

APPENDIX C

RECYCLED RESIN BLENDS

## **APPENDIX C – RECYCLED RESIN BLENDS**

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## C.1 INTRODUCTION

The results from Phase I of the project (Recycled Polyethylene Resins) showed that recycled HDPE had properties that were below the established limits of AASHTO approved pipe. Therefore, the percentage of recycled that can be blended with pipe resin will be limited by the properties. Efforts were undertaken to determine what those limits were and to also enhance the properties of recycled HDPE by blending it with non-pipe virgin resins such as LLDPE and LMDPE. A secondary, but important objective was to determine the relationships between the percentage component in a blend and the resulting blend's properties.

## C.2 RESINS USED FOR BLENDING

The identities and a brief description of all the resins used during the blending study are given in Table C-1.

Table C-1 - Component Resins for Blend Preparation

Resin	Abbreviation	Description
Virgin Resin 1	VR1	PPI certified AASHTO HDPE pipe resin.
Virgin Resin 2	VR2	PPI certified AASHTO HDPE pipe resin.
Virgin Resin 3	VR3	PPI certified AASHTO HDPE pipe resin.
Virgin LLDPE	LLDPE	Commercial linear low density polyethylene resin from a supplier that makes AASHTO pipe resin.
Virgin LMDPE	MDPE	Commercial linear medium density polyethylene resin from a supplier that makes AASHTO pipe resin.
Mixed Color PCR 1	MCR1	Mixed-color post-consumer reprocessed HDPE pellets composed of colored and natural bottles.
Mixed Color PCR 2	MCRG	Mixed-color post-consumer regrind HDPE chips composed of colored and natural bottle.
Natural PCR	NAT	Post consumer reprocessed HDPE pellets made from milk, juice, and water bottles.
Natural PCR + 10% LLDPE	N10LL	Blend of NAT with 10% LLDPE to enhance the properties of the NAT.
Natural PCR + 35% LLDPE	N35LL	Blend of NAT with 35% LLDPE to enhance the properties of the NAT.
PIR Low Density	PIR-LD	Post industrial low density polyethylene reprocessed pellets believed to contain mostly film and bags.
PIR Medium Density	PIR-MD	Post industrial linear medium density polyethylene regrind chips from the sheet market.
PIR High Density	PIR-HD	Blend of PCR high density bottles with PIR polyethylene.

A few selected properties of these resins are shown in Table C-2. The average values will be used in the next chapter for blend optimization for pipe.

Table C-2 - Component Resins for Blending Properties

Resin	Date Tested	Density (g/cm <sup>3</sup> )	Yield Stress (psi)	Break Strain (%)	15% NCTL (hrs)
VR1	2-2-07	0.947	3627 ± 85	468 ± 28	--
	5-25-07	0.955	3882 ± 60	483 ± 86	44.0 ± 2
	6-19-07	0.949	3555 ± 28	484 ± 22	47.6 ± 3
	AVG	<b>0.950</b>	<b>3688 ± 58</b>	<b>478 ± 45</b>	<b>45.8 ± 2.5</b>
VR2	2-2-07	0.949	3805 ± 54	624 ± 58	--
	5-11-07	0.956	3936 ± 51	694 ± 53	39.2 ± 4
	5-25-07	0.956	4026 ± 35	606 ± 108	37.7 ± 4
	6-28-07	0.952	4021 ± 57	675 ± 164	42.4 ± 3
	7-5-07	0.952	3834 ± 95	595 ± 109	34.6 ± 1
	AVG	<b>0.953</b>	<b>3924 ± 58</b>	<b>639 ± 98</b>	<b>38.5 ± 3</b>
VR3	2-2-07	0.950	3640 ± 72	634 ± 81	--
	5-25-07	0.949	3804 ± 49	667 ± 96	44.4 ± 3
	7-10-07	0.949	3849 ± 35	641 ± 72	28.0 ± 2
	AVG	<b>0.949</b>	<b>3764 ± 52</b>	<b>647 ± 83</b>	<b>36.2 ± 2.5</b>
LLDPE	2-07-08	<b>0.919</b>	<b>1616 ± 19</b>	<b>771 ± 94</b>	--
MDPE	2-07-08	<b>0.934</b>	<b>2732 ± 24</b>	<b>645 ± 49</b>	--
MCR1	2-9-07	0.960	3685 ± 49	46 ± 24	8.8 ± 1
	5-11-07	0.960	3556 ± 124	79 ± 30	6.4 ± 1
	AVG	<b>0.960</b>	<b>3620 ± 86</b>	<b>62.5 ± 27</b>	<b>7.6 ± 1</b>
MCRG	3-19-07	0.960	3441 ± 47	158 ± 35	8.0 ± 1
	10-16-07	0.960	3613 ± 69	171 ± 26	7.1 ± 1
	AVG	<b>0.960</b>	<b>3527 ± 58</b>	<b>164 ± 30</b>	<b>7.6 ± 1</b>
NAT	2-13-07	0.960	4489 ± 50	229 ± 78	1.8 ± 0
	5-21-07	0.959	4564 ± 62	313 ± 60	3.0 ± 0
	10-22-07	0.960	4523 ± 14	365 ± 206	2.0 ± 0
	AVG	<b>0.960</b>	<b>4525 ± 42</b>	<b>302 ± 115</b>	<b>2.3 ± 0</b>

