

5102Permit1996 - Batch No. \_\_\_

8

Johnston Co.

51021996

State of North Carolina  
Department of Environment,  
Health and Natural Resources  
Division of Waste Management

James B. Hunt, Jr., Governor  
Jonathan B. Howes, Secretary  
William L. Meyer, Director



October 15, 1996

Mr. Tom Wainwright, PE  
McKim & Creed Engineers, P.A.  
5625 Dillard Road, Suite 117  
Cary, NC 27511

Re: Geotextile Cushion in <sup>J</sup>/~~Johnston~~ County Landfill, Permit Number 51-02

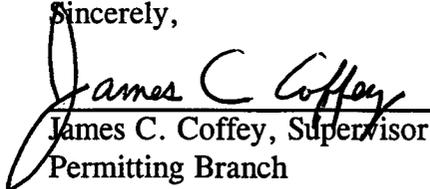
Dear Mr. Wainwright,

The Division of Waste Management, the Solid Waste Section (Section) is in receipt of your letter of 11 October, 1996. This letter requests that the project specifications be amended to allow elimination of the geotextile cushion from under work pads and haul routes. This recommendation is based upon a test pad that was constructed at the landfill which indicated that if the construction procedures follow strict specifications the liner would be satisfactorily protected.

The Section has reviewed the proposed modification to the approved plan. Pursuant to Permit Number 51-02, permit condition 9, the Section has reviewed the changes and hereby accepts them.

Field changes or other deviations from the approved plan, should be included on the as-built drawings and properly identified in the final CQA report as required by the plan. If you have any questions or need additional assistance, please contact the Section.

Sincerely,

  
James C. Coffey, Supervisor  
Permitting Branch  
Solid Waste Section

cc: P. Haywood, Johnston County  
Terry Dover, SWS  
Jim Barber, SWS



# MCKIM & CREED

October 11, 1996

M&C 0358-0060.OR(CQAAC)

Mr. Ed Mussler, PE  
Solid Waste Section  
NCDEHNR  
P O Box 27687  
Raleigh, NC 27611-7687

ENGINEERS

SURVEYORS

ARCHITECTS

PLANNERS

**RE: GEOTEXTILE CUSHION IN JOHNSTON COUNTY LANDFILL  
PERMIT 51-02**

Dear Ed:

Pursuant to your conversation today with Dr. C.J. Poran, please find enclosed a letter report by ENSOL Corporation (ENSOL) describing the geotextile cushion field test including analysis of the results (Tables 1 and 2 of that report).

Based on these results and ENSOL's analysis, McKim & Creed would like to request approval of the Solid Waste Section to eliminate the cushion from under work pads and haul routes. Such elimination will be considered acceptable in conjunction with the strict Specifications detailing construction procedures of the leachate pipes, drainage layer, operational cover and other associated components. In any case "Rub strips" under the leachate collection pipes will be installed according to the Specifications.

Your prompt response will be greatly appreciated. Please do not hesitate to contact me at 233-8091 or Dr. Poran at 233-0407 if you have any questions.

Best regards.

Sincerely,

MCKIM & CREED ENGINEERS, P.A.

Tom Wainwright, PE  
Project Engineer

SUITE 117

BUILDING I

5625 DILLARD ROAD

CARY, NC 27511

PHONE 919/233-8091

FAX 919/233-8031

Attachment: ENSOL's report

cc: Dr. C. J. Poran (ENSOL)

# ENSOL CORPORATION

## ENGINEERING SOLUTIONS

October 11, 1996

Mr. Tom Wainwright, PE  
McKim & Creed  
5625 Dillard Road, Suite 117  
Cary, NC 27511

5625 Dillard Road, Suite 117  
Cary, NC 27511, USA  
Telephone: 919.233.0407  
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INTERNET: cjp@ix.netcom.com

M&C 0358-0060.OR(CQAAC)

### RE: PRELIMINARY TEST RESULTS OF GEOTEXTILE CUSHION

Dear Tom:

Please find Tables 1 and 2 enclosed herewith with analysis of preliminary test results by JLT of the HDPE specimens from the field test. JLT's preliminary results are shown in Appendix A. A complete report on test procedures will be submitted with the hard copy of JLT's results to the Solid Waste Section (SWS) at the North Carolina Department of Environment, Health, and Natural Resources (NCDEHNR) with the subgrade and clay liner submittal. However, a brief description of the field test is included in the following.

#### Field Test

The field test was performed on September 19, 1996 in general accordance with the Specifications, the 60 mil Poly-Flex HDPE liner was subject to actual construction loads of a wide-track Caterpillar D-6 bulldozer that was used for spreading and leveling the 78M stone drainage layer and the operational cover. The test pad consisted of two sections: "Y" section with Amoco 4508 geotextile cushion; and, "N" section without the geotextile cushion. The actual width of the test sections was about 20 feet.

Following test pad construction, a Caterpillar articulated truck model D400D was used to apply 100 axle loads (50 passes). At the completion of these passes the HDPE liner was carefully exposed, and examined. Samples "Y" and "N" were then cut out of the areas that were under the truck wheels load. Sample "C" was cut out of the control (unused) portion of the HDPE roll.

Fifteen specimens (each 14 x 14 inch size) were cut for each for each of the three samples and machine direction (MD) was marked on each specimen. For the "Y" and "N" specimens the MD arrow also indicated the upper side of the liner during the test. The specimens were shipped to JLT for testing that is briefly described in the following:

#### JLT's Laboratory Testing

JLT loaded each of the twelve specimens of Samples "Y" and "N" in a hydrostatic load cell to simulate service conditions (e.g., placed on compacted clay liner, with and without a geotextile cushion between the overlaying drainage stone layer and the specimen, respectively). An hydrostatic pressure of 100 psi was applied on top of the 6-inch thick drainage stone layer in the cell for 24 hours. This pressure is three (3) times the maximum overburden anticipated in this facility. JLT staff examined each "Y" and "N" specimen after removal from the hydrostatic load cell. All three samples were then tested for wide-width strength (ASTM D-4885) to strain levels that substantially exceeded yield. JLT's preliminary results (shown in Appendix A) were analyzed, as follows.

### Analysis of JLT's Preliminary Test Results

Based on the analysis shown in Tables 1 and 2, the following conclusions are made:

- Sample "Y" (with the cushion): Generally, the yield strength of "Y" appears to be unaffected by the severe loading conditions when compared to Sample "C" (control). The strain at yield is only slightly lower than Sample "C". However, a mean value of 19.7% is only 1.2% less than Sample "C".
- Sample "N" (without the cushion): Generally, the yield strength of "N" appears to be almost unaffected by the severe loading conditions when compared to Sample "C" and "Y" (2% and 4% less, respectively). The average strain at yield is 18.6% which is significantly higher than 13% (strain at yield required in the specifications). This strain at yield is only slightly less when compared with 20.9% and 19.7% for Samples "C" and "Y", respectively, indicating a possible small effect of increased brittleness of the sample without the geotextile cushion under such severe loading conditions.

Based on these conclusions please be advised on the following recommendations:

- The effect of the severe loading conditions on the wide-width test results of Sample "N" compared to Samples "Y" and "C" appears to be relatively small. Based on these results, the geotextile cushion may be eliminated with the exception of "rub strips" noted in the Specifications.
- Contingent on SWS approval you could consider to eliminate the cushion from under work pads and haul routes provided that construction procedures of the leachate pipes, drainage layer, operational cover and other associated components must be performed strictly according to the Specifications.

Should JLT revise any test results in their final hard-copy report which is due shortly, I will advise you immediately in case that these changes affect any of the above mentioned conclusions or recommendations. Please do not hesitate to contact me if you have any questions.

