Appendix D

Deschutes Canal-Lining Demonstration Project

Coupon Test Results

Deschutes Canal-Lining Demonstration Project
80-mil Textured HDPE

Table D-1.—Above the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Yield Strength (lbs/inch)	Machine	168	210	222	+ 6 %
	X-Machine			213	+ 1 %
Yield-Elongation (%)	Machine	13	#10	#10	0
	X-Machine			#10	0
Break Strength (lbs/inch)	Machine	46	233	198	- 15 %
	X-Machine			152	- 35 %
Break-Elongation (%)	Machine	100	428	322	- 25 %
	X-Machnie			32	- 93 %
Tear	Machine	60	69	66	- 4 %
	X-Machine			66	- 4 %

Table D-2.—Below the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Yield Strength (lbs/inch)	Machine	168	210	213	+ 1 %
	X-Machine			214	+ 1 %
Yield-Elongation (%)	Machine	13	#10	#10	0
	X-Machnie			#10	0
Break Strength (lbs/inch)	Machine	46	233	220	- 6 %
	X-Machine			197	- 15 %
Break-Elongation (%)	Machine	100	428	416	- 3 %
	X-Machnie			328	- 23 %
Tear	Machine	60	69	67	- 3 %
	X-Machine			67	- 3 %

Deschutes Canal-Lining Demonstration Project
30-mil PVC with Bonded Geotextile

Table D-3.—Above the Water-Line

Physical Property	Direction	Mfr Published Typical	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	121	82	105*	+ 28 %
	X-Machine	95		86	+ 5 %
Elongation (%)	Machine	570	440	117	- 74 %
	X-Machnie	545		225	- 49 %
100 % Modulus	Machine	81	44	105	+ 138 %
	X-Machine	87		81	+ 84 %
Tear	Machine	29		32	+ 10 %
	X-Machine	22		33	+ 50 %
Low Temp Brittleness		Pass @ -20°F		Fail @ + 10°F	> 30°F

* Maximum tensile occurred at yield (54 % elongation) - not at break

Table D-4.—Below the Water-Line

Physical Property	Direction	Mfr Published Typical	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	121	82	113*	+ 37 %
	X-Machine	95		96*	+ 17 %
Elongation (%)	Machine	570	440	143	- 68 %
	X-Machnie	545		181	- 59 %
100 % Modulus	Machine	81	44	113	+ 157 %
	X-Machine	87		96	+ 118 %
Tear	Machine	29		19	- 34 %
	X-Machine	22		35	+ 60 %

* Maximum tensile occurred at yield (approx 70 % elongation) - not at break

Deschutes Canal-Lining Demonstration Project
45-mil Hypalon

Table D-5.—Above the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	250	297	347	+ 17 %
	X-Machine			333	+ 12 %
Tear	Orig	90	95	31	- 67 %
	After Aging	35	---	31	- 11 %
Ply Adhesion (lbs/inch)	Machine	8		8.6	+ 8 %
	X-Machine				
Low Temp (-40 F)	Machine	Pass		Pass	
	X-Machine				

Table D-6.—Below the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	250	297	338	+ 14 %
	X-Machine			323	+ 9 %
Tear	Orig	90	95	62	- 35 %
	After Aging	35	---	62	+ 77 %
Ply Adhes (lbs/inch)	Machine	8		9.3	+ 16 %
	X-Machine				
Low Temp (-40 F)	Machine	Pass		Pass	
	X-Machine				

Deschutes Canal-Lining Demonstration Project
36-mil Hypalon

Table D-7.—Above the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	200	280	277	- 1 %
	X-Machine			273	- 3 %
Tear	Original	80	58	29	- 64 %
	After Aging	35	---	29	- 17 %
Ply Adhesion (lbs/inch)	Machine	8		8.5	+ 6 %
	X-Machine				
Low Temp (-40 F)	Machine	Pass		Pass	
	X-Machine				

Table D-8.—Below the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	200	280	323	+ 15 %
	X-Machine			314	+ 12 %
Tear	Original	80	58	33	- 59 %
	After Aging	35	---	33	- 6 %
Ply Adhesion (lbs/inch)	Machine	8		8.4	+ 5 %
	X-Machine				
Low Temp (-40 F)	Machine	Pass		Pass	
	X-Machine				