Table C-2 - cont.

Resin	Date	Density (g/cm <sup>3</sup> )	Yield Stress (psi)	Break Strain (%)	15% NCTL (hrs)
N10LL	3-5-07	0.958	3976 ± 85	496 ± 189	3.2 ± 0
	6-28-07	0.956	4099 ± 36	327 ± 193	2.7 ± 0
	AVG	<b>0.957</b>	<b>4037 ± 60</b>	<b>411 ± 191</b>	<b>3.0 ± 0</b>
N35LL	8-24-07	--	3203 ± 54	655 ± 32	19.5 ± 3
	AVG		<b>3203 ± 54</b>	<b>655 ± 32</b>	<b>19.5 ± 3</b>
PIR-LD	5-8-07	0.952	1686 ± 42	727 ± 14	>300
		<b>0.952</b>	<b>1686 ± 42</b>	<b>727 ± 14</b>	<b>&gt;300</b>
PIR-MD	5-4-07	0.942	2694 ± 37	723 ± 41	>300
	10-2-07	0.942	2631 ± 17	662 ± 45	>300
	AVG	<b>0.942</b>	<b>2662 ± 27</b>	<b>692 ± 43</b>	<b>&gt;300</b>
PIR-HD	6-19-07	0.965	3087 ± 30	720 ± 9	91.1 ± 9
	7-5-07	0.970	3296 ± 34	612 ± 102	115 ± 8
	7-10-07	0.970	3088 ± 31	720 ± 9	86.5 ± 9
	AVG	<b>0.968</b>	<b>3157 ± 32</b>	<b>684 ± 40</b>	<b>97.5 ± 9</b>

### C.3 BLENDS MADE WITH MIXED COLOR PCR

A total of 29 blends were prepared with the use of Mixed Color PCR bottle resin. They included:

VR1 + MCR1 @ 20, 40, 60 and 80%,  
 VR1 + MCRG @ 20, 40, 60 and 80%,  
 VR2 + MCR1 @ 20, 40, 60 and 80%,  
 VR3 + MCR1 @ 20, 40, 60 and 80%,  
 MCRG + MDPE @ 25, 50 and 75%,  
 MCR1 + MDPE @ 25, 50 and 75%,  
 MCRG + PIR-MD @ 25, 50 and 75%,  
 75% MCR1 + 25% PIR-HD, and  
 50% VR3 + 25% MDPE + 25% MCR1.

The effect of recycled content on the yield strength for four blends of virgin pipe resins with mixed-colored PCR are shown in Figure C-1.

