm)	Dumbell, 2 ipm		114 (20)	152 (27)	228 (40)	304 (53)	380 (67)
Strength at Yield, lb/in-width (N/mm)			63 (11)	84 (15)	126 (22)	168 (29)	210 (37)
Elongation at Break, %	G.L. 2.0 in (51 mm)		700	700	700	700	700
Elongation at Yield, %	G.L. 1.3 in (33 mm)		12	12	12	12	12
Tear Resistance, lb (N)	ASTM D 1004	45,000 lb	21 (93)	28 (125)	42 (187)	56 (249)	70 (311)
Puncture Resistance, lb (N)	ASTM D 4833	45,000 lb	54 (240)	72 (320)	108 (480)	144 (640)	180 (800)
Carbon Black Content, %	ASTM D 1603*/4218	20,000 lb	2.0	2.0	2.0	2.0	2.0
Carbon Black Dispersion	ASTM D 5596	45,000 lb	+Note 1	+Note 1	+Note 1	+Note 1	+Note 1
Notched Constant Tensile Load, hr	ASTM D 5397, Appendix	200,000 lb	300	300	300	300	300
REFERENCE PROPERTY	**TEST METHOD**	**FREQUENCY**	**NOMINAL VALUE**				
Oxidative Induction Time, min	ASTM D 3895, 200° C; O_2, 1 atm	200,000 lb	>100	>100	>100	>100	>100
Roll Length[1] (approximate), ft (m)			1,120 (341)	870 (265)	560 (171)	430 (131)	340 (104)
Roll Width[1], ft (m)			22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)	22.5 (6.9)
Roll Area, ft² (m²)			25,200 (2,341)	19,575 (1,819)	12,600 (1,171)	9,675 (899)	7,650 (711)

NOTES:

- +Note 1: Dispersion only applies to near spherical agglomerates. 9 of 10 views shall be Category 1 or 2. No more than 1 view from Category 3.
- GSE HD is available in rolls weighing about 3,900 lb (1,769 kg)
- All GSE geomembranes have dimensional stability of ±2% when tested with ASTM D 1204 and LTB of <-77° C when tested with ASTM D 746.
- [1]Roll lengths and widths have a tolerance of ± 1%.
- *Modified.

DS005 HD R01/07/08

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GSE STANDARD PRODUCTS

Product Data Sheet

GSE Nonwoven Geotextiles

GSE Nonwoven Geotextiles is a family of polypropylene, staple fiber, nonwoven, needlepunched geotextiles. Manufactured using an advanced manufacturing and quality system, these products are the most uniform and consistent nonwoven, needlepunched geotextile currently available in the industry. GSE combines a fiber selection and approval system with in-line quality control and a state-of-the-art laboratory to ensure that every roll shipped meets customer specifications. The company has performed extensive performance testing to evaluate suitability of its nonwovens for various applications. GSE Nonwoven Geotextiles are available in a range of weights to meet your specific project needs. *These product specifications meet or exceed GRI GT12, GRI GT13 and AASHTO M288.*

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	NW4	NW6	NW8	NW10	NW12	NW16
Product Code			GEO 0408002	GEO 0608002	GEO 0808002	GEO 1008002	GEO 1208002	GEO 1608002
AASHTO M288 Class			3	2	1	>1	>>1	>>>1
Mass per Unit Area, oz/yd² (g/m²)	ASTM D 5261	90,000 ft²	4 (135)	6 (200)	8 (270)	10 (335)	12 (405)	16 (540)
Grab Tensile Strength, lb (N)	ASTM D 4632	90,000 ft²	120 (530)	170 (755)	220 (975)	260 (1,155)	320 (1,420)	390 (1,735)
Grab Elongation, %	ASTM D 4632	90,000 ft²	50	50	50	50	50	50
Puncture Strength, lb (N)	ASTM D 4833	90,000 ft²	60 (265)	90 (395)	120 (525)	165 (725)	190 (835)	240 (1,055)
Trapezoidal Tear Strength, lb (N)	ASTM D 4533	90,000 ft²	50 (220)	70 (310)	95 (420)	100 (445)	125 (555)	150 (665)
Apparent Opening Size, Sieve No. (mm)	ASTM D 4751	540,000 ft²	70 (0.212)	70 (0.212)	80 (0.180)	100 (0.150)	100 (0.150)	100 (0.150)
Permittivity, sec⁻¹	ASTM D 4491	540,000 ft²	1.50	1.50	1.50	1.20	0.80	0.70
Permeability, cm/sec	ASTM D 4491	540,000 ft²	0.22	0.30	0.30	0.30	0.29	0.27
Water Flow Rate, gpm/ft² (l/min/m²)	ASTM D 4491	540,000 ft²	120 (4,885)	110 (4,480)	110 (4,480)	85 (3,460)	60 (2,440)	50 (2,035)
UV Resistance (% retained after 500 hours)	ASTM D 4355	per formulation	70	70	70	70	70	70
Roll Length[1], ft (m)			600 (182)	600 (182)	600 (182)	300 (91)	300 (91)	300 (91)
Roll Width[1], ft (m)			15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)	15 (4.6)
Roll Area, ft² (m²)			9,000 (836)	9,000 (836)	9,000 (836)	4,500 (418)	4,500 (418)	4,500 (418)

NOTES:

- *The property values listed are in weaker principal direction. All values listed are Minimum Average Roll Values (MARV) except apparent opening size in mm and UV resistance. Apparent opening size (mm) is a Maximum Average Roll Value. UV is a typical value.*
- [1]Roll lengths and widths have a tolerance of ±1%.

DS037 NW R08/30/07

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GSE STANDARD PRODUCTS

Product Data Sheet

GSE FabriNet Geocomposites (Double-Sided)

GSE FabriNet geocomposite consists of GSE HyperNet geonet heat-laminated on both sides with a GSE nonwoven needlepunched geotextile. GSE HyperNet is a 200 mil thick geonet manufactured from a premium grade high density polyethylene resin. For the purpose of lamination to geonets, GSE nonwoven needlepunched geotextiles are available in mass per unit area range of 6 oz/yd² (200 g/m²) to 16 oz/yd² (540 g/m²). GSE FabriNet geocomposites are designed and formulated to perform drainage function under a range of anticipated site loads, gradients and boundary conditions. Index properties for the product are provided in the table below. Please contact GSE for further information regarding performance under site-specific conditions.

Product Specifications

TESTED PROPERTY	TEST METHOD	FREQUENCY	MINIMUM AVERAGE ROLL VALUE[a]		
Geocomposite			6 oz/yd²	8 oz/yd²	10 oz/yd²
Product Code			F42060060S	F42080080S	F42100100S
Transmissivity[b], gal/min/ft (m²/sec)	ASTM D 4716	1/540,000 ft²	0.48 (1 x 10^{-4})	0.48 (1 x 10^{-4})	0.43 (9 x 10^{-5})
Ply Adhesion, lb/in (g/cm)	ASTM D 7005	1/50,000 ft²	1.0 (178)	1.0 (178)	1.0 (178)
Roll Width[c], ft (m)			14.5 (4.4)	14.5 (4.4)	14.5 (4.4)
Roll Length[c], ft (m)			230 (70.1)	200 (60.9)	190 (58.0)
Roll Area, ft² (m²)			3,335 (310)	2,900 (269)	2,755 (256)
Geonet core[d]					
Transmissivity,[b] gal/min/ft (m²/sec)	ASTM D 4716		9.66 (2 x 10^{-3})	9.66 (2 x 10^{-3})	9.66 (2 x 10^{-3})
Thickness, mil (mm)	ASTM D 5199	1/50,000 ft²	200 (5)	200 (5)	200 (5)
Density, g/cm³	ASTM D 1505	1/50,000 ft²	0.94	0.94	0.94
Tensile Strength (MD), lb/in (N/mm)	ASTM D 5035	1/50,000 ft²	45 (7.9)	45 (7.9)	45 (7.9)
Carbon Black Content, %	ASTM D 1603*/4218	1/50,000 ft²	2.0	2.0	2.0
Geotextile (prior to lamination)[d,e]					
Mass per Unit Area, oz/yd² (g/m²)	ASTM D 5261	1/90,000 ft²	6 (200)	8 (270)	10 (335)
Grab Tensile, lb (N)	ASTM D 4632	1/90,000 ft²	170 (755)	220 (975)	260 (1,155)
Puncture Strength, lb (N)	ASTM D 4833	1/90,000 ft²	90 (395)	120 (525)	165 (725)
AOS, US sieve (mm)	ASTM D 4751	1/540,000 ft²	70 (0.212)	80 (0.180)	100 (0.150)
Permittivity, (sec⁻¹)	ASTM D 4491	1/540,000 ft²	1.5	1.5	1.2
Flow Rate, gpm/ft² (lpm/m²)	ASTM D 4491	1/540,000 ft²	110 (4,480)	110 (4,480)	85 (3,460)
UV Resistance, % retained	ASTM D 4355 (after 500 hours)	once per formulation	70	70	70

NOTES:

- [a]These are MARV values that are based on the cumulative results of specimens tested and determined by GSE. AOS in mm is a maximum average roll value.
- [b]Gradient of 0.1, normal load of 10,000 psf, water at 70° F between steel plates for 15 minutes.
- [c]Roll widths and lengths have a tolerance of ±1%.
- [d]Component properties prior to lamination.
- [e]Refer to geotextile product data sheet for additional specifications.
- *Modified.

DS018 Fabrinet R01/07/08

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POLY-FLEX, INC.

An Engineering Approach to Groundwater Protection

REFERENCE MANUAL

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POLY-FLEX POLYETHYLENE GEOMEMBRANES

TABLE OF CONTENTS

I POLY-FLEX HDPE & LLDPE LINER SPECIFICATIONS

1. GENERAL REQUIREMENTS 1
   - 1.1 Scope 1
   - 1.2 Qualifications of Contractor Work Activities 1
   - 1.3 Submittals 1
   - 1.4 Meeting 2
   - 1.5 Warranty 2
2. MATERIAL SPECIFICATIONS 3
   - 2.1 Materials 3
   - 2.2 Geomembrane Raw Materials 3
   - 2.3 Rolls 3
   - Smooth HDPE Geomembrane Data Sheets 4
   - Textured HDPE Geomembrane Data Sheets 6
   - Smooth LLDPE Geomembrane Data Sheets 8
   - Textured LLDPE Geomembrane Data Sheets 10
   - 2.4 Quality Control Specifications 12
3. GEOMEMBRANE INSTALLATION 14
   - 3.1 Materials Logistics 14
   - 3.2 Earthwork 14
   - 3.3 Method of Placement 15
   - 3.4 Field Seaming 15
   - 3.5 Cover Material and Backfilling of Anchor Trench 19
   - 3.6 Geomembrane Acceptance 19
   - Inherent Properties of Polyethylene Liners 20

II POLY-FLEX DRAINAGE NET & GEOCOMPOSITE SPECIFICATIONS

1. GENERAL REQUIREMENTS 23
   - 1.1 Scope 23
   - 1.2 Qualifications 23
   - 1.3 Submittals 23
2. MATERIAL SPECIFICATIONS 23
   - 2.1 Materials 23
   - HDPE Drainage Net Data Sheet 24
   - Single-Sided Geocomposite Data Sheets 26
   - Double-Sided Geocomposite Data Sheets 28
   - 2.2 Manufacturer's Quality Control Testing 30
3. INSTALLATION 30
   - 3.1 Transportation and On-Site Storage 30
   - 3.2 Method of Placement 30
   - 3.3 Field Seaming 30
   - 3.4 Cover Material 30
   - 3.5 Repairs 30

Poly-Flex Liner Specifications

Drainage Net & Geocomposite

Polyethylene Embed Channel

Chemical Resistance

Geomembrane Manufacturing QC/QA

Net/Geocomposite Manufacturing QC/QA

TABLE OF CONTENTS

POLY-FLEX POLYETHYLENE GEOMEMBRANES

III POLY-FLEX POLYETHYLENE EMBED CHANNEL SPECIFICATION

1. GENERAL 33
   - 1.1 Scope 33
   - 1.2 References 33
   - 1.3 Submittals 33
   - 1.4 Manufacturer's Quality Control Testing 33
2. PRODUCT 33
   - 2.1 Product 33
   - 2.2 Shipment and Storage 33
3. INSTALLATION 34
   - 3.1 Installation in concrete forms 34
   - 3.2 Fabrication 34
   - 3.3 Seaming 34
   - PEC Design Detail 35

IV CHEMICAL RESISTANCE INFORMATION

1. CHEMICAL COMPATIBILITY OF POLY-FLEX LINERS 39
   - Chemical Compatibility Chart 40

V GEOMEMBRANE MANUFACTURING QUALITY CONTROL & QUALITY ASSURANCE

1. DEFINITIONS 43
2. MANUFACTURING QUALITY CONTROL AND QUALITY ASSURANCE PROGRAM 43
   - 2.1 Raw Material 43
3. MANUFACTURING 45
   - 3.1 Blown Sheet Process 45
   - 3.2 Process Quality Control 45
   - 3.3 Roll Labeling 46
   - 3.4 Storage, Staging and Shipping of Geomembrane Rolls 46
   - 3.5 Laboratory Quality Control & Quality Assurance 47
4. MANUFACTURING QUALITY CONTROL PROGRAM FLOW CHART 48
5. PAPER FLOW FORMS 49
   - 5.1 Product Quality Report 49
   - 5.2 Railcar Resin Report 50
   - 5.3 Quality Control Report 51
   - 5.4 Hold Tag 52

POLYFLEX
POLYETHYLENE GEOMEMBRANES

TABLE OF CONTENTS

VI DRAINAGE NET AND GEOCOMPOSITE MANUFACTURING QUALITY CONTROL & QUALITY ASSURANCE

1. MANUFACTURING QUALITY CONTROL AND QUALITY ASSURANCE 55
   1.1 Applicable Test Methods 55
2. RAW MATERIAL 55
3. MANUFACTURING 56
   3.1 Drainage Net 56
   3.2 Drainage Net/Geotextile Geocomposite 56
   3.3 Roll Labeling 56
   3.4 Storage, Staging and Shipping of Drainage Net and Geocomposite Rolls 56
   3.5 Laboratory Testing Program 57
   3.6 Quality Control Report 58

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

Poly-Flex Liner
Specifications

POLY-FLEX HDPE & LLDPE LINER SPECIFICATIONS

1. GENERAL REQUIREMENTS

1.1 Scope

The following describes parameters for the manufacture, supply, and installation of Poly-Flex polyethylene geomembranes. All procedures, operations, and methods shall be in strict accordance with the engineer's specifications, plans, and drawings.

1.2 Qualifications of Contractor Work Activities

1.2.1 Manufacturing

The manufacturer shall have at least five (5) years continuous experience in manufacturing polyethylene geomembrane and/or experience totaling 10,000,000 square feet of manufactured polyethylene geomembrane.

1.2.2 Installation

The installation contractor shall be the manufacturer or a dealer trained to install the manufacturer's geomembrane.

Installation shall be performed under the constant direction of a field installation supervisor who shall remain on site and be responsible, throughout the liner installation, for liner layout, seaming, testing, repairs, and all other activities by the Installer. The field installation supervisor shall have installed or supervised the installation of a minimum of 2,000,000 square feet of polyethylene geomembrane. Seaming shall be performed under the direction of a master seamer (who may also be the field installation supervisor) who has seamed a minimum of 2,000,000 square feet of polyethylene geomembrane, using the same type of seaming apparatus specified for this project. The field installation supervisor and/or master seamer shall be present whenever seaming is performed.

1.3 Submittals

1.3.1 Manufacturer

The manufacturer shall provide the following information:

A. Submittals with Bid Documents

1. List of material properties.
2. Manufacturing quality control program.

B. Submittals After Contract Award, Prior to Liner Installation

1. Copy of quality control certificates issued by the resin supplier.
2. Copy of quality control certificates for the geomembranes in conformance with Section 2.4.3.

1.3.2 Installation Contractor

The installer shall provide the following written information:

A. Submittals With Bid Documents

A list of completed facilities, totaling a minimum of 2,000,000 square feet, for which the installer has installed polyethylene geomembrane. For each installation, the following information shall be provided:

a. Name and purpose of facility, location, and date of installation.

b. Name of owner, design engineer, manufacturer, and name and telephone number of contact at the facility who can discuss the project.

c. Thickness and quantity of the installed geomembrane.

B. Submittals by Successful Bidder Prior to Commencement of Installation

1. Proposed installation panel layout.
2. Resume(s) of the field installation supervisor and master seamer.

1.4 Meeting

A daily meeting shall be held at the work area just prior to commencement of the work to discuss work activities. The earthwork contractor, the liner installer and the inspector shall be present.

1.5 Warranty

A written Warranty shall be obtained from the manufacturer (for material) and the installation contractor (for workmanship). These documents shall warrant both the quality of the material and workmanship for a specified duration of time.

2. MATERIAL SPECIFICATIONS

2.1 Materials

1. The geomembrane shall be High-Density Polyethylene (HDPE) or Linear Low Density Polyethylene (LLDPE).
2. Gasket material shall be neoprene, closed cell medium, 1/4-inch thick, 2 inches wide with adhesive on one side, or other compatible gasket materials as required.
3. Metal battens or banding and hardware shall be stainless steel.
4. Water cut-off mastic shall be Neoprene Flashing Cement as supplied by Poly-Flex, Inc., or as required.
5. Sealant shall be General Electric Silicone, RTV 103, or equivalent.

2.2 Geomembrane Raw Materials

The geomembrane shall be manufactured of polyethylene resins produced in the United States and shall be compounded and manufactured specifically for the intended purpose. The resin manufacturer shall certify each lot for the following properties.

The natural polyethylene resin without the carbon black shall meet the following requirements:

Property	Test Method	HDPE Requirements	LLDPE Requirements
Density, g/cc	ASTM D 1505 or ASTM D 792	0.935 - 0.940	0.915 - 0.926
Melt Index, g/10 min.	ASTM D 1238	<0.4	<0.6

2.3 Rolls

The geomembrane shall be a minimum 23.0 ft seamless width, as manufactured by Poly-Flex, Inc. (2000 W. Marshall Dr., Grand Prairie, TX 75051, 888-765-9359). Carbon black shall be added to the resin if the resin is not compounded for ultra-violet resistance.

The surface of the smooth geomembrane shall not have striations, roughness, pinholes, or bubbles.

The geomembrane shall be supplied in rolls. Labels on each roll shall identify the thickness of the material, the length and width of the roll, lot and roll numbers, and name of manufacturer.

The geomembrane rolls shall meet the following specifications:

SMOOTH HDPE GEOMEMBRANE ENGLISH UNITS

Property	Test Method	Minimum Average Values 30 mil	40 mil	60 mil	80 mil	100 mil
Thickness, mils	ASTM D 5199					
minimum average		30	40	60	80	100
lowest individual reading		27	36	54	72	90
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940	0.940
Tensile Properties[1]	ASTM D 6693					
1. Yield Strength, lb/in		63	84	126	168	210
2. Break Strength, lb/in		114	152	228	304	380
3. Yield Elongation, %		12	12	12	12	12
4. Break Elongation, %		700	700	700	700	700
Tear Resistance, lb	ASTM D 1004	21	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	54	72	108	144	180
Stress Crack Resistance[2], hrs	ASTM D 5397 (App.)	300	300	300	300	300
Carbon Black Content[3], %	ASTM D 1603	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 4--		
Oxidative Induction Time (OIT)						
Standard OIT, minutes	ASTM D 3895	100	100	100	100	100
Oven Aging at 85°C	ASTM D 5721					
High Pressure OIT - % retained after 90 days	ASTM D 5885	80	80	80	80	80
UV Resistance[5]	GRI GM11					
High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 5885	50	50	50	50	50
Seam Properties	ASTM D 6392 (@ 2 in/min)					
1. Shear Strength, lb/in		57	80	120	160	200
2. Peel Strength, lb/in - Hot Wedge		45	60	91	121	151
- Extrusion Fillet		39	52	78	104	130
Roll Dimensions						
1. Width (feet):		23	23	23	23	23
2. Length (feet)		1000	750	500	375	300
3. Area (square feet):		23,000	17,250	11,500	8,625	6,900
4. Gross weight (pounds, approx.)		3,470	3,470	3,470	3,470	3,470

1 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 1.3 inches; Break elongation is calculated using a gauge length of 2.0 inches.
2 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
3 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
4 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
5 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
6 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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POLY-FLEX
POLYETHYLENE GEOMEMBRANES

SMOOTH HDPE GEOMEMBRANE METRIC UNITS

Property	Test Method	Minimum Average Values 0.75 mm	1.00 mm	1.50 mm	2.00 mm	2.50 mm
Thickness, microns	ASTM D 5199					
minimum average		750	1,000	1,500	2,000	2,500
lowest individual reading		675	900	1,350	1,800	2,250
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940	0.940
Tensile Properties[1]	ASTM D 6693					
1. Yield Strength, kN/m		11	15	22	29	37
2. Break Strength, kN/m		20	27	40	53	67
3. Yield Elongation, %		12	12	12	12	12
4. Break Elongation, %		700	700	700	700	700
Tear Resistance, N	ASTM D 1004	93	125	187	249	311
Puncture Resistance, N	ASTM D 4833	240	320	480	640	800
Stress Crack Resistance[2], hrs	ASTM D 5397 (App.)	300	300	300	300	300
Carbon Black Content[3], %	ASTM D 1603	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 4--		
Oxidative Induction Time (OIT)						
Standard OIT, minutes	ASTM D 3895	100	100	100	100	100
Oven Aging at 85°C	ASTM D 5721					
High Pressure OIT - % retained after 90 days	ASTM D 5885	80	80	80	80	80
UV Resistance[5]	GRI GM11					
High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 5885	50	50	50	50	50
Seam Properties	ASTM D 6392 (@ 5 cm/min)					
1. Shear Strength, kN/m		10	14	21	28	35
2. Peel Strength, kN/m - Hot Wedge		7.9	10.5	15.9	21.2	26.4
- Extrusion Fillet		6.8	9.1	13.6	18.2	22.8
Roll Dimensions						
1. Width (meters):		7	7	7	7	7
2. Length (meters)		304.9	228.7	152.4	114.3	91.5
3. Area (square meters):		2,137	1,603	1,068	801	641
4. Gross weight (kilograms, approx.)		1,574	1,574	1,574	1,574	1,574

1 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 33 mm; Break elongation is calculated using a gauge length of 50 mm.
2 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
3 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
4 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
5 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
6 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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TEXTURED HDPE GEOMEMBRANE ENGLISH UNITS

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

Property	Test Method	Minimum Average Values 40 mil	60 mil	80 mil	100 mil
Thickness, mils	ASTM D 5994				
minimum average		38	57	76	95
lowest individual of 8 of 10 readings		36	54	72	90
lowest individual of 10 readings		34	51	68	85
Asperity Height[1], mils	GRI GM12	10	10	10	10
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940
Tensile Properties[2]	ASTM D 6693				
1. Yield Strength, lb/in		84	126	168	210
2. Break Strength, lb/in		60	90	120	150
3. Yield Elongation, %		12	12	12	12
4. Break Elongation, %		100	100	100	100
Tear Resistance, lb	ASTM D 1004	28	42	56	70
Puncture Resistance, lb	ASTM D 4833	60	90	120	150
Stress Crack Resistance[3], hrs	ASTM D 5397 (App.)	300	300	300	300
Carbon Black Content[4], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596		--Note 5--		
Oxidative Induction Time (OIT)					
Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C	ASTM D 5721				
High Pressure OIT - % retained after 90 days	ASTM D 5885	80	80	80	80
UV Resistance[6]	GRI GM11				
High Pressure OIT[7] - % retained after 1600 hrs	ASTM D 5885	50	50	50	50
Seam Properties	ASTM D 6392 (@ 2 in/min)				
1. Shear Strength, lb/in		80	120	160	200
2. Peel Strength, lb/in - Hot Wedge		60	91	121	151
- Extrusion Fillet		52	78	104	130
Roll Dimensions					
1. Width (feet):		23	23	23	23
2. Length (feet)		750	500	375	300
3. Area (square feet):		17,250	11,500	8,625	6,900
4. Gross weight (pounds, approx.)		3,500	3,500	3,470	3,470

1 Of 10 readings; 8 must be ≥ 7 mils and lowest individual reading must be ≥ 5 mils.
2 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 1.3 inches; Break elongation is calculated using a gauge length of 2.0 inches.
3 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
4 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
5 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
6 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
7 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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POLY-FLEX
POLYETHYLENE GEOMEMBRANES

TEXTURED HDPE GEOMEMBRANE METRIC UNITS

Property	Test Method	Minimum Average Values 1.00 mm	1.50 mm	2.00 mm	2.50 mm
Thickness, microns	ASTM D 5994				
minimum average		950	1,425	1,900	2,375
lowest individual of 8 of 10 readings		900	1,350	1,800	2,250
lowest individual of 10 readings		850	1,275	1,700	2,125
Asperity Height[1], microns	GRI GM12	250	250	250	250
Sheet Density, g/cc	ASTM D 1505/D 792	0.940	0.940	0.940	0.940
Tensile Properties[2]	ASTM D 6693				
1. Yield Strength, kN/m		15	22	29	37
2. Break Strength, kN/m		11	16	21	26
3. Yield Elongation, %		12	12	12	12
4. Break Elongation, %		100	100	100	100
Tear Resistance, N	ASTM D 1004	125	187	249	311
Puncture Resistance, N	ASTM D 4833	267	400	534	667
Stress Crack Resistance[3], hrs	ASTM D 5397 (App.)	300	300	300	300
Carbon Black Content[4], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	–Note 5–			
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C High Pressure OIT - % retained after 90 days	ASTM D 5721 ASTM D 5885	80	80	80	80
UV Resistance[6] High Pressure OIT[7] - % retained after 1600 hrs	GRI GM11 ASTM D 5885	50	50	50	50
Seam Properties	ASTM D 6392 (@ 5 cm/min)				
1. Shear Strength, kN/m		14	24	28	35
2. Peel Strength, kN/m - Hot Wedge		10.5	15.9	21.2	26.4
- Extrusion Fillet		9.1	13.6	18.2	22.8
Roll Dimensions					
1. Width (meters):		7	7	7	7
2. Length (meters):		228.7	152.4	114.3	91.5
3. Area (square meters):		1,603	1,068	801	641
4. Gross weight (kilograms, approx):		1,588	1,588	1,574	1,574

1 Of 10 readings: 8 must be ≥ 180 microns and lowest individual reading must be ≥ 130 microns.
2 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Yield elongation is calculated using a gauge length of 33 mm; Break elongation is calculated using a gauge length of 50 mm.
3 The yield stress used to calculate the applied load for the SP-NCTL test should be the mean value via MQC testing.
4 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
5 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
6 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
7 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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SMOOTH LLDPE GEOMEMBRANE ENGLISH UNITS

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

Property	Test Method	Minimum Average Values 30 Mil	40 Mil	60 Mil	80 Mil
Thickness, mils	ASTM D 5199				
minimum average		30	40	60	80
lowest individual reading		27	36	54	72
Sheet Density, g/cc (max.)	ASTM D 1505/D 792	0.939	0.939	0.939	0.939
Tensile Properties[1]	ASTM D 6693				
1. Break Strength, lb/in		114	152	228	304
2. Break Elongation, %		800	800	800	800
2% Modulus, lb/in^2 (max.)	ASTM D 5323	60,000	60,000	60,000	60,000
Tear Resistance, lb	ASTM D 1004	16	22	33	44
Puncture Resistance, lb	ASTM D 4833	42	56	84	112
Axi-Symetric Break Strain, %	ASTM D 5617	30	30	30	30
Carbon Black Content[2], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596	–Note 3–			
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C High Pressure OIT - % retained after 90 days	ASTM D 5721 ASTM D 5885	60	60	60	60
UV Resistance[4] High Pressure OIT[5] - % retained after 1600 hrs	GRI GM11 ASTM D 5885	35	35	35	35
Seam Properties	ASTM D 6392 (@ 2 in/min)				
1. Shear Strength, lb/in		45	60	90	120
2. Peel Strength, lb/in - Hot Wedge		38	50	75	100
- Extrusion Fillet		34	44	66	88
Roll Dimensions					
1. Width (feet):		23	23	23	23
2. Length (feet):		1,000	750	500	375
3. Area (square feet):		23,000	17,250	11,500	8,625
4. Gross weight (pounds, approx.):		3,435	3,435	3,435	3,435

1 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.
2 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
3 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
4 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
5 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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SMOOTH LLDPE GEOMEMBRANE METRIC UNITS

Property	Test Method	Minimum Average Values 0.75 mm	1.00 mm	1.50 mm	2.00 mm
Thickness, microns	ASTM D 5199				
minimum average		750	1,000	1,500	2,000
lowest individual reading		675	900	1,350	1,800
Sheet Density, g/cc (max.)	ASTM D 1505/D 792	0.939	0.939	0.939	0.939
Tensile Properties[1]	ASTM D 6693				
1. Break Strength, kN/m		20	27	40	53
2. Break Elongation, %		800	800	800	800
2% Modulus, MPa (max.)	ASTM D 5323	414	414	414	414
Tear Resistance, N	ASTM D 1004	70	100	150	200
Puncture Resistance, N	ASTM D 4833	190	250	370	500
Axi-Symetric Break Strain, %	ASTM D 5617	30	30	30	30
Carbon Black Content[2], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596		–Note 3–		
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100	100
Oven Aging at 85°C	ASTM D 5721				
High Pressure OIT - % retained after 90 days	ASTM D 5885	60	60	60	60
UV Resistance[4]	GRI GM11				
High Pressure OIT[5] - % retained after 1600 hrs	ASTM D 5885	35	35	35	35
Seam Properties	ASTM D 6392 (@ 5 cm/min)				
1. Shear Strength, kN/m		7.9	10.5	15.8	21.0
2. Peel Strength, kN/m - Hot Wedge		6.6	8.7	13.1	17.5
- Extrusion Fillet		5.9	7.7	11.5	15.4
Roll Dimensions					
1. Width (meters):		7	7	7	7
2. Length (meters):		304.9	228.7	152.4	114.3
3. Area (square meters):		2,137	1,603	1,068	801
4. Gross weight (kilograms, approx.):		1,558	1,558	1,558	1,558

1 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 50 mm.
2 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
3 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
4 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
5 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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TEXTURED LLDPE GEOMEMBRANE ENGLISH UNITS

Property	Test Method	Minimum Average Values 40 Mil	60 Mil	80 Mil
Thickness, mils	ASTM D 5994			
minimum average		38	57	76
lowest individual of 8 of 10 readings		36	54	72
lowest individual of 10 readings		34	51	68
Asperity Height[1], mils	GRI GM12	10	10	10
Sheet Density, g/cc (max.)	ASTM D 1505/D 792	0.939	0.939	0.939
Tensile Properties[2]	ASTM D 6693			
1. Break Strength, lb/in		60	90	120
2. Break Elongation, %		250	250	250
2% Modulus, lb/in^2 (max.)	ASTM D 5323	60,000	60,000	60,000
Tear Resistance, lb	ASTM D 1004	22	33	44
Puncture Resistance, lb	ASTM D 4833	44	66	88
Axi-Symetric Break Strain, %	ASTM D 5617	30	30	30
Carbon Black Content[3], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596		–Note 4–	
Oxidative Induction Time (OIT) Standard OIT, minutes	ASTM D 3895	100	100	100
Oven Aging at 85°C	ASTM D 5721			
High Pressure OIT - % retained after 90 days	ASTM D 5885	60	60	60
UV Resistance[5]	GRI GM11			
High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 5885	35	35	35
Seam Properties	ASTM D 6392 (@ 2 in/min)			
1. Shear Strength, lb/in		60	90	120
2. Peel Strength, lb/in - Hot Wedge		50	75	100
- Extrusion Fillet		44	66	88
Roll Dimensions				
1. Width (feet):		23	23	23
2. Length (feet):		750	500	375
3. Area (square feet):		17,250	11,500	8,625
4. Gross weight (pounds, approx.):		3,465	3,465	3,435

1 Of 10 readings: 8 must be ≥ 7 mils and lowest individual reading must be ≥ 5 mils.
2 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 2.0 inches.
3 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
4 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
5 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
6 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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TEXTURED LLDPE GEOMEMBRANE METRIC UNITS

Property	Test Method	Minimum Average Values 1.00 mm	1.50 mm	2.00 mm
Thickness, microns	ASTM D 5994			
minimum average		950	1,425	1,900
lowest individual of 8 of 10 readings		900	1,350	1,800
lowest individual of 10 readings		850	1,275	1,700
Asperity Height[1], microns	GRI GM12	250	250	250
Sheet Density, g/cc (max.)	ASTM D 1505/D 792	0.939	0.939	0.939
Tensile Properties[2]	ASTM D 6693			
1. Break Strength, kN/m		11	16	21
2. Break Elongation, %		250	250	250
2% Modulus, MPa (max.)	ASTM D 5323	414	414	414
Tear Resistance, N	ASTM D 1004	100	150	200
Puncture Resistance, N	ASTM D 4833	200	300	400
Axi-Symetric Break Strain, %	ASTM D 5617	30	30	30
Carbon Black Content[3], %	ASTM D 1603	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D 5596		–Note 4–	
Oxidative Induction Time (OIT)				
Standard OIT, minutes	ASTM D 3895	100	100	100
Oven Aging at 85°C	ASTM D 5721			
High Pressure OIT - % retained after 90 days	ASTM D 5885	60	60	60
UV Resistance[5]	GRI GM11			
High Pressure OIT[6] - % retained after 1600 hrs	ASTM D 5885	35	35	35
Seam Properties	ASTM D 6392 (@ 5 cm/min)			
1. Shear Strength, kN/m		10.5	15.8	21.0
2. Peel Strength, kN/m - Hot Wedge		8.7	13.1	17.5
- Extrusion Fillet		5.9	7.7	11.5
Roll Dimensions				
1. Width (meters):		7	7	7
2. Length (meters):		228.7	152.4	114.3
3. Area (square meters):		1,603	1,068	801
4. Gross weight (kilograms, approx.):		1,572	1,572	1,558

1 Of 10 readings; 8 must be ≥ 180 microns and lowest individual reading must be ≥ 130 microns.
2 Machine direction (MD) and cross machine direction (XMD) average values should be on the basis of 5 test specimens each direction. Break elongation is calculated using a gauge length of 50 mm.
3 Other methods such as ASTM D 4218 or microwave methods are acceptable if an appropriate correlation can be established.
4 Carbon black dispersion for 10 different views: Nine in Categories 1 and 2 with one allowed in Category 3.
5 The condition of the test should be 20 hr. UV cycle at 75°C followed by 4 hr. condensation at 60°C.
6 UV resistance is based on percent retained value regardless of the original HP-OIT value.

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2.4 Quality Control Specifications

2.4.1 Raw Materials

A. Resin

All resins for use in geomembrane must pass a candidate pre-approval process before being eligible for use. Each incoming railcar shall be sampled with the following testing performed and compared to the manufacturer's specifications:

1. Density: ASTM D 1505.
2. Melt Index: ASTM D 1238.
3. Oxidative Induction Time (OIT): ASTM D 3895.

B. Additives

All incoming materials are to be tested and approved prior to use with the following testing performed and compared to the manufacturer's specifications:

1. Carbon Black Content: ASTM D 1603.
2. Oxidative Induction Time (OIT): ASTM D 3895.

2.4.2 Finished Product: During Production

A. Inspection

Performed on each roll during manufacturing.

1. **Appearance**

   Sheet surface appearance shall be monitored for flaws.

2. **Thickness**

   A full width sample shall be cut from the end of each roll for thickness measurement.

B. Roll Identification

Four tags per roll shall be used.

1. Outside the core.
2. On the core plug.
3. On the roll surface.
4. On the production roll sample.

C. Out-of-Spec. Material

Any roll not meeting the specification for any of the above inspections shall be separated from other rolls and placed on hold.

2.4.3 Manufacturer's Quality Control & Quality Assurance Testing

A. Sampling

Full width samples shall be taken as retains from the end of each roll to the manufacturer's laboratory.