Deschutes Canal-Lining Demonstration Project
45-mil EPDM

Table D-9.—Above the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	50	57	60	+ 5 %
	X-Machine			63	+ 11 %
Elongation (%)	Machine	500	614	452	- 26 %
	X-Machnie			423	- 31 %
Tear	Machine	9	18	9.5	- 48 %
	X-Machine			8.7	- 52 %

Table D-10.—Below the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	50	57	61	+ 7 %
	X-Machine			61	+ 7 %
Elongation (%)	Machine	500	614	488	- 21 %
	X-Machnie			419	- 32 %
Tear	Machine	9	18	8.9	- 51 %
	X-Machine			9.1	- 49 %

Deschutes Canal-Lining Demonstration Project
30-mil LLDPE

Table D-11.—Above the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	114	165	154	- 7 %
	X-Machine		151	147	- 3 %
Elongation (%)	Machine	800	698	704	+ 1 %
	X-Machnie		688	691	~~0~~
Tear	Machine	16	23	21	- 9 %
	X-Machine		26	23	- 12 %

Table D-12.—Below the Water-Line

Physical Property	Direction	Mfr Published MARV	USBR Test Results		
			Virgin	Aged	% Change
Tensile (lbs/inch)	Machine	114	165	149	- 10 %
	X-Machine		151	135	- 11 %
Elongation (%)	Machine	800	698	713	+ 2 %
	X-Machnie		688	639	- 7 %
Tear	Machine	16	23	21	- 9 %
	X-Machine		26	22	- 15 %

Drexel
UNIVERSITY

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October 3, 2002

Mr. Jay Swihart
U.S. Bureau of Reclamation
P.O. Box 25007, DFC Attn. D-8180
Denver, CO 80225

Re.: 10-year textured HDPE geomembranes

Dear Jay,

Enclosed please find the melt index (MI) and oxidative induction time (OIT) results of three textured HDPE geomembrane samples which are coded as "T", "B" and "O". "T" refers to samples taken from above water line, "B" for below water line and "O" for the original.

The MI values are largely the same after 10 year service regardless the exposure environment. However, we are surprise to see the small difference in the OIT values between samples from above and below water line. The OIT curves of "T" and "B" samples are significantly different. For the "T" samples, there is a long graduate increase in the energy followed by a strong exothermal peak. In contrast, the "B" samples exhibit a sharp exothermal peak. We suspect that there are two types of antioxidants added to the geomembrane. One of the antioxidants has been gradually consumed during the 10-year service time. Overall, the textured HDPE geomembrane still contain fair amount of antioxidants and probably can maintain its mechanical property for another 10-years. However, it would be beneficial to have these two properties being evaluated again after 10-years.

If you have any questions, please don't hesitate to contact me.

Truly yours,

Grace Hsuan, Ph.D.
Associate Professor
Civil and Architectural Engineering

cc. Dr. Robert Koerner
Director of GSI

Table 2 - Oxidative Inductive Time Test according to ASTM D3895

Sample Code	Test	OIT (min)	Avarage OIT (min)
T	1	49.9	**47.1**
	2	39.9	
	3	51.5	
B	1	56.3	**55.9**
	2	55.6	
O	1	69.6	**73.1**
	2	76.7	