Sincerely,

ENSOL Corporation



Chaim J. Poran, PhD, PE  
President

Attachment: Table 1: Analysis of JLT's preliminary test results  
Appendix A: JLT's preliminary results

**Table 1. Preliminary Summary of the Geotextile Cushion Field Test Results**

Ratio Description	Sample C (Control)		Sample Y (W. Cushion)		Sample N (W.O. Cushion)	
	Peak Load	Strain @ Yield	Peak Load	Strain @ Yield	Peak Load	Strain @ Yield
Machine Direction (MD)	1,378	22.2	NA	NA	1,252	26.7
	1,367	24.4	1,402	20.6	1,365	17.3
	1,330	25.6	1,343	19.6	1,230	17.3
	1,342	23.3	1,412	17.6	1,336	17.8
	1,329	21.8	1,430	19.6	1,225	17.6
	1,329	18.9	1,406	16.9	1,220	19.5
Cross Direction (CD)	1,386	22.2	1,441	20.0	1,465	16.2
	1,421	20.0	1,365	20.6	1,430	16.9
	1,443	17.6	1,342	19.6	1,311	17.8
	1,367	18.0	1,449	17.6	1,448	17.3
	1,389	20.0	1,450	19.6	1,434	17.8
	1,504	17.3	1,441	25.0	1,462	20.5
MD Mean (MM)	<b>1,346</b>	<b>22.7</b>	<b>1,398</b>	<b>18.9</b>	<b>1,271</b>	<b>19.4</b>
MD SDEV (MSD)	22	2.3	33	1.5	63	3.7
CD Mean (CM)	<b>1,418</b>	<b>19.2</b>	<b>1,414</b>	<b>20.4</b>	<b>1,425</b>	<b>17.8</b>
CD SDEV (CSD)	50	1.9	48	2.5	58	1.5
Total Mean (TM)	<b>1,382</b>	<b>20.9</b>	<b>1,407</b>	<b>19.7</b>	<b>1,348</b>	<b>18.6</b>
Total SDEV (TSD)	53	2.7	41	2.2	99	2.8

**Table 2. Statistical Ratio Analysis of Preliminary Test Results from Table 1**

Ratio Description	Sample C (Control)		Sample Y (W. Cushion)		Sample N (W.O. Cushion)	
	Peak Load	Strain @ Yield	Peak Load	Strain @ Yield	Peak Load	Strain @ Yield
MM/(MM of "C")	1.00	1.00	1.04	0.83	0.94	0.85
MSD/(MSD of "C")	1.00	1.00	1.53	0.66	2.91	1.58
CM/(CM of "C")	1.00	1.00	1.00	1.06	1.00	0.93
CSD/(CSD of "C")	1.00	1.00	0.96	1.31	1.16	0.78
MM/(MM of "Y")	0.96	1.20	1.00	1.00	0.91	1.03
MSD/(MSD of "Y")	0.65	1.51	1.00	1.00	1.90	2.38
CM/(CM of "Y")	1.00	0.94	1.00	1.00	1.01	0.87
CSD/(CSD of "Y")	1.04	0.77	1.00	1.00	1.20	0.60
TM/(TM of "C")	1.00	1.00	1.02	0.94	0.98	0.89
TSD/(TSD of "C")	1.00	1.00	0.77	0.79	1.87	1.03
TM/(TM of "Y")	0.98	1.06	1.00	1.00	0.96	0.94
TSD/(TSD of "Y")	1.30	1.27	1.00	1.00	2.43	1.30

**APPENDIX A**  
**PRELIMINARY WIDE-WIDTH TEST RESULTS**  
**OF GEOTEXTILE CUSHION**

**By JLT, October 8, 1996**

**ENSOL**  
CORPORATION

# J&L Testing Company, Inc.

938 South Central Avenue  
Canonsburg, PA 15317  
1-800-746-1406  
(412) 746-1441  
Fax: (412) 745-4261

10-8-96 CJP

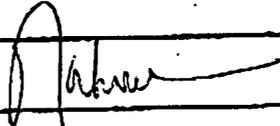
YOU SHOULD RECEIVE ( 4 ) PAGE(S), INCLUDING THIS COVER SHEET. IF YOU DO NOT RECEIVE ALL THE PAGES. PLEASE CALL (800) 746-1406.

Date:	10-7-96
Company:	McKeem & Creed ENG
To:	DR C J. PORAN, PE

Fax:	919 233 8031
Phone:	919 233 8091
From:	DR. MAHRU SHETIMA, PE

COMMENTS:

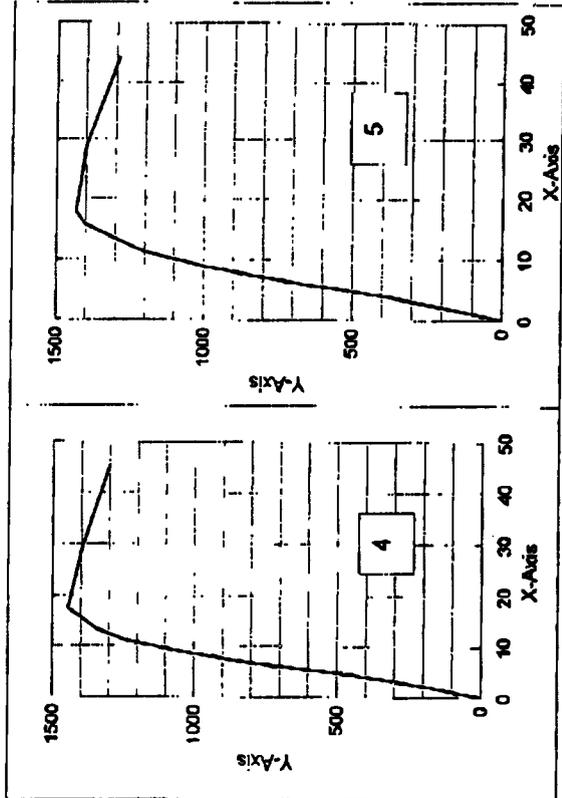
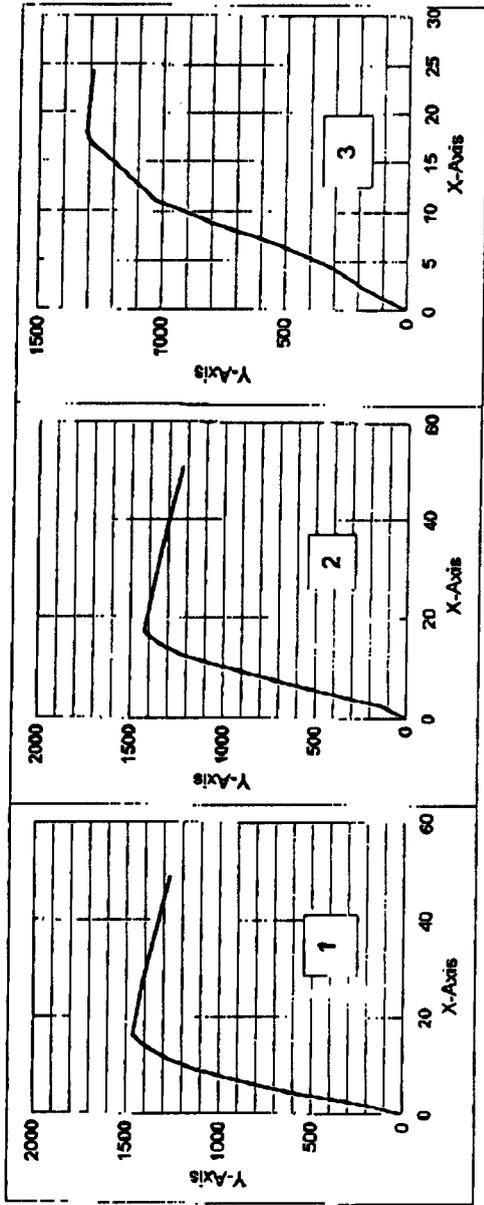
SUMMARY CURVES FOR SAMPLE "C" (MD & CD)  
SUMMARY CURVES FOR SAMPLE "N" (MD)

Signature: 