B. Testing

The geomembrane quality control testing shall meet the following frequency requirements:

Property	Test Method	Testing Frequency (min.)
Thickness (smooth sheet) (textured sheet)	ASTM D 5199 ASTM D 5994	per roll
Asperity Height (textured sheet only) Alternate the measurement side for double-sided textured sheet.	GRI GM12	every second roll
Sheet Density	ASTM D 1505/D 792	200,000 lb (90,000 kg)
Tensile Properties 1. Yield Strength (HDPE only) 2. Break Strength 3. Yield Elongation (HDPE only) 4. Break Elongation	ASTM D 6693	20,000 lb (9,000 kg)
2% Modulus (LLDPE only)	ASTM D 5323	per each formulation
Tear Resistance	ASTM D 1004	45,000 lb (20,000 kg)
Puncture Resistance	ASTM D 4833	45,000 lb (20,000 kg)
Axi-Symetric Break Strain (LLDPE only)	ASTM D 5617	per each formulation
Stress Crack Resistance (HDPE only)	ASTM D 5397 (App.)	per GRI GM10
Carbon Black Content	ASTM D 1603	20,000 lb (9,000 kg)
Carbon Black Dispersion	ASTM D 5596	45,000 lb (20,000 kg)
Oxidative Induction Time (OIT) Standard OIT	ASTM D 3895	200,000 lb (90,000 kg)
Oven Aging at 85°C High Pressure OIT	ASTM D 5721 ASTM D 5885	per each formulation
UV Resistance High Pressure OIT	GRI GM11 ASTM D 5885	per each formulation

C. Welding Rod

A sample of welding rod shall be tested at a frequency of once per 25 rolls of welding rod. The following tests shall be performed on the sample:

1. Diameter	ASTM D 5199
2. Density	ASTM D 1505
3. Melt Index	ASTM D 1238
4. Carbon Black Content	ASTM D 1603

D. Reporting

Results from the testing shall be reviewed by the quality control manager. The test data shall then be transferred to the product data file for roll certification. Material that does not meet specifications shall be identified and placed on hold.

3. GEOMEMBRANE INSTALLATION

3.1 Materials Logistics

3.1.1 Transportation and On-site Storage

The geomembrane rolls shall be shipped by flatbed trailer to the job site. The geomembrane shall be stored so as to be protected from puncture, dirt, grease, moisture and excessive heat. Damaged material shall be stored separately for repair or replacement. The rolls shall be stored on a prepared smooth surface (not wooden pallets) and should not be stacked more than two rolls high.

3.2 Earthwork

3.2.1 General

The owner or his representative (soil quality assurance inspector) shall inspect the subgrade preparation. Prior to liner installation the subgrade shall be compacted in accordance with the project specifications. Weak or compressible areas which cannot be satisfactorily compacted should be removed and replaced with properly compacted fill. All surfaces to be lined shall be smooth and free of all foreign and organic material, sharp objects, or debris of any kind. The subgrade shall provide a firm, unyielding foundation with no sharp changes or abrupt breaks in grade. Standing water or excessive moisture shall not be allowed.

The installer, on a daily basis, shall approve the surface on which the geomembrane will be installed. After the supporting soil surface has been approved, it shall be the installer's responsibility to indicate to the inspector any changes to its condition that may require repair work.

3.2.2 Anchor Trench

The anchor trench shall be excavated to the line, grade, and width shown on the project construction drawings, prior to liner system placement. Slightly rounded corners shall be provided in the trench to avoid sharp bends in the geomembrane.

3.3 Method of Placement

The rolls shall be deployed using a spreader bar assembly attached to a loader bucket or by other methods approved by the project engineer.

The installer shall be responsible for the following:

1. Equipment or tools shall not damage the geomembrane during handling, transportation and deployment.
2. Personnel working on the geomembrane shall not smoke or wear damaging shoes.
3. The method used to unroll the panels shall not cause scratches or crimps in the geomembrane and shall not damage the supporting soil.
4. Adequate loading (e.g., sand bags or similar items that will not damage the geomembrane) shall be placed to prevent uplift by wind (in case of high winds, continuous loading is recommended along edges of panels to minimize risk of wind flow under the panels).

3.3.1 Weather Conditions

Geomembrane deployment shall proceed between ambient temperatures of 32° F and 104° F. Placement can proceed below 32° F only after it has been verified by the inspector that the material can be seamed according to the specification. Geomembrane placement shall not be done during any precipitation, in the presence of excessive moisture (e.g., fog, rain, dew) or in the presence of excessive winds, as determined by the installation supervisor.

3.4 Field Seaming

Approved seaming processes are fusion and extrusion welding. On side slopes, seams shall be oriented in the general direction of maximum slope, i.e., oriented down, not across the slope. In corners and odd-shaped geometric locations, the number of field seams shall be minimized.

No base T-seam shall be closer than 5 feet from the toe of the slope. Seams shall be aligned with the least possible number of wrinkles and "fishmouths." If a fishmouth or wrinkle is found, it shall be relieved and cap-stripped.

3.4.1 Seam Overlap

Geomembrane panels must have a finished minimum overlap of 4 inches for fusion welding and 6 inches for extrusion welding.

Cleaning solvents may not be used unless the product is approved by the liner manufacturer.

3.4.2 Test Seams

Field test seams shall be conducted on the liner to verify that seaming conditions are satisfactory. Test seams shall be conducted at the beginning of each seaming period and at least once every 4 hours, for each seaming apparatus and personnel used that day.

All test seams shall be made in contact with the subgrade. Welding rod used for extrusion welding shall have the same properties as the resin used to manufacture the geomembrane. The test seam samples shall be 10 feet long for fusion welding and 3 feet long for extrusion welding with the seam centered lengthwise. Three specimens shall be cut from each end of the test seams by the inspector. The inspector shall use a tensiometer to test 3 specimens for shear and 3 specimens for peel. Each specimen shall be one inch wide with a grip separation of 4 inches plus the width of the seam. The seam shall be centered between the clamps. The rate of grip separation shall be 2 inches per minute.

3.4.3 Assessment of Seam Test Results

For both smooth and textured seams the strength of two out of three 1.0 inch (25 mm) wide strip specimens should meet or exceed values given in this specification. The third must meet or exceed 80% of the given values. The shear percent elongation should exceed 50%. The assumed gauge length is considered to be the unseamed sheet material on either side of the welded area. Elongation measurements should be omitted for field testing. In addition, the peel separation should not exceed 25% based on the proportion of area of separated bond to the area of the original bonding. Regarding the locus-of-break patterns of the different seaming methods in shear and peel, the following are unacceptable break codes per their description in the ASTM D 6392. In this regard, SIP is an acceptable break code.

Unacceptable Break Codes

Hot Wedge: AD and AD-BRK > 25%

Extrusion Fillet: AD1, AD2 and AD-Weld (unless strength is achieved)

3.4.4 Non-Destructive Seam Testing

The Installer shall non-destructively test all field seams over their full length.

A. Vacuum Box Testing

Equipment for testing extrusion seams shall be comprised of the following:

1. A vacuum box assembly consisting of a rigid housing, a transparent viewing window, a soft rubber gasket attached to the bottom, port hole or valve assembly, and a vacuum gauge.
2. Soapy solution in a plastic bucket with a mop.

The following procedures shall be followed by the installer:

1. Excess sheet overlap shall be trimmed away.
2. Wet a strip of geomembrane approximately 12 inches wide by the length of box with the soapy solution.
3. Place the box over the wetted area and compress.
4. Create a vacuum of 3 - 5 psig.
5. Ensure that a leak-tight seal is created.
6. For a period of approximately 10 seconds, examine the geomembrane through the viewing window for the presence of animated soap bubbles.

7. If no animated bubbles appear after 10 seconds, close the vacuum valve and open the bleed valve, move the box over the next adjoining area with a minimum 3 inches overlap and repeat the process.
8. All areas where animated soap bubbles appear shall be marked, repaired and then retested.

The following procedures shall apply to locations where seams cannot be non-destructively tested.

1. If the seam is accessible to testing equipment prior to final installation, the seam shall be non-destructively tested prior to final installation.
2. If the seam cannot be tested prior to final installation, the seams shall be spark tested according to the spark tester manufacturer's procedures.

B. Air Pressure Testing (For Double Fusion Seams Only)

Equipment for testing double fusion seams shall be comprised of the following:

1. An air pump equipped with pressure gauge capable of generating and sustaining a pressure between 25 and 30 psi.
2. A pressure gauge equipped with a sharp hollow needle.

The following procedures shall be followed by the installer:

1. Seal one end of the seam to be tested.
2. Insert needle or other approved pressure feed device through the sealed end of the channel created by the double wedge fusion weld.
3. Energize the air pump to verify the unobstructed passage of air through the channel.
4. Seal the other end of the channel.
5. Energize the air pump to a pressure between 25 and 30 psi, close valve, allow 2 minutes for the injected air to come to equilibrium in the channel, and sustain pressure for approximately 5 minutes.
6. If loss of pressure exceeds 4 psi, or pressure does not stabilize, locate faulty area, repair and retest.
7. If pressure does not drop below the acceptable value after five minutes, cut the air channel open at the opposite end from the pressure gauge. The air channel should deflate immediately indicating that the entire length of the seam has been tested.

3.4.5 Destructive Seam Testing

Destructive seam testing should be minimized to preserve the integrity of the liner. The installer shall provide the inspector with one destructive test sample per project specifications (usually once per 500 feet of seam length) from a location specified by the inspector.

A. Sampling Procedure

In order to obtain test results prior to completion of liner installation, samples shall be cut by the installer as the seaming progresses. The installer shall also record the date, location, and pass or fail description. All holes in the geomembrane resulting from obtaining the seam samples shall be immediately patched and vacuum tested.

B. Size and Disposition of Samples

The samples shall be 12 inches wide by 36 inches long with the seam centered lengthwise. The sample shall be cut into three equal-length pieces, one to be given to the inspector, one to be given to the owner and one to the installer.

C. Field Laboratory Testing

The inspector shall test ten 1-inch wide specimens from his sample, five specimens for shear strength and five for peel strength.

D. Independent Laboratory Testing

The owner, at his discretion and expense, may send seam samples to a laboratory for testing. The test method and procedures to be used by the independent laboratory shall be the same as used in field testing.

E. Procedures for Destructive Test Failure

The following procedures shall apply whenever a sample fails the field destructive test:

1. The installer shall cap strip the seam between the failed location and any passed test locations.
2. The installer can retrace the welding path to an intermediate location (usually 10 feet from the location of the failed test), and take a sample for an additional field test. If this test passes, then the seam shall be cap stripped between that location and the original failed location. If the test fails, then the process is repeated.
3. Over the length of seam failure, the installer shall either cut out the old seam, reposition the panel and reseam, or add a cap strip.

3.4.6 Defects and Repairs

All seams and non-seam areas of the geomembrane shall be inspected by the inspector for defects, holes, blisters, undispersed raw materials, and any sign of contamination by foreign matter. The surface of the geomembrane shall be clean at the time of inspection.

A. Evaluation

Each suspect location in seam and non-seam areas shall be non-destructively tested as appropriate in the presence of the inspector. Each location that fails the non-destructive testing shall be marked by the inspector, and repaired accordingly.

B. Repair Procedures

1. Defective seams shall be cap stripped or replaced.
2. Small holes shall be repaired by extrusion welding a bead of extrudate over the hole. If the hole is larger than 1/4 inch, it shall be patched.
3. Tears shall be repaired by patching. If the tear is on a slope or an area susceptible to stress and has a sharp end it must be rounded prior to patching.
4. Blisters, large cuts and undispersed raw materials shall be repaired by patches.

5. Patches shall be completed by extrusion welding. The weld area shall be ground no more than 10 minutes prior to welding. No more than 10% of the thickness shall be removed by grinding. Welding shall commence where the grinding started and must overlap the previous seam by at least 2 inches. Reseaming over an existing seam without regrinding shall not be permitted. The welding shall restart by grinding the existing seam and rewelding a new seam.

   Patches shall be round or oval in shape, made of the same geomembrane, and extend a minimum of 6 inches beyond the edge of defects.

C. Verification of Repairs

Each repair shall be non-destructively tested. Repairs that pass the non-destructive test shall be taken as an indication of an adequate repair. Failed tests indicate that the repair shall be repeated and retested until passing test results are achieved.

The inspector shall keep daily documentation of all non-destructive and destructive testing. This documentation shall identify all seams that initially failed the test and include evidence that these seams were repaired and successfully retested.

3.5 Cover Material and Backfilling of Anchor Trench

The geomembrane shall be covered as soon as possible. The covering operation shall not damage the geomembrane. The cover soil material shall be free of foreign and organic material, sharp objects, or debris of any kind, which could potentially damage the geomembrane. No construction equipment or machinery shall operate directly on the geomembrane. The use of lightweight machinery (i.e., generator, etc.) with low ground pressure is allowed.

The anchor trench shall be backfilled by the earthwork contractor. Trench backfill material shall be placed and compacted in accordance with the project specifications.

Care shall be taken when backfilling the trenches to prevent any damage to the geomembrane. If damage occurs, it shall be repaired prior to backfilling.

3.6 Geomembrane Acceptance

The installer shall retain all ownership and responsibility for the geomembrane until accepted by the owner.

Final acceptance is when all of the following conditions are met:

1. Installation is finished.
2. Verification of the adequacy of all field seams and repairs, including associated testing, is complete.

INHERENT PROPERTIES OF POLYETHYLENE LINERS

The properties listed in the table below are primarily inherent on the resin type used to produce the liner or are directly proportional to the thickness of the liner and less dependent on the manufacturing method. Therefore, these properties will not change from roll to roll or even lot to lot. Hence, they should not be included as part of routine quality control testing. The exception to this is Oxidative Induction Time. This test is a measurement of the amount of anti-oxidant added to the resin to produce the finished sheet. This test can function both as a performance test and a quality control test. As a quality control test it is desirable to run the test at high temperatures to keep the test duration short. This test is routinely run at the time of manufacture. As a performance test it is desirable to run the test at lower temperatures. Testing at lower temperatures cannot be done for quality control purposes.

The information given below is based on nominal values. Individual test results may vary from these values depending upon the reproducibility of the test.

NOMINAL PROPERTIES

TEST DESCRIPTION	TEST METHOD	UNITS	HDPE	LLDPE
Modulus of Elasticity	ASTM D 6693	lb/in^2	110,000	45,000
Secant Modulus	ASTM D 5323	lb/in^2	60,000	45,000
Volatile Loss	ASTM D 1203	%	0.1	0.1
Dimensional Stability	ASTM D 1204	%	+/- 0.5	+/- 1.0
Water Absorption (24 hr @ 23 °C)	ASTM D 570	% change	0.1	0.1
Coefficient of Linear Thermal Expansion	ASTM D 696	(cm/cm • °c)	1.2 x 10-4	1.4 x 10-4
Moisture Vapor Transmission Rate (100 °F and 100% relative humidity)	ASTM E 96	g/m^2·day 100 mil	0.17	—
		80 mil	0.20	0.25
		60 mil	0.26	0.33
		40 mil	0.39	0.45
		30 mil	0.50	0.57
Low Temperature Brittleness	ASTM D 746	°F	<-112	<-112
Oxidative Induction Time	ASTM D 3895	minutes @ 200 °C	100	100
		minutes @ 150 °C	2000	2000
Multi-Axial Tension	ASTM D 5617	stress, lb/in^2	2200	1500
		strain, %	18	40+
Melt Index	ASTM D 1238	g/10 minutes	0.20	0.20

POLY·FLEX
POLYETHYLENE GEOMEMBRANES

POLY·FLEX DRAINAGE NET & GEOCOMPOSITE SPECIFICATIONS

Drainage Net & Geocomposite

POLY•FLEX DRAINAGE NET & GEOCOMPOSITE SPECIFICATIONS

1. GENERAL REQUIREMENTS

1.1 Scope

The following describes parameters for the manufacture, supply, and installation of Poly-Flex Drainage Net and Geocomposites.

1.2 Qualifications

The drainage net manufacturer shall have successfully manufactured 5,000,000 square feet of polyethylene drainage net.

1.3 Submittals

The manufacturer shall provide the following information:

A. List of material properties.

B. Quality control certificate for the drainage net, geotextile, and geocomposite rolls, upon request.

2. MATERIAL SPECIFICATIONS

2.1 Materials

2.1.1 Drainage Net

The drainage net shall be manufactured by extruding two sets of polyethylene strands to form a three dimensional structure to provide for planar flow. The drainage net shall be manufactured of polyethylene resin produced in the United States and compounded and manufactured specifically for the intended application. The natural polyethylene resin without the carbon black shall meet the following requirements:

Property	Test Method	Requirements
Density, g/cc	ASTM D 1505 or ASTM D 792	0.945 - 0.955
Melt Index, g/10 min.	ASTM D 1238	< 1.0

The drainage net shall be supplied in rolls 14 feet wide, as manufactured by Poly-Flex, Inc. (2000 W. Marshall Dr., Grand Prairie, Texas 75051). Labels on each roll shall identify the thickness of the material, the width and length of the roll, roll number, and name of the manufacturer. The drainage net rolls shall meet the requirements in this specification.

2.1.2 Geotextile

The geotextile shall be a non-woven, needle punched polyester or polypropylene fabric manufactured in the United States for the specific application. The geotextile rolls shall be 15 feet wide and shall meet the requirements in this specification.

2.1.3 Geocomposite

The geocomposite shall consist of the Poly-Flex HDPE drainage net heat bonded to one layer or sandwiched between two layers of geotextile to create a single-sided or double-sided geocomposite. The geocomposite shall be 13.5 feet wide. The geotextiles shall extend a minimum of 6 inches beyond the edges of drainage net on both sides of the geocomposite roll. The geotextile shall not be bonded to the drainage net within 6 inches from the edges of the rolls.

The drainage net and geocomposite rolls shall meet the following specifications:

HDPE DRAINAGE NET ENGLISH UNITS

Property	Test Method	Minimum Average Values GN-200	GN-250
Thickness	ASTM D 5199	200 mils	250 mils
Density, min.	ASTM D 1505	0.940 g/cc	0.940 g/cc
Carbon Black Content	ASTM D 1603	1.5 - 3.0%	1.5 - 3.0%
Tensile Strength, (Peak, MD)	ASTM D 7179	45 lb/in	60 lb/in
Transmissivity, (MD) metal plate/net/metal plate hydraulic gradient, i = 1 normal pressure = 10,000 lb/ft² seat time = 15 minutes	ASTM D 4716	5.0 gal/min-ft	7.2 gal/min-ft
Roll Dimensions			
1. Roll Width		14 ft	14 ft
2. Roll Length		325 ft	275 ft
3. Roll Area		4550 ft²	3850 ft²

The above property values, unless otherwise specified, are the minimum acceptable average test results for any roll based on the specified test methods and do not refer to an individual test specimen.
This data is provided for informational purposes only and is not intended as a warranty or guarantee. Poly-Flex, Inc. assumes no responsibility in connection with the use of this data. These values are subject to change without notice. REV. 11/06A

HDPE DRAINAGE NET
METRIC UNITS

Property	Test Method	Minimum Average Values GN-200	GN-250
Thickness	ASTM D 5199	5.1 mm	6.3 mm
Density, min.	ASTM D 1505	0.940 g/cc	0.940 g/cc
Carbon Black Content	ASTM D 1603	1.5 - 3.0%	1.5 - 3.0%
Tensile Strength (Peak, MD)	ASTM D 7179	7.9 kN/m	10.5 kN/m
Transmissivity, (MD) metal plate/net/metal plate hydraulic gradient, i = 1 normal pressure = 480 kPa seat time = 15 minutes	ASTM D 4716	1.0×10^{-3} m²/sec (62 l/min·m)	1.5×10^{-3} m²/sec (89 l/min·m)
Roll Dimensions			
1. Roll Width		4.27 m	4.27 m
2. Roll Length		99.0 m	83.8 m
3. Roll Area		422.7 m²	357.7 m²

The above property values, unless otherwise specified, are the minimum acceptable average test results for any roll based on the specified test methods and do not refer to an individual test specimen.
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SINGLE-SIDED GEOCOMPOSITES
ENGLISH UNITS

GEOCOMPOSITE PROPERTIES Property	Test Method	Minimum Average Values GC-06S-2.0	GC-08S-2.0	GC-06S-2.5	GC-08S-2.5
Transmissivity, (MD), gal/min·ft metal plate/geocomposite/metal plate hydraulic gradient, i = 1 normal pressure = 10,000 lb/ft² seat time = 15 minutes	ASTM D 4716	1.2 (2.5×10^{-4} m²/sec)	1.0 (2×10^{-4} m²/sec)	2.4 (5×10^{-4} m²/sec)	1.4 (2.9×10^{-4} m²/sec)
Ply Adhesion, lb/in	ASTM D 7005	1	1	1	1
Roll Dimensions					
1. Width, ft		13.5	13.5	13.5	13.5
2. Length, ft		300	250	225	175
COMPONENT PROPERTIES					
Geonet					
Thickness, mil	ASTM D 5199	200	200	250	250
Density, min., g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Carbon Black Content, %	ASTM D 1603	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0
Tensile Strength, (Peak, MD), lb/in	ASTM D 7179	45	45	60	60
Transmissivity, (MD), gal/min·ft metal plate/net/metal plate hydraulic gradient, i = 1 normal pressure = 10,000 lb/ft² seat time = 15 minutes	ASTM D 4716	5.0 (1.0×10^{-3} m²/sec)	5.0 (1.0×10^{-3} m²/sec)	7.2 (1.5×10^{-3} m²/sec)	7.2 (1.5×10^{-3} m²/sec)
Geotextile					
Unit Weight, oz/yd²	ASTM D 5261	6	8	6	8
Grab Strength, lb	ASTM D 4632	160	220	160	220
Grab Elongation, %	ASTM D 4632	50	50	50	50
Tear Strength, lb	ASTM D 4533	65	80	65	80
Puncture Strength, lb	ASTM D 4833	90	120	90	120
Permittivity, sec^{-1}	ASTM D 4491	1.3	1.3	1.3	1.3
AOS, MaxARV	ASTM D 4751	70 sieve	80 sieve	70 sieve	80 sieve
UV Stability, % ret. (500 hr.)	ASTM D 4355	70	70	70	70

The above property values, unless otherwise specified, are the minimum acceptable average test results for any roll based on the specified test methods and do not refer to an individual test specimen. Geotextile property values are Minimum Average Roll values, except for AOS, which is Maximum Average Roll Value. Geonet and Geotextile properties are tested prior to lamination.
This data is provided for informational purposes only and is not intended as a warranty or guarantee. Poly-Flex, Inc. assumes no responsibility in connection with the use of this data. These values are subject to change without notice. REV. 11/06

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

SINGLE-SIDED GEOCOMPOSITES METRIC UNITS

GEOCOMPOSITE PROPERTIES		Minimum Average Values			
Property	Test Method	GC-06S-2.0	GC-08S-2.0	GC-06S-2.5	GC-08S-2.5
Transmissivity, (MD), m^2/sec	ASTM D 4716	2.5×10^{-4}	2.0×10^{-4}	5.0×10^{-4}	2.9×10^{-4}
metal plate/geocomposite/metal plate		(15 l/min·m)	(12 l/min·m)	(30 l/min·m)	(17 l/min·m)
hydraulic gradient, i = 1					
normal pressure = 480 kPa					
seat time = 15 minutes					
Ply Adhesion, kN/m	ASTM D 7005	0.17	0.17	0.17	0.17
Roll Dimensions					
1. Roll Width, m		4.1	4.1	4.1	4.1
2. Roll Length, m		91.4	76.2	68.6	53.4

COMPONENT PROPERTIES					
Geonet					
Thickness, mm	ASTM D 5199	5.1	5.1	6.3	6.3
Density, min., g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Carbon Black Content, %	ASTM D 1603	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0
Tensile Strength, (Peak, MD), kN/m	ASTM D 7179	7.9	7.9	10.5	10.5
Transmissivity, (MD), m^2/sec	ASTM D 4716	1.0×10^{-3}	1.0×10^{-3}	1.5×10^{-3}	1.5×10^{-3}
metal plate/net/metal plate		(62 l/min·m)	(62 l/min·m)	(89 l/min·m)	(89 l/min·m)
hydraulic gradient, i = 1					
normal pressure = 480 kPa					
seat time = 15 minutes					
Geotextile					
Unit Weight, g/m^2	ASTM D 5261	203	271	203	271
Grab Strength, N	ASTM D 4632	712	979	712	979
Grab Elongation, %	ASTM D 4632	50	50	50	50
Tear Strength, N	ASTM D 4533	289	356	289	356
Puncture Strength, N	ASTM D 4833	400	534	400	534
Permittivity, sec^{-1}	ASTM D 4491	1.3	1.3	1.3	1.3
AOS, MaxARV, mm	ASTM D 4751	0.212	0.180	0.212	0.180
UV Stability, % ret. (500 hr.)	ASTM D 4355	70	70	70	70

The above property values, unless otherwise specified, are the minimum acceptable average test results for any roll based on the specified test methods and do not refer to an individual test specimen. Geotextile property values are Minimum Average Roll values, except for AOS, which is Maximum Average Roll Value. Geonet and Geotextile properties are tested prior to lamination.
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DOUBLE-SIDED GEOCOMPOSITES ENGLISH UNITS

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

GEOCOMPOSITE PROPERTIES		Minimum Average Values			
Property	Test Method	GC-06D-2.0	GC-08D-2.0	GC-06D-2.5	GC-08D-2.5
Transmissivity, (MD), gal/min·ft	ASTM D 4716	0.4	0.2	1.0	0.5
metal plate/geocomposite/metal plate		(0.8×10^{-4} m^2/sec)	(4.0×10^{-5} m^2/sec)	(2.0×10^{-4} m^2/sec)	(1.0×10^{-4} m^2/sec)
hydraulic gradient, i = 1					
normal pressure = 10,000 lb/ft^2					
seat time = 15 minutes					
Ply Adhesion, lb/in	ASTM D 7005	1	1	1	1
Roll Dimensions					
1. Roll Width, ft		13.5	13.5	13.5	13.5
2. Roll Length, ft		250	200	175	150

COMPONENT PROPERTIES					
Geonet					
Thickness, mil	ASTM D 5199	200	200	250	250
Density, min., g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Carbon Black Content, %	ASTM D 1603	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0
Tensile Strength, (Peak, MD), lb/in	ASTM D 7179	45	45	60	60
Transmissivity, (MD), gal/min·ft	ASTM D 4716	5.0	5.0	7.2	7.2
metal plate/net/metal plate		(1.0×10^{-3} m^2/sec)	(1.0×10^{-3} m^2/sec)	(1.5×10^{-3} m^2/sec)	(1.5×10^{-3} m^2/sec)
hydraulic gradient, i = 1					
normal pressure = 10,000 lb/ft^2					
seat time = 15 minutes					
Geotextile					
Unit Weight, oz/yd^2	ASTM D 5261	6	8	6	8
Grab Strength, lb	ASTM D 4632	160	220	160	220
Grab Elongation, %	ASTM D 4632	50	50	50	50
Tear Strength, lb	ASTM D 4533	65	80	65	80
Puncture Strength, lb	ASTM D 4833	90	120	90	120
Permittivity, sec^{-1}	ASTM D 4491	1.3	1.3	1.3	1.3
AOS, MaxARV	ASTM D 4751	70 sieve	80 sieve	70 sieve	80 sieve
UV Stability, % ret. (500 hr.)	ASTM D 4355	70	70	70	70

The above property values, unless otherwise specified, are the minimum acceptable average test results for any roll based on the specified test methods and do not refer to an individual test specimen. Geotextile property values are Minimum Average Roll values, except for AOS, which is Maximum Average Roll Value. Geonet and Geotextile properties are tested prior to lamination.
This data is provided for informational purposes only and is not intended as a warranty or guarantee. Poly-Flex, Inc. assumes no responsibility in connection with the use of this data. These values are subject to change without notice. REV. 11/06

DOUBLE-SIDED GEOCOMPOSITES METRIC UNITS

GEOCOMPOSITE PROPERTIES		**Minimum Average Values**			
Property	Test Method	GC-06D-2.0	GC-08D-2.0	GC-06D-2.5	GC-08D-2.5
Transmissivity, (MD), m^2/sec	ASTM D 4716	0.8×10^{-4}	4.0×10^{-5}	2.0×10^{-4}	1.0×10^{-4}
metal plate/geocomposite/metal plate		(5.0 l/min-m)	(2.5 l/min-m)	(12 l/min-m)	(6.2 l/min-m)
hydraulic gradient, i = 1					
normal pressure = 480 kPa					
seat time = 15 minutes					
Ply Adhesion, kN/m	ASTM D 7005	0.17	0.17	0.17	0.17
Roll Dimensions					
1. Roll Width, m		4.1	4.1	4.1	4.1
2. Roll Length, m		76.2	61	53.4	45.7

COMPONENT PROPERTIES					
Geonet					
Thickness, mm	ASTM D 5199	5.1	5.1	6.3	6.3
Density, min., g/cc	ASTM D 1505	0.940	0.940	0.940	0.940
Carbon Black Content, %	ASTM D 1603	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0	1.5 - 3.0
Tensile Strength, (Peak, MD), kN/m	ASTM D 7179	7.9	7.9	10.5	10.5
Transmissivity, (MD), m^2/sec	ASTM D 4716	1.0×10^{-3}	1.0×10^{-3}	1.5×10^{-3}	1.5×10^{-3}
metal plate/net/metal plate		(62 l/min-m)	(62 l/min-m)	(89 l/min-m)	(89 l/min-m)
hydraulic gradient, i = 1					
normal pressure = 480 kPa					
seat time = 15 minutes					
Geotextile					
Unit Weight, g/m^2	ASTM D 5261	203	271	203	271
Grab Strength, N	ASTM D 4632	712	979	712	979
Grab Elongation, %	ASTM D 4632	50	50	50	50
Tear Strength, N	ASTM D 4533	289	356	289	356
Puncture Strength, N	ASTM D 4833	400	534	400	534
Permittivity, sec^{-1}	ASTM D 4491	1.3	1.3	1.3	1.3
AOS, MaxARV, mm	ASTM D 4751	0.212	0.180	0.212	0.180
UV Stability, % ret. (500 hr.)	ASTM D 4355	70	70	70	70

The above property values, unless otherwise specified, are the minimum acceptable average test results for any roll based on the specified test methods and do not refer to an individual test specimen. Geotextile property values are Minimum Average Roll values, except for AOS, which is Maximum Average Roll Value. Geonet and Geotextile properties are tested prior to lamination.
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2.2 Manufacturer's Quality Control Testing

The Drainage Net shall be tested by its manufacturer once every 50,000 square feet for listed properties, except the transmissivity, which shall be tested once every 100,000 square feet.

The geotextile shall be tested by its manufacturer once every 100,000 square feet, except for AOS and Permittivity, which shall be tested once every 500,000 square feet and UV stability, which shall be per manufacturer historical date.

The geocomposite shall be tested by its manufacturer once every 100,000 square feet for the listed properties.

Any rolls not meeting the requirements of the specification shall be rejected. The manufacturer shall prepare a quality control report to be submitted to the project engineer upon request.

3. INSTALLATION

3.1 Transportation and On-site Storage

The drainage net and geocomposite rolls shall be wrapped in a plastic cover. The drainage net and geocomposite rolls shall be shipped to the job site in a manner not to damage the rolls.

3.2 Method of Placement

The subgrade shall be free of foreign and organic material, sharp objects, or debris of any kind, which could potentially damage the geocomposite. The rolls shall be deployed using a spreader bar assembly attached to a loader bucket or by other methods approved by the project engineer. On side slopes, the rolls shall be deployed in the general direction of the maximum slope. The deployment equipment shall not damage the underlying subgrade or geosynthetics. A smooth rub sheet may be needed for installation of the geocomposite over a textured geomembrane. The rub sheet is placed between the geocomposite and the textured geomembrane to prevent damage to geocomposite during positioning. The rub sheet is removed after deployment. Drainage net and geocomposite shall be placed and secured in an anchor trench as shown on the project drawings. Sandbags shall be placed on leading edges of the panels to prevent wind uplift. An extra layer of drainage net or geocomposite may be required at the intersection of any two sideslopes to cover the area where the panels are staggered.

3.3 Field Seaming

Drainage net panels shall be overlapped by a minimum of 2 inches. Non-black plastic ties shall be used at 5-foot intervals in the direction of the roll length and at 2-foot intervals across the end of the panel to tie the drainage net panels. Metallic ties shall not be allowed. On slopes, the spacing of ties across the roll end shall be 6 inches. The geotextile flaps of the adjacent panels shall be heat-bonded or sewn on all sides in accordance with the project specification.

3.4 Cover Material

The drainage net and geocomposite shall be covered as soon as possible. The covering operation shall not damage the drainage net or the geocomposite. The cover soil material shall be free of foreign and organic material, sharp objects, or debris of any kind, which could potentially damage the geocomposite. No construction equipment or machinery shall operate directly on the geocomposite. The use of lightweight machinery (i.e., generator, etc.) with low ground pressure is allowed.

3.5 Repairs

All panels shall be inspected for damage. Any damaged area shall be repaired by a patch of the same material extending one foot beyond the edges of the damaged area.

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

POLY-FLEX POLYETHYLENE EMBED CHANNEL SPECIFICATION

Polyethylene Embed Channel

GENERAL

1.1 Scope

The following describes parameters for the manufacture, supply, and installation of Poly-Flex High Density Polyethylene Embed Channel (PEC). All procedures, operations, and methods shall be in strict accordance with the engineer's specifications and drawings.

1.2 References

American Society for Testing and Materials

1.3 Submittals

1. The manufacturer shall maintain test records of the resins used to manufacture the PEC. This record shall be made available to the Engineer upon request.
2. The contractor shall submit shop drawings showing the exact location and installation procedures.
3. At the engineer's request, sample(s) of PEC shall be submitted.

1.4 Manufacturer's Quality Control Testing

All resins for use in PEC must pass the Poly-Flex raw material specifications before being eligible for use. Each lot shall be sampled and tested in the Poly-Flex, Inc. laboratory. The tests shall include density, melt index, and carbon black content. All additives and concentrates must pass Poly-Flex specifications.

PRODUCT

2.1 Product

The PEC shall be manufactured by Poly-Flex, Inc. The raw material shall be made of polyethylene resins manufactured in the United States. Carbon black shall be added to the resin if the resin is not precompounded for ultra-violet resistance. The final product shall meet the following values:

Density:	ASTM D1505	≥ 0.940 g/cc
Melt Index:	ASTM D1238	≤ 0.4 g/10 minutes
Carbon Black Content:	ASTM D1603	2% - 3%
Tensile Strength at Yield:	ASTM D6693	2,100 lb/in^2
Dimensions:	As shown on the drawing on page 35.	
Weight:	0.45 lb/ft	
Length:	5 ft and 10 ft	

2.2 Shipment and Storage

PEC shall be shipped in a manner not to be damaged by packaging or handling and shall be stored in a clean environment.

INSTALLATION

PEC can be nailed to wooden forms or pushed or vibrated into poured concrete. A 3-inch clearance is recommended from concrete edges or corners.

3.1 Installation in concrete forms

PEC shall be installed inside the concrete forms in accordance with the shop drawings prior to pouring concrete. Place PEC in the designated locations with the surface of PEC in contact with the form. PEC shall be secured to the wooden forms by means of nails driven from the inside of PEC into the forms (see Step 1 drawing). All exposed nails shall be clipped at the surface of PEC after removal of the forms (see Step 2 drawing).

3.2 Fabrication

PEC can be prefabricated into frames and vibrated into freshly poured concrete. Small air vent holes shall be drilled in approximately 3-foot intervals in the surface of PEC prior to its placement into fresh concrete.

Butt welded connections are made by extrusion welding the back side of the 3.5-inch surface and the outside of the legs. Backup HDPE plates are sometimes used behind the surface to be butt welded to reinforce the connection. A very flat extrusion weld bead is then placed on the 3.5-inch surface. PEC can also be butt welded similar to HDPE pipe welding techniques (See Figure 1). The two pieces (A & B) to be welded are laid on a flat surface. Each piece is held in contact with the "welding mirror" (C) for approximately 45 seconds until a melt bead (D) forms at the mirror; the mirror is removed (E) and the pieces are pushed together (F) fusing the molten plastic. This process gives a full perimeter weld of the PEC. Care must be exercised to assure alignment of the channels after the weld. This method can also be used for miter joints.