Table 2 - Melt Index Test according to ASTM D

Sample: Bureau of Reclamation

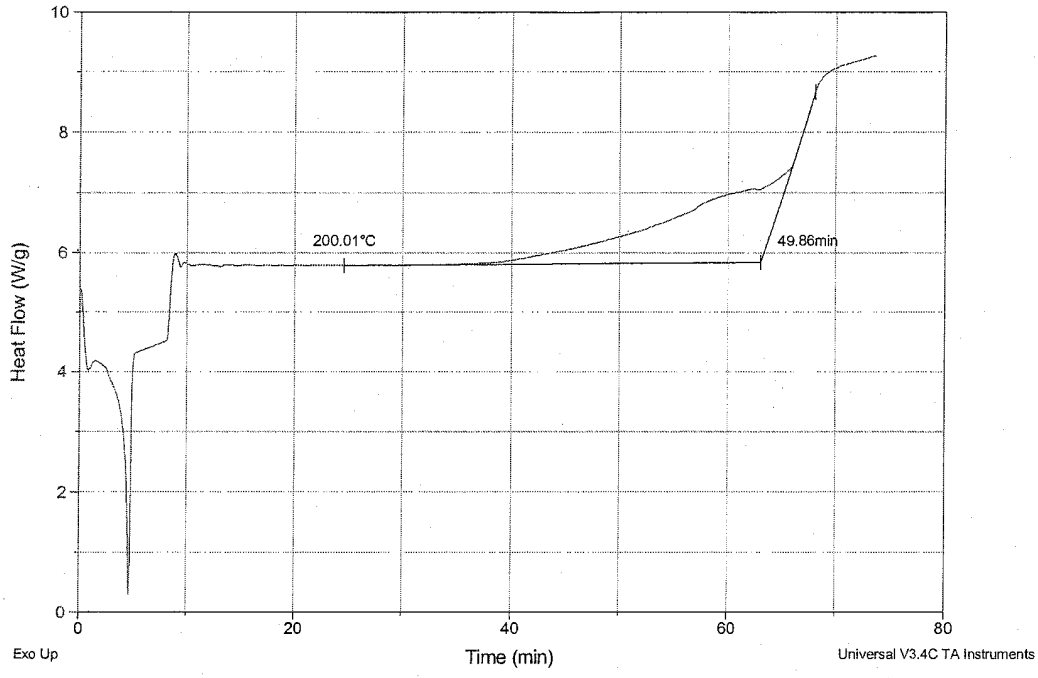
Recorded by: Jingyu Zhang Date: Aug 16, 02

Sample Code	Specimen	Cut No.	Mass (g)	MFR (g/10min)	Average MFR (g/10min)
T	I	1	0.08	0.13	**0.13**
		2	0.08	0.13	
		3	0.08	0.13	
	II	1	0.08	0.13	
		2	0.08	0.13	
		3	0.08	0.13	
B	I	1	0.08	0.13	**0.13**
		2	0.08	0.13	
		3	0.08	0.13	
	II	1	0.08	0.13	
		2	0.09	0.15	
		3	0.08	0.13	
O	I	1	0.09	0.15	**0.14**
		2	0.08	0.13	
		3	0.08	0.13	
	II	1	0.09	0.15	
		2	0.08	0.13	
		3	0.09	0.15	

Sample: Bureau of Reclamation HDPE GM
Size: 3.1000 mg
Method: Oxygen Induction Time
Comment: Bureau of Reclamation HDPE GM 10years _Top the waterline

DSC

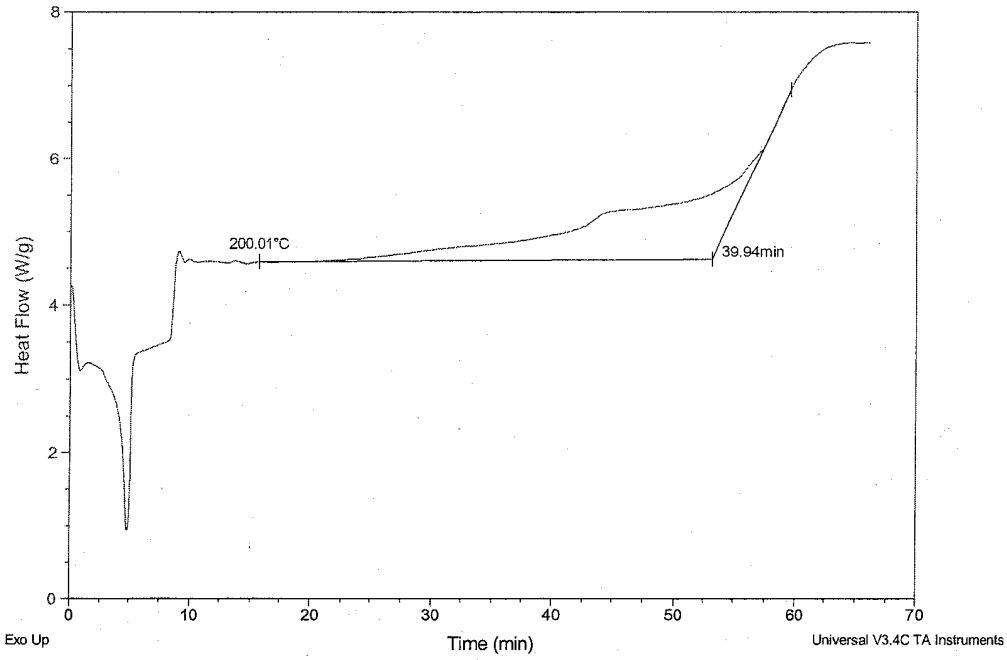
File: A:\BR_HDPE_T.003
Operator: grace
Run Date: 18-Sep-02 15:32
Instrument: 2920 DSC V2.6A