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# fax

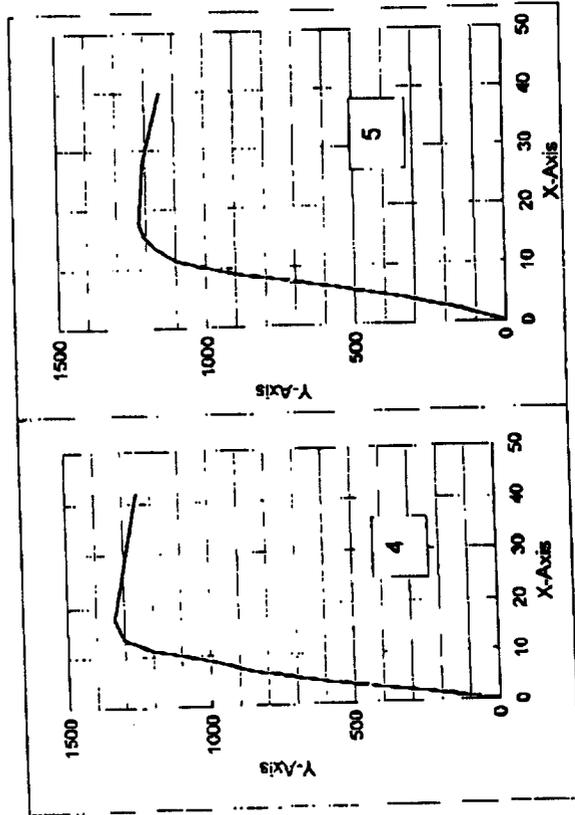
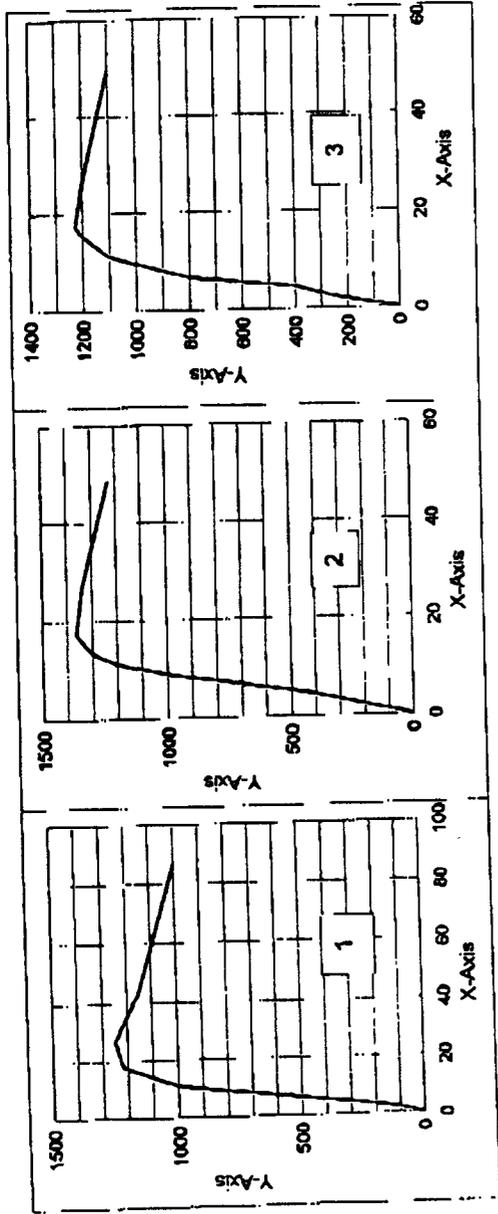
## TRANSMISSION



REPLICATE NO.	PEAK LOAD lb	STRAIN @ PEAK %
1	1465.2	16.2
3	1429.7	16.9
4	1310.7	17.8
5	1447.7	17.3
6	1434.2	17.8
2	1462.2	20.5

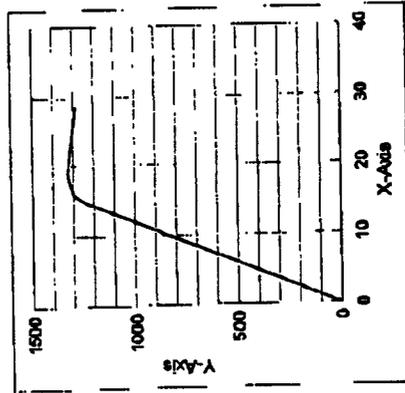
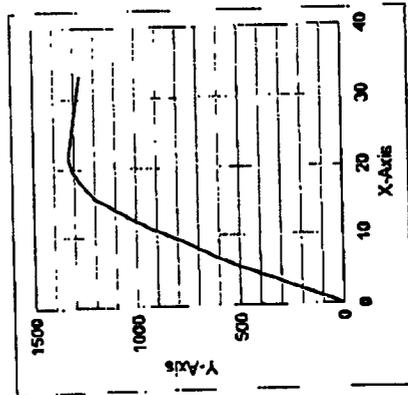
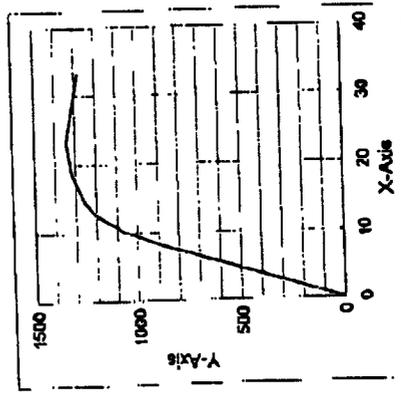
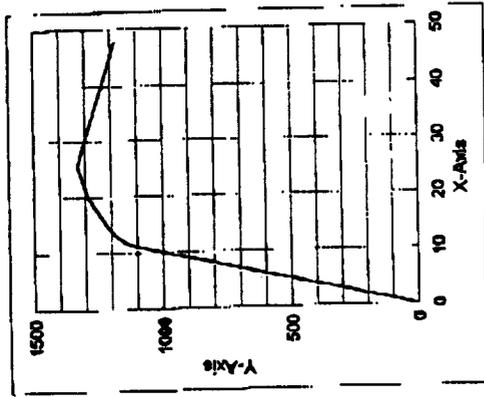
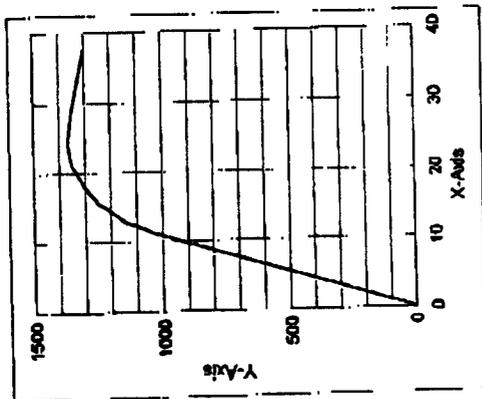
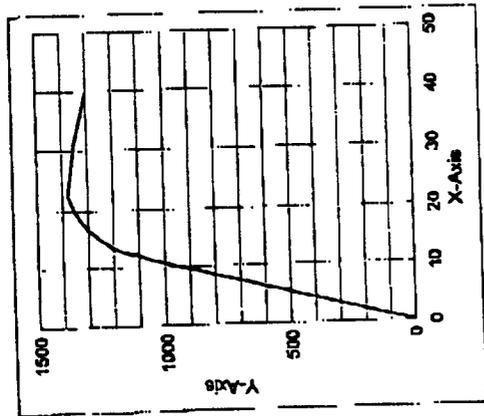
SAMPLE "N" (MD)

JOHNSTON COUNTY LANDFILL

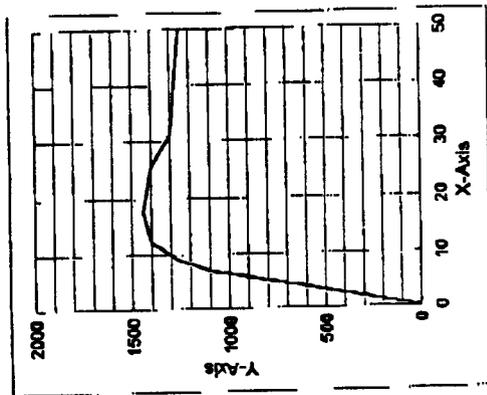


REPLICATE NO.	PEAK LOAD lb	STRAIN @ PEAK %
1	1251.7	26.7
2	1364.7	17.3
3	1229.7	17.3
4	1335.7	17.8
5	1225.0	17.6
6	1220.2	19.5