It is necessary to prevent gaps or repair gaps caused by thermal contraction or improper placement of the PEC. The liner-to-PEC connection will not be water tight unless the PECs are properly joined at their ends. Other PEC installation details are available from Poly-Flex, Inc.

3.3 Seaming

All seaming shall be done in accordance with the Poly-Flex extrusion seaming procedures, as outlined in this manual, and by experienced technicians who are qualified by Poly-Flex, Inc. to seam Poly-Flex liners.

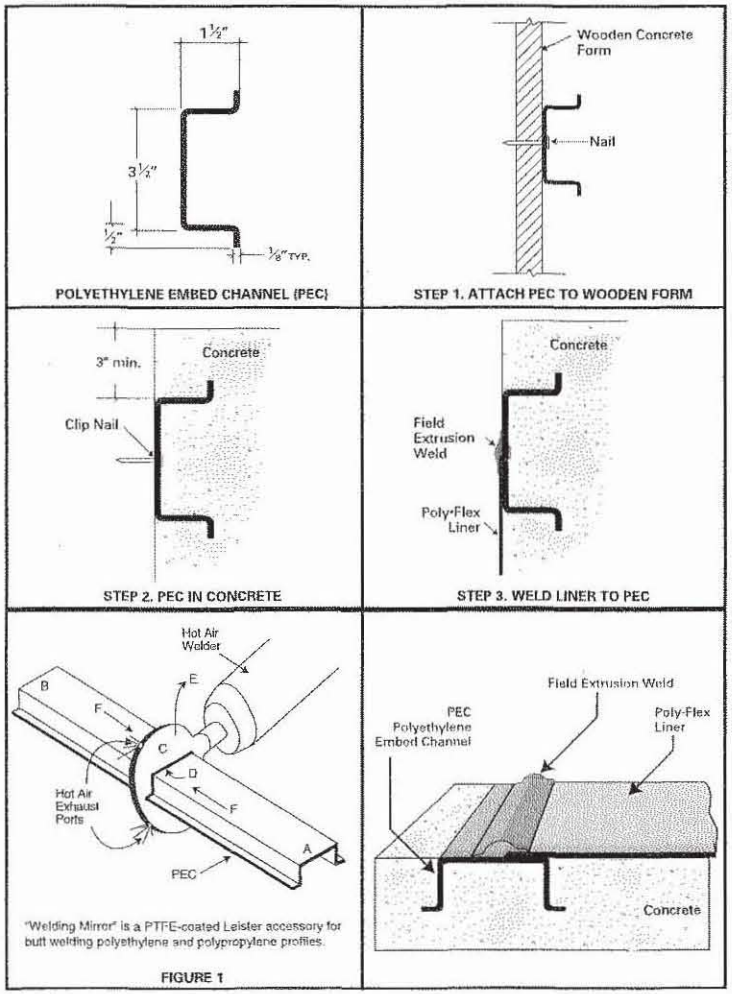
The following steps shall be followed prior to welding Poly-Flex liners to the PEC:

1. Remove cement paste, form oils, curing compound or other contaminants from the surface of PEC. The 3.5-inch wide surface shall be clean and dry. The welding surfaces of the PEC can be taped prior to its installation. The tape is removed after the concrete is hardened to expose the clean surfaces of PEC for welding.
2. Use a hot air gun to tack liner to PEC in a straight line in the center of the PEC surface.
3. A grinder with 80-grit disc shall be used to remove the surface contamination and oxidation from the welding surface area prior to the extrusion welding. Place the extrudate on the center line (see Step 3 drawing). All air vent or nail holes shall also be ground and covered with the extrudate.

All seams shall be non-destructively tested, whenever possible, by using a vacuum box apparatus if the PEC connection is designed to be waterproof.

Since destructive seam testing is not possible, it is very important that seaming be done by qualified technicians.

POLYETHYLENE EMBED CHANNEL SPECIFICATION



POLY-FLEX
POLYETHYLENE GEOMEMBRANES

CHEMICAL RESISTANCE INFORMATION

Chemical Resistance

CHEMICAL COMPATIBILITY OF POLY-FLEX LINERS

Chemical compatibility or resistance, as applied to geomembranes, is a relative term. Actual compatibility would mean that one material dissolves in the other such as alcohol in water or grease in gasoline. An example of incompatibility would be oil and water. In liners it is undesirable to have the chemicals dissolve in the liner, hence the term compatibility is the reverse of what is normally meant in the chemical industry. In the strictest sense and from a laboratory perspective, chemical compatibility, as the term applies to this industry, would imply that the chemical has no effect on the liner. On the other hand, from an engineering perspective, chemical compatibility means that a liner survives the exposure to a given chemical even though the chemical could have some effect on the performance of the liner, but not enough to cause failure. Therefore, one must understand and define chemical compatibility for a specific project.

Generally polyethylene is effected by chemicals in one of three ways.

1. No effect—This means that the chemical in question and the polyethylene do not interact. The polyethylene does not gain (lose) weight or swell, and the physical properties are not significantly altered.
2. Oxidizes (cross linking)—Chemicals classed as oxidizing agents cause the polyethylene molecules to cross link and cause irreversible changes to the physical properties of the liner. Basically they make the liner brittle.
3. Plasticizes—Chemicals in this classification are soluble in the polyethylene structure. They do not change the structure of the polyethylene itself but act as a plasticizer. In doing so, the liner experiences weight gain of 3-15%, may swell by up to 10%, and has measurable changes in physical properties (e.g. the tensile strength at yield may decrease by up to 20%). Even under these conditions the liner maintains its integrity and is not breached by liquids, provided the liner has not been subjected to any stress. These effects are reversible once the chemicals are removed and the liner has time to dry out.

Aside from the effect that chemicals have on a liner is the issue of vapor permeation through the liner. Vapor permeation is molecular diffusion of chemicals through the liner. Vapor transmission for a given chemical is dependent primarily on liner type, contact time, chemical solubility, temperature, thickness, and concentration gradient, but not on hydraulic head or pressure. Transmission through the liner can occur in as little as 1-2 days. Normally, a small amount of chemical is transmitted. Generally HDPE has the lowest permeation rate of the liners that are commercially available.

As stated above chemical compatibility is a relative term. For example, the use of HDPE as a primary containment of chlorinated hydrocarbons at a concentration of 100% may not be recommended, but it may be acceptable at 0.1% concentration for a limited time period or may be acceptable for secondary containment. Factors that go into assessment of chemical compatibility are type of chemical(s), concentration, temperature and the type of application. No hard and fast rules are available to make decisions on chemical compatibility. Even the EPA 9090 test is just a method to generate data so that an opinion on chemical compatibility can be more reliably reached.

A simplified table on chemical resistance is provided to act as a screening process for chemical containment applications.

CHEMICAL CLASS	CHEMICAL EFFECT	PRIMARY CONTAINMENT (LONG TERM CONTACT) HDPE	PRIMARY CONTAINMENT (LONG TERM CONTACT) LLDPE	SECONDARY CONTAINMENT (SHORT TERM CONTACT) HDPE	SECONDARY CONTAINMENT (SHORT TERM CONTACT) LLDPE
CARBOXYLIC ACID	1				
- Unsubstituted (e.g. Acetic acid)		B	C	A	C
- Substituted (e.g. Lactic acid)		A	B	A	A
- Aromatic (e.g. Benzoic Acid)		A	B	A	A
ALDEHYDES	3				
- Aliphatic (e.g. Acetaldehyde)		B	C	B	C
- Hetrocyclic (e.g. Furfural)		C	C	B	C
AMINE	3				
- Primary (e.g. Ethylamine)		B	C	B	C
- Secondary (e.g. Diethylamine)		C	C	B	C
- Aromatic (e.g. Aniline)		B	C	B	C
CYANIDES (e.g. Sodium Cyanide)	1	A	A	A	A
ESTER (e.g. Ethyl acetate)	3	B	C	B	C
ETHER (e.g. Ethyl ether)		C	C	B	C
HYDROCARBONS	3				
- Aliphatic (e.g. Hexane)		C	C	B	C
- Aromatic (e.g. Benzene)		C	C	B	C
- Mixed (e.g. Crude oil)		C	C	B	C
HALOGENATED HYDROCARBONS	3				
- Aliphatic (e.g. Dichloroethane) +A4		C	C	B	C
- Aromatic (e.g. Chlorobenzene)		C	C	B	C
ALCOHOLS	1				
- Aliphatic (e.g. Ethyl alcohol)		A	A	A	A
- Aromatic (e.g. Phenol)		A	C	A	B
INORGANIC ACID					
- Non-oxidizers (e.g. Hydrochloric acid)	1	A	A	A	A
- Oxidizers (e.g. Nitric Acid)	2	C	C	B	C
INORGANIC BASES (e.g. Sodium hydroxide)	1	A	A	A	A
SALTS (e.g. Calcium chloride)	1	A	A	A	A
METALS (e.g. Cadmium)	1	A	A	A	A
KETONES (e.g. Methyl ethyl ketone)	3	C	C	B	C
OXIDIZERS (e.g. Hydrogen peroxide)	2	C	C	C	C

Chemical Effect (see discussion on Chemical Resistance)

1. No Effect—Most chemicals of this class have no or minor effect.
2. Oxidizer—Chemicals of this class will cause irreversible degradation.
3. Plasticizer—Chemicals of this class will cause a reversible change in physical properties.

Chart Rating

A. Most chemicals of this class have little or no effect on the liner.
Recommended regardless of concentration or temperature (below 150° F).

B. Chemicals of this class will affect the liner to various degrees.
Recommendations are based on the specific chemical, concentration and temperature.
Consult with Poly-Flex, Inc.

C. Chemicals of this class at high concentrations will have significant effect on the physical properties of the liner.
Generally not recommended but may be acceptable at low concentrations and with special design considerations.
Consult with Poly-Flex, Inc.

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POLYFLEX
POLYETHYLENE GEOMEMBRANES

GEOMEMBRANE MANUFACTURING QUALITY CONTROL & QUALITY ASSURANCE

Geomembrane
Manufacturing QC/QA

1. DEFINITIONS

Manufacturing Quality Control (MQC) is a planned system of routine inspections that is used to directly monitor and control the quality of a material.

Manufacturing Quality Assurance (MQA) is independent of the MQC and includes inspections, verifications, audits, and evaluations of materials and workmanship necessary to determine and document the quality of a material.

2. MANUFACTURING QUALITY CONTROL AND QUALITY ASSURANCE PROGRAM

2.1 Raw Material

Poly-Flex, Inc.'s quality control and quality assurance for HDPE and LLDPE geomembrane manufacturing starts with the testing of the raw materials. The resin manufacturers provide documentation confirming that the raw materials comply with Poly-Flex, Inc. specifications.

Resin manufacturers report the following properties with each resin shipment:

Density	This property is a measure of unit weight and is an indicator of the degree of crystallinity. It can be related to the material's chemical resistance, rigidity, permeability, tensile strength, and deformation characteristics.
Melt Index	This property is an indication of the molecular weight and rheological properties of the polymer and can be related to the processability.
Carbon Black Content (pre-compounded only)	The carbon black content is an important property to ensure protection against ultraviolet radiation. The raw materials may be pre-compounded with the carbon black. However, if resins are not pre-compounded, Poly-Flex, Inc. will supplement them with the appropriate quantity of carbon black before manufacturing liner.

2.1.1 Geomembrane Material Railcar Acceptance

All resins, additives and concentrates used in Poly-Flex geomembranes must have their physical integrity validated before they can be released into the production material stream. All incoming railcars are sampled; incoming materials not delivered by railcar are statistically sampled. Upon verification of the resin compliance with the specifications, the resin is pumped from the railcar into the silos dedicated to the production of the geomembrane.

1. Resin samples are taken from each of the four payload compartments in an incoming railcar.
2. Resin samples are sent to the laboratory. Using state of the art equipment, highly trained Quality Assurance personnel test the resin to ensure that it meets the specifications for producing Poly-Flex geomembranes. The following tests are performed and compared against Poly-Flex specifications:

Property	Resins	Additives & Concentrates
Density (ASTM D 1505)	•	
Melt Index (ASTM D 1238)	•	
Carbon Black Content (ASTM D 1603)		•
Oxidative Induction Time (ASTM D 3895)	•	•

3. After meeting production specifications, the resin is pumped from its railcar into a silo dedicated to that material.
4. Off-spec material is returned to the vendor.

Applicable Test Methods

American Society for Testing and Materials (ASTM)

ASTM D 792	Specific gravity (relative density) and density of plastics by displacement
ASTM D 1004	Initial tear resistance of plastic sheeting
ASTM D 1238	Flow rates of thermoplastics by extrusion plastometers
ASTM D 1505	Density of plastics by the Density-Gradient technique
ASTM D 1603	Carbon black in olefin plastics
ASTM D 1898	Sampling of plastics
ASTM D 3895	Test method for oxidative induction time of polyolefins by thermal analysis
ASTM D 4833	Index Puncture Resistance of geotextiles, geomembranes and related products
ASTM D 5199	Test method for measuring nominal thickness of geotextiles and geomembrane
ASTM D 5323	Determination of 2% secant modulus for polyethylene geomembranes
ASTM D 5397	Procedure to perform a single point notched constant tensile load - Appendix (SP-NCTL) test
ASTM D 5596	Test method for microscopic evaluation of the dispersion of carbon black in polyolefin geosynthetics
ASTM D 5617	Multi-axial tension test for geosynthetics
ASTM D 5721	Practice for air-oven aging of polyolefin geomembranes
ASTM D 5885	Test method for oxidative induction time of polyolefin geosynthetics by high pressure differential scanning calorimetry
ASTM D 5994	Test method for measuring the core thickness of textured geomembranes
ASTM D 6392	Determining the integrity of nonreinforced geomembrane seams produced using thermo-fusing methods
ASTM D 6693	Determining tensile properties of nonreinforced polyethylene and nonreinforced flexible polypropylene geomembranes

Geosynthetic Research Institute (GRI) Standards

GM 10	Specification for the stress crack resistance of geomembrane sheet
GM 11	Accelerated weathering of geomembranes using a florescent UVA-condensation exposure device
GM 12	Measurement of the asperity height of textured geomembranes using a depth gauge

Addendum to Test Procedures

The following are modifications or clarifications to test procedures.

1. Specifications are based on the average of Machine Direction (MD) and Cross Direction (XMD) values.
2. Specimens shall be taken uniformly across the width of the sheet as stated in ASTM D 1898.

3. MANUFACTURING

3.1 Blown Sheet Process

Polyethylene resin is pumped directly from storage silos or from totes on the floor to hoppers above the extruder.

Hoppers feed resin into the extruder. The resin is heated to the melting point in the extruder barrel. It is conveyed through the barrel by the rotation of a specially designed screw which, in conjunction with heating elements along the barrel, provides consistency to produce a molten polymer stream.

The molten material is forced through a screen pack, which act as a final filter for impurities or contaminants, and up through a die. It extrudes from the circular die as a film tube ("bubble"), pulled vertically by a set of nip rollers located at the top of a cooling tower. An IBC (Internal Bubble Cooling) unit, part of the extruder, maintains consistent bubble diameter. Material gauge is monitored and maintained by a computer system which controls the operation of the extruder.

At the top of the tower the bubble passes through a collapsing frame and is pulled through the nip rollers. The material is directed back toward the ground, and continues cooling as it approaches a winding machine. Before being taken up by the winder, the tube is split and spread to its deployable width. The winder rolls the finished geomembrane onto a specially made heavy-duty core.

3.2 Process Quality Control

Poly-Flex geomembranes are manufactured via the blown sheet process. This is a continuous process. The key elements to successfully producing a high-quality liner is to maintain consistency in both the raw material and the process. As described above, raw material consistency is established in the laboratory when the resin is initially received. Consistency during the processing is assured by an on-line quality control monitor. This representative of the quality department has been specially trained to monitor the process and the liners during the manufacturing process.

The extrusion process starts with the verification of the formulation. This is done at the beginning of each order or blend change by the extrusion manager and then is continuously monitored by the on-line quality control representative.

The process conditions during manufacturing have been optimized for each resin formulation. These conditions are kept in a log book which is available to the line operator. These process conditions must be maintained throughout the production run. Any variation of process parameters from the set point range recorded on the process log book are immediately reported to the production supervisor by the on-line quality control representative. If the variation exceeds the control range, the quality control representative places the material being produced on hold. Materials are placed on hold until the process is brought under control.

The on-line quality monitor can also place material on hold if the material has any visual defect (holes, water spots, or scratches) or dimensional abnormalities (width, length, and thickness).

All materials placed on hold will be further inspected and tested. If the material passes specification and is approved by the quality control manager and/or production manager, the material will then be released into stock. If the material fails to pass specification or does not get approval of either the quality control manager or production manager then the material will be reclassified or scrapped. In either case it cannot be sold as a prime Poly-Flex geomembrane.

Poly-Flex geomembranes are continuously monitored for pinholes during the manufacturing process by spark testing equipment. The spark tester unit is a perpetual monitor of any holes that could surface in the sheet. The spark tester monitors the entire layflat width of the sheet as it is being manufactured. The detector operates from a 120 V AC power supply. The 120 volts are transformed to a higher voltage that ranges from 0-24 kilovolts. The electrode is made up of a long semiconductor blanket that is positioned to lay over the sheet as it passes over a steel roller prior to final winding. A grounding conductor is connected to the roller with a return line to the controller. If a hole passes under the electrically charged blanket, the voltage will arc to the steel roller and the detection system will sense the voltage drop, thus triggering an audible alarm and shutting down the winder. Twice per shift, the quality control technician tests the spark tester by introducing a 1/32" pinhole in the sheet. This hole is at the end of a roll after the scheduled footage has been achieved. The winder continues to run until the hole is detected. Once the hole is detected, the alarm sounds and the winder shuts down. The quality control. technician restarts the winder and cuts out the entire layflat area of the pinhole.

After a roll of material has been produced it is labeled and a retain is cut for laboratory evaluation.

3.3 Roll Labeling

Three labels are affixed to each roll, as described below:

1. One label on the outside of the core.
2. One label on the core plug.
3. One label on the roll surface.

An additional label is attached to the laboratory sample.

3.4 Storage, Staging and Shipping of Geomembrane Rolls

Finished rolls (verified and labeled) are moved to the storage area using a specially designed cart and remain in storage until a Purchase Order is received. Rolls selected for shipment are moved to a staging area, where they are held for a truck. Before loading the order for shipment, all documentation is checked against the information on the roll labels. Rolls are lifted and moved using a loading arm equipped with rigging and hooks. Fork-lifting machinery are never to be used to lift or move geomembrane rolls.

3.5 Laboratory Quality Control & Quality Assurance

Based on the philosophy that quality cannot be inspected into a product and that a consistent raw material and a consistent process will yield a consistent liner, laboratory testing of Poly-Flex geomembrane is provided primarily for roll certification.

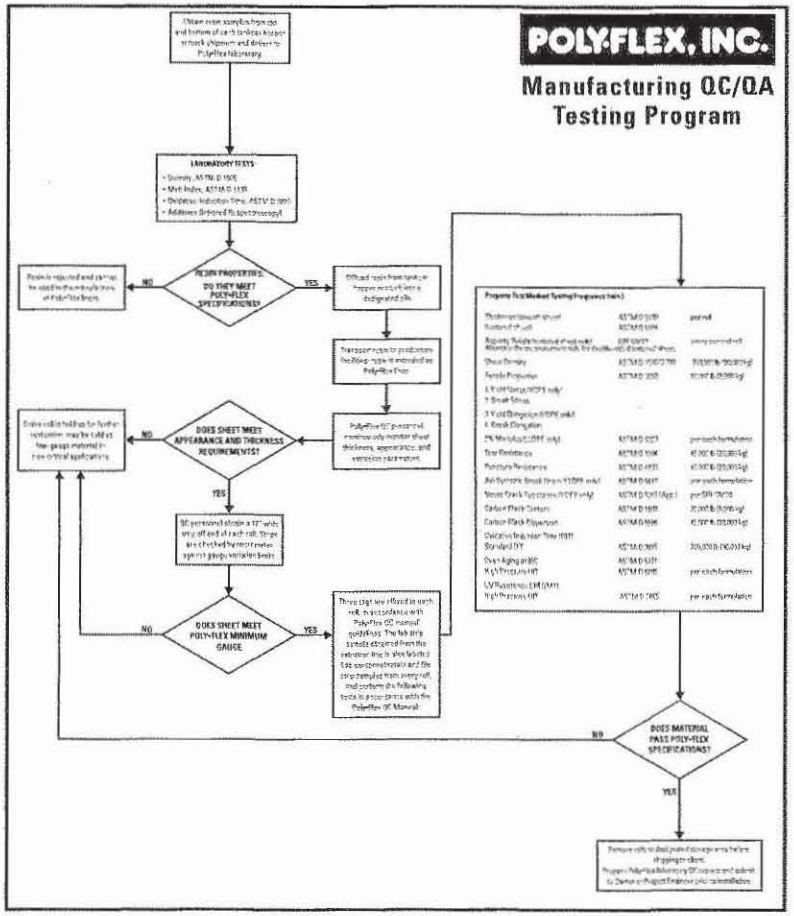
A retain from each roll is provided for the laboratory. Testing is conducted on the retains as indicated below.

Property	Test Method	Testing Frequency (min.)
Thickness (smooth sheet) (textured sheet)	ASTM D 5199 ASTM D 5994	per roll
Asperity Height (textured sheet only) Alternate the measurement side for double-sided textured sheet.	GRI GM12	every second roll
Sheet Density	ASTM D 1505/D 792	200,000 lb (90,000 kg)
Tensile Properties 1. Yield Strength (HDPE only) 2. Break Strength 3. Yield Elongation (HDPE only) 4. Break Elongation	ASTM D 6693	20,000 lb (9,000 kg)
2% Modulus (LLDPE only)	ASTM D 5323	per each formulation
Tear Resistance	ASTM D 1004	45,000 lb (20,000 kg)
Puncture Resistance	ASTM D 4833	45,000 lb (20,000 kg)
Axi-Symetric Break Strain (LLDPE only)	ASTM D 5617	per each formulation
Stress Crack Resistance (HDPE only)	ASTM D 5397 (App.)	per GRI GM10
Carbon Black Content	ASTM D 1603	20,000 lb (9,000 kg)
Carbon Black Dispersion	ASTM D 5596	45,000 lb (20,000 kg)
Oxidative Induction Time (OIT) Standard OIT	ASTM D 3895	200,000 lb (90,000 kg)
Oven Aging at 85°C High Pressure OIT	ASTM D 5721 ASTM D 5885	per each formulation
UV Resistance High Pressure OIT	GRI GM11 ASTM D 5885	per each formulation

After the testing has been completed, the data is reviewed by the quality control manager. If any rolls do not meet specifications, additional testing is conducted on that roll. If the roll still does not meet specifications the production manager is notified and the roll is placed on hold.

After the data has been reviewed it is entered into a product file which is used for roll certification.

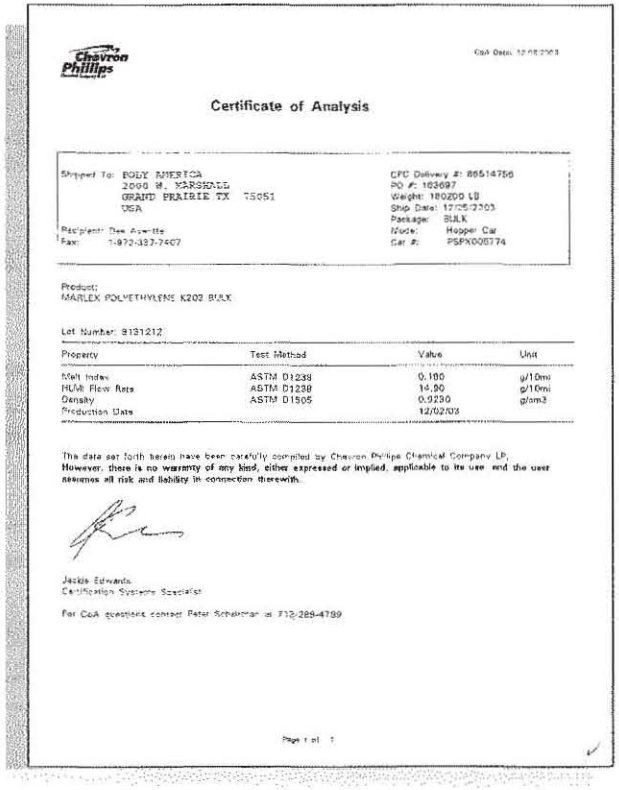
4. MANUFACTURING QUALITY CONTROL PROGRAM FLOW CHART



5. PAPER FLOW FORMS

5.1 Product Quality Report

This report documents the raw material manufacturer's test results for the physical properties of the incoming resin. Each incoming shipment to Poly-Flex is accompanied by such a report. A copy of this report is sent to the engineer/client with the finished product.



Chevron Phillips

CoA Date: 12/02/03

Certificate of Analysis

Shipped To: POLY AMERICA
2000 N. KARGOLD
GRAND PRAIRIE TX 75051
USA

Recipient: Dee Aswette
Fax: 1-972-337-7407

CPC Delivery #: 86514756
PO #: 103697
Weight: 180200 LB
Ship Date: 12/05/2003
Package: BULK
Mode: Hopper Car
Car #: PSPX005774

Product:
MARLEX POLYETHYLENE K203 BULK

Lot Number: 9131212

Property	Test Method	Value	Unit
Melt Index	ASTM D1238	0.100	g/10min
HLMI Flow Rate	ASTM D1238	14.90	g/10min
Density	ASTM D1505	0.9230	g/cm3
Production Date		12/02/03	

This data set forth herein have been carefully compiled by Chevron Phillips Chemical Company LP. **However, there is no warranty of any kind, either expressed or implied, applicable to its use and the user assumes all risk and liability in connection therewith.**

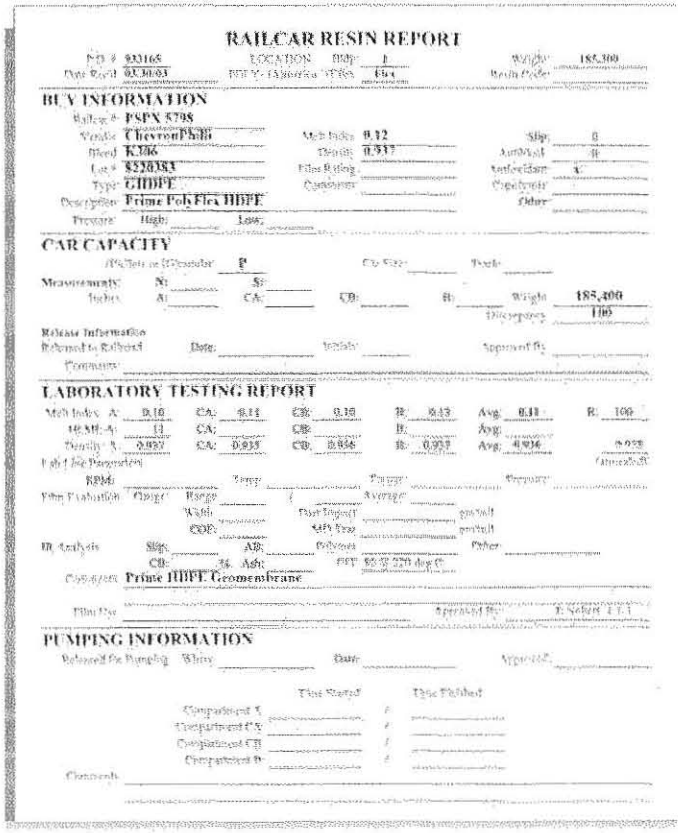
Jackie Edwards
Certification Systems Specialist

For CoA questions contact Peter Schaltman at 713-289-4799

Page 1 of 1

5.2 Railcar Resin Report

This report is used by Poly-Flex's laboratory to document results of tests performed on incoming raw material. These results are checked against Poly-Flex's raw material specifications and the Product Quality Report issued by the material manufacturer.



RAILCAR RESIN REPORT

PO # 93165 LOCATION Bldg: 1 Weight: 185,300
Date Rec'd 03.30.03 POLY-FLEX Office Bldg Resin Order

BUY INFORMATION

Railcar # PSPX 5798
Vendor Chevron Phillips Melt Index 0.12 Slip: 0
Blend K206 Density 0.917 AntiStat: N
Lot # 8220383 Film Rolling: Antioxidant: N
Type: GHDPE Comments: Checkout:
Description Prime Poly Flex HDPE Other:
Pressure: High: Low:

CAR CAPACITY

Hatches or Manways: P Car Cap: Tank:
Measurements: N: S:
Inches A: CA: CB: B: Weight 185,300
Discrepancy 100

Release Information
Released to Railroad Date: Initials: Approved By:
Comments:

LABORATORY TESTING REPORT

Melt Index A: 0.10 CA: 0.11 CB: 0.10 B: 0.13 Avg: 0.11 R: 100
HLMI A: 13 CA: CB: B: Avg:
Density A: 0.917 CA: 0.915 CB: 0.916 B: 0.917 Avg: 0.916 0.918
Light Fee Properties Calculated
RPM: Temp: Pressure: Pressure:
Film Evaluation Gauge: Range: Average:
Width: Dart Impact: gram/mil
COF: MD Tear: gram/mil
IR Analysis Slip: AB: Odorant: Other:
CB: % Ash: PPM: 00.00 220 deg C
Comments Prime HDPE Geomembrane
Film Dye Approved By: Initials

PUMPING INFORMATION

Released for Pumping Time: Date: Approved:

	Time Started	Time Finished
Compartment A	/	
Compartment CA	/	
Compartment CB	/	
Compartment B	/	

Comments

5.3 Quality Control Report

This report is sent to the engineer/client as Poly-Flex, Inc's standard quality control report. It documents the property values of the specific rolls shipped to a project.

CERTIFICATION SHEET DATE: _____ **POLY-FLEX, INC.**
2000 W. Marshall Drive
Grand Prairie, Texas 75051

PROJECT NO: _____ ORDER NO: _____
TRIP NO: _____ CERTIFIED BY: _____

TEST DESCRIPTION		THICKNESS	CARBON BLACK	TEAR	PUNCTURE	TENSILE@ YIELD	ELONG @ YIELD	TENSILE@ BREAK	ELONG @ BREAK	CAR. BLK. DISPERSION	DENSITY	NCTL
ASTM METHOD		D5199	D1603	D1004	D4833	D6693	D6693	D6693	D6693	D5596	D1505	D5397
(modifications)		min/avg										Appendix
UNITS		mils	%	lb	lb	lb/in	%	lb/in	%		g/cc	hours
SPECIFICATION												
ROLL NUMBER	BLEND											

5.4 Hold Tag

During production, any roll found to be defective is tagged and immediately removed. The roll will not be released for shipment, but it will be studied to determine the cause of the defect.

HOLD

**FOR QUALITY DEPARTMENT EVALUATION.
DO NOT SEND THIS MATERIAL TO WAREHOUSE.**

DATE _____ SHIFT _____
TIME _____ FILM LINE _____
QA INSP _____ ROLL NO. _____
PRODUCT CODE _____
REASON PRODUCT BEING HELD _____

QUALITY DEPARTMENT ASSESSMENT

DATE _____
AUTHORIZATION _____
_____ RELEASE
_____ SCRAP
INSTRUCTIONS _____

POLY-FLEX
POLYETHYLENE GEOMEMBRANES

DRAINAGE NET AND GEOCOMPOSITE MANUFACTURING QUALITY CONTROL & QUALITY ASSURANCE

Net/geocomposite
Manufacturing QC/QA

1. MANUFACTURING QUALITY CONTROL AND QUALITY ASSURANCE

This section describes the manufacturing quality control and quality assurance for Poly-Flex drainage net and geocomposite products.

1.1 Applicable Test Methods

American Society for Testing and Materials (ASTM)

ASTM D 1505	Density of plastics by the density-gradient technique
ASTM D 1603	Carbon black in olefin plastics
ASTM D 4355	Deterioration of geotextiles by exposure to light, moisture and heat in Xenon Arc type apparatus
ASTM D 4491	Water permeability of geotextiles by the permittivity method
ASTM D 4533	Trapezoid tearing strength of geotextiles
ASTM D 4632	Breaking load and elongation of geotextiles (grab method)
ASTM D 4716	Determining the (in-plane) flow rate per unit width and hydraulic transmissivity of geosynthetics using constant head
ASTM D 4751	Determining apparent opening size of geotextiles
ASTM D 4833	Index puncture resistance of geotextiles, geomembranes, and related products
ASTM D 5199	Measuring nominal thickness of geotextiles and geomembranes
ASTM D 5261	Measuring mass per unit area of geotextiles
ASTM D 7005	Determining the bond strength ply adhesion of geocomposites
ASTM D 7179	Determining geonet breaking force

2. RAW MATERIAL

All resins, additives and concentrates used in Poly-Flex drainage net must meet Poly-Flex specifications before being released into the production material stream. Resin samples are taken from each incoming railcar. The resin density, melt index and carbon black content (for precompounded resins) are determined in the Poly-Flex laboratory. Upon verification of the resin compliance with the specifications, the resin is pumped from its railcar into a silo dedicated to production of the drainage net.

3. MANUFACTURING

3.1 Drainage Net

Poly-Flex drainage net consists of approximately 97% polyethylene, 1.5 to 3.0% carbon black, and other additives. The drainage net is continuously monitored during the manufacturing process. The key element to successfully manufacturing high quality drainage nets is to maintain consistency in both the raw material and the process. Raw material consistency is established in the laboratory when the resin is initially received and tested. An on-line quality control monitor establishes consistency during the processing. This representative of the quality department has been specially trained to monitor the process and the products during the manufacturing process. The on-line quality monitor can place material on hold if the material has any visual defects or dimensional abnormalities. All materials placed on hold will be further inspected and tested. If the material passes specification and is approved by the quality control manager and/or production manager, the material will then be released into stock. If the material fails to pass the specification or does not get approval of the quality control manager or production manager then the material will be reclassified or scrapped. In either case it cannot be sold as a prime Poly-Flex drainage net.

3.2 Drainage Net/Geotextile Geocomposite

Poly-Flex geocomposites consist of a geotextile bonded to one or both sides of the Poly-Flex drainage net. All geotextiles must meet the specifications before being eligible for production of geocomposites. Poly-Flex utilizes a heat bonding process to laminate the geotextile to the drainage net. An on-line quality control monitor establishes consistency during the processing. This representative of the quality department has been specially trained to monitor the process and the products during the lamination process. The on-line quality monitor can place material on hold if the material has any visual defects or dimensional abnormalities. All materials placed on hold will be further inspected and tested. If the material passes specification and is approved by the quality control manager and/or production manager, the material will then be released into stock. If the material fails to pass the specification or does not get approval of the quality control manager or production manager then the material will be reclassified or scrapped. In either case it cannot be sold as a prime Poly-Flex geocomposite.

3.3 Roll Labeling

Three labels are affixed to each roll as described below:

1. One label on the inside of the core.
2. One label on the face on the roll.
3. One label on the end of the roll.

An additional label is attached to the laboratory sample.

3.4 Storage, Staging and Shipping of Drainage Net and Geocomposite Rolls

All drainage net and geocomposite rolls are stretch wrapped prior to moving them to the storage area. Before shipment, all documentation is checked against the information on the roll labels. A full truckload consists of 24 rolls of drainage net and/or geocomposite material.

3.5 Laboratory Testing Program

3.5.1. Drainage Net

A 15 inch wide sample is cut across the width of every 10th roll and brought to the Poly-Flex laboratory for testing. The sample is checked for visual defects and then tested according to the following:

Property	Test Method	Testing Frequency
Thickness	ASTM D 5199	50,000 sf
Density	ASTM D 1505	50,000 sf
Carbon Black Content	ASTM D 1603	50,000 sf
Tensile Strength	ASTM D 7179	50,000 sf
Transmissivity[1]	ASTM D 4716	100,000 sf

The laboratory manager reviews all test results to insure the product meets the specification. Any roll that does not meet the specification is immediately reported to the on-line quality control manager and the roll(s) is placed on hold for further evaluation.