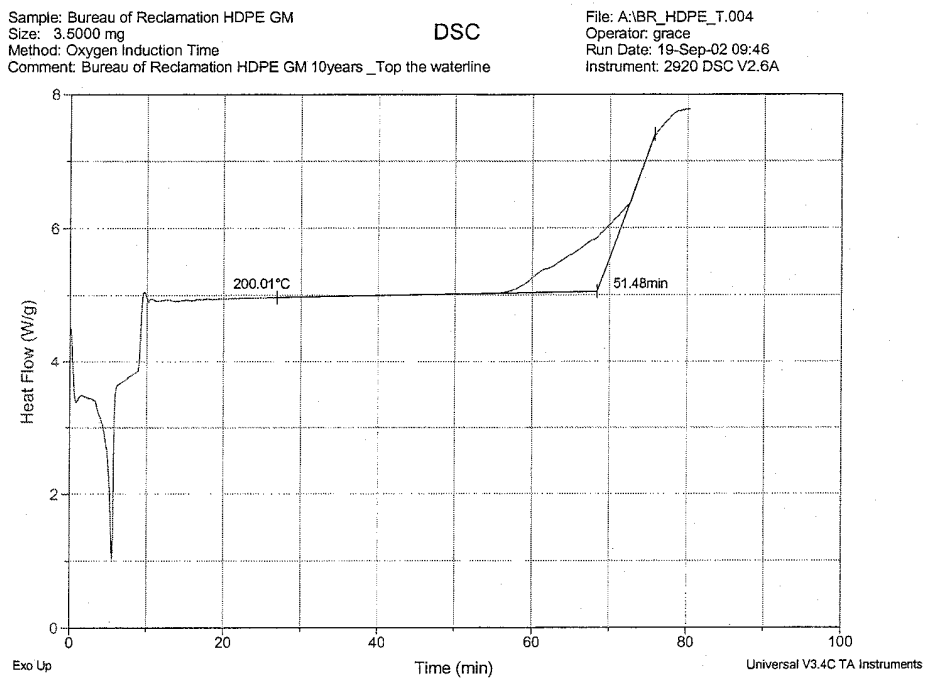


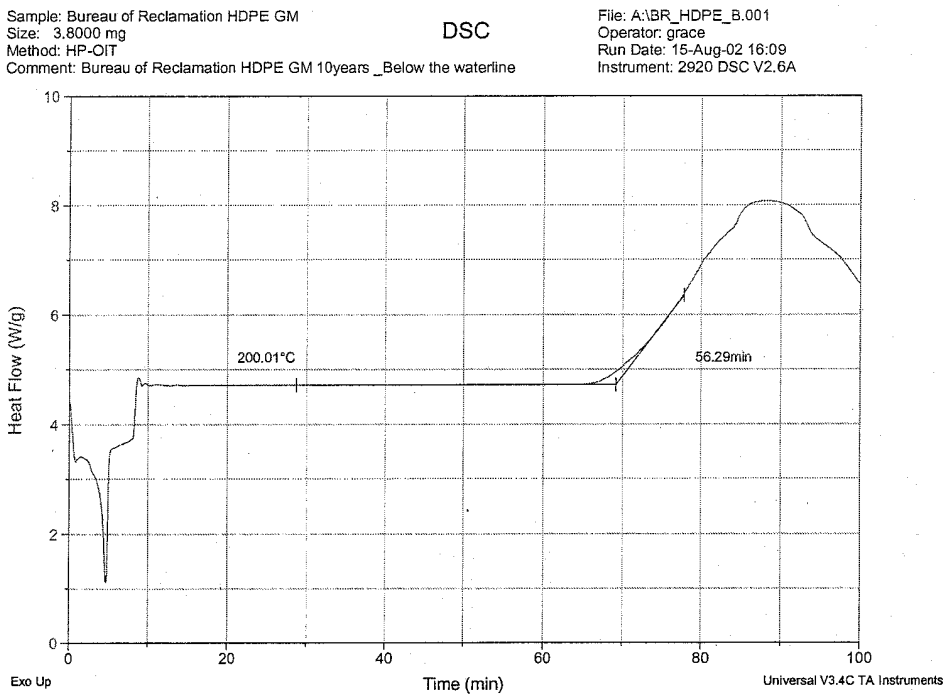
Sample: Bureau of Reclamation HDPE GM
Size: 3.9000 mg
Method: HP-OIT
Comment: Bureau of Reclamation HDPE GM 10years _Top the waterline