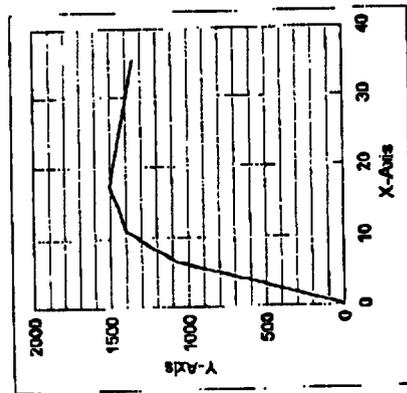
JOHNSTON COUNTY LANDFILL



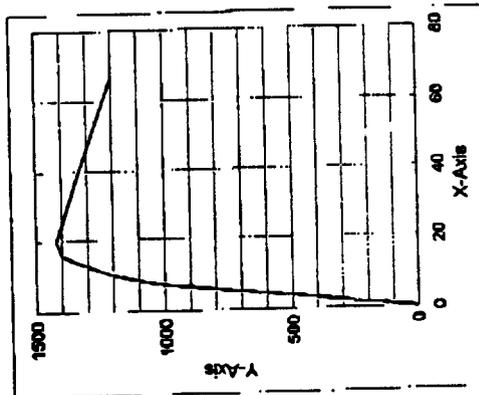
JOHNSTON COUNTY LANDFILL



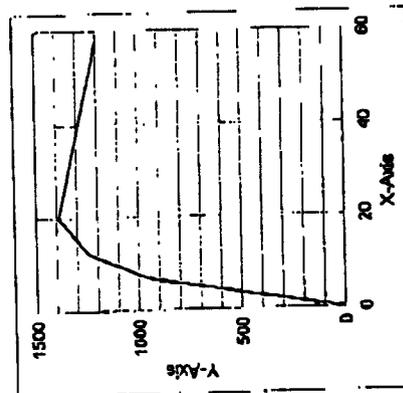
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STRAIN @ PEAK, % 17.6



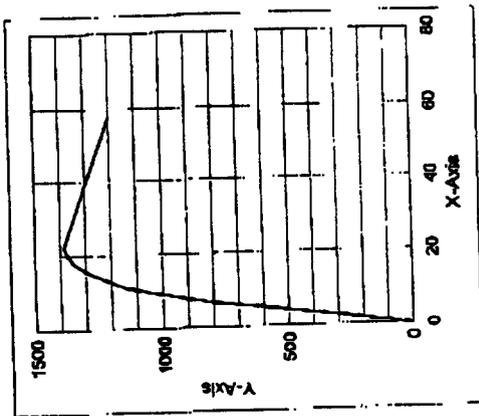
PEAK LOAD, lb 1504  
STRAIN @ PEAK, % 17.3



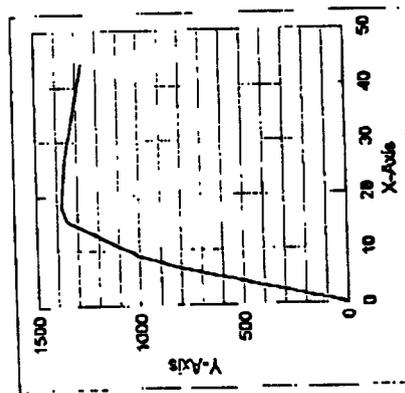
PEAK LOAD, lb 1421.0  
STRAIN @ PEAK, % 20.0



PEAK LOAD, lb 1389  
STRAIN @ PEAK, % 20



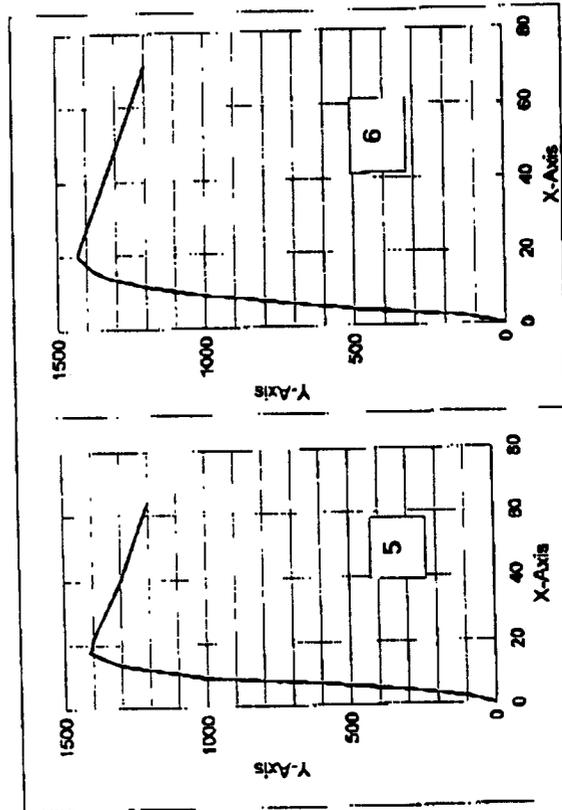
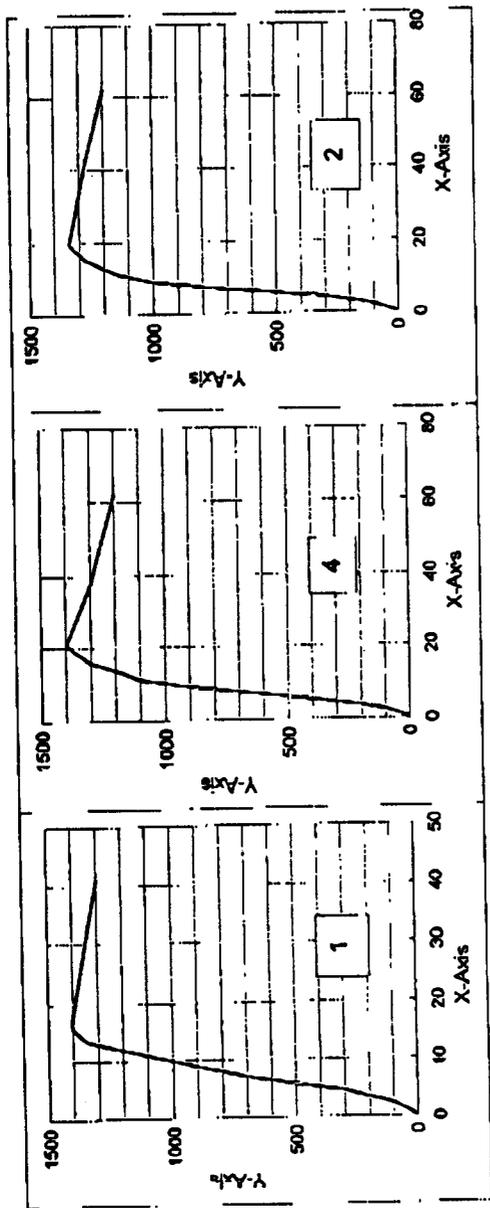
PEAK LOAD, lb 1386.0  
STRAIN @ PEAK, % 22.2



PEAK LOAD, lb 1376.0  
STRAIN @ PEAK, % 18.0

SAMPLE "Y" (MD)