3.5.2. Geotextile

The manufacturer of the geotextile shall submit quality control test results for the geotextile rolls. The rolls must meet the specifications before they are accepted for production of geocomposites.

The geotextile manufacturer shall perform the following tests:

Property	Test Method	Testing Frequency
Unit Weight	ASTM D 5261	100,000 sf
Grab Strength	ASTM D 4632	100,000 sf
Grab Elongation	ASTM D 4632	100,000 sf
Tear Strength	ASTM D 4533	100,000 sf
Puncture Resistance	ASTM D 4833	100,000 sf
Permittivity	ASTM D 4491	500,000 sf
AOS	ASTM D 4751	500,000 sf
UV Stability	ASTM D 4355	Manufacturer Historical Data

3.5.3. Geocomposite

A 15 inch wide sample is cut across the width of every 20th roll and brought to the Poly-Flex laboratory for testing. The sample is checked for visual defects and then tested according to the following:

Property	Test Method	Testing Frequency
Transmissivity[1]	ASTM D 4716	100,000 sf
Ply Adhesion	ASTM D 7005	100,000 sf

1. Transmissivity test is performed with the drainage net or the geocomposite between two metal plates at a hydraulic gradient of 1.0 and a normal pressure of 10,000 psf (480 kPa). The seating time is 15 minutes.

The laboratory manager reviews all test results to ensure the product meets the specification. Any roll that does not meet the specification is immediately reported to the on-line quality control manager and the roll(s) is placed on hold for further evaluation.

3.6 Quality Control Report

The following reports are sent to the engineer/client as Poly-Flex, Inc.'s standard quality control reports. They document the property values of the specific rolls shipped to the project.

3.6.1 Drainage Net Certification Sheet

CERTIFICATION SHEET DATE: _____ **POLY-FLEX, INC.**
2000 W. Marshall Drive
Grand Prairie, Texas 75051

PROJECT NO: _____ ORDER NO: _____
TRIP NO: _____ CERTIFIED BY: _____

TEST DESCRIPTION	THICKNESS	DENSITY	CARBON BLACK	PEAK TENSILE STRENGTH (MD)	TRANSMISSIVITY (MD)
ASTM METHOD	D5199	D1505	D1603	D7179	D4716
(modifications)	avg				
UNITS	mils	g/cc	%	lb/in	m²/s
SPECIFICATION					
ROLL NUMBER					

3.6.2 Geocomposite Certification Sheet

CERTIFICATION SHEET

DATE: _____

PROJECT NO: _____

ORDER NO: _____

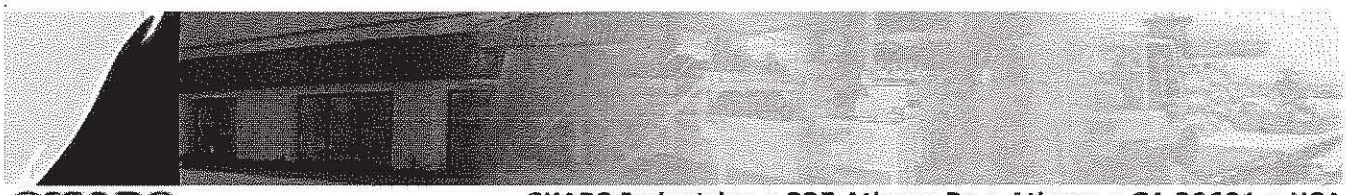
TRIP NO: _____

CERTIFIED BY: _____

POLY-FLEX, INC.
2000 W. Marshall Drive
Grand Prairie, Texas 75051

TEST DESCRIPTION				TRANSMISSIVITY (MD)	PLY ADHESION	
ASTM METHOD				D 4716	D 7005	
(modifications)					TOP	BOTTOM
UNITS				m^2/s	lb/in	lb/in
SPECIFICATION						
COMPOSITE ROLL NUMBER	GEONET ROLL NUMBER	GEOTEXTILE TOP	GEOTEXTILE BOTTOM			

POLY-FLEX, INC.
2000 West Marshall Drive
Grand Prairie, Texas 75051
888-POLYFLX (888-765-9359)
972-337-7113 Fax 972-337-7233
www.poly-flex.com



SKAPS Industries • 335 Athena Dr • Athens • GA 30601 • USA

DRAINAGE NET

SKAPS TRANSNET™ HDPE GEOCOMPOSITE WITH 220 MIL GEONET

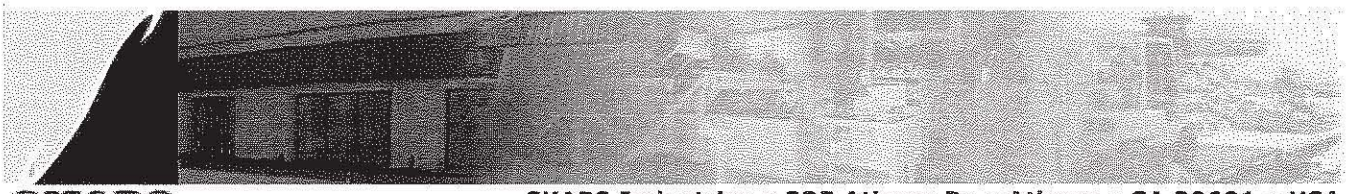
SKAPS TRANSNET™ GeoComposite consists of SKAPS GeoNet made from HDPE resin with non-woven polypropylene GeoTextile fabric heat bonded on both sides of GeoNet.

Property	Test Method	Unit	Required Value			Qualifier
			with 6 oz.	with 8 oz.	with 10 oz.	
GeoNet						
Mass per unit area	ASTM D 5261	lb/ft^2	0.17	0.17	0.17	Minimum
Thickness	ASTM D 5199	mil	220±20	220±20	220±20	Range
Carbon Black	ASTM D 4218	%	2 to 3	2 to 3	2 to 3	Range
Tensile Strength	ASTM D 5035	lb/in	45	45	45	Minimum
Melt Flow	ASTM D 1238[3]	g/10 min	1	1	1	Maximum
Density	ASTM D 1505	g/cm^3	0.94	0.94	0.94	Minimum
Transmissivity1	ASTM D 4716	m^2/sec	$1x10^{-3}$	$1x10^{-3}$	$1x10^{-3}$	MARV2
Composite						
Ply Adhesion (Minimum)	GRI GC7	m^2/sec	0.5	0.5	0.5	MARV
Ply Adhesion (Average)	GRI GC7	lb/in	1	1	1	MARV
Transmissivity[1a]	ASTM D 4716	m2/sec	$2.75x10^{-4}$	$2.25x10^{-4}$	$2.0x10^{-4}$	MARV
GeoTextile						
Fabric Weight	ASTM D 5261	oz/yd^2	6	8	10.0	MARV
Grab Strength	ASTM D 4632	lb	150	225	270	MARV
Grab Elongation	ASTM D 4632	%	50	50	50	MARV
Tear Strength	ASTM D 4533	lb	60	90	100	MARV
Puncture Resistance	ASTM D 4833	gpm/ft^2	95	130	165	MARV
Mullen Burst	ASTM D 3786[4]	psi	325	450	550	MARV
Water Flow Rate	ASTM D 4491	gpm/ft^2	125	100	75	MARV
Permittivity	ASTM D 4491	sec^{-1}	1.63	1.26	0.94	MARV
Permeability	ASTM D 4491	cm/sec	0.48	0.3	0.30	MARV
AOS	ASTM D 4751	US Sieve	70	80	100	MARV

Notes:

1. Transmissivity measured using water at 21 ± 2°C (70 ± 4°F) with a gradient of 1.0 and a confining pressure of 15000 psf between steel plates after 15 minutes. Values may vary between individual labs.

   [1a] Transmissivity measured using water at 21 ± 2°C (70 ± 4°F) with a gradient of 0.1 and a confining pressure of 10000 psf between steel plates after 15 minutes. Values may vary between individual labs.
2. MARV is statistically defined as mean minus two standard deviations and it is the value which is exceeded by 97.5% of all the test data.
3. Condition 190/2.16
4. Modified



SKAPS Industries • 335 Athena Dr • Athens • GA 30601 • USA

SKAPS GT-112
Nonwoven Geotextiles

SKAPS **GT-112** is a needle-punched nonwoven geotextile made of 100% polypropylene staple fibers, which are formed into a random network for dimensional stability. SKAPS GT-112 resists ultraviolet deterioration, rotting, biological degradation, naturally encountered basics and acids. Polypropylene is stable within a pH range of 2 to 13. SKAPS GT-112 conforms to the physical values listed below:

:: Go Back ::

PROPERTY	TEST METHOD	UNIT	M.A.R.V. (Minimum Average Roll Value)
Weight (Typical)	ASTM D5261	oz/yd^2 (g/m^2)	12.0 (407)
Grab Tensile	ASTM D4632	lbs (kN)	300 (1.33)
Grab Elongation	ASTM D4632	%	50
Trapezoid Tear Strength	ASTM D4533	lbs (kN)	115 (0.511)
Puncture Resistance	ASTM D4833	lbs (kN)	180 (0.80)
Mullen Burst	ASTM D3786	psi (kPa)	600 (4134)
Permittivity*	ASTM D4491	sec^{-1}	1.0
Water Flow*	ASTM D4491	gpm/ft^2 (l/min/m^2)	75 (3055)
A.O.S.*	ASTM D4751	U.S. Sieve (mm)	100 (0.150)
U.V. Resistance	ASTM D4355	%/hrs	70/500

* At the time of manufacturing. Handling, storage, and shipping may change these properties.

PACKAGING	
Roll Dimension (W x L) - Ft	12.5 x 360 / 15 x 300
Square Yards per Roll	500
Estimated Roll Weight - lbs	375

* At the time of manufacturing. Handling may change these properties.

This information is provided for reference purposes only and is not intended as a warranty or guarantee. SKAPS assumes no liability in connection with the use of this information.

ATTACHMENT #3
EPA 9090 LABORATORY TESTING ON LINER SYSTEM MATERIALS

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

May 30, 1997

Mr. Paul Barker
AGRU/America, Inc.
300 West Davis, Suite 520
Conroe, Texas 77305

Dear Mr. Barker:

TRI/Environmental, Inc. (TRI) is pleased to present this 120 Day Final Report for geosynthetic chemical compatibility studies via EPA Method performed on AGRU smooth 60 mil HDPE geomembrane.

TRI thanks AGRU/America for the opportunity to work on this project. Please call me if you have any questions or require any additional information.

Respectfully submitted,

Martin D. Nelson

Martin D. Nelson
Project Manager: Geosynthetic Technologies

cc: Mr. Sam R. Allen
Program Manager

9063 Bee Caves Road • Austin, TX 78733-6201 • (512) 263-2101 • FAX 263-2558 • 1-800-880-T-E-S-T

FOREWORD

The testing reported herein is based upon accepted industry practice as well as the test method listed. TRI/Environmental Inc. (TRI) neither accepts responsibility for nor makes claim as to the final use and purpose of the materials tested.

Tests were performed under laboratory conditions and not under actual usage conditions. TRI can give no conclusions as to the serviceability, life expectancy or general durability of the products tested when used in a lining and/or leachate collection system.

A 120 Day Final Report:

Laboratory Testing of Geosynthetics
for Waste Containment
EPA Method 9090

May 1997

Submitted to:
AGRU/America, Inc.
300 West Davis, Suite 520
Conroe, Texas 77305

Attn: **Mr. Paul Barker**

Submitted by:

TRI/Environmental, Inc.
9063 Bee Caves Rd.
Austin, Texas 78733

1.0 INTRODUCTION

This report describes the work performed by TRI/Environmental, Inc. (TRI) to determine the chemical compatibility of one geomembrane product with one waste leachate. The objective was to determine the resistance of the geomembrane to changes caused by exposure to leachate. Changes in physical and mechanical properties were measured after exposure to the leachate at 23°C and 50°C for 30, 60, 90 and 120 days. Exposures were performed in accordance with the exposure regimen specified in United States Environmental Protection Agency (EPA) Method 9090A.

Methods, results and discussion are provided in the sections which follow. Test results are provided in the Tables of Results which accompany this report.

2.0 METHODS

2.1 Materials

The material selected for evaluation in this chemical compatibility study was 60 mil smooth High Density Polyethylene (HDPE) geomembrane manufactured by Agru/America, Inc. Roll #638571 was provided by Agru/America.

2.2 Leachate

The exposure leachate used during the testing was a synthetic municipal solid waste (MSW) leachate. TRI generated the synthetic municipal waste leachate by spiking a quantity of actual MSW leachate (secured from the NENT Landfill in Hong Kong) with various chemical constituents as required by the Pennsylvania Department of Environmental Regulation (PADER). Spiking was accomplished using standard solutions used for instrument calibration for organics and salts used for the inorganics. Spiking was performed to assure a minimum concentration as defined by the PADER requirements. The exposure media met all requirements as defined by PADER.

After spiking, the leachate, contained in a fifty-five gallon drum, was stirred for twenty four hours and allowed to settle. Leachate was then transferred to exposure cells for chemical resistance testing.

2.3 Exposure Conditions

Geomembrane specimens were exposed to the waste leachate following the specifications of EPA Method 9090A as they relate to exposure to waste fluids. The tanks used for these exposures were maintained at 23 ± 2°C and 50 ± 2°C throughout the 120-day exposure period. Tanks were constructed from chemically resistant glass, fitted with stirrers and heated with a circulating hot

water heat exchanger system. The 50°C tanks were sealed with a lid, and a reflux condenser was installed to minimize loss of volatile leachate components.

2.4 Testing Procedures

Table 2 lists tests performed on the geomembrane. The number of test replicates was doubled for baseline determinations on unexposed material.

Table 2. Tests performed on geomembranes

Test or Physical Property	Method	Number of replicate specimens
Dimensions and weight	EPA 9090	3 readings
Hardness	ASTM D 2240 D scale	5
Volatiles and Extractables	EPA SW 870 Appendix III	2
Specific Gravity	ASTM D 792	3
Tensile Properties	ASTM D 638	3
Modulus of Elasticity	ASTM D 882 Tangential Modulus	3
Hydrostatic Resistance	ASTM D 751 Method A	3
Tear Strength	ASTM D 1004	3
Puncture Resistance	FTMS 101C Method 2065	3
Environmental Stress Crack Resistance	ASTM D 1693	2

Where appropriate testing was performed in both the machine and transverse directions.

3.0 Results and Discussion

Test results are presented in the Test Results section which is included with this report. Test results are presented in tabular form as well as graphical form.

In considering these results, it must be determined through engineering judgment whether observed differences in the value of test results measured before and after immersion are due to product variability, unidentified factors relating to the test procedure, or leachate interaction with the products. Any significant chemical interaction with leachate would be expected to result in degradation trends which are consistent across the various properties being evaluated, and not isolated to one set of test results only. However, with each type of material there may be specific properties which are highly sensitive to leachate-induced effects. These factors must be considered in evaluating the various test results for a given product.

Also of critical importance is the issue of product variability. With geomembranes, a range of physical and mechanical index test values covering 15% or more of the average is not uncommon. This can be traced to variability inherent in the product, and the randomness associated with the onset of failure under the specified testing conditions. However, in chemical compatibility testing the statistical sampling of a broad range of manufactured product is not possible. Therefore, the small size of the sample population tested at each time point must be taken into consideration. The criteria to be applied in evaluating data measured before and after leachate immersion should be that property changes, if observed, are consistent and so great that product variability and experimental factors can be ruled out.

In this report, standard deviations (STD) are reported for most measurements involving three or more replicate specimens. In statistics, the standard deviation is defined as root of the mean squared deviations of individual test results about the mean value. The standard deviation is a quantitative measure of variability within a group of measurements.

One related measure of variability observed within a sample set, relative to the magnitude of the mean value itself, is the *coefficient of variation or variance* (COV). The coefficient of variance is defined as the standard deviation divided by the mean associated with a group of specimens, and may be expressed as a percentage. The COV provides an indication of what proportion of the mean value may be attributable to random experimental factors or product variability. It is useful to consider apparent changes in property values against the criterion of COV since observed changes which fall below the COV may not be significant. This approach was used in preparing the tables in the next sections.

The term *range* refers to the difference between the extreme highest and lowest points within a group of measured values. Considering range as a percentage of the mean values provides another measure of variability within a dataset.

In the tables, the high and low extremes for percentage change in mean values are listed for comparison against COV and range as a percentage of mean from the baseline sample group. The high and low percentage changes are the extremes from data measured at 30, 60, 90 and 120 days.

Agru/America 60 mil smooth HDPE Geomembrane

Table 3 illustrates the range of variability in baseline data compared with some of the observed changes in average test values measured after immersion for the HDPE geomembrane.

Table 3. Baseline coefficients of variation and range of percentage change results for Agru/America 60 mil HDPE Geomembrane (mechanical properties testing only)

Test	Baseline COV (%)*	Baseline Range as % of Mean*	High Observed % Change	Low Observed % Change
Stress @ yield (MD)	3	8	+5	-6
Elongation @ yield (MD)	5	12	+20	+1
Stress @ break (MD)	5	14	+14	-13
Elongation @ break (MD)	4	11	+8	-18
Tangential Modulus (MD)	4	12	+9	-6
Tear Strength (MD)	2	6	+4	-2
Puncture Resistance	2	6	+8	0
Hydrostatic Resistance	2	5	+4	0

* Note that the greatest baseline change for the four exposure periods was reported.

4.0 CONCLUSION

Changes in certain measured physical and mechanical properties were noted for the geomembrane. However, the observed changes were random and are believed to be the effects of product variability and experimental factors. In the opinion of the authors, the data, considered together, support the conclusion that observed changes were not caused by exposure to the test leachate.

TRI/Environmental, Inc. is pleased to have been selected to participate in this project. We trust that the information provided in this report meets your requirements for technical documentation of this chemical compatibility study. Please do not hesitate to call if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen
Program Manager
Geosynthetics Technologies

TRI/Environmental, Inc.

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

Analysis: March 02-27, 1999

Analytes	LOQ (ug/L)	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Organics: SW 846 Methods 624, 625, 608			
Acenaphthene	10	ND	113
Acenaphthylene	25	ND	67
Anthracene	10	ND	52
Benzene	10	ND	811
Benzo(a)anthracene	10	ND	28
Benzo(a)pyrene	10	ND	52
Benzo(ghi)perylene	10	ND	45
Benzo(k)flouranthene	50	ND	33
3,4-benzofluoranthene	25	ND	49
Chrysene	10	ND	52
Dibenzo(a,h)anthracene	10	ND	48
Ethyl benzene	10	ND	2600
Fluoranthene	10	ND	54
Fluorene	10	ND	52
Indeno(1,2,3,c,d)pyrene	50	ND	63
Naphthalene	10	ND	288
Phenanthrene	10	ND	65
Pyrene	10	ND	45
Styrene	10	ND	170
Toluene	10	ND	15000
Xylenes	10	ND	280
PCBs	10	ND	ND
Aldrin	10	ND	ND
1,2-Dichlorobenzene	10	ND	1200
1,4-Dichlorobenzene	10	ND	700
Hexachlorobenzene	10	ND	300
Pentachlorobenzene	10	ND	170
Trichlorobenzene**	50	ND	160
Tetrachlorobenzene**	10	ND	150
2-chloronaphthalene	10	ND	100
Chlorobenzene	10	ND	19000
4,4-DDT	10	ND	ND
4,4-DDE	50	ND	ND
4,4-DDD	10	ND	ND

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

Analysis: March 02-27, 1999

Analytes	LOQ (ug/L)	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Organics: SW 846 Methods 624, 625, 608 (Continued)			
Heptane	10	ND	70
Hexane	10	ND	70
Octane	10	ND	60
Bromoform	10	ND	1200
Carbon tetrachloride	25	ND	500
Chlorodibromomethane	10	ND	30
Chloroethane	10	ND	1000
Chloroform	10	ND	6800
Dichlorobromomethane	10	ND	140
Dichlorodifluoromethane	30	ND	600
1,1-Dichloroethane	50	ND	10300
1,2-Dichloroethane	25	ND	16050
Dichloropropane	10	ND	1300
cis-Dichloroethene	10	ND	350
trans-Dichloroethene	40	ND	700
Ethylene dichloride *12DCA	10	ND	ND
Hexachloroethane	10	ND	600
Methyl bromide	50	ND	120
Methyl chloride	10	ND	120
Methylene chloride	50	ND	12000
Tetrachloroethene	50	ND	700
Tetrachloroethane**	50	ND	800
1,1,1-Trichloroethane	10	ND	900
1,1,2-Trichloroethane	10	ND	500
Trichloroethene	10	ND	800
Trichlorofluoromethane	10	ND	75
Vinyl chloride	10	ND	185

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

Analysis: March 02-27, 1999

Analytes	LOQ (ug/L)	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Organics: SW 846 Methods 624, 625, 608 (Continued)			
Acrolein	10	ND	345
Acrylonitrile	25	ND	45
Acetone	10	ND	15000
Amyl acetate	10	ND	70
Benzidine	10	ND	70
Butyl alcohol**	10	ND	220
Bis(2-chloroethoxy)methane	10	ND	32
Bis(2-chloroethoxy)ether	50	ND	70
Bis(2-chloroisopropyl)ether	25	ND	70
Bis(2-ethylhexyl)phthalate	10	ND	900
4-bromophenyl phenyl ether	10	ND	60
Butyl benzyl phthalate	10	ND	200
cresol**	10	ND	425
Chlordane	10	ND	ND
alpha-BHC	50	ND	ND
beta-BHC	10	ND	ND
gamma-BHC	10	ND	ND
delta-BHC	10	ND	ND
Dieldrin	10	ND	ND
Dichlorobenzidine	10	ND	100
Diethyl phthalate	10	ND	30
Dibutyl phthalate	10	ND	70
Dimethyl phthalate	10	ND	70
Isobutyl alcohol	10	ND	12000
Isopropyl alcohol	10	ND	200
Methyl alcohol	10	ND	160
2-chloroethyl vinyl ether	10	ND	700
2-chlorophenol	50	ND	1400
Dichlorophenol**	10	ND	1300
Dimethyl phenol**	10	ND	50
Dinitro-o-cresol	10	ND	60
Dinitrophenol**	10	ND	60
Dinitrotoluene**	10	ND	100
Diphenylhydrazine	10	ND	50
Ethyl acetate	10	ND	110
Ethyl ether	10	ND	100
Ethyl alcohol	10	ND	25000
Endosulfan	10	ND	50
Endrin	10	ND	19

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

Analysis: March 02-27, 1999

Analytes	LOQ (ug/L)	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Organics: SW 846 Methods 624, 625, 608 (Continued)			
Formaldehyde	10	ND	ND
Heptachlor	50	ND	ND
Hexachlorocyclopentadiene	10	ND	80
Haxachlorobutadiene	10	ND	500
Isophorone	10	ND	6000
Methyl ethyl ketone	10	ND	13500
Methyl isobutyl ketone	10	ND	750
Nitrophenol**	10	ND	20
N-nitrosodimethylamine	10	ND	120
N-nitrosodi-n-propylamine	10	ND	120
Nitrobenzene	10	ND	600
Pentachlorophenol	10	ND	450
Phenol	10	ND	15000
Pyridine	10	ND	700
Toluene	50	ND	1260
Toxophene	50	ND	300
Trichlorophenol**	10	ND	400
2,4,5-TP	10	ND	50
METALS (EPA Method 200 Series)			(mg/L)
Aluminum (202.1)	1	ND	15
Antimony (204.1)	1	ND	20
Arsenic (206.2)	1	ND	5
Barium (208.1)	1	ND	120
Beryllium (210.1)	1	ND	2
Boron (212.3)	1	ND	15
Cadmium (213.1)	1	ND	15
Chromium (218.1)	1	ND	10
Copper (220.1)	1	ND	10
Iron (236.1)	1	ND	800
Lead (239.1)	1	ND	10
Manganese (243.1)	1	ND	1000
Mercury (245.1)	1	ND	ND
Molybdenum (246.1)	1	ND	5
Nickel (249.1)	1	ND	ND
Silver (272.1)	1	ND	8
Selenium (270.2)	1	ND	ND
Tin (282.1)	1	ND	ND
Titanium (283.1)	1	ND	ND
Thallium (279.1)	1	ND	ND
Zinc (289.1)	1	ND	25
CONVENTIONALS (EPA Methods)			(mg/L)
Oil and Grease (413.1)	20	ND	500
Total petroleum hydrocarbons (418.1)	10	ND	9000
Ammonia-nitrogen (350.2)	50	ND	600
Cyanide (335.2)	15	ND	ND
Flouride (340.1-340.2)	15	ND	500
Chloride (325.3)	10	ND	8000
Nitrate (353.3)	1	ND	3
Nitrite (353.3)	1	ND	ND
Sulfate (375.4)	1	ND	250
TDS	1	ND	13400
pH	NA	ND	7.2

TRI GEOSYNTHETICS SERVICES DIVISION
PaDEP Leachate Analysis
Testing performed by TRI/Environmental, Inc.

QUALITY ASSURANCE REPORT

Analysis: March 02-27, 1999

Analytes	Blank (ug/L)	PaDEP Synthetic Leachate (ug/L)
Surrogate Recoveries		
1,2-Dichloroethane-d4	156%	124%
Toluene-d8	100%	95%
Bromofluorobenzene	117%	73%
Trifluorotoluene	120%	113%
2-Fluorophenol (Acid Surr)	110%	110%
Phenol-d6 (Acid Surr)	98%	123%
Nitrobenzene-d5 (BN Surr)	68%	74%
2-Fluorobiphenyl (BN Surr)	124%	102%
2,4,6-Tribomophenol (Acid Surr)	92%	76%
p-Terphenyl-d14 (BN Surr)	90%	96%

Compounds	Matrix Spike	Matrix Spike Dup
Phenol	17%	32%
2-Chlorophenol	30%	89%
1,4-Dichlorobenzene	26%	97%
N-Nitroso-Di-N-Propylamine	69%	105%
1,2,4-Trichlorobenzene	39%	86%
4-Chloro-3-Methylphenol	83%	100%
Acenaphthene	88%	120%
4-Nitrophenol	17%	13%
2,4-Dinitrotoluene	72%	96%
Pentachlorophenol	71%	73%
Pyrene	88%	118%
METALS		
Arsenic	90%	87%
Barium	98%	101%
Cadmium	92%	93%
Chromium	84%	86%
Lead	79%	80%
Mercury	94%	98%
Selenium	82%	89%
Silver		

A Final Report:

Laboratory Testing of Geomembrane for Waste Containment EPA Method 9090A

October 1999

Submitted to:

Poly-Flex Inc.
2000 W. Marshall Drive
Grand Prairie, Texas 75051

Attn: **Mr. Lou Jacobsen**

Submitted by:

TRI/Environmental, Inc.
9063 Bee Caves Rd.
Austin, Texas 78733

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

October 24, 1999

Mr. Lou Jaconsen
Poly-Flex, Inc.
2000 W. Marshall Drive
Grand Prairie, Texas 75051

Dear Mr. Jacobsen:

TRI/Environmental, Inc. (TRI) is pleased to present this Final Report for geomembrane chemical compatibility studies via EPA Method 9090A.

TRI thanks Poly-Flex, Inc. for the opportunity to participate in this project and trusts this report fully documents all testing performed. Please call me if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetic Services

9063 Bee Caves Road • Austin, TX 78733-6201 • (512) 263-2101 • FAX (512) 263-2558

1.0 INTRODUCTION

This report describes the work performed by TRI/Environmental, Inc. (TRI) to determine the chemical compatibility of one geomembrane product with one waste leachate. The objective was to determine the resistance of the geomembrane to changes caused by exposure to leachate. Changes in physical and mechanical properties were measured after exposure to the leachate at 23°C and 50°C for 30, 60, 90 and 120 days. Exposures were performed in accordance with the exposure regimen specified in United States Environmental Protection Agency (EPA) Method 9090A.

Methods, results and discussion are provided in the sections which follow. Test results are provided in the Tables of Results which accompany this report.

2.0 METHODS

2.1 Materials

The material selected for evaluation in this chemical compatibility study was 60 mil smooth high density polyethylene (HDPE) geomembrane manufactured by PolyFlex, Inc..

2.2 Leachate

The exposure leachate used during the testing was a synthetic municipal solid waste (MSW) leachate. TRI generated the synthetic municipal waste leachate by spiking a quantity of actual MSW leachate (secured from the NENT Landfill in Hong Kong) with various chemical constituents as required by the Pennsylvania Department of Environmental Regulation (PADER). Spiking was accomplished using standard solutions used for instrument calibration for organics and salts used for the inorganics. Spiking was performed to assure a minimum concentration as defined by the PADER requirements. The exposure media met all requirements as defined by PADER.

After spiking, the leachate, contained in a fifty-five gallon drum, was stirred for twenty four hours and allowed to settle. Leachate was then transferred to exposure cells for chemical resistance testing.

2.3 Exposure Conditions

Geomembrane specimens were exposed to the waste leachate following the specifications of EPA Method 9090A as they relate to exposure to waste fluids. The tanks used for these exposures were maintained at 23 ± 2°C and 50 ± 2°C throughout the 120-day exposure period. Tanks were constructed from chemically resistant glass, fitted with stirrers and heated with a circulating hot

water heat exchanger system. The 50°C tanks were sealed with a lid, and a reflux condenser was installed to minimize loss of volatile leachate components.

2.4 Testing Procedures

Table 1 lists tests performed on the geomembrane. The number of test replicates was doubled for baseline determinations on unexposed material.

Table 1. Tests performed on geomembranes

Test or Physical Property	Method	Number of replicate specimens
Dimensions and weight	EPA 9090	3 readings
Hardness	ASTM D 2240 D scale	5
Volatiles and Extractables	EPA SW 870 Appendix III	2
Specific Gravity	ASTM D 792	3
Tensile Properties	ASTM D 638	3
Modulus of Elasticity	ASTM D 882 Tangential Modulus	3
Hydrostatic Resistance	ASTM D 751 Method A	3
Tear Strength	ASTM D 1004	3
Puncture Resistance	FTMS 101C Method 2065	3
Environmental Stress Crack Resistance	ASTM D 1693	2

Where appropriate testing was performed in both the machine and transverse directions.

3.0 Results and Discussion

Test results are presented in the Test Results section which is included with this report. Test results are presented in tabular form as well as graphical form.

In considering these results, it must be determined through engineering judgment whether observed differences in the value of test results measured before and after immersion are due to product variability, unidentified factors relating to the test procedure, or leachate interaction with the products. Any significant chemical interaction with leachate would be expected to result in degradation trends which are consistent across the various properties being evaluated, and not isolated to one set of test results only. However, with each type of material there may be specific properties which are highly sensitive to leachate-induced effects. These factors must be considered in evaluating the various test results for a given product.

Also of critical importance is the issue of product variability. With geomembranes, a range of physical and mechanical index test values covering 15% or more of the average is not uncommon. This can be traced to variability inherent in the product, and the randomness associated with the onset of failure under the specified testing conditions. However, in chemical compatibility testing the statistical sampling of a broad range of manufactured product is not possible. Therefore, the small size of the sample population tested at each time point must be taken into consideration. The criteria to be applied in evaluating data measured before and after leachate immersion should be that property changes, if observed, are consistent and so great that product variability and experimental factors can be ruled out.

In this report, standard deviations (STD) are reported for most measurements involving three or more replicate specimens. In statistics, the standard deviation is defined as root of the mean squared deviations of individual test results about the mean value. The standard deviation is a quantitative measure of variability within a group of measurements.

One related measure of variability observed within a sample set, relative to the magnitude of the mean value itself, is the *coefficient of variation or variance* (COV). The coefficient of variance is defined as the standard deviation divided by the mean associated with a group of specimens, and may be expressed as a percentage. The COV provides an indication of what proportion of the mean value may be attributable to random experimental factors or product variability. It is useful to consider apparent changes in property values against the criterion of COV since observed changes which fall below the COV may not be significant. This approach was used in preparing the tables in the next sections.

The term *range* refers to the difference between the extreme highest and lowest points within a group of measured values. Considering range as a percentage of the mean values provides another measure of variability within a dataset.

In the tables, the high and low extremes for percentage change in mean values are listed for comparison against COV and range as a percentage of mean from the baseline sample group. The high and low percentage changes are the extremes from data measured at 30, 60, 90 and 120 days.

Poly-Flex 60 mil smooth HDPE Geomembrane

Table 2 illustrates the range of variability in baseline data compared with some of the observed changes in average test values measured after immersion for the HDPE geomembrane.

Table 2. Baseline coefficients of variation and range of percentage change results for PolyFlex 60 mil HDPE Geomembrane (mechanical properties testing only)

Test	Baseline COV (%)*	Baseline Range as % of Mean*	High Observed % Change	Low Observed % Change
Stress @ yield (MD)	2	5	+5	1
Elongation @ yield (MD)	2	6	+6	-1
Stress @ break (MD)	6	16	+7	-1
Elongation @ break (MD)	6	22	+4	-4
Tangential Modulus (MD)	13	33	+7	-9
Tear Strength (MD)	2	6	+1	-2
Puncture Resistance	2	4	+4	-3
Hydrostatic Resistance	1	3	+1	-3

* Note that the greatest baseline change for the four exposure periods was reported.

4.0 CONCLUSION

Changes in certain measured physical and mechanical properties were noted for the geomembrane. However, the observed changes were random and are believed to be the effects of product variability and experimental factors. In the opinion of the authors, the data, considered together, support the conclusion that observed changes were not caused by exposure to the test leachate.

TRI/Environmental, Inc. is pleased to have been selected to participate in this project. We trust that the information provided in this report meets your requirements for technical documentation of this chemical compatibility study. Please do not hesitate to call if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetics Technologies

TRI/Environmental, Inc.

FOREWORD

The testing reported herein is based upon accepted industry practice as well as the test method listed. TRI/Environmental Inc. (TRI) neither accepts responsibility for nor makes claim as to the final use and purpose of the materials tested.

Tests were performed under laboratory conditions and not under actual usage conditions. TRI can give no conclusions as to the serviceability, life expectancy or general durability of the products tested when used in a lining and/or leachate collection system.