DSC

File: A:\BR_HDPE_T.002
Operator: grace
Run Date: 15-Aug-02 14:53
Instrument: 2920 DSC V2.6A



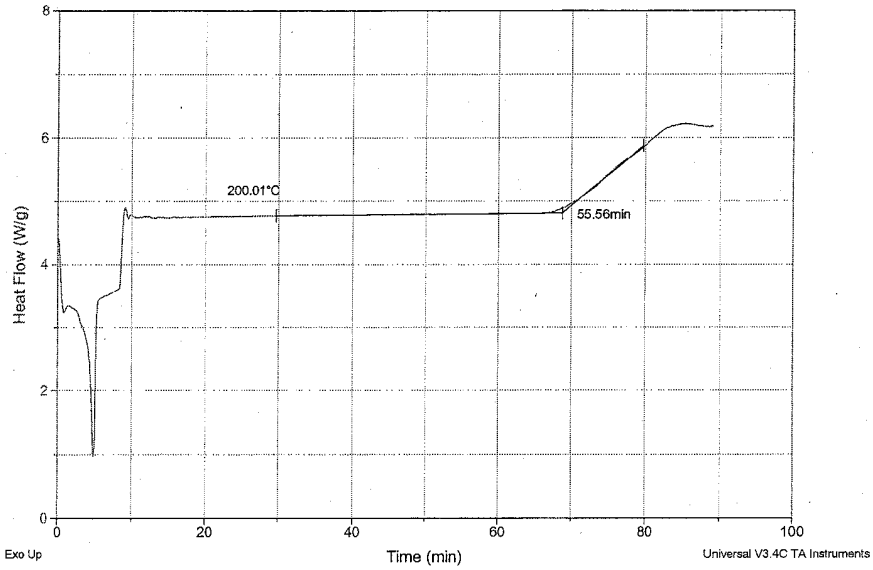

Sample: Bureau of Reclamation HDPE GM
Size: 3.5000 mg
Method: Oxygen Induction Time
Comment: Bureau of Reclamation HDPE GM 10years _Top the waterline
DSC
File: A:\BR_HDPE_T.004
Operator: grace
Run Date: 19-Sep-02 09:46
Instrument: 2920 DSC V2.6A
200.01°C
51.48min
Heat Flow (W/g)
Time (min)
Exo Up
Universal V3.4C TA Instruments


Sample: Bureau of Reclamation HDPE GM
Size: 3.8000 mg
Method: HP-OIT
Comment: Bureau of Reclamation HDPE GM 10years _Below the waterline
DSC
File: A:\BR_HDPE_B.001
Operator: grace
Run Date: 15-Aug-02 16:09
Instrument: 2920 DSC V2.6A
200.01°C
56.29min
Heat Flow (W/g)
Time (min)
Exo Up
Universal V3.4C TA Instruments

Sample: Bureau of Reclamation HDPE-T GM
Size: 3.7000 mg
Method: HP-OIT
Comment: Bureau of Reclamation HDPE-T GM 10years _Below the waterline