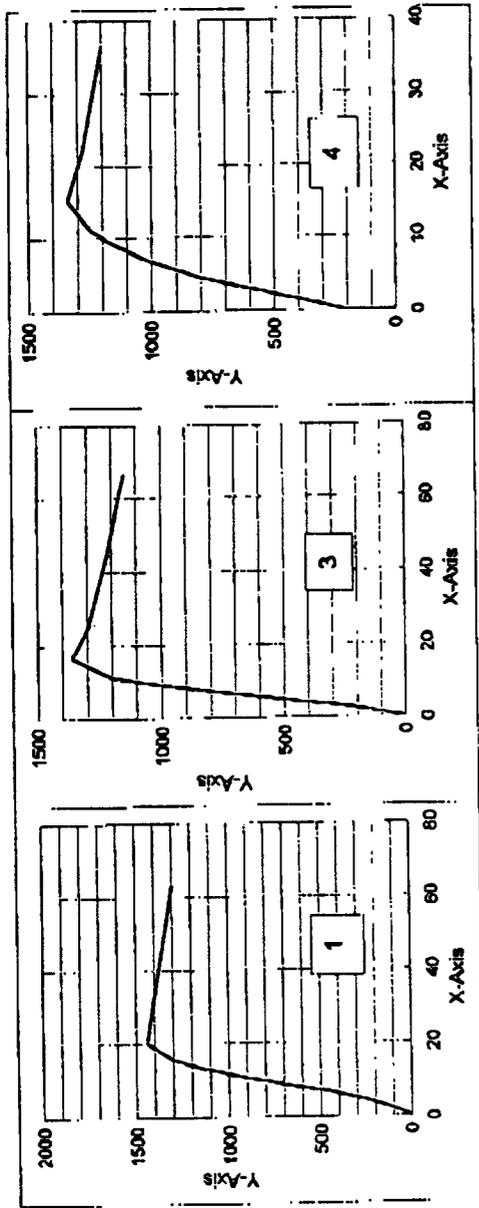
JOHNSTON COUNTY LANDFILL



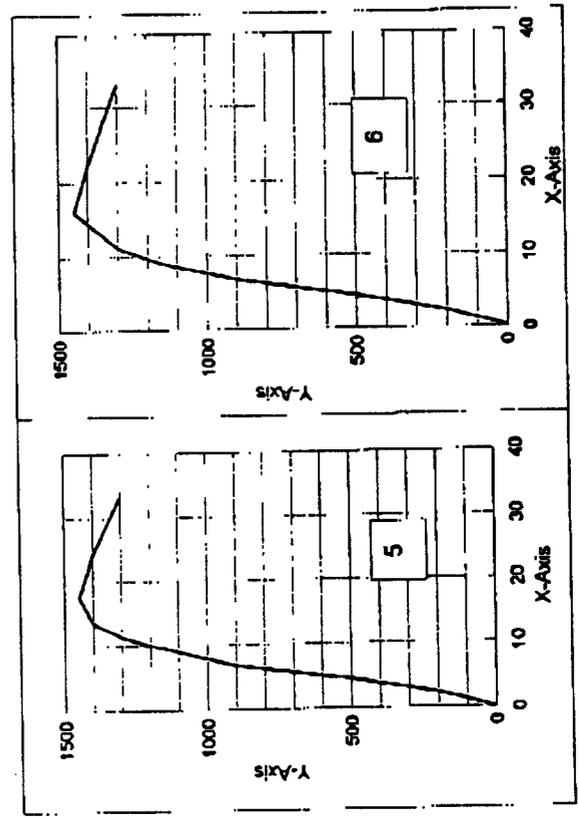
REPLICATE NO.	PEAK LOAD lb	STRAIN @ PEAK %
1	1406.0	16.9
2	1402.0	20.6
3	1342.5	19.6
4	1411.5	17.6
5	1430.7	19.6

SAMPLE "Y" (CD)

JOHNSTON COUNTY LANDFILL



REPLICATE NO.	PEAK LOAD lb	STRAIN @ PEAK %
1	1440.5	20.0
3	1365.0	20.6
4	1341.5	19.6
5	1448.7	17.6
6	1449.5	19.6
2	1440.5	25.0%





March 15, 1996

M&C 0358-0060.OR(BIDOC)

Edward F. Mussler, III  
 Environmental Engineer  
 NCDEHNR, Division of Solid Waste Management  
 Solid Waste Section  
 P.O. Box 27687  
 Raleigh, North Carolina 27611-7687

ENGINEERS

SURVEYORS

ARCHITECTS

PLANNERS

RE: Revision of 60 mil HDPE Geomembrane Specifications  
 in the Bid Documents for the Proposed Johnston County  
 Subtitle D Landfill, Johnston County, North Carolina

Dear Ed:

Pursuant to our previous correspondence, McKim & Creed has reviewed recent literature to evaluate the feasibility of reducing the tensile strength requirement of the HDPE geomembrane, so that more nationally-known manufacturers could qualify. The literature review included:

- Current minimum specifications of leading HDPE liner manufacturers including GSE, NSC, and Poly-Flex.
- Recommended Specifications from the National Sanitation Foundation (NSF) 54 ANNEX, 1990.
- Specifications from the Upper Piedmont Regional Subtitle d Landfill, submitted to NCDEHNR, Division of Solid Waste Management, Solid Waste Section (SWS) in January 1996.
- Recommended Specifications by G. N. Richardson from the ASCE Seminar Entitled: "Waste Containment and Final Closure Systems," 1995.

Based on these references, the tensile strength specifications have been revised as shown in the enclosed copy of Table IV-F1 (Page IV-F30) from the Construction Quality Assurance (CQA) of the Permit to Construct Application (PTCA) that was approved by the SWS in December 1995. The revised values are noted near the former stricken-out values. These values are based on the lowest common denominator of the minimum specifications submitted by GSE, NSC, and Poly-Flex. Copies of these specifications are enclosed, and the minimum values that affected the revised specifications are circled on these data sheets, respectively.

SUITE 117

BUILDING I

5625 DILLARD ROAD

CARY, NC 27511

PHONE 919/233-8091

FAX 919/233-8031

V:\0358\60\60315C\JP.LET

Edward F. Mussler, III  
March 15, 1996  
Page 2

Please note that the shear and peel strength requirements were originally based on absolute values from NSF recommendations (Table IV-F2). Therefore, these absolute values of 120 and 78 pounds per inch width (lb/in) do not change. They equal to 95% and 62% of the required minimum yield strength (126 lb/in), for shear and peel strength, respectively.

These revised specifications do not affect or impact the liner stress calculations, e.g., the revised tensile strengths are adequate.

It will be greatly appreciated if you can review these revisions and send us your written approval promptly. Please send us a copy of your approval letter by fax as soon as it is ready.

Please call me or Dr. Poran if you have any questions.

Thank you.

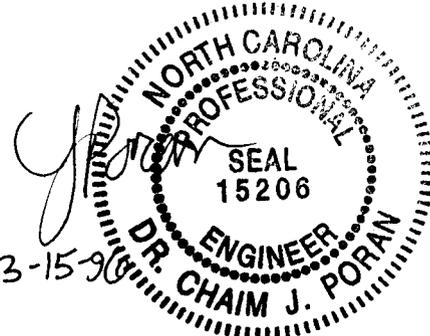
Sincerely,

McKIM & CREED ENGINEERS, P.A.

*Mark P. Ashness*

Mark Ashness, PE  
Project Manager

*3/15/96*



cc: Haywood Phthisic, Johnston County  
C.J. Poran, Ensol Corporation

Attachments: Revised Table IV-F1

TABLE IV-F1

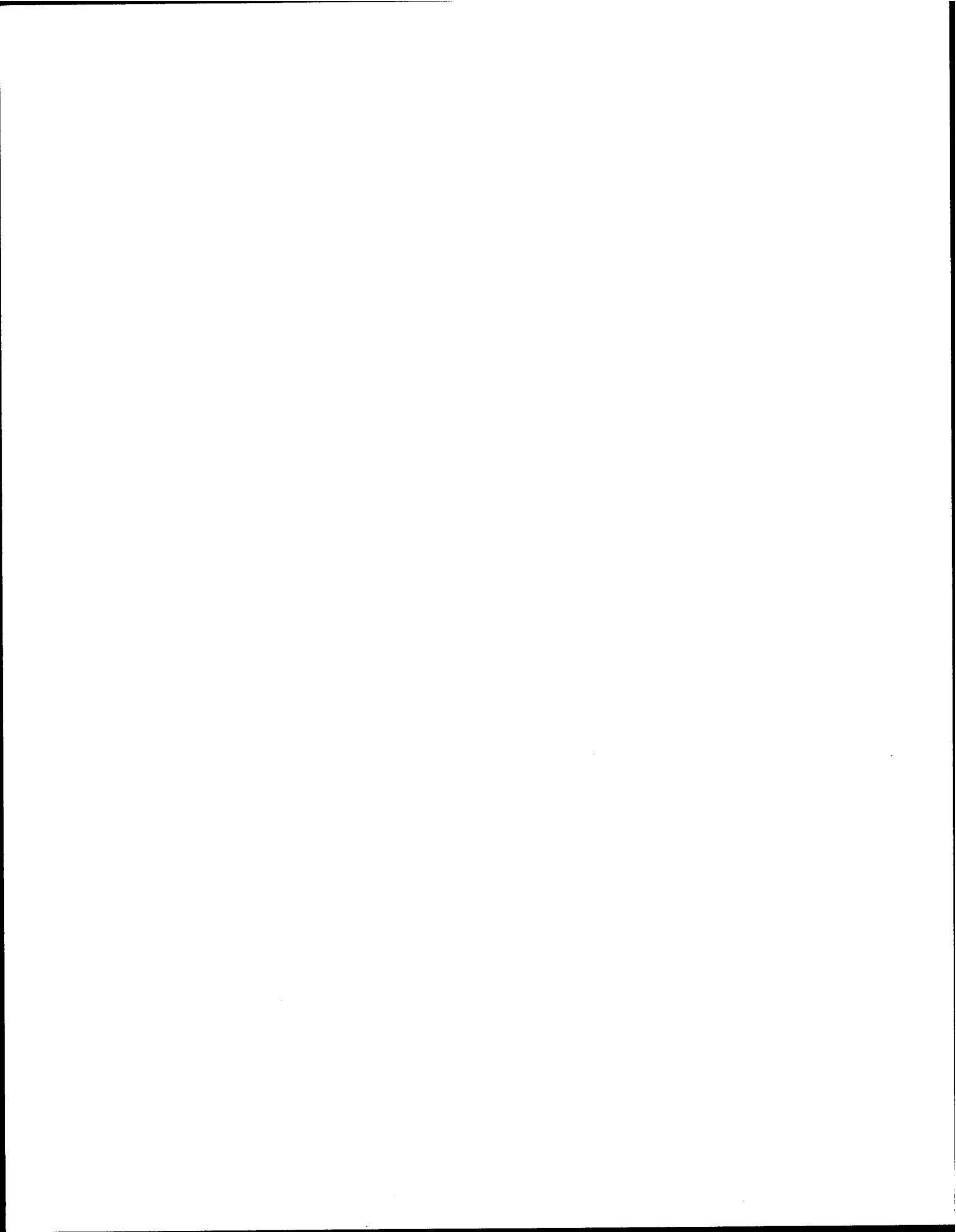
**Material Properties  
High Density Polyethylene (HDPE) Liner**