EPA METHOD 9090A TEST RESULTS

GEOSYNTHETIC DIMENSIONS

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate
Dimensional Stability Data

Date: October, 1999

Exposure Time and Temperature

SRA
Quality Review

Test Parameters	Temp.	Baseline	30 Day Exposed	% Change	Baseline	60 Day Exposed	% Change	Baseline	90 Day Exposed	% Change	Baseline	120 Day Exposed	% Change
POLYFLEX GEOMEMBRANE: 60 mil HDPE													
Thickness (mils)	23C	58	59	1.7	61	61	0.0	58	58	0.0	65	64	-1.5
	50C	61	61	0.0	61	61	0.0	61	61	0.0	61	61	0.0
Length (inches)	23C	10.03	10.02	-0.1	10.04	10.04	0.0	10.04	10.04	0.0	10.02	10.01	-0.1
	50C	10.02	10.02	0.0	10.00	10.00	0.0	10.01	10.01	0.0	10.01	10.00	-0.1
Width (inches)	23C	8.02	8.01	-0.1	8.00	8.00	0.0	8.02	8.02	0.0	8.01	8.01	0.0
	50C	8.01	8.01	0.0	8.00	8.00	0.0	8.01	8.01	0.0	8.00	8.00	0.0
Mass (g)	23C	71.98	72.06	0.1	76.34	76.81	0.6	72.65	72.89	0.3	79.39	79.62	0.3
	50C	76.29	76.39	0.1	75.03	75.26	0.3	75.69	75.91	0.3	76.43	76.82	0.5

Project: POLYFLEX File: 770-poly.WB1

EPA METHOD 9090A TEST

POLY-FLEX 60 mil SMOOTH HDPE GEOMEMBRANE

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	30 Day Baseline	30 Day 23C	30 Day 50C	60 Day Baseline	60 Day 23C	60 Day 50C	90 Day Baseline	90 Day 23C	90 Day 50C	120 Day Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tensile Properties:	2597	2619	2675	2656	2662	2752	2454	2582	2524	2629	2717	2514
Tensile Stress @ Yield (psi)	2625	2754	2693	2610	2777	2698	2476	2422	2476	2652	2624	2768
ASTM D638	2561	2573	2666	2505	2563	2685	2365	2447	2511	2711	2639	2771
Machine Direction	2673			2590			2402			2674		
	2593			2570			2380			2617		
	2537			2522			2419			2540		
Average	2598	2649	2678	2576	2667	2705	2416	2484	2504	2637	2660	2684
STD	44	77	11	61	87	36	39	70	20	53	41	120
Coefficient of Variation	2	3	0	2	3	1	2	3	1	2	2	4
% Change		2	3		4	5		3	4		1	2
Tensile Properties:	4639	4622	4508	3611	4737	4268	4619	4674	4808	4915	4773	4190
Tensile Strength @ Break (psi)	4454	4411	4614	3921	4456	4705	4529	4765	4789	4850	4438	4822
ASTM D638	3942	4215	4355	4781	4022	4193	4470	4497	4780	4034	4603	4720
Machine Direction	4638			3767			4377			5055		
	4672			4964			4510			4295		
	4520			4912			4374			4664		
Average	4478	4416	4492	4326	4405	4389	4480	4645	4786	4636	4605	4577
STD	251	166	106	569	294	226	86	111	20	360	137	277
Coefficient of Variation	6	4	2	13	7	5	2	2	0	8	3	6
% Change		-1	0		2	1		4	7		-1	-1
nsile Properties:	13.8	13.8	13.8	13.1	13.4	13.0	13.4	14.0	14.2	13.1	13.6	13.6
ongation @ Yield (%)	13.8	13.8	13.8	14.0	14.0	13.0	12.8	13.6	14.0	13.3	13.6	13.6
ASTM D638	12.9	13.1	12.9	12.7	13.4	14.2	12.3	13.8	14.0	13.1	12.7	13.6
Machine Direction	13.8			14.0			13.5			13.8		
	13.8			12.5			13.8			13.6		
	13.4			14.2			14.1			12.9		
Average	13.6	13.6	13.5	13.4	13.6	13.4	13.3	13.8	14.1	13.3	13.3	13.6
STD	0.3	0.3	0.4	0.7	0.3	0.6	0.6	0.2	0.1	0.3	0.4	0.0
Coefficient of Variation	2	2	3	5	2	4	5	1	1	2	3	0
% Change		-0	-1		1	-0		4	6		0	2

SZA 10/24/99
Quality Review/Date

Client: WCS, File: 418-wcs .WB1

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	Baseline	30 Day 23C	30 Day 50C	Baseline	60 Day 23C	60 Day 50C	Baseline	90 Day 23C	90 Day 50C	Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tensile Properties:	605	594	609	479	630	564	638	609	625	632	599	581
Elongation @ Break (%)	602	585	612	528	598	594	697	618	637	623	556	611
ASTM D638	532	559	650	620	523	565	616	655	627	519	598	598
Machine Direction	603			516			596			644		
	599			638			614			568		
	664			642			689			619		
Average	601	579	624	571	584	574	642	627	630	601	584	597
STD	38	15	19	65	45	14	38	20	5	44	20	12
Coefficient of Variation	6	3	3	11	8	2	6	3	1	7	3	2
% Change		-4	4		2	1		-2	-2		-3	-1
Tensile Properties:	675	600	600	575	700	625	730	690	670	690	630	665
Set after Break (%)	684	580	620	670	670	680	720	710	740	700	575	695
ASTM D638	642	580	685	680	580	650	720	760	680	595	700	660
Machine Direction	681			610			720			720		
	605			700			750			720		
	465			750			740			680		
Average	625	587	635	664	650	655	730	720	697	684	635	673
STD	77	9	36	57	51	23	12	29	31	42	51	15
Coefficient of Variation	12	2	6	9	8	3	2	4	4	6	8	2
% Change		-6	2		-2	-1		-1	-5		-7	-2
Tensile Properties:	2113	2122	2162	2161	2091	2115	1959	2155	2140	2176	2187	2030
Tensile Stress @ 100% Elongation (psi)	2112	2130	2144	2130	2030	2150	1980	2198	2031	2153	2129	2240
ASTM D638	2112	2111	2187	2122	2051	2123	1976	1896	2152	2204	2175	2307
Machine Direction	2236			2092			1985			2210		
	2132			2136			1983			2147		
	2065			2150			2013			2135		
Average	2128	2121	2164	2132	2057	2129	1983	2083	2108	2171	2164	2192
STD	52	8	16	22	25	15	16	133	54	28	25	118
Coefficient of Variation	2	0	1	1	1	1	1	6	3	1	1	5
% Change		-0	2		-4	-0		5	6		-0	1
Tensile Properties:	2151	2158	2164	2251	2107	2217	2049	2219	2177	2271	2233	2097
Tensile Stress @ 200% Elongation (psi)	2144	2171	2188	2246	1933	2148	2132	2193	2089	2214	2164	2318
ASTM D638	2130	2135	2190	2208	2084	2193	2110	1999	2140	2309	2176	2275
Machine Direction	2252			2183			2119			2220		
	2165			2244			2111			2188		
	2107			2144			1929			2170		
Average	2160	2155	2161	2213	2041	2186	2075	2137	2135	2229	2191	2230
STD	49	15	12	39	77	29	70	96	36	48	30	96
Coefficient of Variation	2	1	1	2	4	1	3	5	2	2	1	4
% Change		-0	1		-8	-1		3	3		-2	0

SZA 10-24-99
Quality Review/Date

Client: WCS. File: 418-wcs .WB1

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	30 Day Baseline	30 Day 23C	30 Day 50C	60 Day Baseline	60 Day 23C	60 Day 50C	90 Day Baseline	90 Day 23C	90 Day 50C	120 Day Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tensile Properties:	2758	2638	2801	2590	2801	2731	2804	2819	2876	2763	2788	2819
Tensile Stress @ Yield (psi)	2711	2743	2768	2874	2752	2767	2736	2767	2901	2786	2795	2861
ASTM D638	2763	2730	2822	2706	2760	2775	2665	2814	2653	2745	2832	2870
Transverse Direction	2775			2712			2702			2796		
	2835			2685			2579			2776		
	2713			2673			2631			2679		
Average	2759	2704	2804	2707	2774	2758	2686	2800	2877	2758	2805	2850
STD	42	47	14	85	19	19	73	23	20	39	19	22
Coefficient of Variation	2	2	0	3	1	1	3	1	1	1	1	1
% Change		-2	2		3	2		4	7		2	3
Tensile Properties:	4428	4745	4179	4862	5168	4106	4624	4381	4079	4547	4850	4328
Tensile Strength @ Break (psi)	4020	4238	3744	5015	4844	4529	4676	5198	4810	4385	4534	4702
ASTM D638	4512	4827	5018	4927	4597	5084	5002	4341	5176	4358	4456	4924
Transverse Direction	4108			3750			4307			4495		
	4797			4554			5012			4022		
	4142			4997			4441			4849		
Average	4335	4537	4314	4688	4870	4573	4710	4640	4688	4443	4613	4651
STD	271	217	529	446	234	400	266	395	456	247	170	246
Coefficient of Variation	6	5	12	10	5	9	6	9	10	6	4	5
% Change		5	-0		4	-2		-1	-0		4	5
Tensile Properties:	12.1	12.7	12.9	12.5	11.9	12.7	12.4	11.9	12.5	12.9	12.3	12.7
Elongation @ Yield (%)	12.9	11.5	12.9	12.5	11.9	12.5	12.5	12.7	12.5	12.1	12.1	12.1
ASTM D638	12.9	12.1	12.3	12.5	12.5	12.5	12.6	12.5	12.3	12.3	12.7	13.6
Transverse Direction	12.9			12.5			12.5			12.9		
	12.9			12.5			12.6			13.2		
	12.7			12.5			12.5			12.7		
Average	12.7	12.1	12.7	12.5	12.1	12.6	12.5	12.4	12.4	12.7	12.4	12.8
STD	0.3	0.5	0.3	0.0	0.3	0.1	0.1	0.3	0.1	0.4	0.2	0.6
Coefficient of Variation	2	4	2	0	2	1	1	3	1	3	2	5
% Change		-5	-0		-3	1		-1	-1		-2	1
Tensile Properties:	668	689	677	695	692	592	656	619	557	626	660	612
Elongation @ Break (%)	675	697	641	680	653	618	654	722	568	603	624	640
ASTM D638	663	636	696	703	732	694	635	618	704	603	611	598
Transverse Direction	672			680			694			620		
	634			655			625			563		
	693			730			633			580		
Average	668	674	671	691	692	635	650	653	643	616	632	617
STD	16	27	23	23	32	43	23	49	63	35	21	17
Coefficient of Variation	3	4	3	3	5	7	4	7	10	6	3	3
% Change		1	1		0	-8		1	-1		3	0

SZA 10-24-99
Quality Review/Date

Client: WCS, File: 418-wcs .WB1

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	30 Day Baseline	30 Day 23C	30 Day 50C	60 Day Baseline	60 Day 23C	60 Day 50C	90 Day Baseline	90 Day 23C	90 Day 50C	120 Day Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tensile Properties:	632	625	630	780	800	740	750	670	640	710	720	645
Set after Break (%)	664	650	640	750	700	700	740	770	740	830	670	690
ASTM D638	641	660	675	780	770	730	740	720	780	680	680	740
Transverse Direction	635			710			770			695		
	615			740			750			660		
	646			800			710			740		
Average	639	645	648	760	757	723	743	720	720	688	890	692
STD	15	15	19	30	42	17	18	41	59	35	22	39
Coefficient of Variation	2	2	3	4	6	2	2	6	8	5	3	6
% Change		1	1		-0	-5		-3	-3		1	1
Tensile Properties:	1964	1970	1919	1906	1993	1917	1923	1956	2013	1963	1999	1997
Tensile Stress @ 100% Elongation (psi)	1929	1979	1963	1948	2002	2026	1902	1928	2006	1995	2011	2079
ASTM D638	2003	1949	2021	1907	1952	1995	1824	1957	1971	1978	1994	1992
Transverse Direction	1964			1915			1932			1963		
	2074			1888			1845			2000		
	1972			1883			1929			1954		
Average	1984	1966	1968	1908	1982	1979	1893	1947	1997	1975	2001	2023
STD	46	13	42	21	22	46	43	13	18	17	7	40
Coefficient of Variation	2	1	2	1	1	2	2	1	1	1	0	2
% Change		-1	-1		4	4		3	6		1	2
Tensile Properties:	2076	2022	1977	1972	2088	2033	1968	1988	2075	2024	2026	2144
Tensile Stress @ 200% Elongation (psi)	1996	2095	2174	2068	2069	2160	1906	1973	2018	2129	2149	2122
ASTM D638	2033	1979	2046	1952	1970	2014	1861	1956	1985	2146	2123	2148
Transverse Direction	2072			2056			1966			2049		
	2232			1941			1894			2114		
	2021			1907			1929			1975		
Average	2072	2032	2056	1983	2042	2069	1921	1972	2026	2073	2099	2137
STD	77	48	82	59	52	65	38	13	37	62	53	11
Coefficient of Variation	4	2	4	3	3	3	2	1	2	3	3	1
% Change		-2	-0		3	4		3	5		1	3
Modulus of Elasticity:	124744	91394	103184	81704	71107	78795	79633	67663	73895	124744	106123	103176
Tangential (psi)	104279	103855	87868	79006	77275	71089	65292	83822	76812	104279	99124	110352
ASTM D882	117219	93445	130990	86535	74467	81924	69526	82388	77912	117219	103275	99978
Machine Direction	90144			77189			73605			90144		
	96237			75676			78201			96237		
	98766			72165			69619			98766		
Average	105232	96231	107347	78713	74283	77269	72646	77958	76206	105232	102841	104502
STD	13234	6681	21860	4558	2521	4553	5059	7303	1695	12081	2874	4338
Coefficient of Variation	13	7	20	6	3	6	7	9	2	11	3	4
% Change		-9	2		-6	-2		7	5		-2	-1

SEA 10.24.99
Quality Review/Date

Client: WCS, File: 418-wcs .WB1

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	Baseline	30 Day 23C	30 Day 50C	Baseline	60 Day 23C	60 Day 50C	Baseline	90 Day 23C	90 Day 50C	Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Modulus of Elasticity:	132588	133256	116768	86096	72302	75135	70206	82564	94042	132568	135318	150382
Tangential (psi)	139879	126438	128450	84982	88661	94898	87874	73789	66801	139879	144267	129457
ASTM D882	127699	121289	112879	77760	81035	85404	76071	90021	85349	161236	145930	146805
Transverse Direction	122310			77047			78012			156135		
	123564			85623			79633			163050		
	129848			96784			81637			129848		
Average	129311	126994	119355	84718	80667	85145	75239	82125	82064	147119	141838	142215
STD	8438	6003	8104	6527	6584	8069	4849	6834	11361	13520	4660	9138
Coefficient of Variation	5	5	7	8	8	9	6	8	14	9	3	6
% Change		-2	-8		-5	1		9	9		-4	-3
Indentation Hardness:	61	61	62	63	62	63	65	64	62	62	63	64
Reading	60	61	62	62	62	62	65	63	64	63	64	63
ASTM D2240	61	62	63	62	62	62	65	63	63	63	63	63
(with TYPE D DUROMETER)	62			64			63			63		
	62			63			63			62		
	62			62			64			63		
Average	61	61	62	63	62	62	64	63	63	63	63	63
STD	1	1	1	1	0	0	1	0	1	0	0	0
Coefficient of Variation	1	1	1	1	0	1	1	1	1	1	1	1
% Change		0	2		-1	-1		-1	-2		1	1
cific Gravity:	0.949	0.950	0.950	0.950	0.948	0.949	0.950	0.949	0.950	0.949	0.949	0.949
Specific Gravity (grams/cu.cm)	0.949	0.949	0.950	0.950	0.949	0.950	0.949	0.948	0.948	0.949	0.948	0.949
ASTM D792, Method A	0.950	0.950	0.950	0.948	0.949	0.947	0.948	0.948	0.948	0.949	0.949	0.949
	0.951			0.948			0.949			0.949		
	0.949			0.948			0.949			0.948		
	0.950			0.947			0.948			0.950		
Average	0.950	0.950	0.950	0.949	0.949	0.949	0.949	0.948	0.949	0.949	0.949	0.949
STD	0.001	0.001	0.000	0.001	0.000	0.001	0.001	0.000	0.001	0.001	0.000	0.000
Coefficient of Variation	0.086	0.061	0.000	0.118	0.050	0.131	0.072	0.050	0.099	0.061	0.050	0.000
% Change		0.00	0.04		0.02	0.02		-0.05	-0.02		-0.04	0.00
Environmental Stress Crack Resistance:												
ASTM D1693, Condition B												
Machine Direction (% Failed)	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0
Transverse Direction (% Failed)	N/A	0	0	N/A	0	0	N/A	0	0	N/A	0	0

SR 10·24·99
Quality Review/Date

Client: WCS, File: 418-wcs .WB1

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

Test Parameters	30 Day Baseline	30 Day 23C	30 Day 50C	60 Day Baseline	60 Day 23C	60 Day 50C	90 Day Baseline	90 Day 23C	90 Day 50C	120 Day Baseline	120 Day 23C	120 Day 50C
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Puncture Resistance:	91	90	96	86	93	95	87	89	91	88	91	92
Load @ Rupture (lbs)	91	91	94	89	92	94	89	86	90	92	92	96
FTMS 101C Method 2065	92	92	93	91	89	94	87	88	90	97	89	97
	93			92			94			96		
	93			93			90			96		
	89			94			91					
Average	92	91	94	91	91	94	90	88	90	94	91	95
STD	1	1	1	3	2	0	2	1	0	3	1	2
Coefficient of Variation	2	1	1	3	2	0	3	1	1	4	1	2
% Change		-1	3		1	4		-2	1		-3	1
Volatiles and Extractables:	-0.05	-0.05	-0.03	-0.03	0.00	-0.10	-0.05	-0.15	-0.05	0.03	-0.05	0.00
Diameter Change (%)	-0.05	-0.08	0.03	0.00	-0.05	-0.08	0.03	0.00	-0.05	-0.05	-0.03	-0.05
SW 870 - Appendix III-D	0.00			-0.10			-0.05			-0.05		
Machine Direction	0.00			-0.08			-0.20			0.00		
Average	-0.03	-0.07	0.00	-0.05	-0.03	-0.09	-0.07	-0.08	-0.05	-0.02	-0.04	-0.03
STD	0.03	0.02	0.03	0.04	0.03	0.01	0.08	0.08	0.00	0.03	0.01	-100
Volatiles and Extractables:	0.28	0.18	0.15	0.10	0.13	0.20	0.15	0.25	0.10	0.18	0.20	0.08
Diameter Change (%)	0.08	0.23	0.18	0.15	0.05	0.13	0.00	0.03	0.18	0.18	0.18	0.10
SW 870 - Appendix III-D	0.23			0.03			0.13			0.03		
Transverse Direction	0.05			0.25			0.38			0.73		
Average	0.16	0.21	0.17	0.13	0.09	0.17	0.17	0.14	0.14	0.26	0.19	0.09
STD	0.10	0.02	0.02	0.08	0.04	0.04	0.14	0.11	0.04	0.27	0.01	0.01
Volatiles and Extractables:	0.07	0.06	0.10	0.08	0.07	0.08	0.05	0.07	0.08	0.05	0.05	0.08
% Volatiles	0.07	0.08	0.08	0.08	0.08	0.08	0.06	0.08	0.07	0.05	0.05	0.05
SW 870 - Appendix III-D	0.08			0.07			0.04			0.05		
	0.08			0.07			0.04			0.05		
Average	0.08	0.07	0.09	0.07	0.08	0.08	0.05	0.08	0.08	0.05	0.05	0.08
STD	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01
Volatiles and Extractables:	0.21	0.21	0.22	0.20	0.21	0.25	0.28	0.22	0.22	0.21	0.22	0.22
% Extractables	0.20	0.22	0.21	0.22	0.19	0.18	0.25	0.21	0.22	0.19	0.21	0.22
SW 870 - Appendix III-D	0.20			0.20			0.31			0.22		
	0.21			0.18			0.32			0.20		
Average	0.21	0.22	0.22	0.20	0.20	0.22	0.29	0.22	0.22	0.21	0.22	0.22
STD	0.00	0.01	0.01	0.01	0.01	0.04	0.03	0.01	0.00	0.01	0.01	0.00

SRA 10·24·99
Quality Review/Date

Client: WCS, File: 418-wcs .WB1

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Exposure to PADER Waste Leachate

Report Date: October 1999

Exposure Time and Temperature

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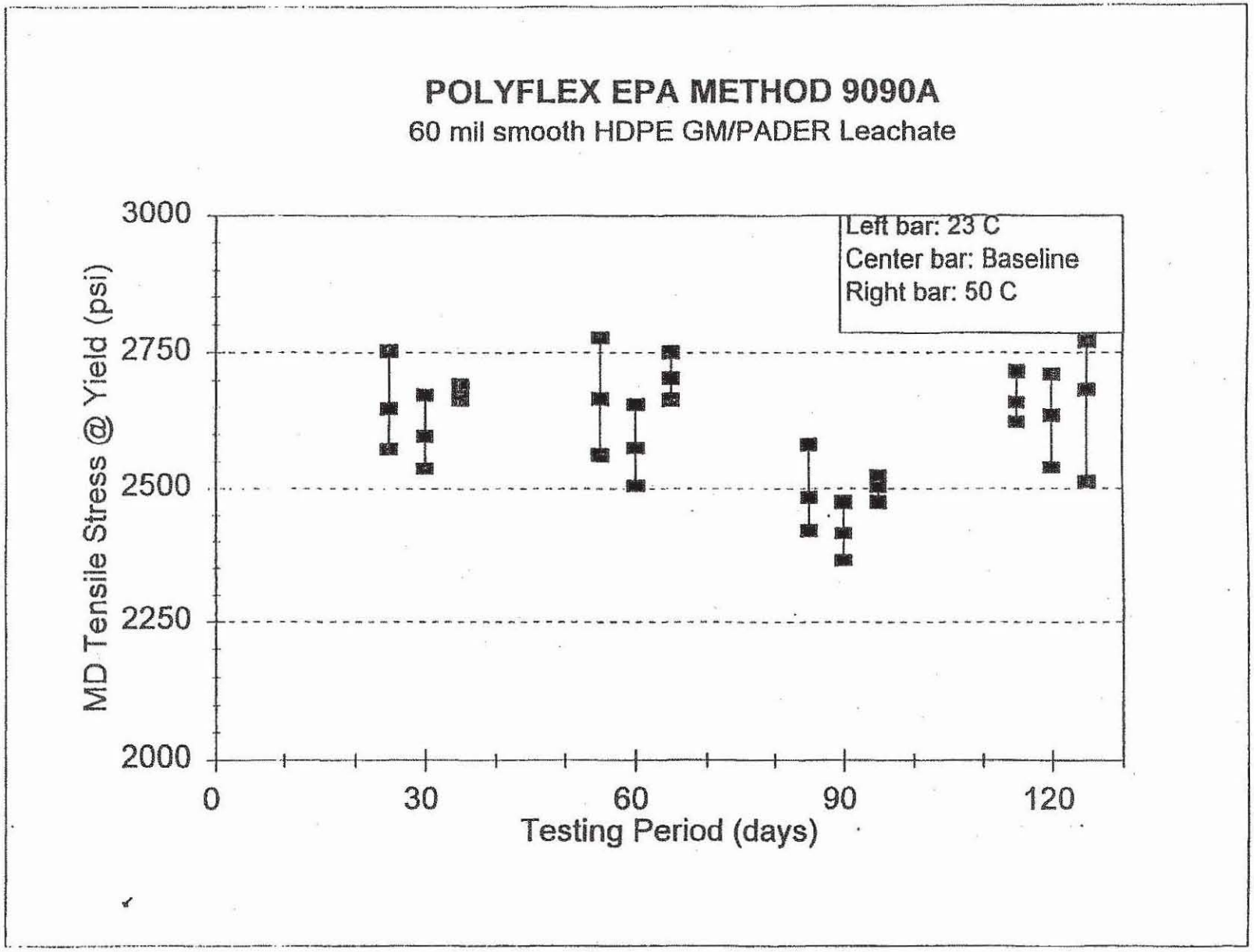
POLYFLEX GEOMEMBRANE: 60 mil HDPE												
Tear Resistance:	55	54	54	55	53	53	57	55	55	55	54	56
Tear Resistance (lbs)	54	54	54	53	54	52	55	55	54	55	53	54
ASTM D1004	54	52	55	54	54	55	55	57	55	53	53	53
Machine Direction	54			52			57			54		
	52			52			54			54		
	55			53			57			57		
Average	54	53	54	53	54	53	56	56	55	55	53	54
STD	1	1	1	1	0	1	1	1	0	1	0	1
Coefficient of Variation	2	2	1	2	1	2	2	2	1	2	1	2
% Change		-1	1		1	0		-0	-2		-2	-1
Tear Resistance:	51	54	53	52	55	51	51	51	51	51	53	53
Tear Resistance (lbs)	50	54	51	52	51	51	53	51	51	50	53	52
ASTM D1004	51	51	52	50	54	55	53	59	52	50	52	52
Transverse Direction	50			46			56			50		
	49			48			55			50		
	54			48			54			52		
Average	51	53	52	49	53	52	54	54	51	51	53	52
STD	2	2	1	2	2	2	2	4	0	1	0	0
Coefficient of Variation	3	3	2	4	3	4	3	7	1	2	1	1
% Change		4	2		8	6		0	-4		4	4
Hydrostatic Resistance:	490	495	500	500	495	500	500	495	495	500	495	505
Load @ Rupture (psi)	500	510	510	490	495	490	515	505	495	495	510	505
ASTM D751	505	500	500	505	490	490	520	490	495	510	500	500
	500			510			515			490		
	495			495			505			500		
	500						510			500		
Average	496	502	503	500	493	493	511	497	495	499	502	503
STD	5	8	6	7	2	5	7	6	0	6	6	2
Coefficient of Variation	1	2	1	1	0	1	1	1	0	1	1	0
% Change		1	1		-1	-1		-3	-3		1	1

SRA 10·24·99
Quality Review/Date

Client: WCS, File: 418-wcs .WB1



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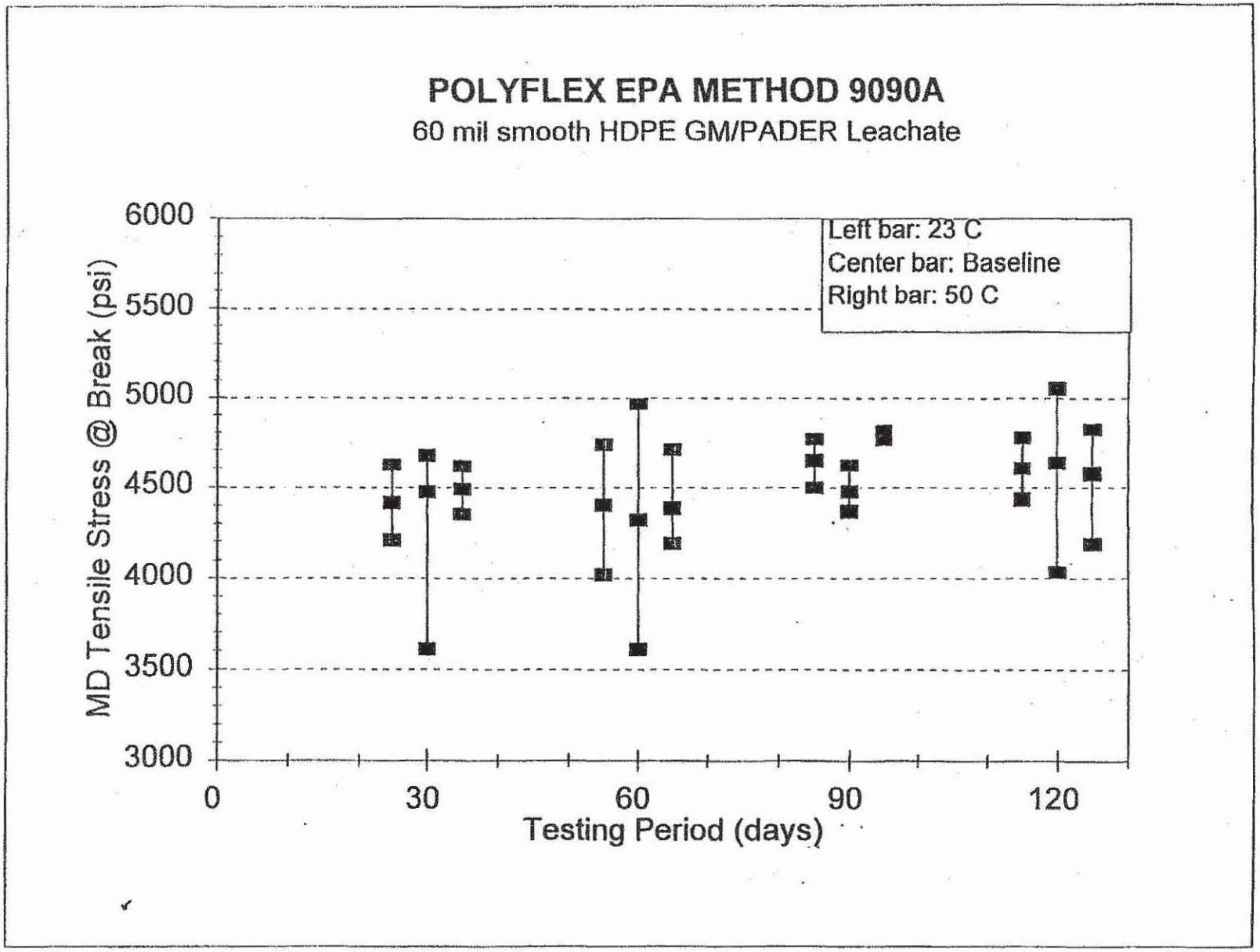

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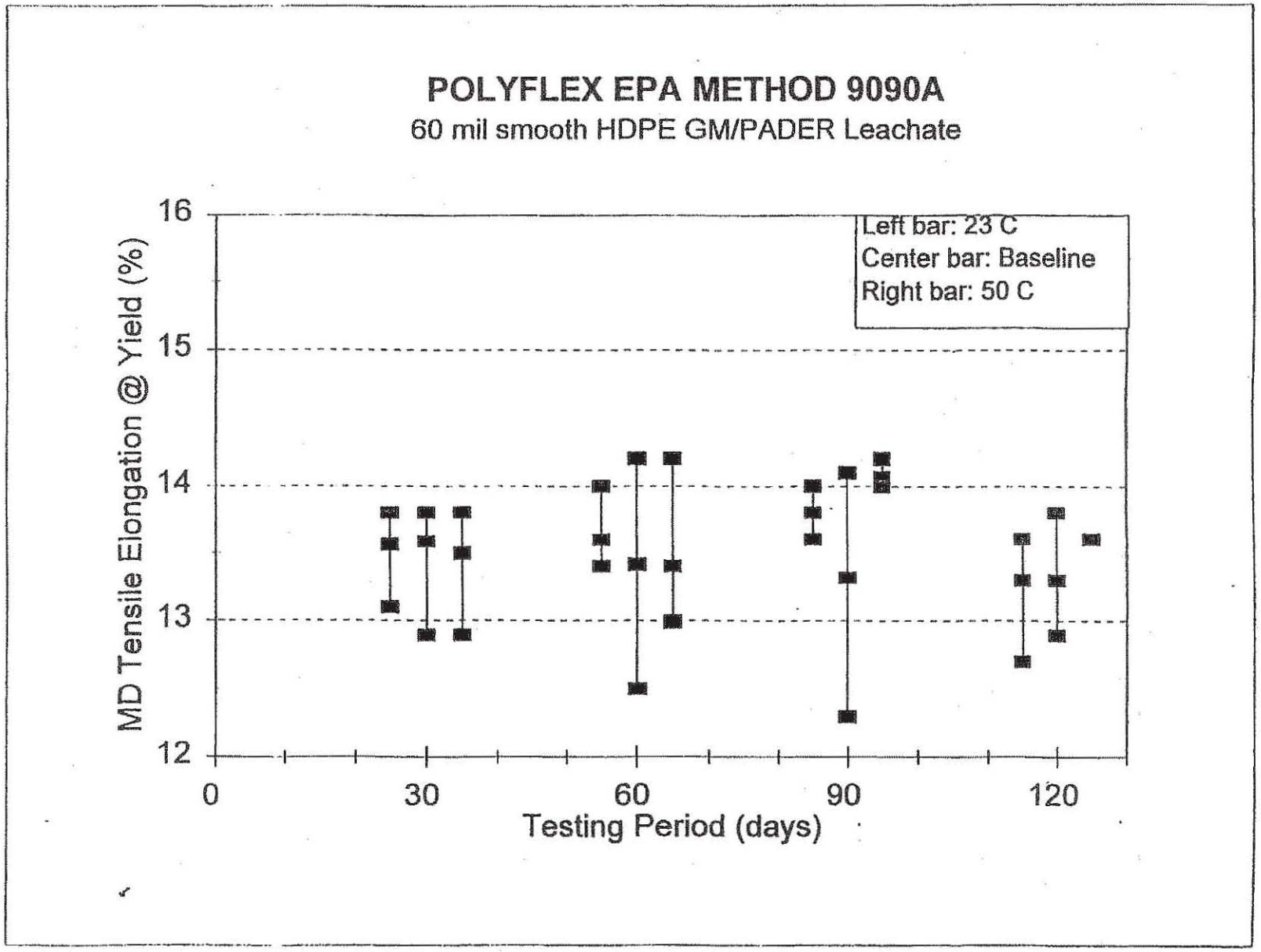

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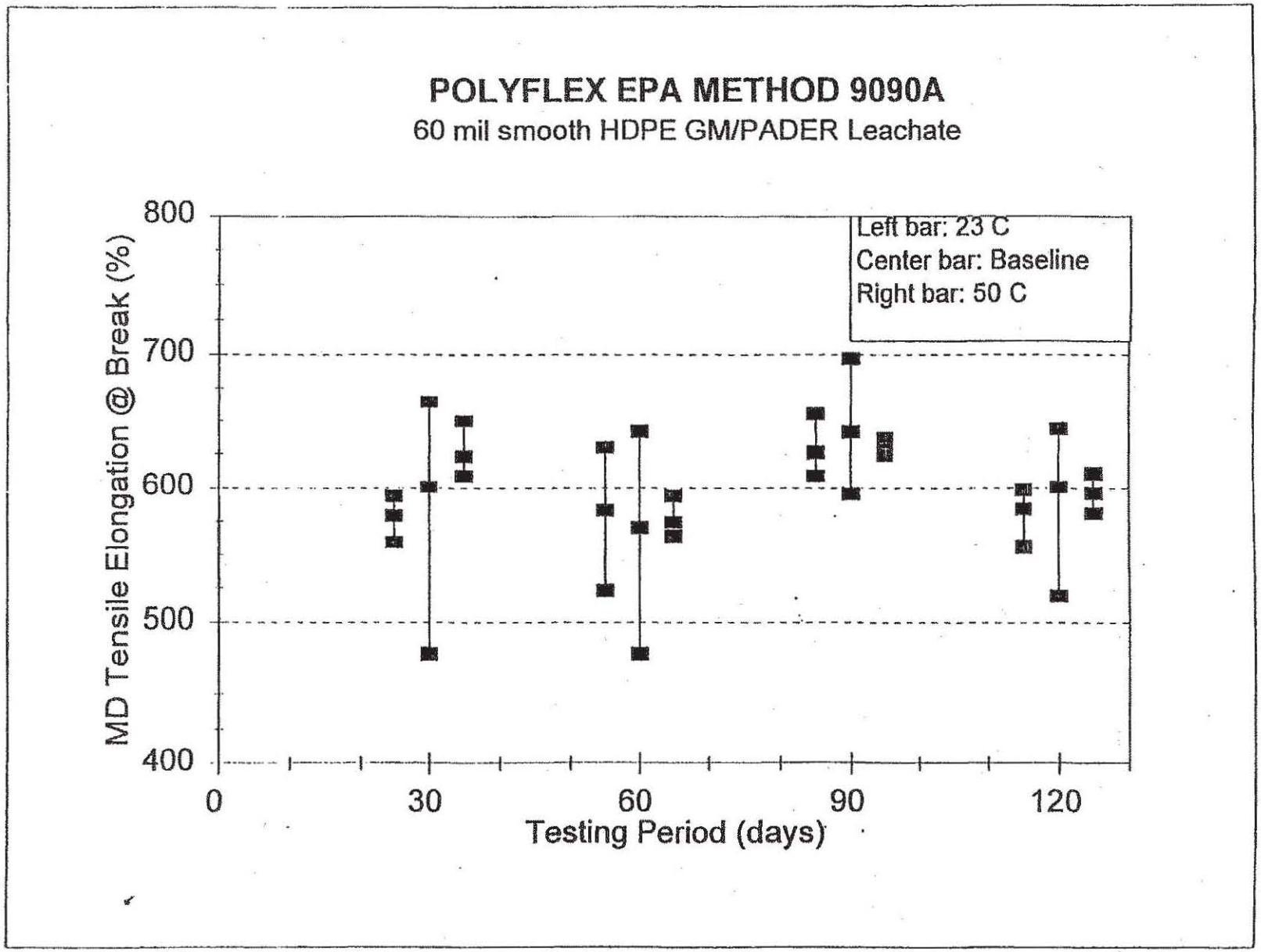