DSC

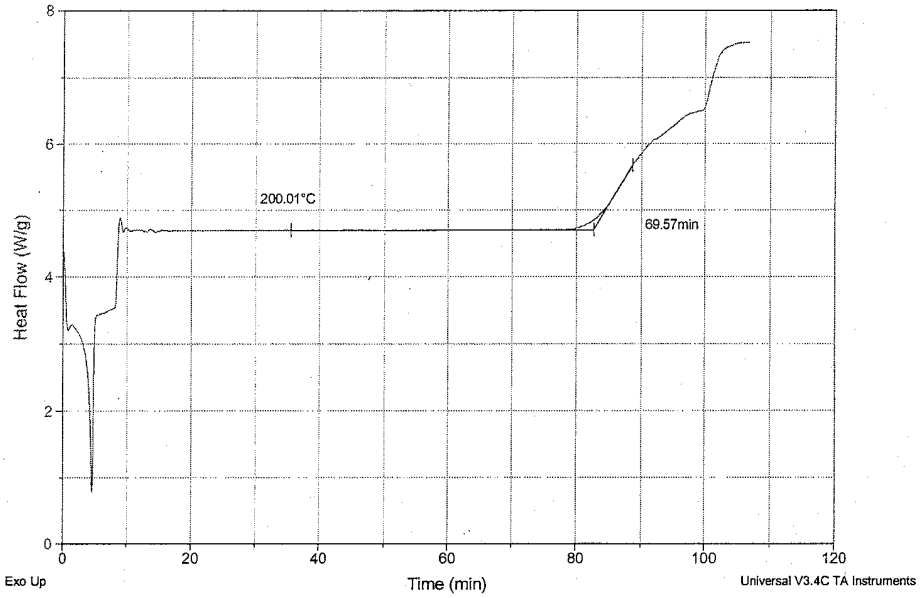
File: A:\BR_HDPE_B.002
Operator: grace
Run Date: 19-Aug-02 10:00
Instrument: 2920 DSC V2.6A

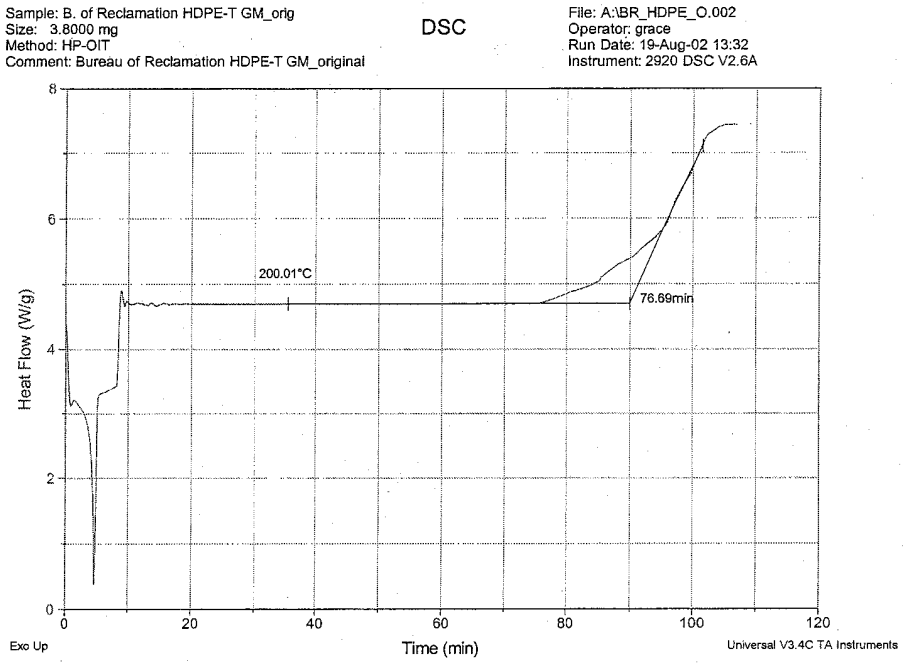


Sample: B. of Reclamation HDPE-T GM_orig
Size: 3.8000 mg
Method: HP-OIT
Comment: Bureau of Reclamation HDPE-T GM_original

DSC

File: A:\BR_HDPE_O.001
Operator: grace
Run Date: 19-Aug-02 11:38
Instrument: 2920 DSC V2.6A




Sample: B. of Reclamation HDPE-T GM_orig
Size: 3.8000 mg
Method: HP-OIT
Comment: Bureau of Reclamation HDPE-T GM_original
DSC
File: A:\BR_HDPE_O.002
Operator: grace
Run Date: 19-Aug-02 13:32
Instrument: 2920 DSC V2.6A
200.01°C
76.69min
Heat Flow (W/g)
Time (min)
Exo Up
Universal V3.4C TA Instruments