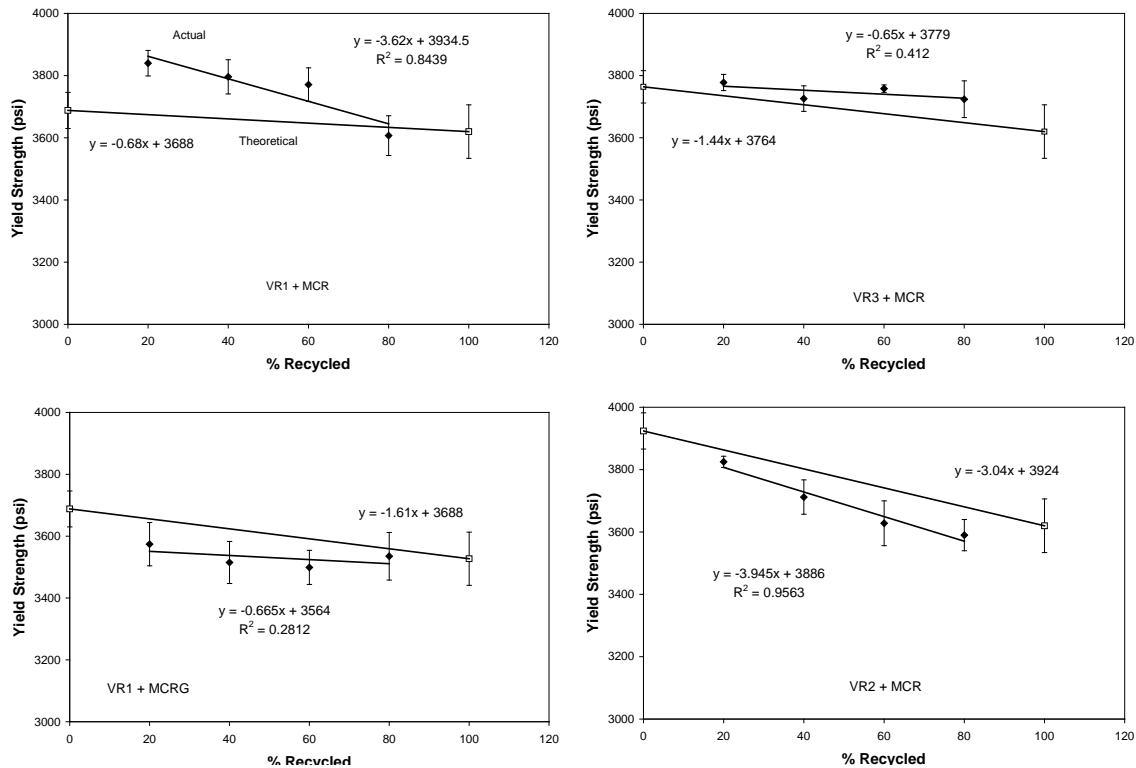


Figure C-1 - The Effect of Recycled Content on Yield Strength on Blends of Virgin Pipe Resins and Mixed Color PCR-HDPE

It is fairly clear from these graphs that the yield strength is a linear function with respect to recycled content. That means that a simple mixing equation can be used to approximate the yield strength of a blend. This information will allow one to blend different resins to make sure that the resulting blend always stays within the specified yield strength requirements. The correlations are not always good, but this is likely caused by the combination of the two blend components not being too far apart in strength and the higher scatter found with recycled materials.

Similar plots are shown for the breaking strain in Figure C-2. Notice that these are even farther away from the theoretical line, and the scatter in the results is quite high. This is a reflection of the contaminants found in PCR resins and demonstrates the need to control contamination.