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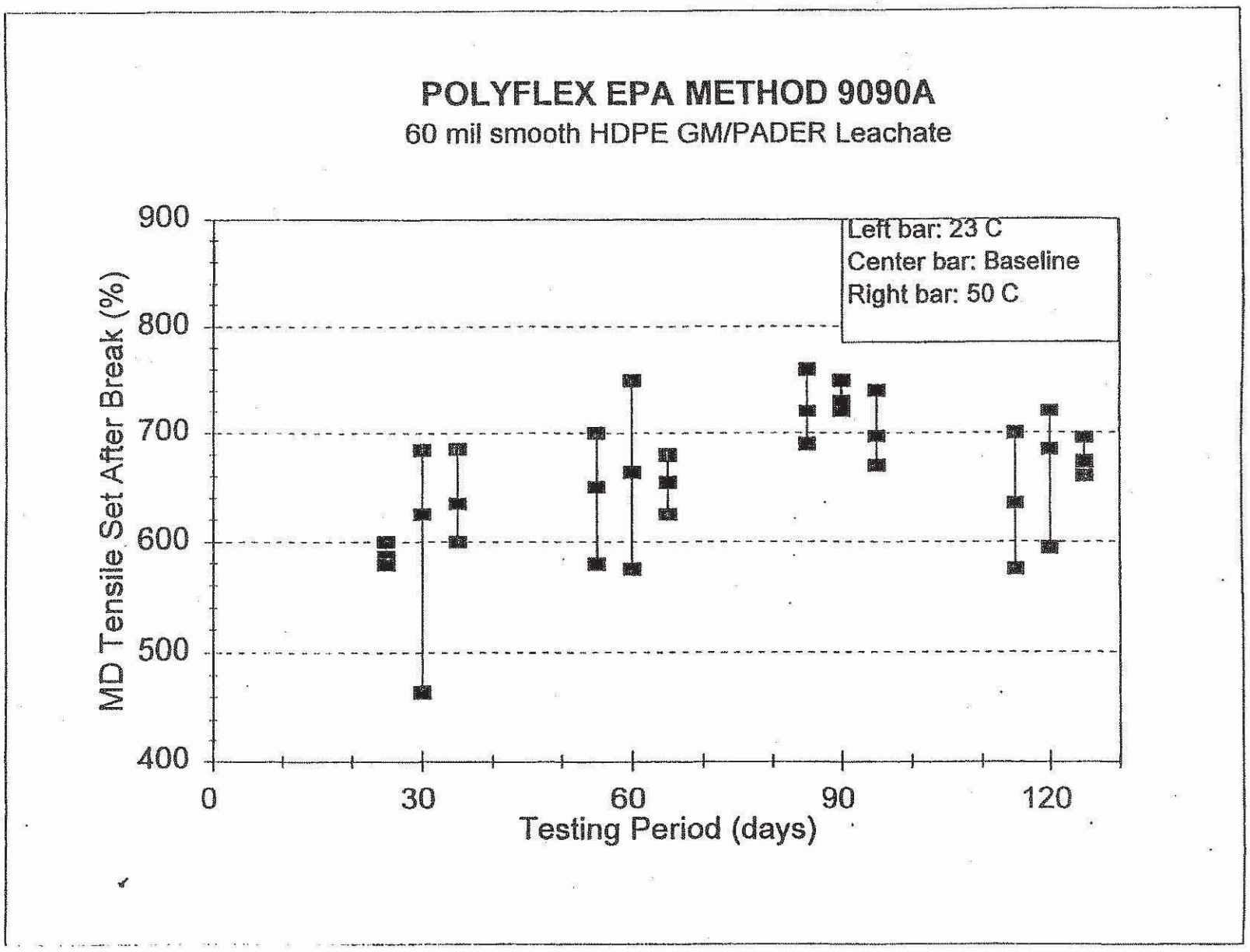

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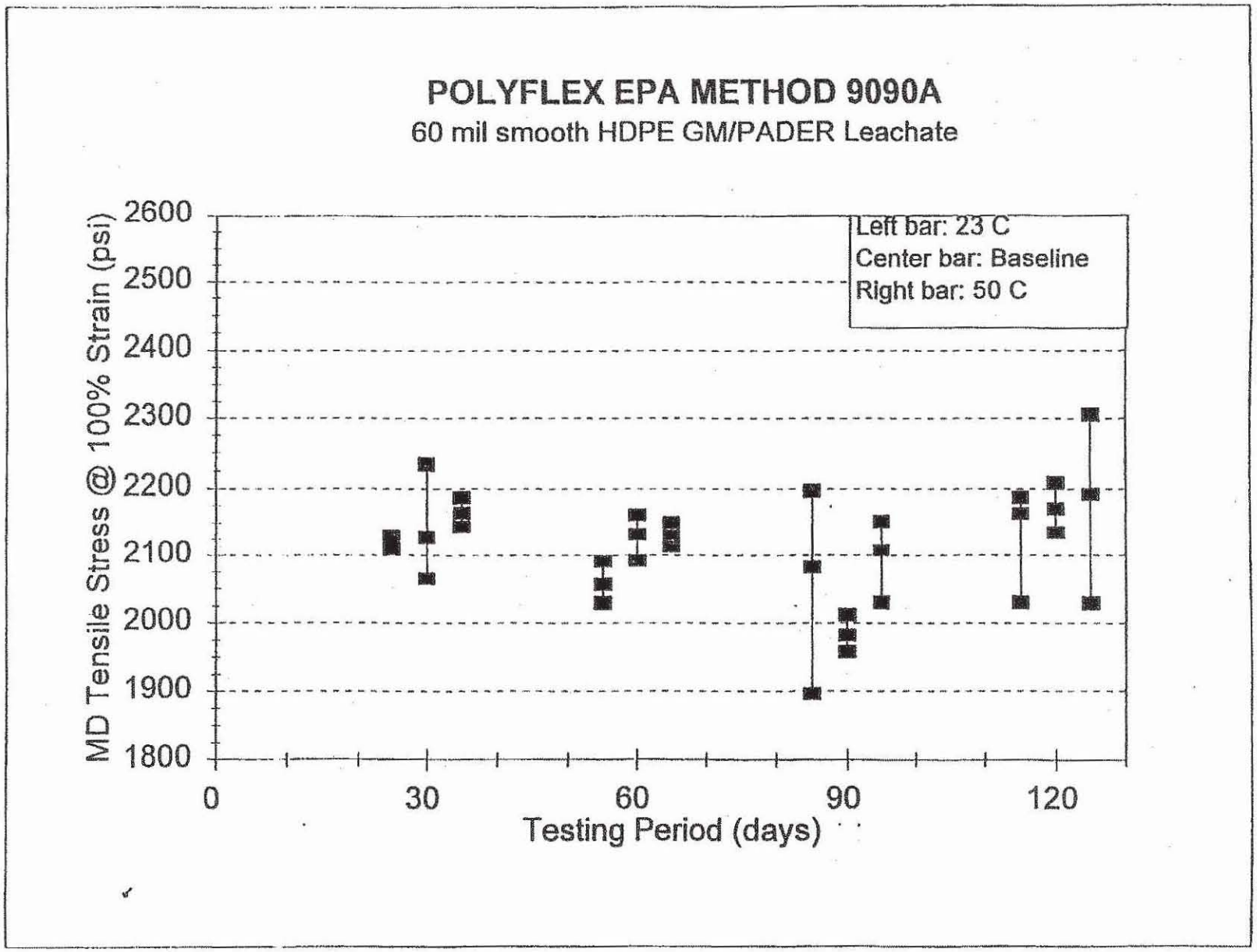

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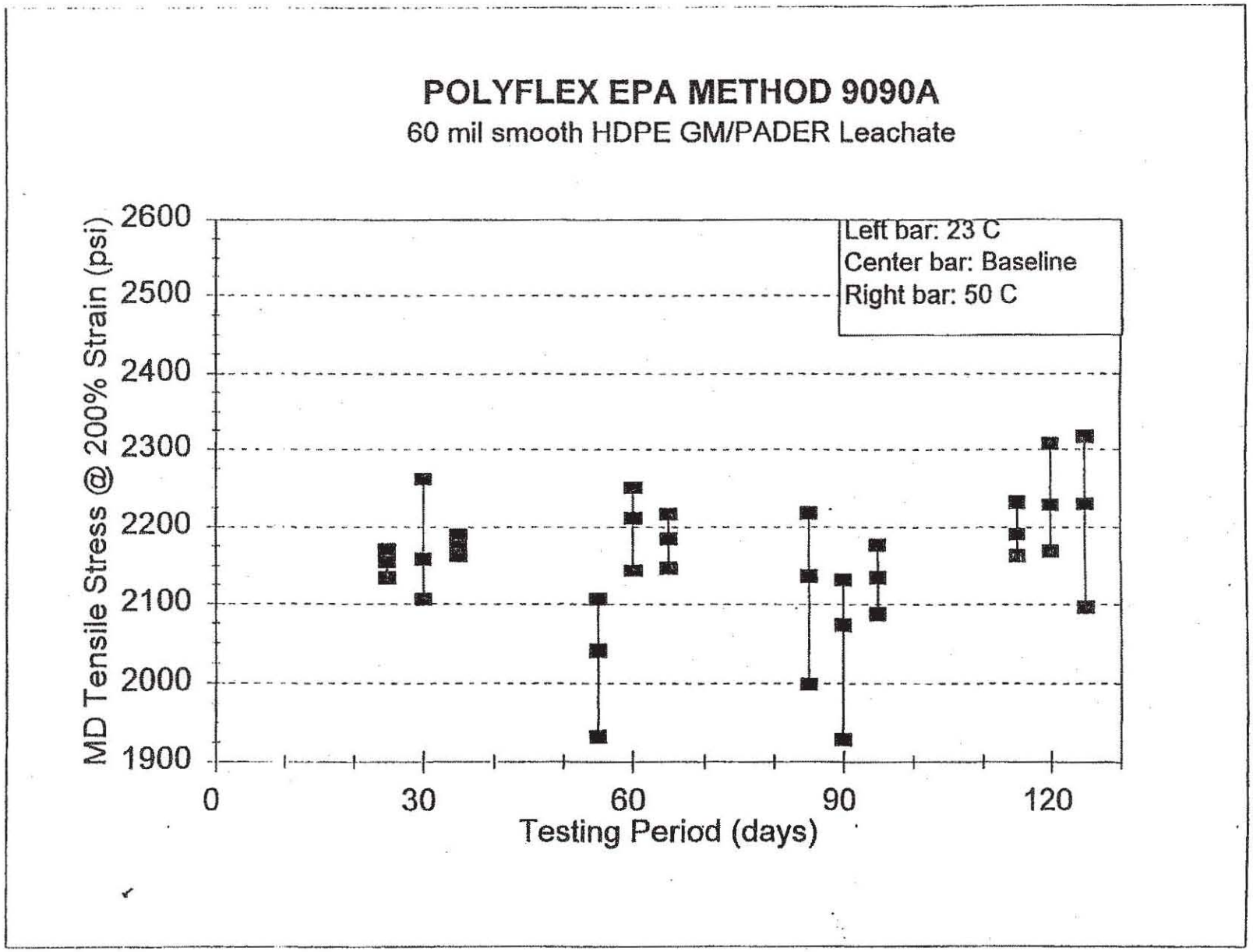

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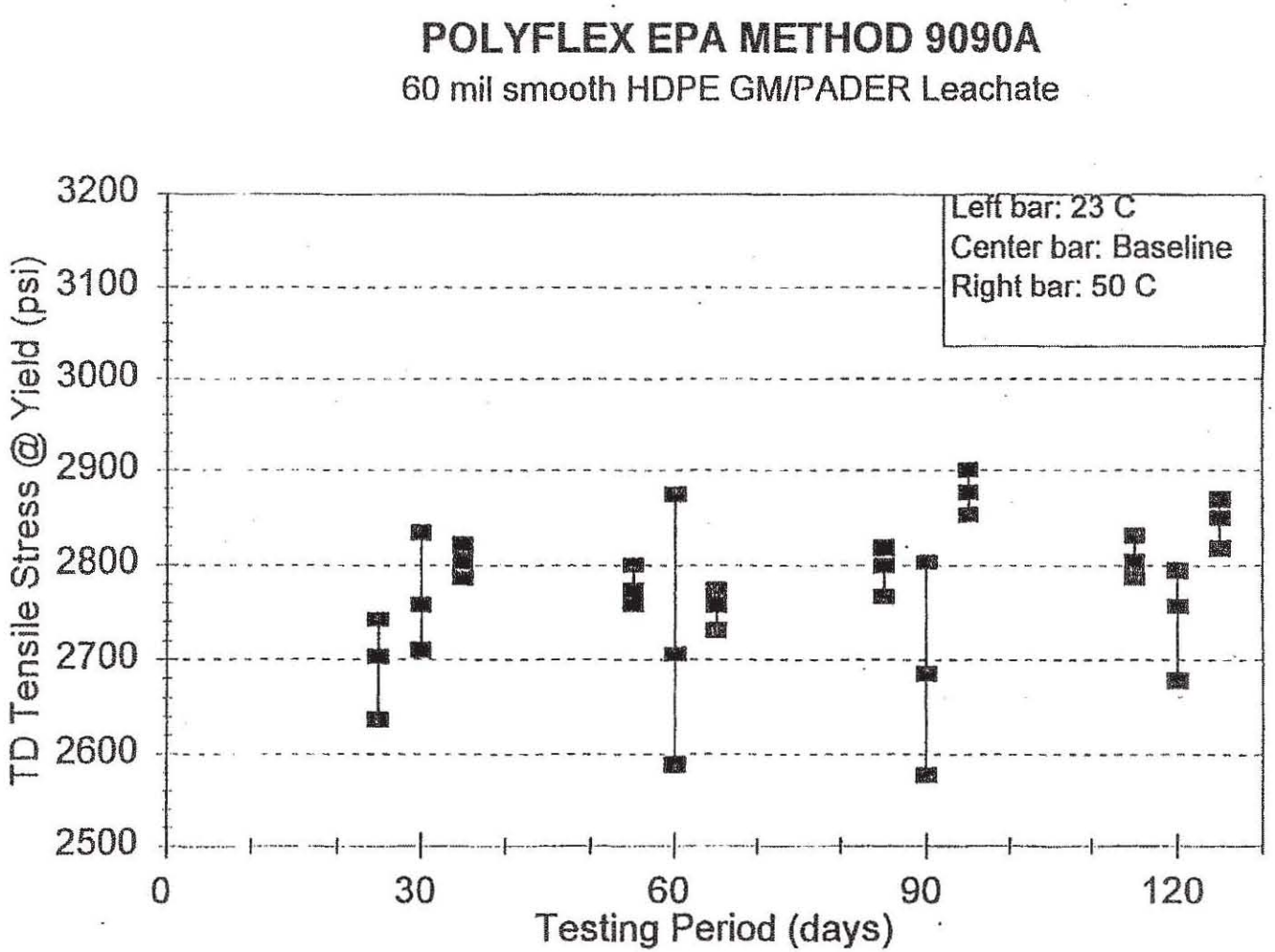
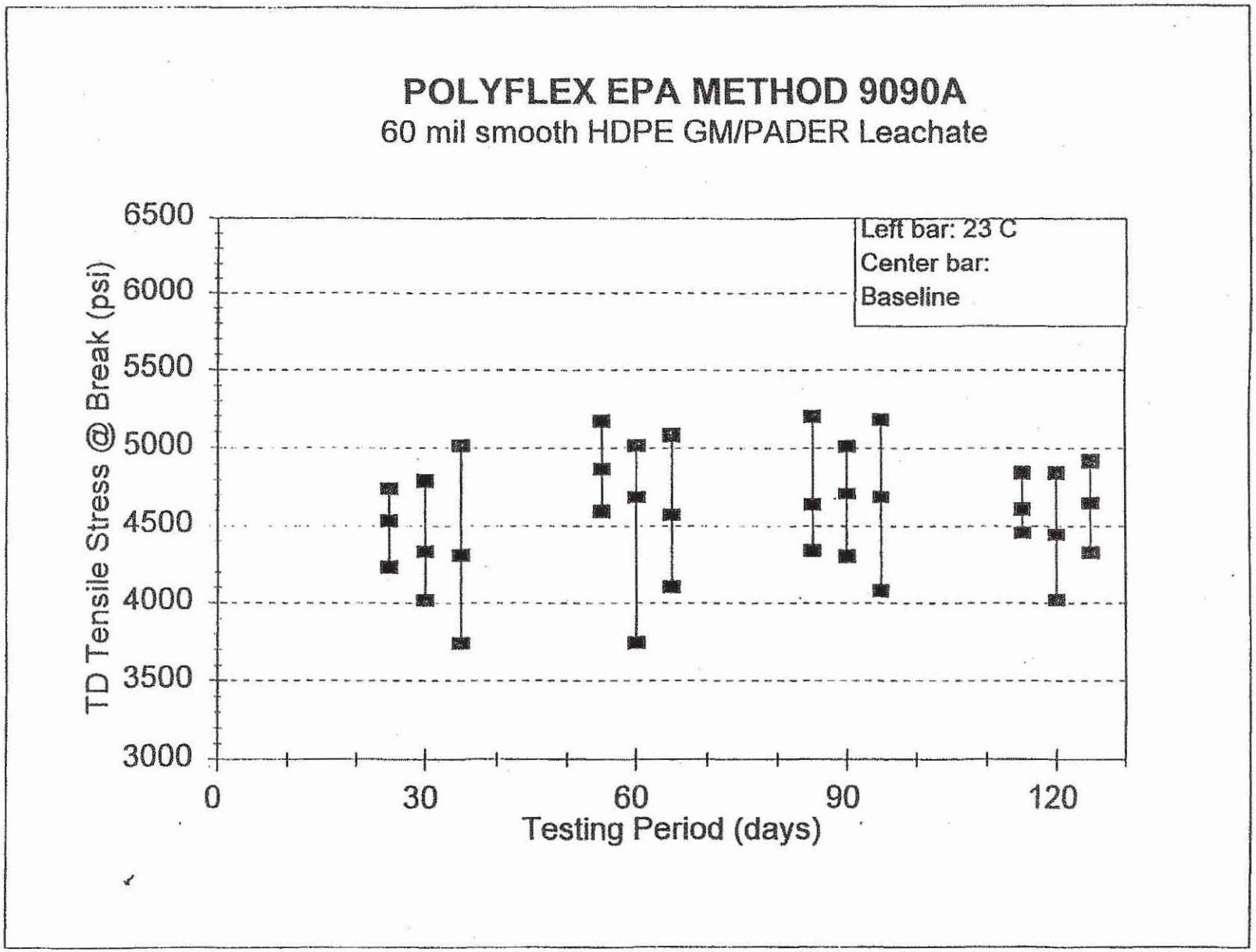

POLYFLEX EPA METHOD 9090A
60 mil smooth HDPE GM/PADER Leachate
Left bar: 23 C
Center bar: Baseline
Right bar: 50 C
TD Tensile Stress @ Yield (psi)
3200
3100
3000
2900
2800
2700
2600
2500
0
30
60
90
120
Testing Period (days)



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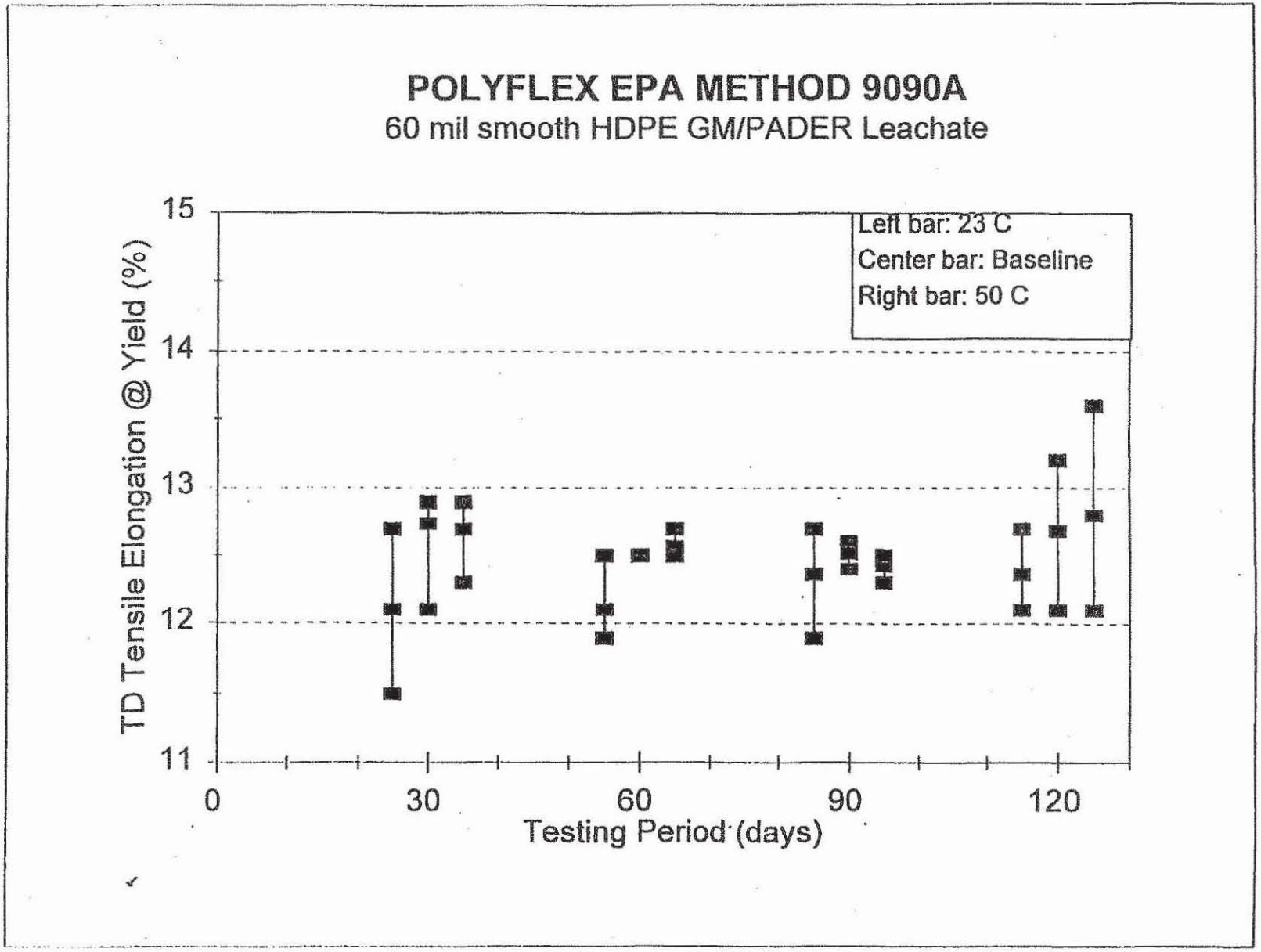

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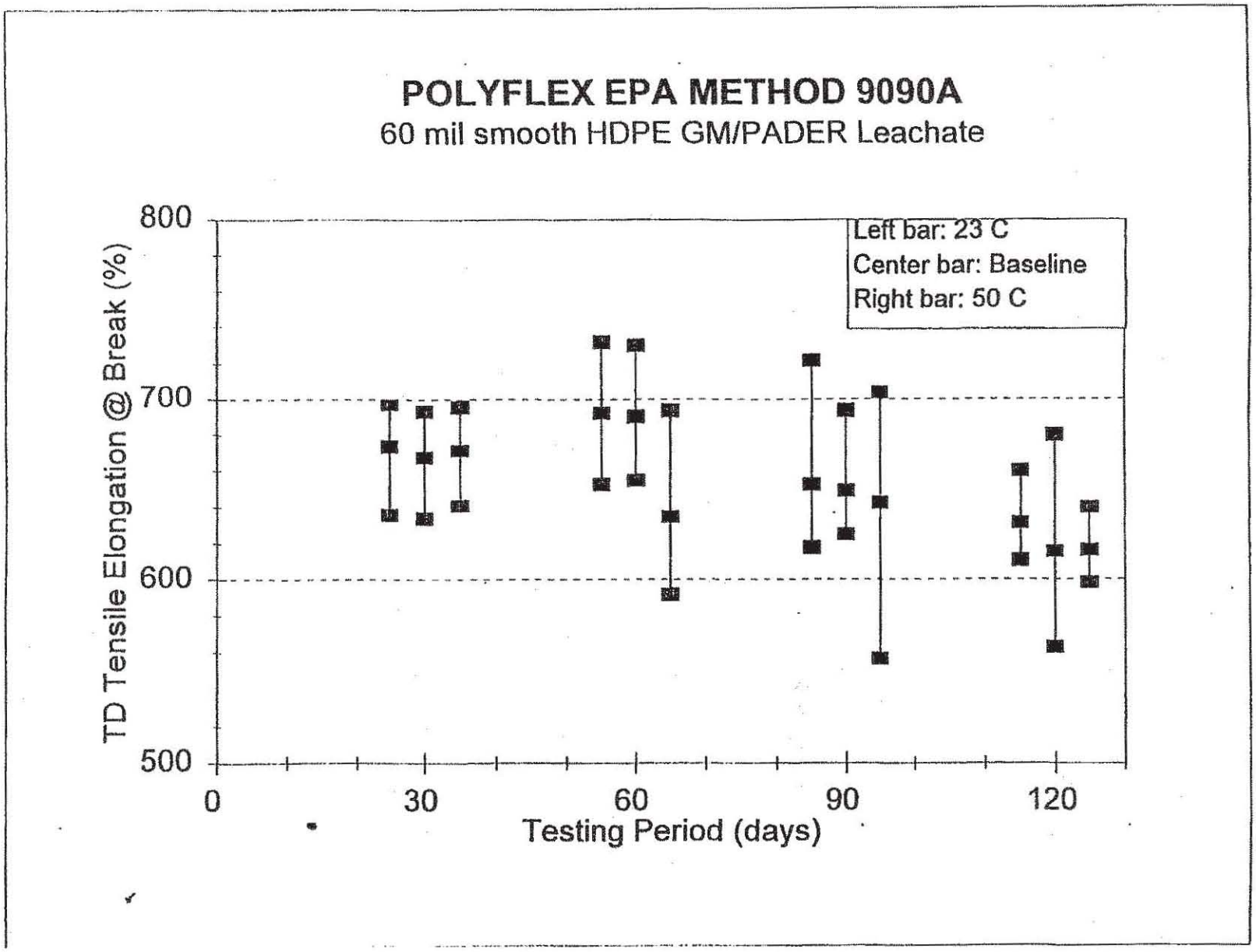

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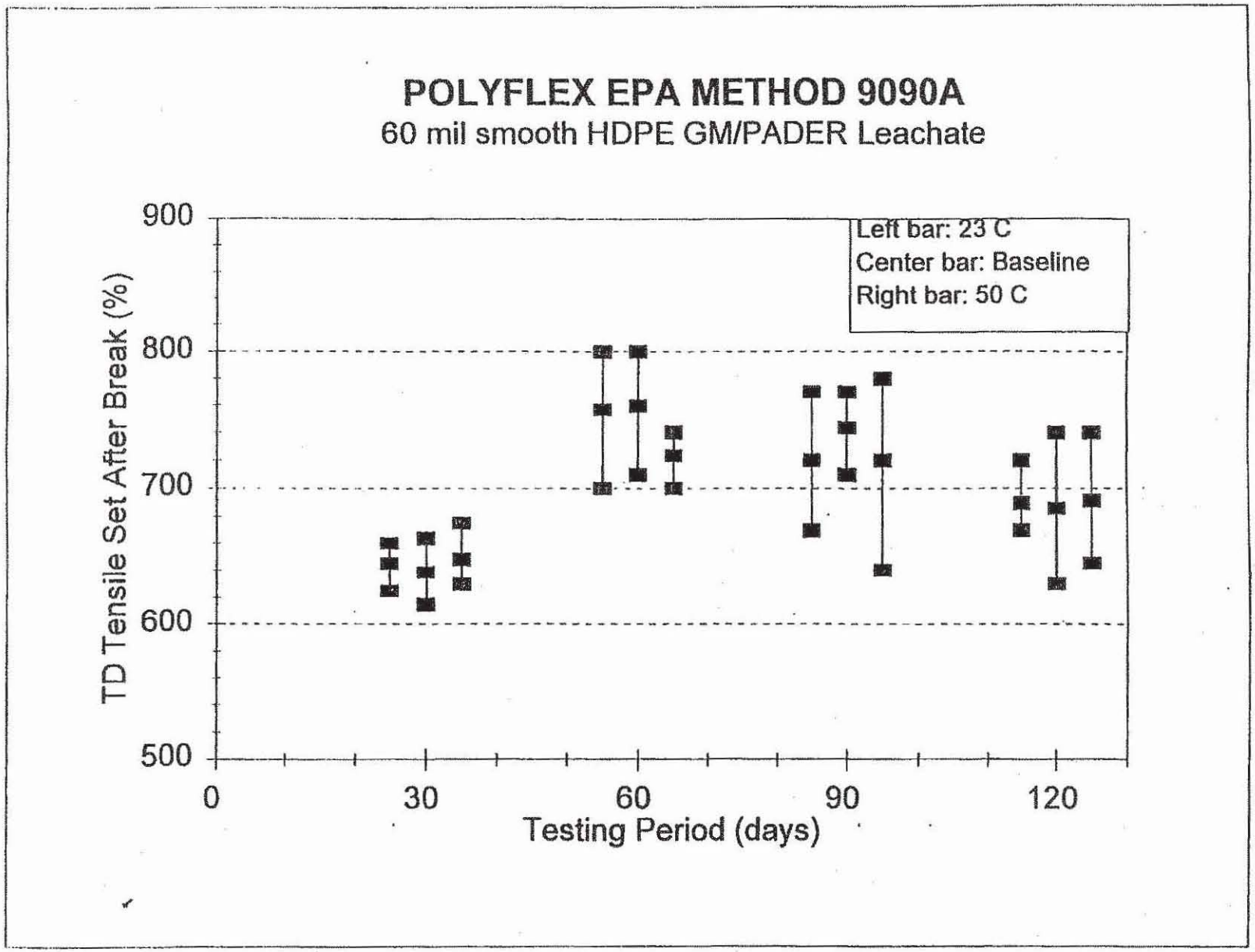

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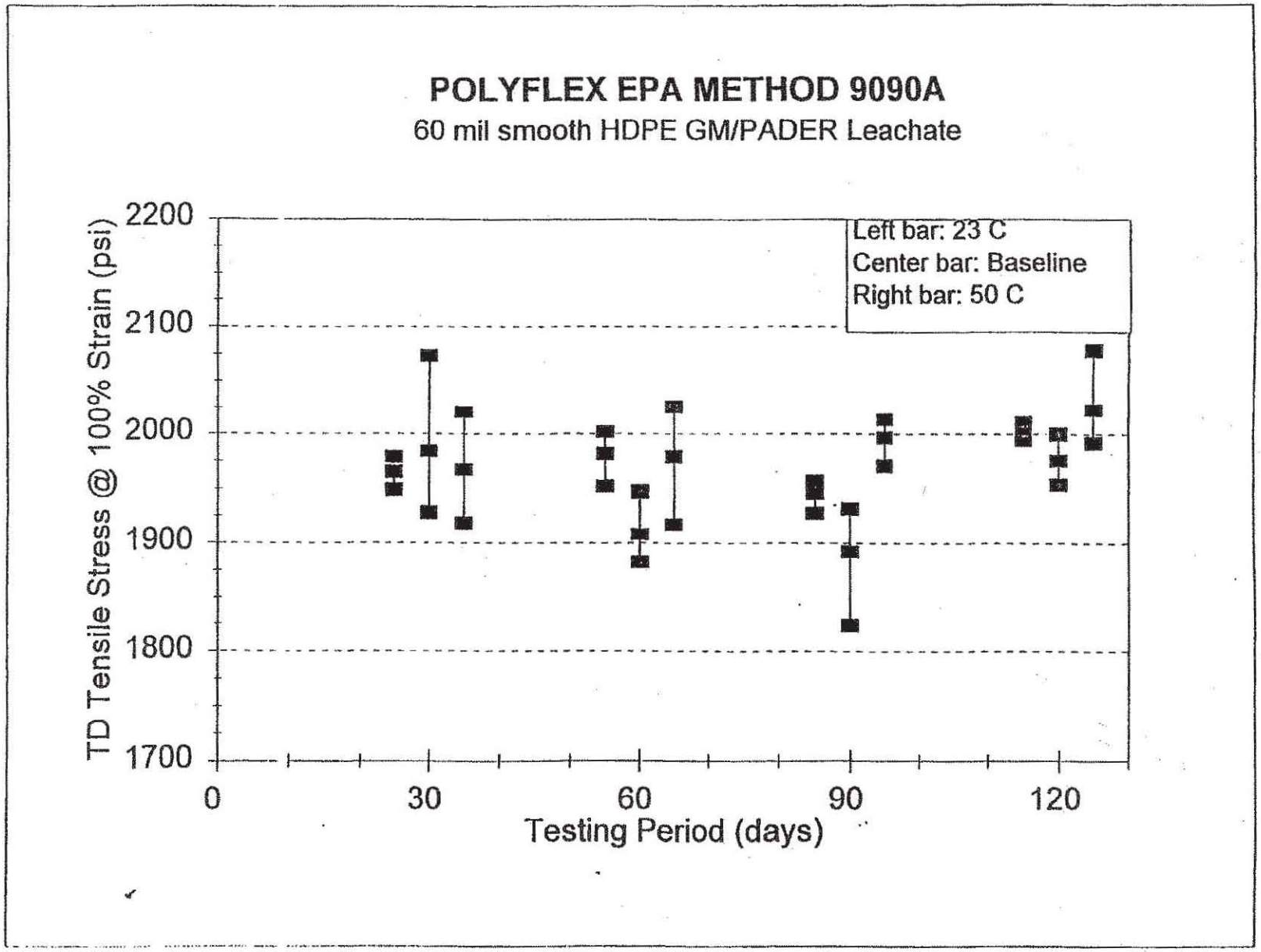

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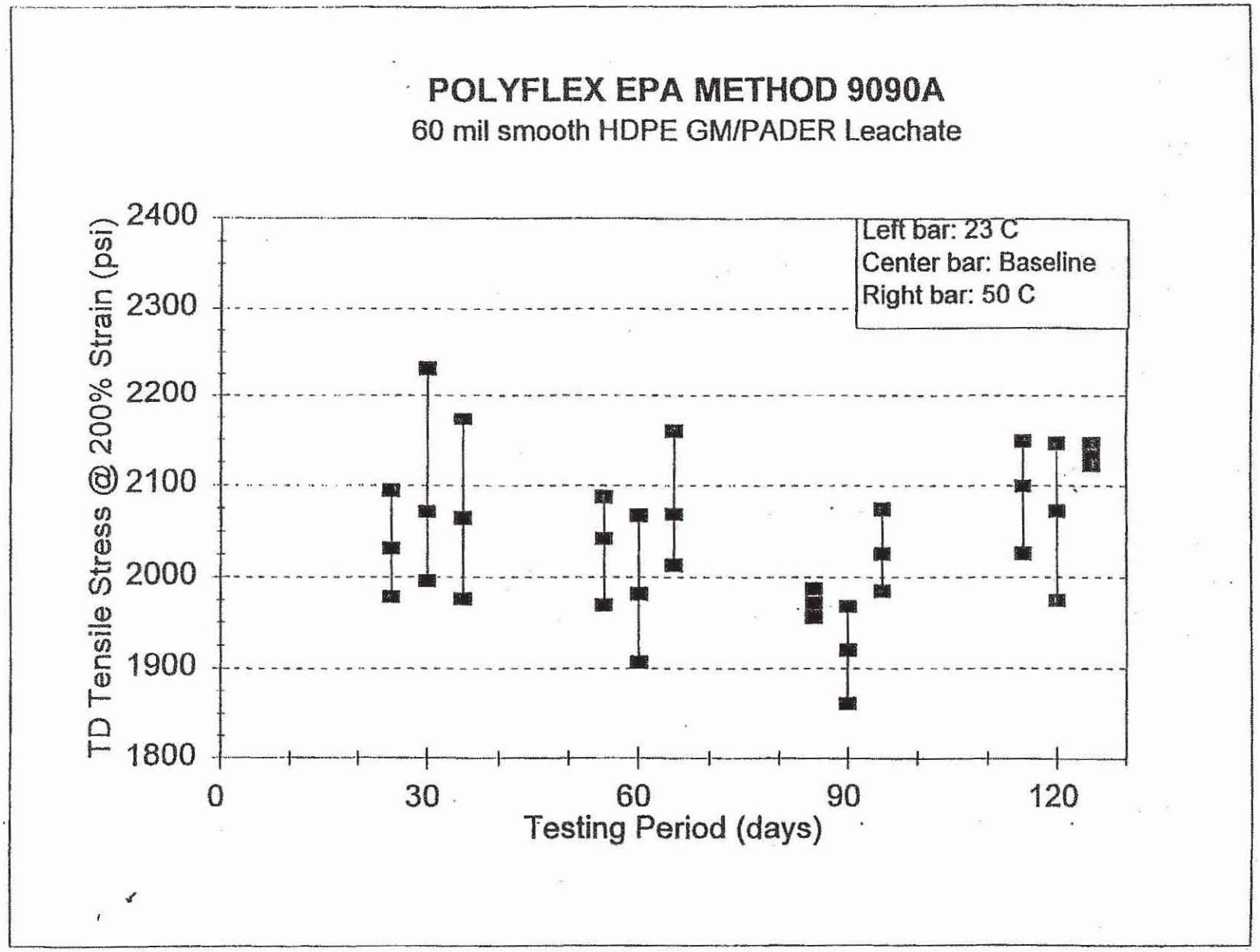