<u>Property</u>	<u>Unit</u>	<u>Limit</u>	<u>Test Method</u>	<u>Values</u>	
				<u>Textured</u>	<u>Smooth</u>
Thickness	mils	minimum	(a), (b)	57 <sup>(a)</sup>	57 <sup>(b)</sup>
Thickness	mils	min. average	(a), (b)	57 <sup>(a)</sup>	60 <sup>(b)</sup>
Density	g/ccb/ee	minimum	ASTM D1505	0.940	0.940
Tensile Properties (Each Direction)			ASTM D638		
1. Yield Strength	lb/in	minimum		126 440	130 440
2. Break Strength	lb/in	minimum		100 75	228 75
3. Elongation at Yield	%	minimum		13	13
4. Elongation at Break	%	minimum		160 450	560 450
Tear Resistance	lb	minimum	ASTM D1004	42 45	42 45
Puncture Resistance	lb	minimum	FTMS 101 Method 2065	80	80
Low Temperature	C	minimum	ASTM D746	-77	-77
Dimensional Stability	%	maximum	ASTM D1204 1 hr @ 100C	±2.0	±2.0
Environmental Stress Crack	hours	minimum	ASTM D1693	1,500	1,500
Carbon Black Content	%	range	ASTM D1603	2.0 to 3.0	2.0 to 3.0
Carbon Black Dispersion	N/A	rating	ASTM D3015	A1, A2,B1	A1,A2,B1

**Notes:**

<sup>(a)</sup> According to *Proposed ASTM Guide for Thickness Measurement of Textured Geomembranes*, 1995. Based on a modification of ASTM D751 using flat tip wire probes 0.04-inch diameter.

<sup>(b)</sup> ASTM D5199





March 13, 1996

M&C 0358-0060.OR(BIDOC)

Edward F. Mussler, III  
Environmental Engineer  
NCDEHNR, Division of Solid Waste Management  
Solid Waste Section  
P.O. Box 27687  
Raleigh, North Carolina 27611-7687

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Edward F. Mussler, III  
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Page 2

Please note that the shear and peel strength requirements were originally based on absolute values from NSF recommendations (Table IV-F2). Therefore, these absolute values of 120 and 78 pounds per inch width (lb/in) do not change. They equal to 95% and 62% of the required minimum yield strength (126 lb/in), for shear and peel strength, respectively.

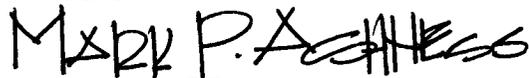
It will be greatly appreciated if you can review these revisions and send us your written approval promptly. Please send us a copy of your approval letter by fax as soon as it is ready.

Please call me or Dr. Poran if you have any questions.

Thank you.

Sincerely,

McKIM & CREED ENGINEERS, P.A.



Mark Ashness, PE  
Project Manager

cc: Haywood Phthisic, Johnston County  
C.J. Poran, Ensol Corporation

Attachments: Revised Table IV-F1  
Manufacturers Specifications

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TABLE IV-F1

**Material Properties**  
**High Density Polyethylene (HDPE) Liner**

<u>Property</u>	<u>Unit</u>	<u>Limit</u>	<u>Test Method</u>	<u>Values</u>	
				<u>Textured</u>	<u>Smooth</u>
Thickness	mils	minimum	(a), (b)	57 <sup>(a)</sup>	57 <sup>(b)</sup>
Thickness	mils	min. average	(a), (b)	57 <sup>(a)</sup>	60 <sup>(b)</sup>
Density	g/cc <del>lee</del>	minimum	ASTM D1505	0.940	0.940
Tensile Properties (Each Direction)			ASTM D638		
1. Yield Strength	lb/in	minimum		126 <del>140</del>	130 <del>140</del>
2. Break Strength	lb/in	minimum		100 <del>75</del>	228 <del>75</del>
3. Elongation at Yield	%	minimum		13	13
4. Elongation at Break	%	minimum		160 <del>150</del>	560 <del>150</del>
Tear Resistance	lb	minimum	ASTM D1004	42 <del>45</del>	42 <del>45</del>
Puncture Resistance	lb	minimum	FTMS 101 Method 2065	80	80
Low Temperature	C	minimum	ASTM D746	-77	-77
Dimensional Stability	%	maximum	ASTM D1204 1 hr @ 100C	±2.0	±2.0
Environmental Stress Crack	hours	minimum	ASTM D1693	1,500	1,500
Carbon Black Content	%	range	ASTM D1603	2.0 to 3.0	2.0 to 3.0
Carbon Black Dispersion	N/A	rating	ASTM D3015	A1, A2, B1	A1, A2, B1

**Notes:**

<sup>(a)</sup> According to *Proposed ASTM Guide for Thickness Measurement of Textured Geomembranes*, 1995. Based on a modification of ASTM D751 using flat tip wire probes 0.04-inch diameter.

<sup>(b)</sup> ASTM D5199

Both 60-mil Smooth and FrictionFlex <sup>(A)</sup> Textured (March 1996)

ROLL DIMENSIONS $\approx \pm 1\%$	
ROLL NUMBER:	AF-4450
PROD DATE:	09/02/95
SHEET AREA:	11267 sq. ft. 1047 sq. meters
LENGTH:	475 feet 145 meters
WIDTH:	23.72 feet 7.2 meters
WEIGHT:	3432 pounds 1557 kilograms

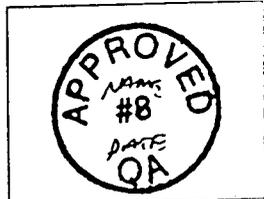
RESIN LOT INFORMATION			
LOT NUMBER	U-40735		
RESIN TYPE	600 SERIES		
PROPERTY	UNITS	METHOD	RESULT
DENSITY	g/cc	D1505	0.935
MOISTURE	%	D570	< 0.09
BRITTLINESS	°C	D746	<-70
MELT INDEX	g/10 min.	D1238	0.510

PROPERTY	ASTM METHOD	GSE MINIMUMS		ACTUAL TEST VALUES	
		ENGLISH	METRIC	ENGLISH	METRIC
<b>TENSILE YIELD STRENGTH</b>	D638				
CD -		130 lb/in	24 kg/cm	139 lb/in	25 kg/cm
MD -		130	24	139	25
<b>YIELD ELONGATION</b>	D638				
CD -		13 %		22 %	
MD -		13		20	
<b>TENSILE BREAK STRENGTH</b>	D638				
CD -		243 lb/in	44 kg/cm	339 lb/in	61 kg/cm
MD -		243	44	314	56
<b>BREAK ELONGATION</b>	D638				
CD -		560 %		790 %	
MD -		560		757	
<b>INITIAL TEARING STRENGTH</b>	D1004				
CD -		45 lb	20 kg	51 lb	23 kg
MD -		45	20	51	23
<b>PUNCTURE STRENGTH</b>	FTMS 101C/2065	76 lb	34 kg	87 lb	40 kg
<b>SHRINKAGE</b>	D1204				
CD -	(1 HR @ 100C)	+/- 2.00 %		0.1 %	
MD -		+/- 2.00		0.2	
<b>CARBON BLACK DISPERSION</b>	D3015	A2		A2	
<b>CARBON BLACK CONTENT</b>	D1603	2.00 %		2.25 %	
<b>GEOMEMBRANE DENSITY</b>	D792		0.940 g/cc		0.944 g/cc
<b>ESCR</b>	D1693-B	1500 hours		Start 9/08/95	
<b>THICKNESS</b>	D1593/D751				
NOMINAL		60 mil	1.52 mm	60 mil	1.52 mm
MINIMUM		54	1.37	57	1.45
AVG. THICKNESS				60	1.53