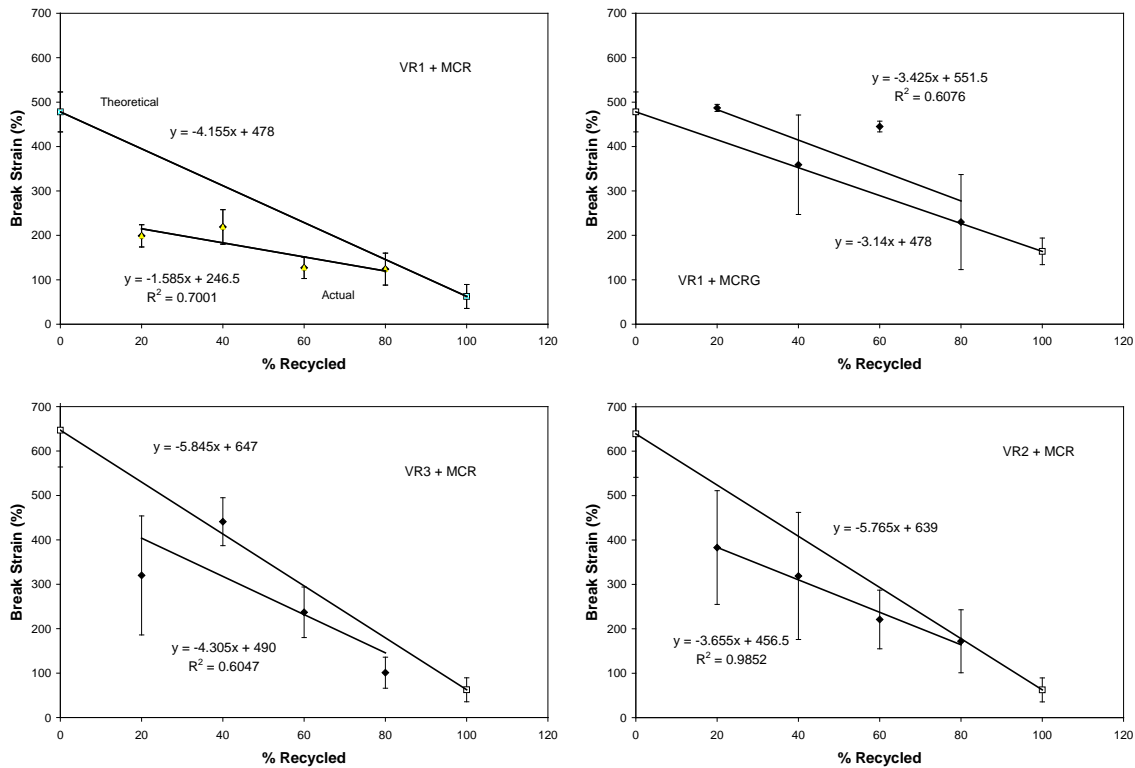


Figure C-2 - The Effect of Recycled Content on Break Strain on Blends of Virgin Pipe Resins and Mixed Color PCR-HDPE

Plots of the NCTL stress crack resistance determined at 15% of the yield strength are shown in Figure C-3. In this case, the curves are obviously exponential in nature and the match between theoretical and actual is much better.

Section C.8 contains summary tables for all the blends made with PCR-MCR, plots of properties versus % recycled, and individual property reports for the 29 blends. Examination of the results reveals that all the properties change in either a linear or an exponential manner. More specifically, all the property changes are linear except for the melt index (both loads) and the stress crack resistance. This is powerful information because the properties of blends can be predicted based on these relationships. On the other hand, some of the inherent scatter found in certain properties makes such predictions unreliable. However, it is believed that the relationships can be used as a guide for preparing blends with the understanding that actual blend testing will still be required.