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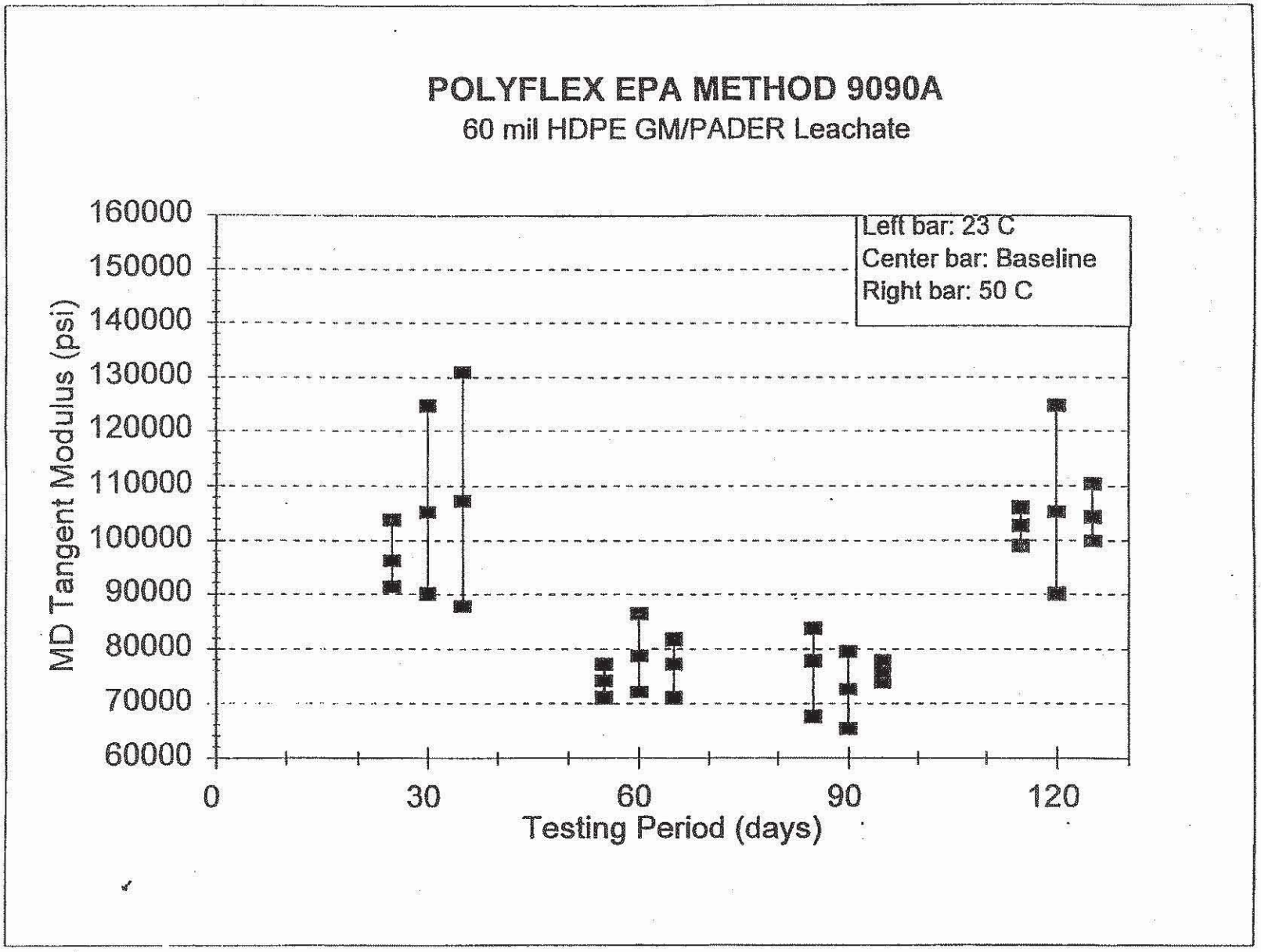

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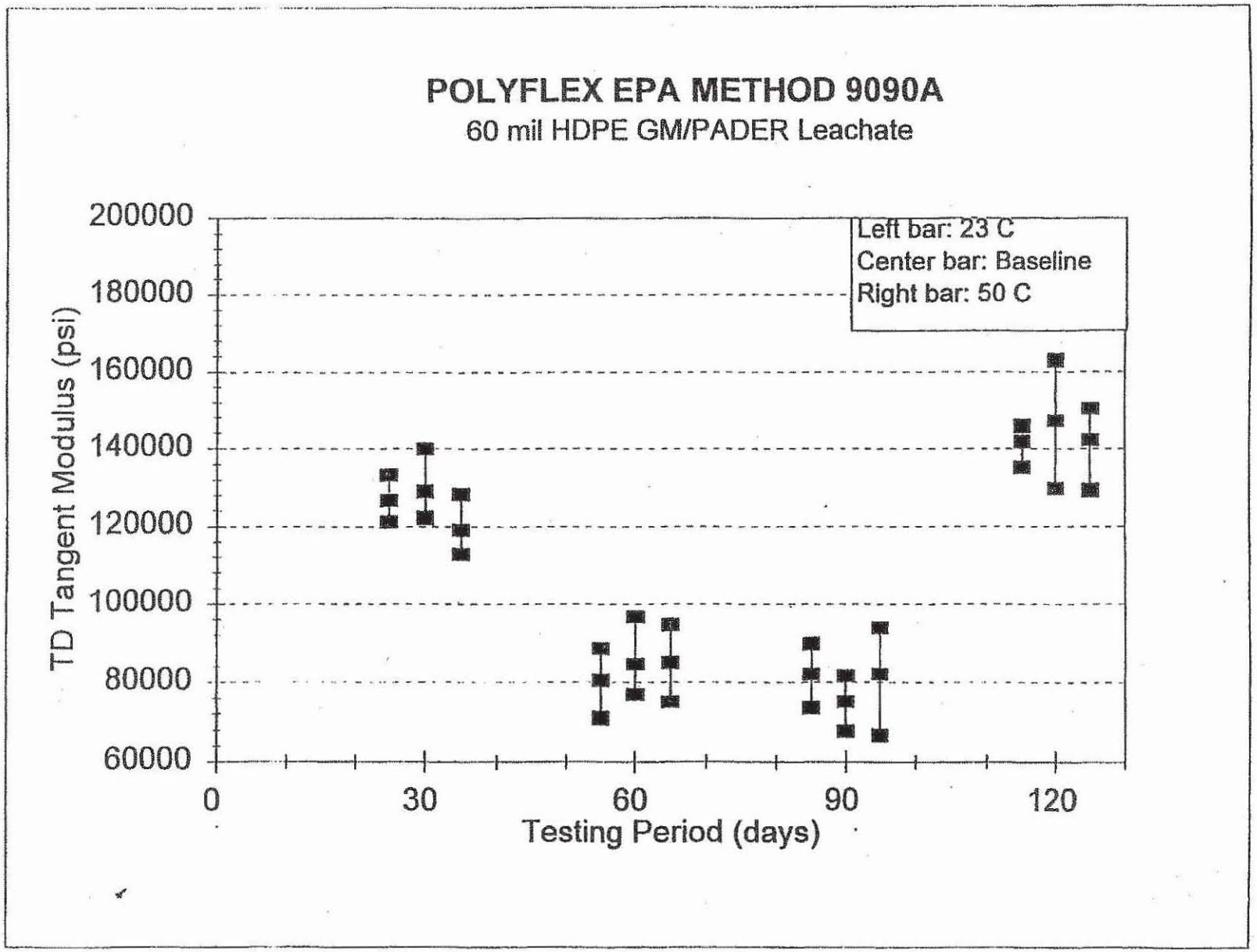

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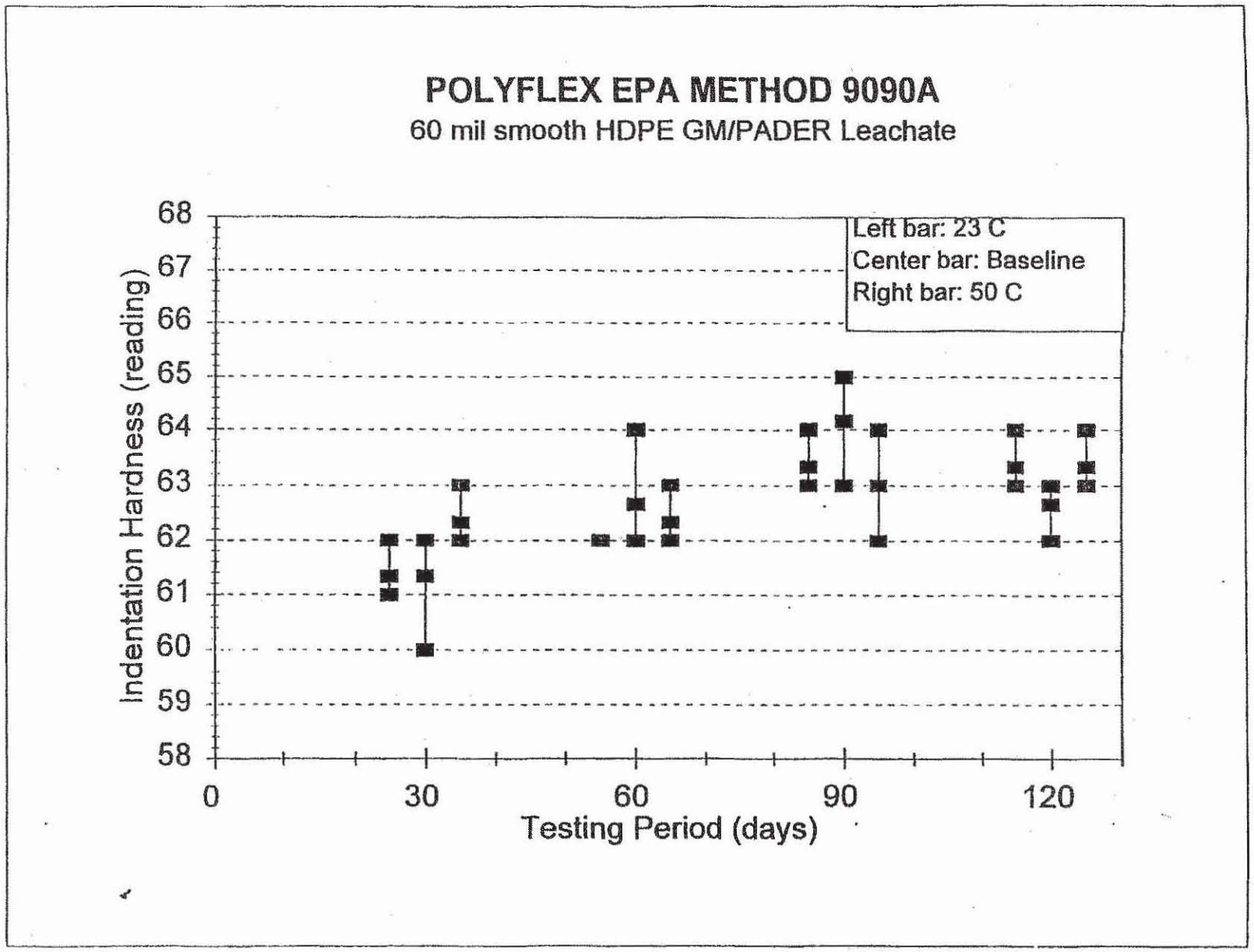

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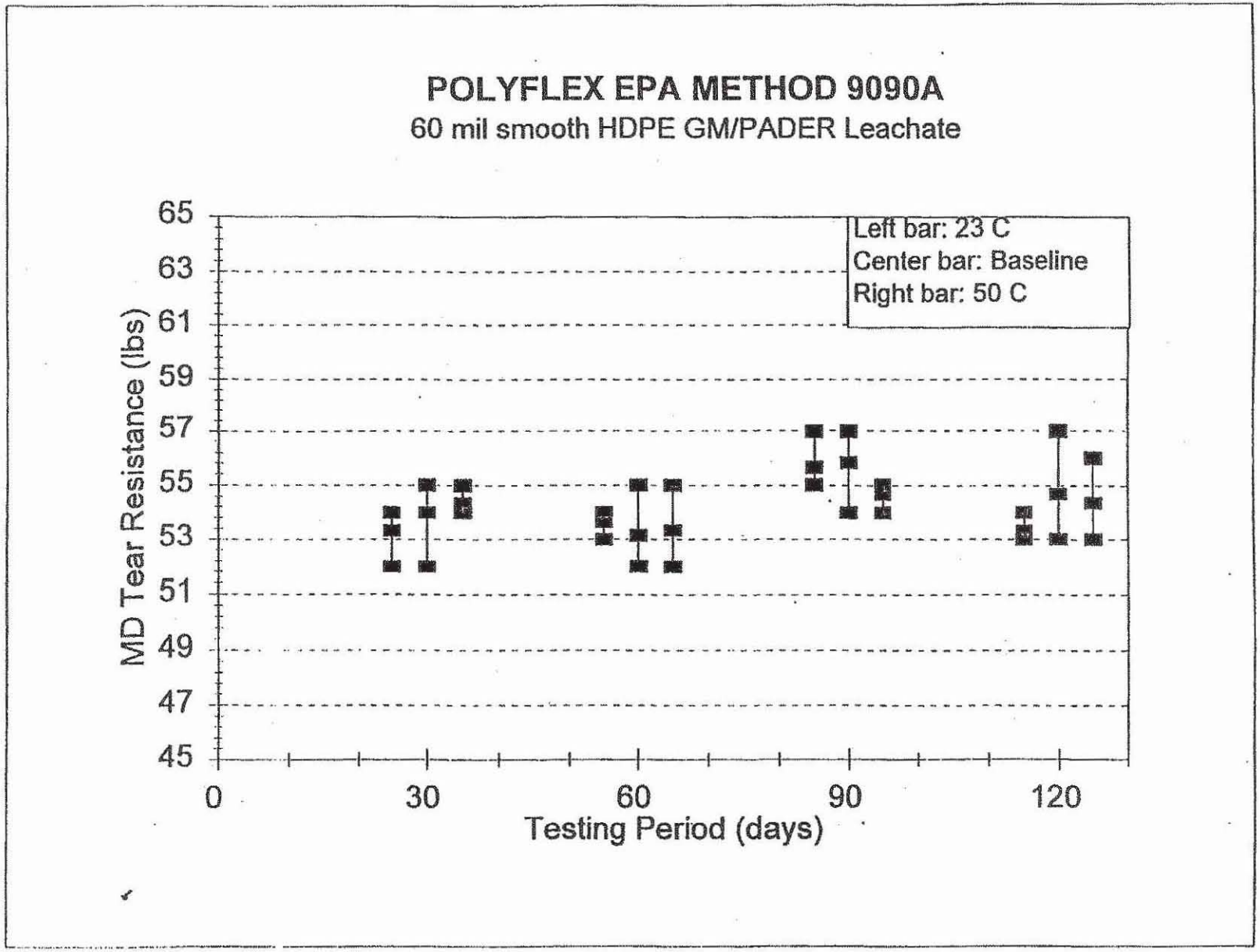

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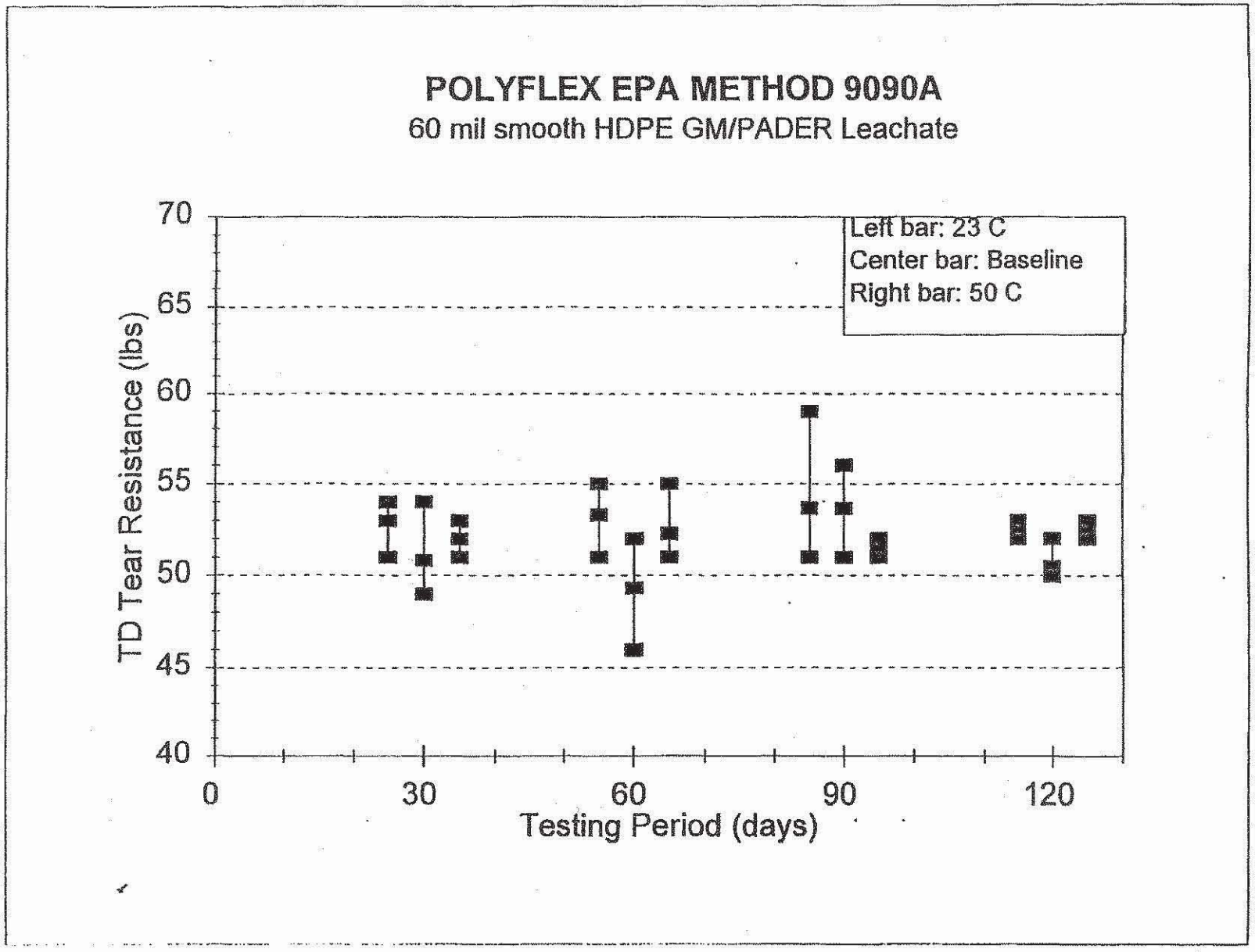

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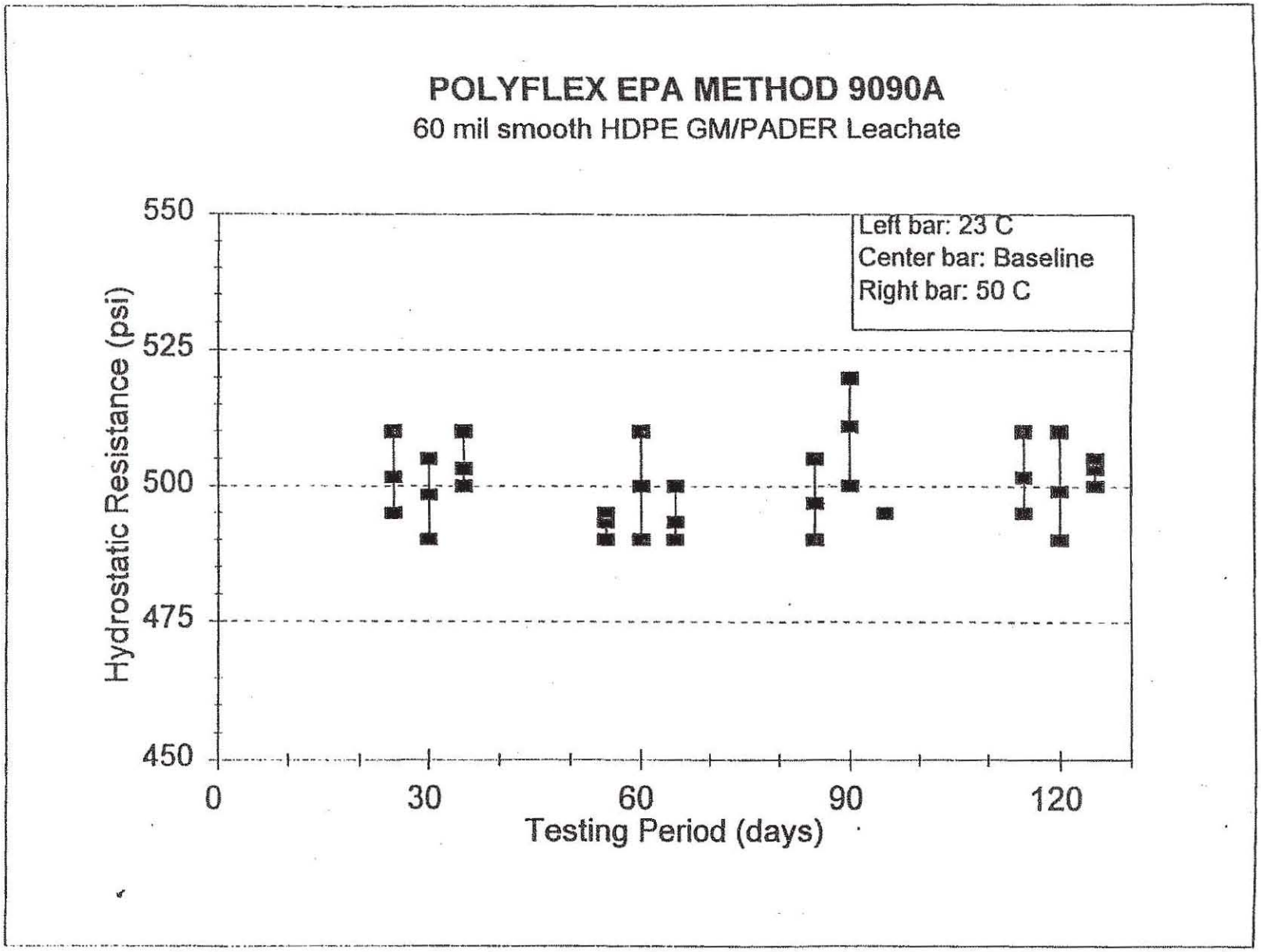

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A Final Report:

Laboratory Testing of SKAPS Industries HDPE Geonet EPA Method 9090A

January 2003

Submitted to:

SKAPS Industries
571 Industrial Parkway
Commerce, GA 30529

Attn: **Mr. Perry Vyas**

Submitted by:

TRI/Environmental, Inc.
9063 Bee Caves Rd.
Austin, Texas 78733

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

January 10, 2003

Mr. Perry Vyas
SKAPS Industries
571 Industrial Parkway
Commerce, GA 30529

Dear Mr. Vyas:

TRI/Environmental, Inc. (TRI) is pleased to present this Final Report for a geonet chemical compatibility study performed in general accordance with EPA Method 9090A.

TRI is very pleased to be of service to SKAPS Industries. Please call me if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetic Services Division

9063 Bee Caves Road, Austin, TX 78733 / 512 263 2101 / fax: 512 263 2558

FOREWORD

The testing reported herein is based upon accepted industry practice as well as the test method listed. TRI/Environmental Inc. (TRI) neither accepts responsibility for nor makes claim as to the final use and purpose of the materials tested.

Tests were performed under laboratory conditions and not under actual usage conditions. TRI can give no conclusions as to the serviceability, life expectancy or general durability of the products tested when used in a lining and/or leachate collection system.

1.0 INTRODUCTION

This report describes the work performed by TRI/Environmental, Inc. (TRI) to determine the chemical compatibility of one HDPE geonet product with one waste leachate. The objective was to determine the resistance of the geonet to changes caused by exposure to leachate. Changes in physical, mechanical and hydraulic properties were measured after exposure to the leachate at 23°C and 50°C for 30, 60, 90 and 120 days. Exposures were performed in accordance with the exposure regimen specified in United States Environmental Protection Agency (EPA) Method 9090A.

All samples were logged in and all testing performed under TRI log number E2173-46-05. Methods, results and discussion are provided in the sections which follow. Test results are provided in the Tables of Results which accompany this report.

2.0 METHODS

2.1 Materials

The material selected for evaluation in this chemical compatibility study was Skaps Industries HDPE biplaner geonet.

2.2 Leachate

The waste leachate used was supplied by TRI and was a synthetic MSW leachate approximating the PaDER leachate recipe.

2.3 Exposure Conditions

Geonet specimens were exposed to the waste leachate following the specifications of EPA Method 9090A as they relate to exposure to waste fluids. The tanks used for these exposures were maintained at 23 ± 2°C and 50 ± 2°C throughout the 120-day exposure period. Tanks were constructed from chemically resistant glass fitted with stirrers. The 50°C tanks were heated with a circulating hot water heat exchanger system. They were also sealed with a lid, and a reflux condenser was installed to minimize loss of volatile leachate components.

2.4 Testing Procedures

Table 1 lists tests performed on the geonet. The number of test replicates was doubled for baseline determinations on unexposed material.

Table 1. Tests performed on Skaps Industries HDPE Geonet

Test or Physical Property	Method	Number of replicate specimens
Dimensions and weight	EPA 9090	2 readings
Strip Tensile Strength	ASTM D 5035	3 MD & TD readings
Strip Tensile Elongation	ASTM D 5035	3 MD & TD readings
Compressive Strength	ASTM D 1621	3 readings
Transmissivity	ASTM D 4716	3 readings
CBR Puncture	ASTM D 6241	3 readings
Volatiles and Extractables	SW870 - Appendix III-D	2 readings

3.0 RESULTS AND DISCUSSION

Test results are presented in the Test Results section which is included with this report. Test results are presented in tabular form as well as graphical form.

In considering these results, it must be determined through engineering judgment whether observed differences in the value of test results measured before and after immersion are due to product variability, unidentified factors relating to the test procedure, or leachate interaction with the product. Any significant chemical interaction with leachate would be expected to result in degradation trends which are consistent across the various properties being evaluated, and not isolated to one set of test results only. However, with each type of material there may be specific properties which are highly sensitive to leachate-induced effects. These factors must be considered in evaluating the various test results for a given product.

Also of critical importance is the issue of product variability. With HDPE geonets, a range of physical and mechanical index test values covering 20% or more of the average is not uncommon. This can be traced to variability inherent in the product, and the randomness associated with the onset of failure under the specified testing conditions. However, in chemical compatibility testing the statistical sampling of a broad range of manufactured product is not possible. Therefore, the small size of the sample population tested at each time point must be taken into consideration. The criteria to be applied in evaluating data measured before and after leachate immersion should be that property changes, if observed, are consistent and so great that product variability and experimental factors can be ruled out.

In this report, standard deviations (STD) are reported for measurements involving three or more replicate specimens. In statistics, the standard deviation is defined as root of the mean squared deviations of individual test results about the mean value. The standard deviation is a quantitative measure of variability within a group of measurements.

One related measure of variability observed within a sample set, relative to the magnitude of the mean value itself, is the *coefficient of variation or variance* (COV). The coefficient of variance is defined as the standard deviation divided by the mean associated with a group of specimens, and may be expressed as a percentage. The COV provides an indication of what proportion of the mean value may be attributable to random experimental factors or product variability. It is useful to consider apparent changes in property values against the criterion of COV since observed changes which fall below the COV may not be significant. This approach was used in preparing the tables in the next section.

The term *range* refers to the difference between the extreme highest and lowest points within a group of measured values. Considering range as a percentage of the mean values provides another measure of variability within a dataset.

In the tables, the high and low extremes for percentage change in mean values are listed for comparison against COV and range as a percentage of mean from the baseline sample group. The high and low percentage changes are the extremes from data measured at 30, 60, 90 and 120 days.

Skaps Industries HDPE Biplaner Geonet

Table 2 illustrates the range of variability in baseline data compared with some of the observed changes in average test values measured after immersion for the geonet.

Table 2. Baseline coefficients of variation and range of percentage change results

Test	Baseline COV (%)*	Baseline Range as % of Mean*	High Observed % Change	Low Observed % Change
Strip Tensile Strength (MD)	7	17	9	-9
Strip Tensile Elongation @ Maximum Load (MD)	6	18	9	-8
Compressive Strength	6	17	4	-6
Transmissivity	2.18	6.63	-0.17	-9.54
CBR Puncture	7	20	9	-9

4.0 CONCLUSION

Changes in certain measured physical and mechanical properties were noted for the geonet. However, the observed variances were random and are believed to be the effects of product variability and experimental factors. In the opinion of the authors, the data, considered together, support the conclusion that observed variances were not caused by exposure to the test leachate.

TRI/Environmental, Inc. is pleased to have been selected to participate in this project. We trust that the information provided in this report meets your requirements for technical documentation of this chemical compatibility study. Please do not hesitate to call if you have any questions or require any additional information.

Respectfully submitted,

Sam R. Allen

Sam R. Allen
Vice President and Division Manager
Geosynthetic Services Division

TRI/Environmental, Inc.

APPENDIX:

EPA METHOD 9090A TEST RESULTS

SKAPS INDUSTRIES HDPE GEONET TEST RESULTS

Dimensions

TRI LOG NUMBER: E2173-46-05

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: January 2003
TRI Log Number: E2173-46-05

Exposure Time and Temperature

Test Parameters	Temp.	30 Day Baseline	30 Day Exposed	30 Day % Change	60 Day Baseline	60 Day Exposed	60 Day % Change	90 Day Baseline	90 Day Exposed	90 Day % Change	120 Day Baseline	120 Day Exposed	120 Day % Change
GEONET: HDPE GEONET EXPOSED TO PADER MSW SYNTHETIC LEACHATE													
Thickness (mils)	23C	224	228	1.8	234	234	0.0	230	230	0.0	228	228	0.0
	50C	232	232	0.0	228	229	0.4	230	231	0.4	229	229	0.0
Length (inches)	23C	6.00	6.00	0.0	6.00	5.85	-2.5	6.00	5.96	-0.7	6.02	6.01	-0.2
	50C	6.00	5.83	-2.8	6.00	5.89	-1.8	6.00	6.00	0.0	5.99	6.00	0.2
Width (inches)	23C	4.04	4.06	0.5	4.01	4.02	0.2	4.01	4.04	0.7	4.02	4.04	0.5
	50C	4.02	4.02	0.0	4.01	4.01	0.0	4.03	4.03	0.0	4.03	4.01	-0.5
Mass (g)	23C	14.91	14.92	0.1	15.46	15.47	0.1	15.30	15.31	0.1	15.23	15.25	0.1
	50C	17.06	17.06	0.0	16.86	16.86	0.0	17.05	17.05	0.0	14.93	14.93	0.0

EPA METHOD 9090A TEST RESULTS

SKAPS INDUSTRIES HDPE GEONET TEST RESULTS

TRI LOG NUMBER: E2173-46-05

NOTE ON TEST RESULTS

This section includes generated test data provided in both tabular and graphical form. Each graph is represented by a series of "I" beam plots. Each "I" beam represents a single test population and illustrates the high and low value as the end points, and the mean as a central box on the beam.

At each testing period, two "I" beams are shown. The left beam represents the 23°C exposed specimens while the right beam represents the 50°C specimens. The initial "I" beam represents the baseline or unexposed test specimens.