TEST NOTES: MD=MACHINE DIRECTION CD=CROSS DIRECTION ESCR START DATE IS GIVEN  
 -FOR TENSILE ELONGATION TEST GAUGE LENGTH=1.3 ON YIELD, 2.5 ON BREAK  
 ALL STRENGTH VALUES BASED ON NOMINAL THICKNESS

CUSTOMER:  
 JOB NO.  
 COMMENTS \_\_\_\_\_  
30041234

DATE SHIPPED \_\_\_\_\_



# DURA SEAL® HD GEOMEMBRANE SPECIFICATIONS

60 mil (1.5 mm)

National Seal Company's DURA SEAL HD high density polyethylene (HDPE) geomembranes are produced from virgin, first quality, high molecular weight resins and are manufactured specifically for containment in hydraulic structures. DURA SEAL HD geomembranes have been formulated to be resistant to chemicals, ultraviolet degradation, as well as leaching of additives.

Refer to NSC's Manufacturing Quality Control Manual to determine test methods and frequencies used as a part of NSC's quality control program.

All properties meet or exceed NSF Standard Number 54.

RESIN PROPERTIES	METHOD	UNITS	MINIMUM <sup>1</sup>	TYPICAL
Melt Flow Index <sup>2</sup>	ASTM D 1238	g/10 min	0.50	0.25
Oxidative Induction Time	ASTM D 3895, Al pan, 200°C, 1 atm O <sub>2</sub>	minutes	100	120
SHEET PROPERTIES	METHOD	UNITS	MINIMUM <sup>1</sup>	TYPICAL
Thickness	ASTM D 5199			
Average		mils	60.0	61.5
Average		mils	57.0	59.7
Individual (23)		mils	54.0	59.5
Density	ASTM D 1505	g/cm <sup>3</sup>	0.940	0.947
Carbon Black Content	ASTM D 4218	percent	2.0	2.49
Carbon Black Dispersion	ASTM D 5596	rating	A1, A2, B1	A1
Tensile Properties	ASTM D 638			
Stress at Yield		psi	2200	2520
		ppi	132	155
Stress at Break		psi	3800	4973
		ppi	228	308
Strain at Yield	1.3" gage length (NSF)	percent	13.0	16.5
Strain at Break	2.0" gage or extensometer	percent	700	890
	2.5" gage length (NSF)	percent	580	710
Dimensional Stability <sup>2</sup>	ASTM D 1204, NSF mod.	percent	1.0	0.2
Tear Resistance	ASTM D 1004	ppi	750	894
		lbs	45	55
Puncture Resistance	ASTM D 4833	ppi	1800	2407
		lbs	108	148
Constant Load ESCR	ASTM D 5397 (Single Point)	hours	200	>400

<sup>1</sup> This value represents the minimum acceptable test value for a roll as tested according to NSC's Manufacturing Quality Control Manual. Individual test specimen values are not addressed in this specification except thickness.

<sup>2</sup> Indicates Maximum Average Roll Value

# NSC

NATIONAL SEAL COMPANY  
1245 Corporate Blvd., Suite 300  
Aurora, IL 60504  
(708) 898-1161 (800) 323-3820

# DURA SEAL® HD GEOMEMBRANE

## PHYSICAL PROPERTIES

60 mil (1.5 mm)

PROPERTIES	METHOD	UNITS	MINIMUM <sup>1</sup>	TYPICAL
Multi-Axial Tensile Elongation	ASTM D 5617	percent	20.0	28.0
Critical Cone Height	ASTM D 5514	cm	1.0	1.5
Wide Width Tensile	ASTM D 4885			
Stress at Yield		psi	2000	2110
Strain at Yield		%	15.0	20.0
Brittleness Temp. by Impact <sup>2</sup>	ASTM D 746	°C	-75	<-90
Coef. of Linear Thermal Exp. <sup>2</sup>	ASTM E 831	°C <sup>-1</sup>	1.5 x 10 <sup>-4</sup>	1.2 x 10 <sup>-4</sup>
ESCR, Bent Strip	ASTM D 1693	hours	1500	>10,000
Hydrostatic Resistance	ASTM D 751	psi	450	510
Modulus of Elasticity	ASTM D 638	psi	80,000	135,000
Ozone Resistance	ASTM D 1149, 168 hrs	P/F	P	P
Permeability <sup>2</sup>	ASTM E 98	cm/sec · Pa	2.3x10 <sup>-14</sup>	8.1 x 10 <sup>-15</sup>
Puncture Resistance	FTMS 101, method 2065	ppl	1300	1642
		lbs	78	101
Soil Burial Resistance <sup>2</sup>	ASTM D 3083, NSF mod.	% change	10	0
Tensile Impact	ASTM D 1822	ft lbs/in <sup>2</sup>	250	420
Volatile Loss <sup>2</sup>	ASTM D 1203, A	percent	0.10	0.08
Water Absorption <sup>2</sup>	ASTM D 570, 23°C	percent	0.10	0.04
Water Vapor Transmission <sup>2</sup>	ASTM E 96	g/day · m <sup>2</sup>	0.024	0.008

SEAM PROPERTIES	METHOD	UNITS	MINIMUM <sup>1</sup>	TYPICAL
Shear Strength	ASTM D 4437, NSF mod.	psi	2000	2700
		ppl	120	166
Peel Strength (hot wedge fusion)	ASTM D 4437, NSF mod.	psi	1500	1870
		ppl	90	115
Peel Strength (fillet extrusion)	ASTM D 4437, NSF mod.	psi	1300	1590
		ppl	78	98

Seam testing is the responsibility of the installer and/or CQA personnel.

### STANDARD ROLL WIDTHS

15 FT. - 23.FT. - 30.5 FT.

This information contained herein has been compiled by National Seal Company and is, to the best of our knowledge, true and accurate. All suggestions and recommendations are offered without guarantee. Final determination of suitability for use based on any information provided, is the sole responsibility of the user. There is no implied or expressed warranty of merchantability or fitness of the product for the contemplated use.

NSC reserves the right to update the information contained herein in accordance with technological advances in the material properties.

6H-0895

# NSC

**NATIONAL SEAL COMPANY**  
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 Aurora, IL 60504  
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# FRICTION SEAL® HD GEOMEMBRANE SPECIFICATIONS

60 mil (1.5 mm)

FRICTION SEAL HD, National Seal Company's textured high density polyethylene (HDPE) geomembrane, is manufactured by attaching a friction surface to NSC's high quality DURA SEAL® HD. FRICTION SEAL HD is made from high molecular weight polyethylene resin compounded specifically for use in NSC geomembranes. The resin has been formulated to be resistant to chemicals, ultraviolet degradation, as well as leaching additives. NSC produces FRICTION SEAL HD with a textured surface on one or both sides of the base sheet.

Refer to NSC's Manufacturing Quality Control Manual to determine the test methods and frequencies used as a part of NSC's quality control program.

RESIN PROPERTIES	METHOD	UNITS	MINIMUM <sup>1</sup>	TYPICAL
Melt Flow Index <sup>2</sup>	ASTM D 1238	g/10 min	0.50	0.25
Oxidative Induction Time	ASTM D 3895, Al pan, 200°C, 1 atm O <sub>2</sub>	minutes	100	120

SHEET PROPERTIES	METHOD	UNITS	MINIMUM <sup>1</sup>	TYPICAL
Mass per Unit Area	ASTM D 5261	lb/ft <sup>2</sup>	0.31	0.32
Thickness <sup>3</sup>	ASTM D 5199			
Average		mils	60.0	61.5
Individual		mils	57.0	59.7
Density <sup>3</sup>	ASTM D 1505	g/cm <sup>3</sup>	0.940	0.948
Carbon Black Content <sup>3</sup>	ASTM D 4218	percent	2.0	2.49
Carbon Black Dispersion <sup>3</sup>	ASTM D 5596	rating	A1, A2, B1	A1
Tensile Properties <sup>4</sup>	ASTM D 638			
Stress at Yield		psi	2200	2661
		ppl	132	164
Stress at Break		psi	2300	3945
		ppl	138	242
Strain at Yield	1.3" gage length (NSF)	percent	13.0	16.2
Strain at Break	2.0" gage or extensometer	percent	200	678
	2.5" gage length (NSF)	percent	160	542
Dimensional Stability <sup>2,3</sup>	ASTM D 1204, NSF mod.	percent	1.0	0.4
Tear Resistance	ASTM D 1004	ppl	750	947
		lbs	45	58
Puncture Resistance	ASTM D 4833	ppl	1800	2358
		lbs	108	145
Constant Load ESCR, <sup>3</sup>	ASTM D 5397 (Single Point)	hours	200	>400

<sup>1</sup> This value represents the minimum acceptable test value for a roll as tested according to NSC's Manufacturing Quality Control Manual. Individual test specimen values are not addressed in this specification except thickness.

<sup>2</sup> Indicates Maximum Average Roll Value.

<sup>3</sup> Testing performed on base sheet.

<sup>4</sup> The minimum stress values are normalized to the nominal base sheet thickness. NSC certifies properties based on values calculated using nominal base sheet thickness only. Stress values calculated using actual product thickness is not guaranteed due to the lack of industry accepted thickness test procedures for friction sheet.

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# FRICTION SEAL® HD GEOMEMBRANE

## PHYSICAL PROPERTIES

60 mil (1.5 mm)

PROPERTIES	METHOD	UNITS	MINIMUM <sup>1</sup>	TYPICAL
Multi-Axial Tensile Elongation	ASTM D 5617	percent	20.0	22.3
Critical Cone Height	ASTM D 5514	cm	1.0	1.5
Wide Width Tensile <sup>3</sup>	ASTM D 4885			
Stress at Yield		psi	2000	2110
Strain at Yield		%	15.0	20.0
Brittleness Temp. by Impact <sup>2</sup>	ASTM D 748	°C	-75	<-90
Coef. of Linear Thermal Exp. <sup>2,3</sup>	ASTM E 831	°C <sup>-1</sup>	1.5 x 10 <sup>-4</sup>	1.2 x 10 <sup>-4</sup>
ESCR, Bent Strip <sup>3</sup>	ASTM D 1693	hours	1500	>10,000
Hydrostatic Resistance	ASTM D 751	psi	450	550
Modulus of Elasticity	ASTM D 638	psi	80,000	116,000
Ozone Resistance <sup>3</sup>	ASTM D 1149, 168 hrs	P/F	P	P
Permeability <sup>2,3</sup>	ASTM E 96	cm <sup>3</sup> /sec · Pa	2.3x10 <sup>-14</sup>	8.1 x 10 <sup>-15</sup>
Puncture Resistance	FTMS 101, method 2065	ppl	1300	1545
		lbs	78	95
Soil Burial Resistance <sup>2,3</sup>	ASTM D 3083, NSF mod.	% change	10	0
Tensile Impact	ASTM D 1822	ft lbs/in <sup>2</sup>	130	160
Volatile Loss <sup>2</sup>	ASTM D 1203, A	percent	0.10	0.08
Water Absorption <sup>2,3</sup>	ASTM D 570, 23°C	percent	0.10	0.04
Water Vapor Transmission <sup>2,3</sup>	ASTM E 96	g/day · m <sup>2</sup>	0.024	0.009

SEAM PROPERTIES	METHOD	UNITS	MINIMUM <sup>1</sup>	TYPICAL
Shear Strength	ASTM D 4437, NSF mod.	psi	2000	2700
		ppl	120	166
Peel Strength (hot wedge fusion)	ASTM D 4437, NSF mod.	psi	1500	1870
		ppl	90	115
Peel Strength (fillet extrusion)	ASTM D 4437, NSF mod.	psi	1300	1590
		ppl	78	98

Seam testing is the responsibility of the installer and/or CQC personnel.

### STANDARD ROLL WIDTH

15 FT.

This information contained herein has been compiled by National Seal Company and is, to the best of our knowledge, true and accurate. All suggestions and recommendations are offered without guarantee. Final determination of suitability for use based on any information provided, is the sole responsibility of the user. There is no implied or expressed warranty of merchantability or fitness of the product for the contemplated use.

NSC reserves the right to update the information contained herein in accordance with technological advances in the material properties.

6FH-0895

# NSC

NATIONAL SEAL COMPANY  
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Minimum Values

Property	Test Method	20 Mil	30 Mil	40 Mil	60 Mil	80 Mil	100 Mil
Thickness, mils	ASTM D 1593	18	27	36	54	72	90
Sheet Density, g/cc	ASTM D 1505	0.940	0.940	0.940	0.940	0.940	0.940
Melt Index, g/10 minutes (max.)	ASTM D 1238	0.40	0.40	0.40	0.40	0.40	0.40
Carbon Black Content, %	ASTM D 1603	2-3	2-3	2-3	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D 3015	A1, A2, B1					
<b>Tensile Properties</b>							
ASTM D 638 (Mod. per NSF Std. 54)							
1. Tensile Strength at Yield, ppi		46	69	92	138	184	230
2. Elongation at Yield, %		13	13	13	13	13	13
3. Tensile Strength at Break, ppi		80	120	160	240	320	400
4. Elongation at Break, (2.0" G.L.) %		750	750	750	750	750	750
(2.5" G.L.) %		600	600	600	600	600	600
5. Modulus of Elasticity, psi		80,000	80,000	80,000	80,000	80,000	80,000
Tear Strength, lbs.	ASTM D 1004	14	21	28	42	56	70
Puncture Resistance, lbs.	FTMS 101 - 2065	30	45	60	90	120	150
	ASTM D 4833	40	60	80	120	160	190
Low Temperature Brittleness	ASTM D 746	<-94°F	<-94°F	<-94°F	<-94°F	<-94°F	<-94°F
Environmental Stress Crack Resistance, hours	ASTM D 1693 (Cond. B)	2,000	2,000	2,000	2,000	2,000	2,000
Dimensional Stability, %	ASTM D 1204	+/- 1	+/- 1	+/- 1	+/- 1	+/- 1	+/- 1
<b>Seam Properties</b>							
ASTM D 4437 (Mod. per NSF Std. 54)							
1. Shear Strength, ppi		44	66	87	131	175	218
2. Peel Strength, ppi		29 & FTB	43 & FTB	57 & FTB	86 & FTB	114 & FTB	143 & FTB

Minimum values, unless otherwise specified, are the average roll values as reported by the specified test methods.  
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.

**Minimum Values**

Property	Test Method	40 Mil	60 Mil	80 Mil
Thickness, mils	ASTM D 1593	36	54	72
Sheet Density, g/cc	ASTM D 1505	0.940	0.940	0.940
Melt Index, g/10 minutes	ASTM D 1238	0.40 (max.)	0.40 (max.)	0.40 (max.)
Carbon Black Content, %	ASTM D 1603	2-3	2-3	2-3
Carbon Black Dispersion	ASTM D 3015	A1, A2, B1	A1, A2, B1	A1, A2, B1
<b>Tensile Properties</b>				
	ASTM D 638 (Mod. per NSF Std. 54)			
1. Tensile Strength at Yield, ppi		90	126	160
2. Elongation at Yield, %		13	13	13
3. Tensile Strength at Break, ppi		80	100	155
4. Elongation at Break, (2.0" G.L.) %		200	200	200
<b>Tear Properties</b>				
	ASTM D 1004	30	42	52
Tear Strength, lbs.	FTMS 101 - 2065	55	75	95
Puncture Resistance, lbs.	ASTM D 4833	80	95	120
<b>Temperature Properties</b>				
Low Temperature Brittleness	ASTM D 746	<-94°F	<-94°F	<-94°F
Environmental Stress Crack Resistance, hours	ASTM D 1693 (Cond. B)	2,000	2,000	2,000
Dimensional Stability, %	ASTM D 1204	+/- 1	+/- 1	+/- 1
<b>Seam Properties</b>				
	ASTM D 4437 (Mod. per NSF Std. 54)			
1. Shear Strength, ppi		85	120	152
2. Peel Strength, ppi		56 & FTB	78 & FTB	99 & FTB

Minimum values, unless otherwise specified, are the average roll values as reported by the specified test methods.  
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