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: January 2003
TRI Log Number: E2173-46-05

Test Parameters	Baseline	Exposure Time and Temperature: 30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
GEONET: HDPE GEONET EXPOSED TO PaDER MSW SYNTHETIC LEACHATE									
Strip Tensile Properties:	143	158	173	130	167	131	166	168	133
Maximum Strength (lbs)	167	144	162	153	152	167	148	165	150
ASTM D5035	153	151	147	149	173	126	157	172	144
Machine Direction	150								
	170								
	144								
Average	155	151	161	144	164	141	157	168	142
STD	11	6	11	10	9	18	7	3	7
Coefficient of Variation	7	4	7	7	5	13	5	2	5
% Change		-2	4	-7	6	-9	2	9	-8
Strip Tensile Properties:	33	34	35	30	35	35	31	35	33
Elongation @ Max. Strength (%)	36	28	32	35	42	34	33	36	28
ASTM D5035	35	33	24	32	31	31	35	33	31
Machine Direction	30								
	31								
	33								
Average	33	32	30	32	36	33	33	35	31
STD	2	3	5	2	5	2	2	1	2
Coefficient of Variation	6	8	15	6	13	5	5	4	7
% Change		-4	-8	-2	9	1	0	5	-7

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: January 2003
TRI Log Number: E2173-46-05

Test Parameters	Baseline	Exposure Time and Temperature: 30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
GEONET: HDPE GEONET EXPOSED TO PaDER MSW SYNTHETIC LEACHATE									
Strip Tensile Properties:	56	55	60	57	49	59	53	60	47
Maximum Strength (lbs)	57	53	59	57	56	54	53	61	59
ASTM D5035	64	51	60	56	62	51	52	58	56
Transverse Direction	57								
	51								
	53								
Average	56	53	60	57	56	55	53	60	54
STD	4	2	0	0	5	3	0	1	5
Coefficient of Variation	7	3	1	1	10	6	1	2	9
% Change		-6	6	1	-1	-3	-7	6	-4
Strip Tensile Properties:	129	171	163	151	169	148	155	135	165
Elongation @ Max. Strength (%)	172	160	139	159	157	141	168	147	177
ASTM D5035	153	115	133	160	189	149	167	149	148
Transverse Direction	133								
	151								
	149								
Average	148	149	145	157	172	146	163	144	163
STD	14	24	13	4	13	4	6	6	12
Coefficient of Variation	10	16	9	3	8	2	4	4	7
% Change		1	-2	6	16	-1	10	-3	10

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

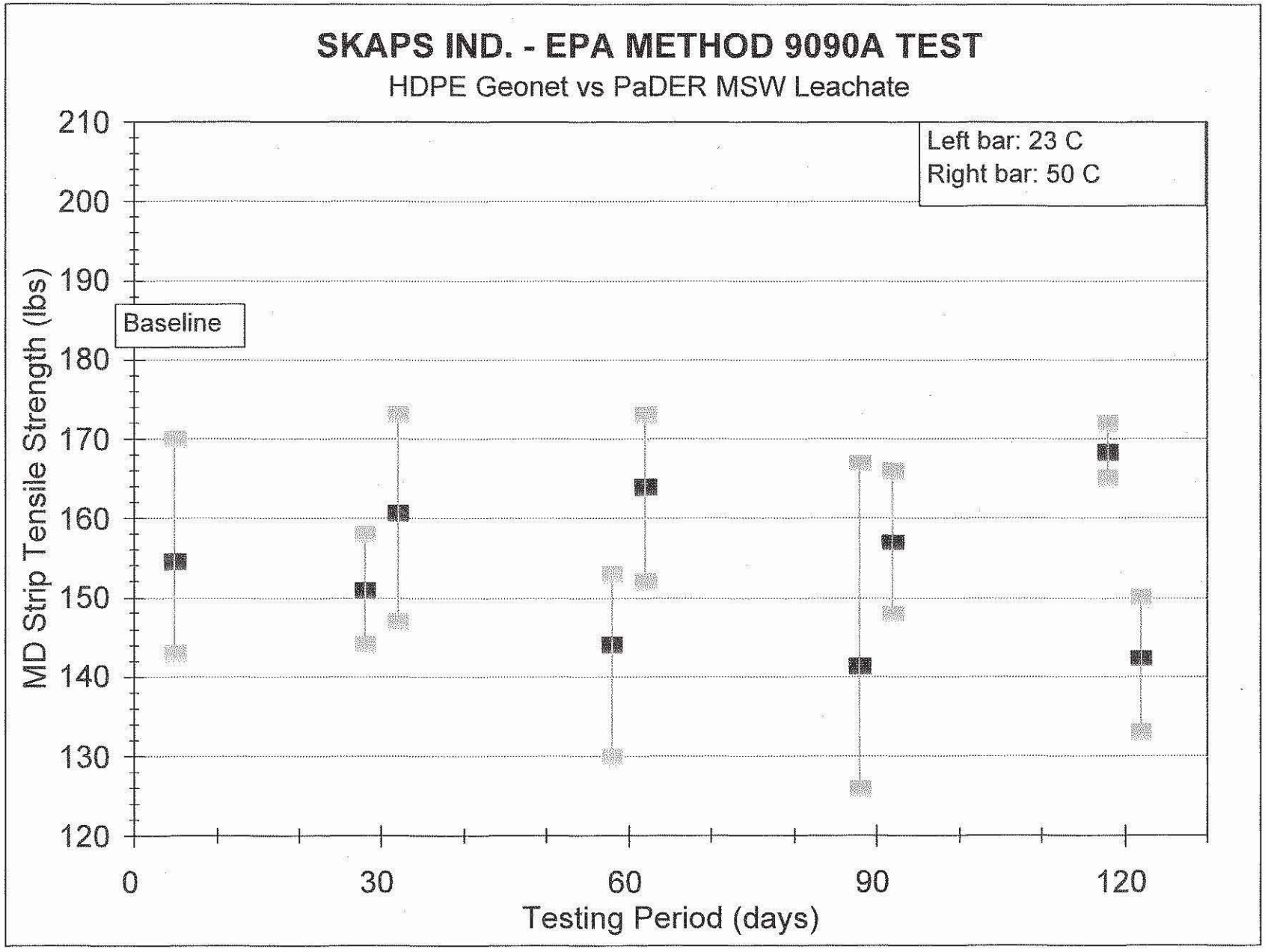
Report Date: January 2003
TRI Log Number: E2173-46-05

Test Parameters	Baseline	Exposure Time and Temperature: 30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
GEONET: HDPE GEONET EXPOSED TO PaDER MSW SYNTHETIC LEACHATE									
Compressive Strength:	35951	36083	33732	25141	34508	39672	33045	35164	31349
Strength at Rib Layover (psf)	35677	31833	39106	40149	23798	32742	32879	34119	33234
ASTM D1621	38252	34801	31922	37048	42045	37877	39494	40486	36492
	36837								
	32100								
	33888								
Average	35451	34239	34920	34113	33450	36764	35139	36590	33692
STD	1989	1780	3051	6469	7487	2937	3080	2788	2124
Coefficient of Variation	6	5	9	19	22	8	9	8	6
% Change		-3	-1	-4	-6	4	-1	3	-5
Transmissivity:	1.96E-03	1.88E-03	1.91E-03	1.77E-03	1.94E-03	1.87E-03	1.90E-03	1.96E-03	1.90E-03
(m2/sec)	1.95E-03	1.88E-03	1.89E-03	1.76E-03	1.91E-03	1.84E-03	1.93E-03	1.96E-03	1.96E-03
ASTM D4716	2.01E-03	1.89E-03	1.94E-03	1.78E-03	1.84E-03	1.82E-03	1.95E-03	1.94E-03	1.89E-03
	1.94E-03								
	2.00E-03								
	1.88E-03								
Average	1.96E-03	1.88E-03	1.91E-03	1.77E-03	1.90E-03	1.84E-03	1.93E-03	1.95E-03	1.92E-03
STD	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Coefficient of Variation	2.18	0.25	1.07	0.46	2.21	1.11	1.07	0.48	1.61
% Change		-3.75	-2.21	-9.54	-3.07	-5.79	-1.53	-0.17	-2.04
CBR Puncture:	292	238	292	279	345	296	308	279	256
Puncture Resistance (lbs)	235	247	298	289	276	278	311	265	275
ASTM D6241	280	270	265	240	273	255	289	246	288
	285								
	286								
	284								
Average	277	252	285	269	298	276	303	263	273
STD	19	13	14	21	33	17	10	14	13
Coefficient of Variation	7	5	5	8	11	6	3	5	5
% Change		-9	3	-3	8	-0	9	-5	-1

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: January 2003
TRI Log Number: E2173-46-05

		Exposure Time and Temperature							
		30 Day		60 Day		90 Day		120 Day	
Test Parameters	Baseline	23C	50C	23C	50C	23C	50C	23C	50C
GEONET: HDPE GEONET EXPOSED TO PaDER MSW SYNTHETIC LEACHATE									
Volatiles and Extractables:	-1.51	-1.51	-1.01	-2.00	-0.51	0.00	-1.00	-0.50	-1.01
Machine Diameter Change (%)	-3.02	-2.51	-1.51	-1.01	-1.50	-1.01	-2.01	-2.53	-0.51
SW 870 - Appendix III-D	-2.51								
	-1.01								
Average	-2.01	-2.01	-1.26	-1.51	-1.01	-0.51	-1.51	-1.52	-0.76
STD	0.79	0.50	0.25	0.50	0.50	0.51	0.50	1.02	0.25
Volatiles and Extractables:	-3.02	-3.48	-1.51	-1.04	-1.01	-1.49	-0.51	-1.03	-1.54
Transverse Diameter Change (%)	-3.98	-3.48	-1.00	-3.05	-1.00	-1.52	-1.02	-1.54	-1.53
SW 870 - Appendix III-D	-1.99								
	-0.50								
Average	-2.37	-3.48	-1.26	-2.05	-1.01	-1.51	-0.77	-1.29	-1.54
STD	1.29	0.00	0.26	1.01	0.01	0.02	0.26	0.25	0.00
Volatiles and Extractables:	0.07	0.11	0.09	0.11	0.16	0.12	0.11	0.12	0.11
% Volatiles	0.07	0.11	0.12	0.10	0.16	0.08	0.10	0.13	0.08
SW 870 - Appendix III-D	0.07								
	0.07								
Average	0.07	0.11	0.11	0.11	0.16	0.10	0.11	0.13	0.10
STD	0.00	0.00	0.02	0.00	0.00	0.02	0.00	0.01	0.01
Volatiles and Extractables:	0.16	0.25	0.21	0.16	0.13	0.22	0.08	0.18	0.10
% Extractables	0.14	0.18	0.25	0.32	0.30	0.27	0.19	0.35	0.30
SW 870 - Appendix III-D	0.16								
	0.25								
Average	0.18	0.22	0.23	0.24	0.22	0.25	0.14	0.27	0.20
STD	0.04	0.04	0.02	0.08	0.09	0.03	0.05	0.08	0.10



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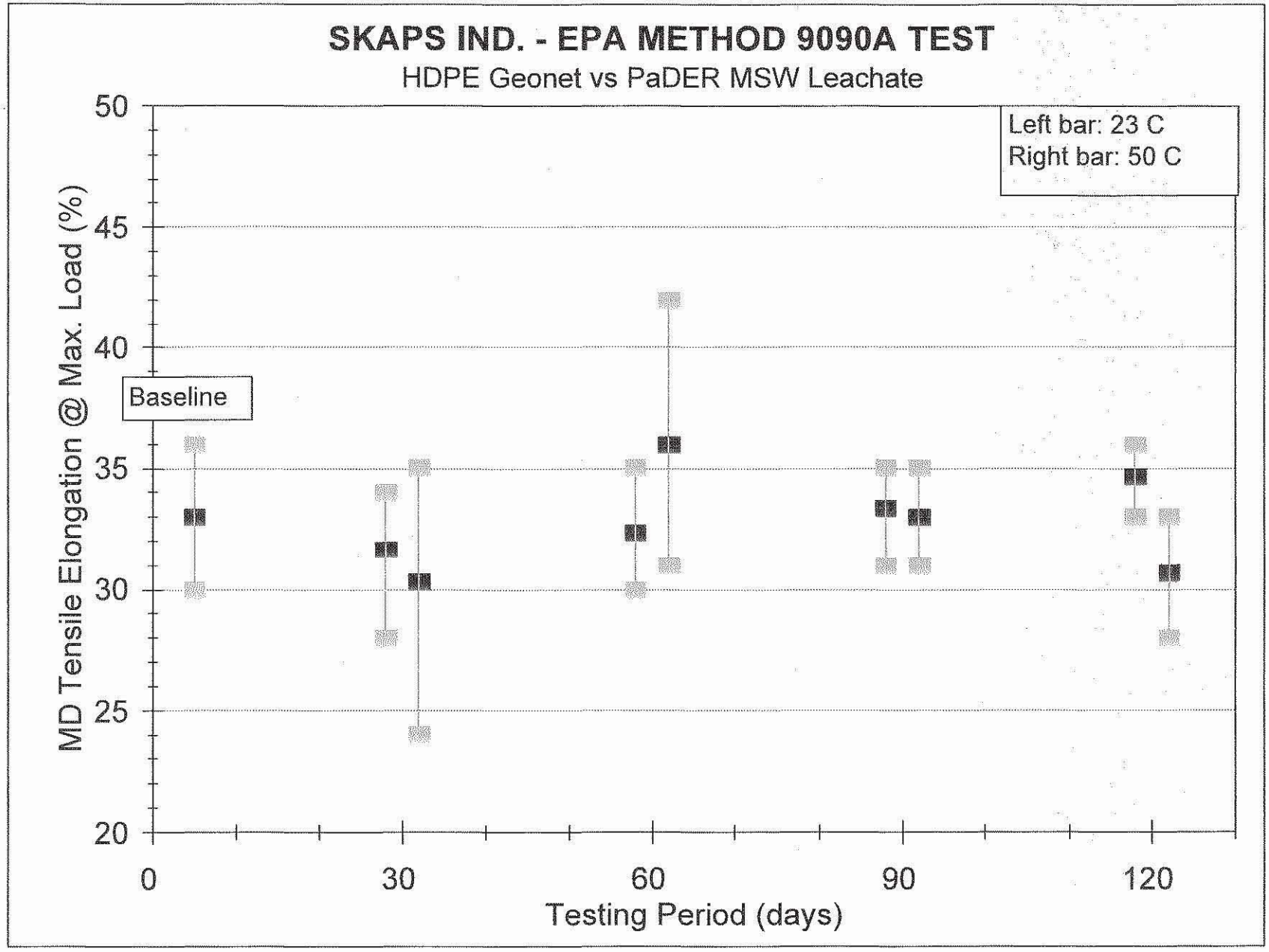

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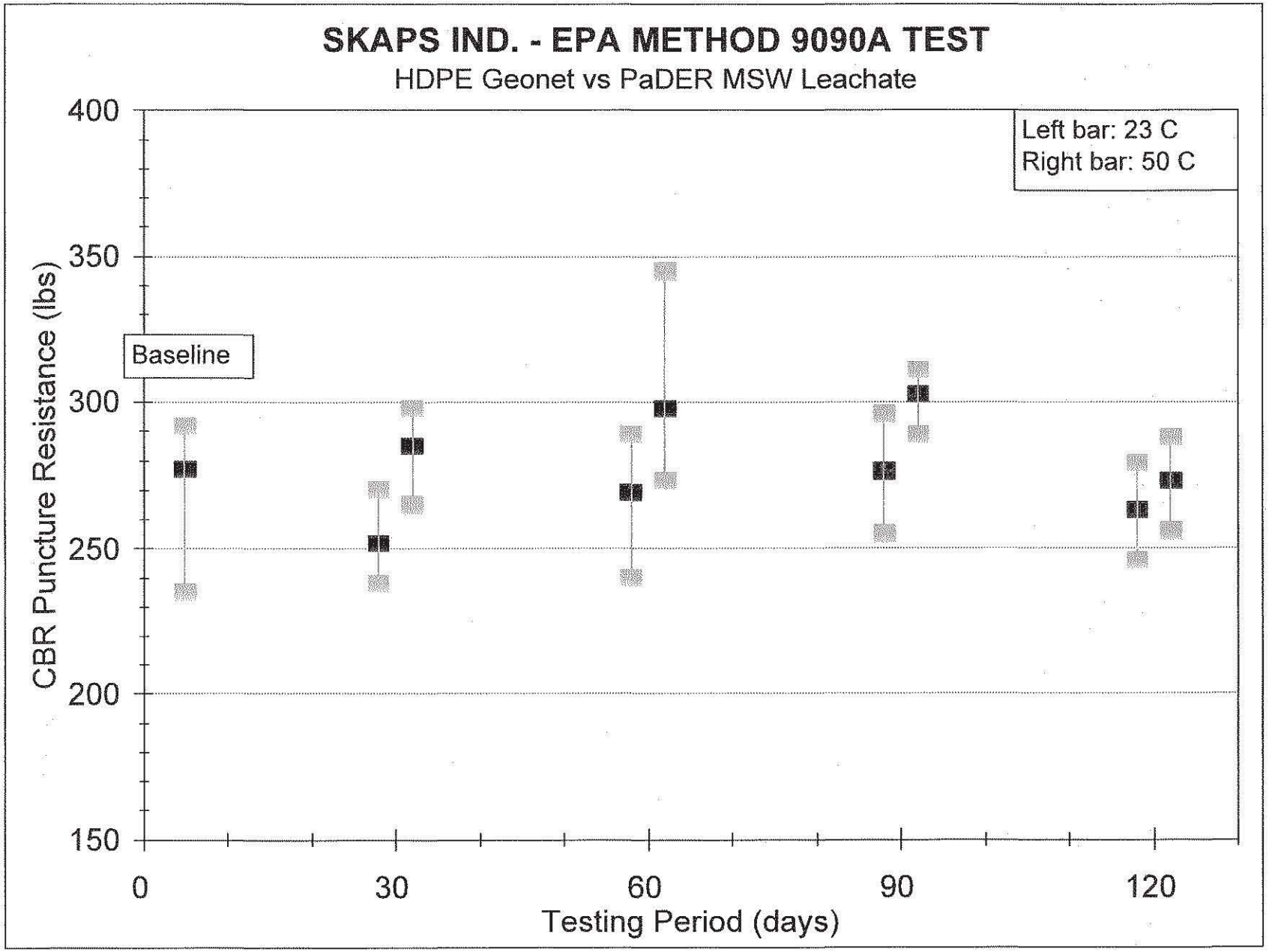

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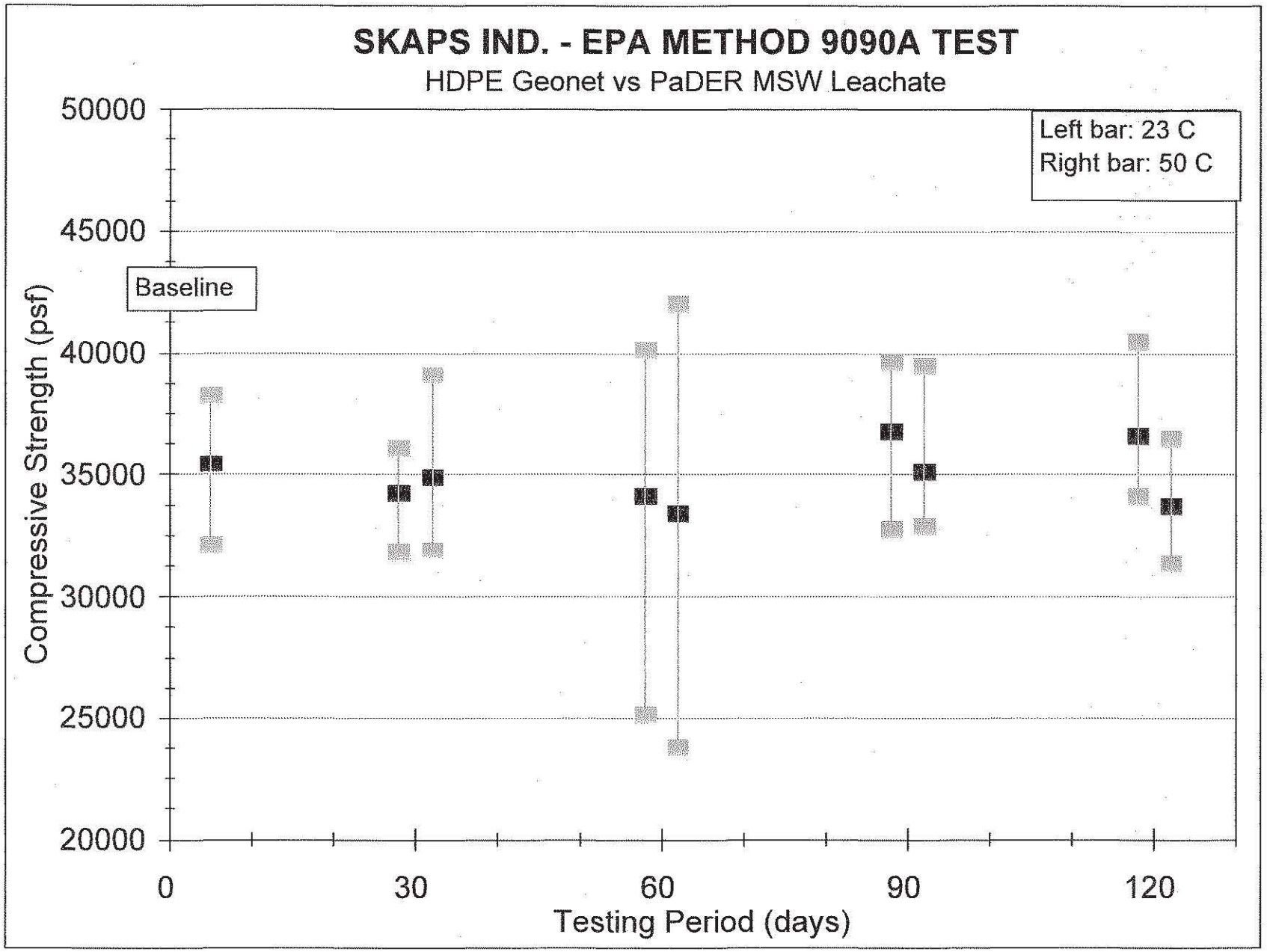

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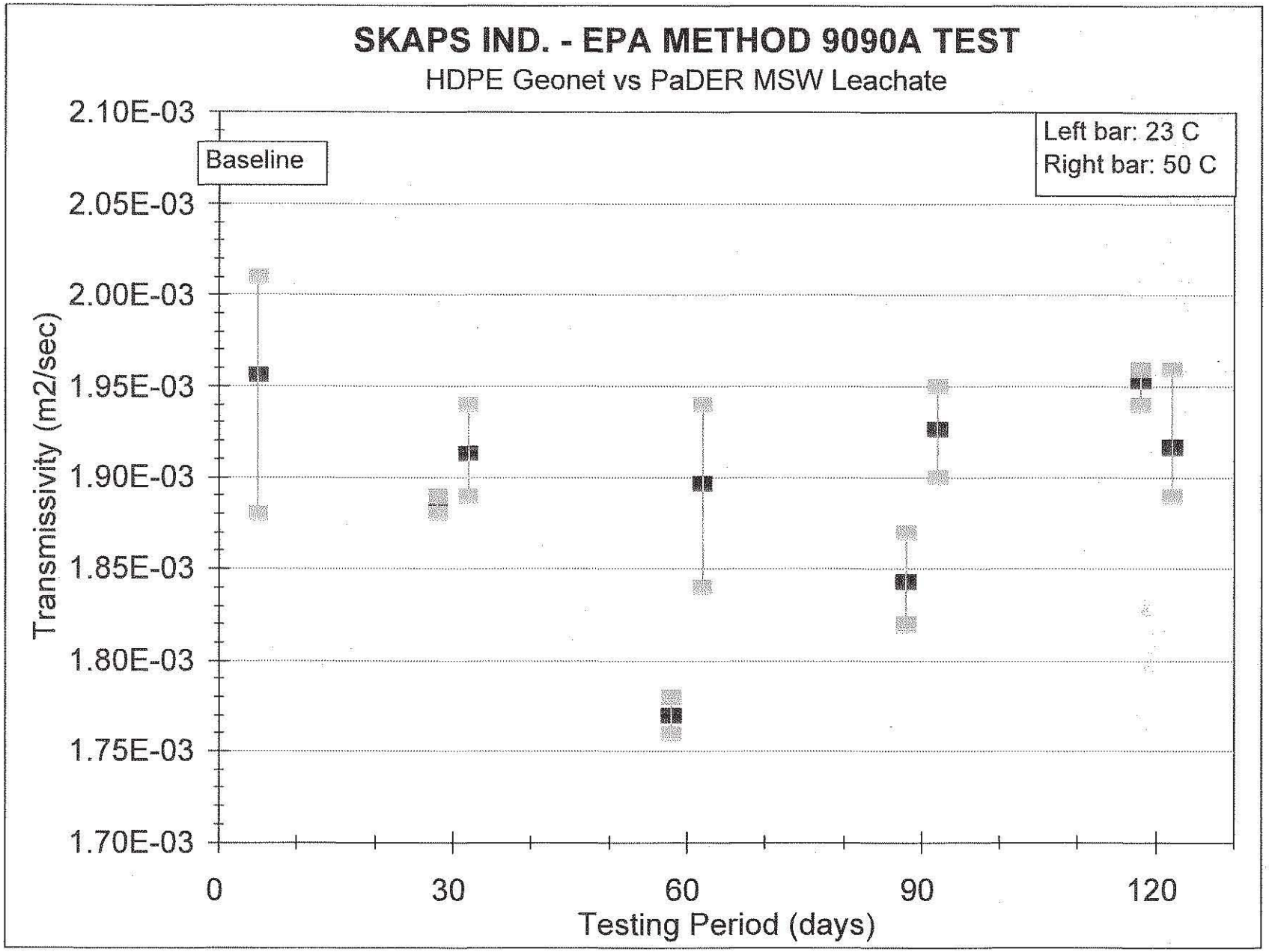

TRI Geosynthetics Division Client: Skaps Industries, File: 465-skaps-gn .WB1

TRI/ENVIRONMENTAL, INC.
A Texas Research International Company

February 11, 2004

Mr. Anarag
Skaps Industries
571 Industrial Parkway
Commerce, GA 30529

Dear Mr. Anarag:

TRI/Environmental, Inc. (TRI) is pleased to present this Final Report for a geotextile chemical resistance study performed in general accordance with EPA Method 9090A as applied by ASTM D 6389-99, *Standard Practice for Tests to Evaluate the Chemical Resistance of Geotextiles to Liquids.*

TRI is very pleased to be of service to Skaps Industries. Please call me if you have any questions or require any additional information (800 880 8378).

Respectfully submitted,

Sam R. Allen

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A Final Report:

Laboratory Testing of Geotextile for Waste Containment EPA Method 9090A

February 2004

Submitted to:

Skaps Industries

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Attn: **Mr. Anarag**

Submitted by:

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FOREWORD

The testing reported herein is based upon accepted industry practice as well as the test method listed. TRI/Environmental Inc. (TRI) neither accepts responsibility for nor makes claim as to the final use and purpose of the materials tested.

Tests were performed under laboratory conditions and not under actual usage conditions. TRI can give no conclusions as to the serviceability, life expectancy or general durability of the products tested when used in a lining and/or leachate collection system.

1.0 INTRODUCTION

This report describes the work performed by TRI/Environmental, Inc. (TRI) to determine the chemical compatibility of one geotextile product with one synthetic waste leachate. The objective was to determine the resistance of the geotextile to changes caused by exposure to leachate. Changes in physical, mechanical and hydraulic properties were measured after exposure to the leachate at 23°C and 50°C for 30, 60, 90 and 120 days. Exposures were performed in accordance with the exposure regimen specified in United States Environmental Protection Agency (EPA) Method 9090A.

All samples were logged in and all testing performed under TRI log number E2183-79-10. Methods, results and discussion are provided in the sections which follow. Test results are provided in the Tables of Results which accompany this report.

2.0 METHODS

2.1 Materials

The material selected for evaluation in this chemical compatibility study was Skaps.GTE 160 polypropylene staple fiber nonwoven needlepunched geotextile.

2.2 Leachate

The waste leachate used was supplied by TRI and was a synthetic MSW leachate approximating the PaDER leachate recipe.

2.3 Exposure Conditions

Geotextile specimens were exposed to the waste leachate following the specifications of EPA Method 9090A as they relate to exposure to waste fluids. The tanks used for these exposures were maintained at 23 ± 2°C and 50 ± 2°C throughout the 120-day exposure period. Tanks were constructed from chemically resistant glass fitted with stirrers. The 50°C tanks were heated with a circulating hot water heat exchanger system. They were also sealed with a lid, and a reflux condenser was installed to minimize loss of volatile leachate components.

2.4 Testing Procedures

Table 1 lists tests performed on the geotextile. The number of test replicates was doubled for baseline determinations on unexposed material.

Table 1. Tests performed on TNS - Nevown, Inc. nonwoven geotextile

Test or Physical Property	Method	Number of replicate specimens
Dimensions and weight	EPA 9090A	2 readings
Grab Tensile Strength	ASTM D 4632	3 MD & TD readings
Grab Tensile Elongation	ASTM D 4632	3 MD & TD readings
Trapezoidal Tear Strength	ASTM D 4533	3 MD & TD readings
Puncture Resistance	ASTM D 4833	3 readings
Mullen Burst	ASTM D 3786	3 readings
Permittivity	ASTM D 4491	3 readings

3.0 RESULTS AND DISCUSSION

Test results are presented in the Test Results section which is included with this report. Test results are presented in tabular form as well as graphical form.

In considering these results, it must be determined through engineering judgment whether observed differences in the value of test results measured before and after immersion are due to product variability, unidentified factors relating to the test procedure, or leachate interaction with the product. Any significant chemical interaction with leachate would be expected to result in degradation trends which are consistent across the various properties being evaluated, and not isolated to one set of test results only. However, with each type of material there may be specific properties which are highly sensitive to leachate-induced effects. These factors must be considered in evaluating the various test results for a given product.

Also of critical importance is the issue of product variability. With nonwoven geotextiles, a range of physical and mechanical index test values covering 20% or more of the average is not uncommon. This can be traced to variability inherent in the product, and the randomness associated with the onset of failure under the specified testing conditions. However, in chemical compatibility testing the statistical sampling of a broad range of manufactured product is not possible. Therefore, the small size of the sample population tested at each time point must be taken into consideration. The criteria to be applied in evaluating data measured before and after leachate immersion should be that property changes, if observed, are consistent and so great that product variability and experimental factors can be ruled out.

In this report, standard deviations (STD) are reported for measurements involving three or more replicate specimens. In statistics, the standard deviation is defined as root of the mean squared deviations of

individual test results about the mean value. The standard deviation is a quantitative measure of variability within a group of measurements.

One related measure of variability observed within a sample set, relative to the magnitude of the mean value itself, is the *coefficient of variation or variance* (COV). The coefficient of variance is defined as the standard deviation divided by the mean associated with a group of specimens, and may be expressed as a percentage. The COV provides an indication of what proportion of the mean value may be attributable to random experimental factors or product variability. It is useful to consider apparent changes in property values against the criterion of COV since observed changes which fall below the COV may not be significant. This approach was used in preparing the tables in the next section.

The term *range* refers to the difference between the extreme highest and lowest points within a group of measured values. Considering range as a percentage of the mean values provides another measure of variability within a dataset.

In the tables, the high and low extremes for percentage change in mean values are listed for comparison against COV and range as a percentage of mean from the baseline sample group. The high and low percentage changes are the extremes from data measured at 30, 60, 90 and 120 days.

SKAPS GTE 160 nonwoven polypropylene geotextile

Table 2 illustrates the range of variability in baseline data compared with some of the observed changes in average test values measured after immersion for the geotextile.

Table 2. Baseline coefficients of variation and range of percentage change results for geotextile

Test	Baseline COV (%)*	Baseline Range as % of Mean*	High Observed % Change	Low Observed % Change
Grab Tensile Strength (MD)	8	22	12	-1
Grab Tensile Elongation @ Maximum Load (MD)	8	24	2	-4
Trapezoidal Tear Strength (MD)	8	22	7	-8
Puncture Strength	17	50	3	-9
Mullen Burst Strength	8	26	5	-9

4.0 CONCLUSION

While some changes in certain measured physical and mechanical properties were noted for the geotextile, the observed variances were random and are believed to be the effects of product variability and experimental factors.

TRI/Environmental, Inc. is pleased to have been selected to participate in this project. We trust that the information provided in this report meets your requirements for technical documentation of this chemical compatibility study. Please do not hesitate to call if you have any questions or require any additional information.

Respectfully submitted,

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APPENDIX:

EPA METHOD 9090A TEST RESULTS

SKAPS GTE 160 Nonwoven Geotextile TEST RESULTS

Dimensions

TRI LOG NUMBER: E2183-79-10

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: February 2004
TRI Log Number: E2189-79-10

Exposure Time and Temperature

Test Parameters	Temp.	30 Day Baseline	30 Day Exposed	30 Day % Change	60 Day Baseline	60 Day Exposed	60 Day % Change	90 Day Baseline	90 Day Exposed	90 Day % Change	120 Day Baseline	120 Day Exposed	120 Day % Change
GEOTEXTILE: POLYPROPYLENE NONWOVEN EXPOSED TO PaDER SYNTHETIC MSW LEACHATE													
GEOTEXTILE ROLL ID: GTE-160													
Thickness (mils)	23C	115	112	-2.6	112	112	0.0	118	118	0.0	108	107	-0.9
	50C	107	104	-2.8	118	117	-0.8	117	113	-3.4	114	117	2.6
Length (inches)	23C	8.06	8.04	-0.2	8.07	8.03	-0.5	8.10	8.00	-1.2	8.05	8.00	-0.6
	50C	8.08	7.97	-1.4	8.06	7.96	-1.2	8.08	7.95	-1.6	8.01	7.94	-0.9
Width (inches)	23C	4.05	4.01	-1.0	4.02	4.00	-0.5	4.00	3.96	-1.0	3.98	3.95	-0.8
	50C	4.00	3.92	-2.0	4.01	3.99	-0.5	4.06	4.02	-1.0	4.06	4.04	-0.5
Mass (g)	23C	4.88	4.87	-0.2	4.88	4.95	1.4	5.01	5.01	0.0	6.55	6.51	-0.6
	50C	4.38	4.38	0.0	5.15	5.08	-1.4	5.08	5.05	-0.6	5.60	5.53	-1.2

EPA METHOD 9090A TEST RESULTS

SKAPS GTE 160 Nonwoven Geotextile TEST RESULTS

TRI LOG NUMBER: E2183-79-10

NOTE ON TEST RESULTS

This section includes generated test data provided in both tabular and graphical form. Each graph is represented by a series of "I" beam plots. Each "I" beam represents a single test population and illustrates the high and low value as the end points, and the mean as a central box on the beam.

At each testing period, two "I" beams are shown. The left beam represents the 23°C exposed specimens while the right beam represents the 50°C specimens. The initial "I" beam represents the baseline or unexposed test specimens.

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: February 2004
TRI Log Number: E2183-79-10

Test Parameters	Baseline	Exposure Time and Temperature: 30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
GEOTEXTILE: POLYPROPYLENE NONWOVEN EXPOSED TO PADER SYNTHETIC MSW LEACHATE									
GEOTEXTILE ROLL ID: GTE-160									
Grab Tensile Properties:	164	206	183	182	215	208	204	214	230
Maximum Strength (lbs)	167	185	208	184	223	196	199	246	205
ASTM D4632	202	211	222	232	240	215	192	161	218
Machine Direction	204								
	187								
	155								
Average	180	201	204	199	226	206	198	207	218
STD	19	11	16	23	10	8	5	35	10
Coefficient of Variation	11	6	8	12	5	4	2	17	5
% Change		12	14	11	26	15	10	15	21
Grab Tensile Properties:	96	109	93	119	94	91	91	95	108
Elongation @ Max. Strength (%)	89	105	100	106	95	98	99	107	98
ASTM D4632	95	107	101	113	91	101	87	103	103
Machine Direction	104								
	109								
	155								
Average	108	107	98	113	93	97	92	102	103
STD	22	2	4	5	2	4	5	5	4
Coefficient of Variation	20	2	4	5	2	4	5	5	4
% Change		-1	-9	4	-14	-10	-15	-6	-5

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: February 2004
TRI Log Number: E2183-79-10

Test Parameters	Baseline	Exposure Time and Temperature: 30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
GEOTEXTILE: POLYPROPYLENE NONWOVEN EXPOSED TO PADER SYNTHETIC MSW LEACHATE									
GEOTEXTILE ROLL ID: GTE-160									
Grab Tensile Properties:	321	345	289	308	338	323	290	285	274
Maximum Strength (lbs)	325	343	310	338	277	317	309	303	309
ASTM D4632	282	252	282	287	252	329	292	310	298
Transverse Direction	288								
	220								
	258								
Average	282	313	294	311	289	323	297	299	294
STD	36	43	12	21	36	5	9	11	15
Coefficient of Variation	13	14	4	7	12	2	3	4	5
% Change		11	4	10	2	14	5	6	4
Grab Tensile Properties:	98	97	93	97	98	93	99	91	93
Elongation @ Max. Strength (%)	115	112	104	109	99	100	99	103	104
ASTM D4632	94	94	103	97	85	93	92	94	95
Transverse Direction	83								
	95								
	99								
Average	97	101	100	101	94	95	97	96	97
STD	9	8	5	6	6	3	3	5	5
Coefficient of Variation	10	8	5	6	7	3	3	5	5
% Change		4	3	4	-3	-2	-1	-1	0

TABLE OF CHEMICAL COMPATIBILITY TEST RESULTS
Client: Skaps Industries

Report Date: February 2004
TRI Log Number: E2183-79-10

Test Parameters	Baseline	Exposure Time and Temperature: 30 Day 23C	30 Day 50C	60 Day 23C	60 Day 50C	90 Day 23C	90 Day 50C	120 Day 23C	120 Day 50C
GEOTEXTILE: POLYPROPYLENE NONWOVEN EXPOSED TO PADER SYNTHETIC MSW LEACHATE									
GEOTEXTILE ROLL ID: GTE-160									
Mullen Burst Strength:	455	380	415	390	450	450	435	415	380
Burst Strength (psi)	420	400	380	400	430	415	410	405	385
ASTM D3786	425	345	415	400	410	410	380	365	350
	400								
	350								
	405								
Average	409	375	403	397	430	425	408	395	372
STD	32	23	16	5	16	18	22	22	15
Coefficient of Variation	8	6	4	1	4	4	6	5	4
% Change		-8	-1	-3	5	4	-0	-3	-9
Permittivity:	1.63	1.61	1.79	1.53	1.66	1.97	1.83	2.06	1.72
(sec -1)	1.81	1.64	1.64	1.97	1.97	2.18	1.97	1.67	1.61
ASTM D4491	1.63	1.53	1.88	1.97	1.83	1.88	1.91	1.91	2.00
	1.79								
	1.76								
	1.68								
Average	1.72	1.59	1.77	1.82	1.82	2.01	1.90	1.88	1.78
STD	0.07	0.05	0.10	0.21	0.13	0.13	0.06	0.16	0.16
Coefficient of Variation	4.28	2.91	5.59	11.38	6.96	6.25	3.01	8.54	9.24
% Change		-7.18	3.11	6.21	6.02	17.09	10.87	9.51	3.50
Trapezoidal Tear	87	97	78	85	106	61	85	102	101
Tear Strength - (lbs)	86	87	94	82	91	78	101	70	104

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