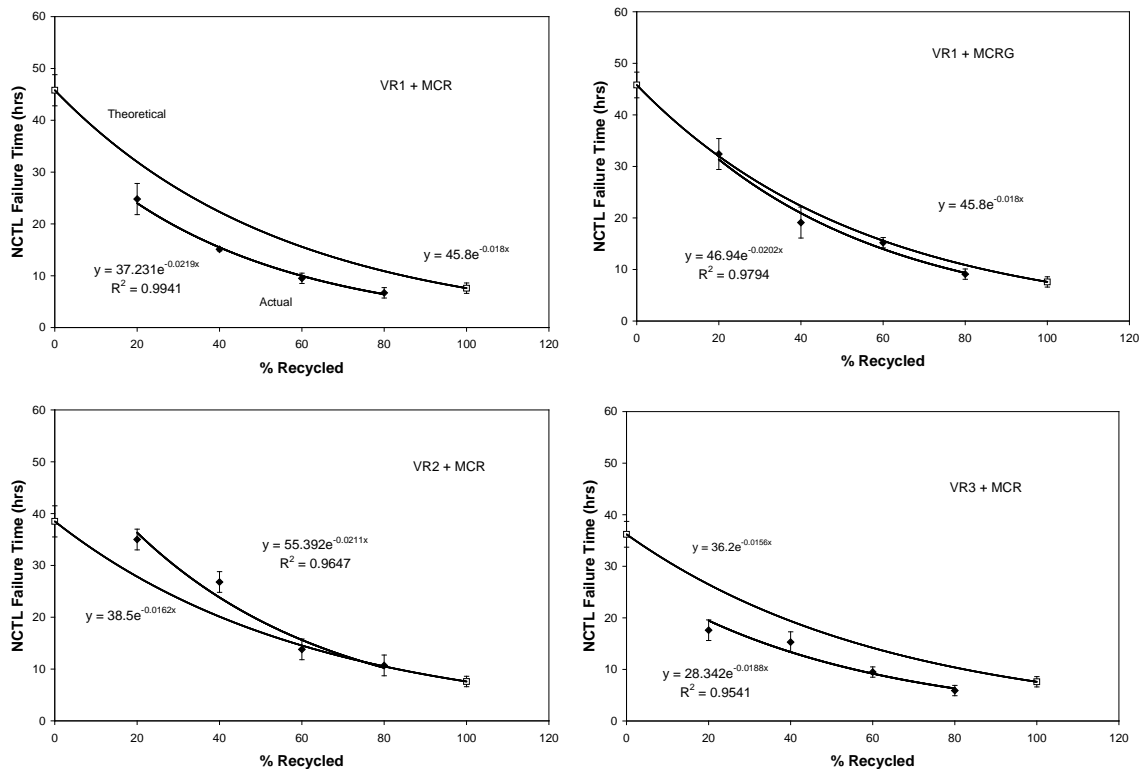


Figure C-3 - The Effect of Recycled Content on the 15% NCTL on Blends of Virgin Pipe Resins and Mixed Color PCR-HDPE

There is a great deal of information in Section C.8. One way to summarize it is through an examination of the best-fit lines or curves, which are shown on each plot. The correlation coefficient ( $R^2$ ) shows how well the data fit the line or exponential curve, and the Y-intercept is the predicted value for the first component in a two component blend. So, how far  $R^2$  is from unity and how close the predicted value is to a measured value show both the quality of the fit, and how accurate the line or curve is.

Tables C-3 and C-4 are summaries of the  $R^2$  values and how close the y-intercepts are to the measured values for the blends in Section C.8.

The shaded values are those values that are below 0.80. The low correlations in the Density and Melt Index seem to be outliers since all the other correlations are excellent. The low values seen in the Yield Stress and Break Strain occur more often and are believed to be representative of the samples tested. It's clear from these data that the break strain shows the poorest correlation. This is most likely caused by the presence of contamination in the recycled resins. Any inhomogeneity can cause an early break in a tensile test, and would also tend to flatten the slope and increase the scatter in a series of samples.

Table C-4 shows the inaccuracies of the relationships described by the lines or curves.

Table C-3 - Correlation Coefficients ( $R^2$ ) from Blend Plots found in Section C.8

Blend	Density	Melt Index	Ash	Yield Stress	Break Strain	15% NCLS
VR1 + MCR1	0.963	0.994	0.972	0.844	0.700	0.994
VR1 + MCRG	0.882	0.995	0.999	0.281	0.608	0.979
VR2 + MCR1	0.953	0.985	0.997	0.956	0.985	0.965
VR3 + MCR1	0.085	0.990	0.999	0.412	0.605	0.954
MCRG + MDPE	0.973	0.987	0.996	0.933	0.992	0.962
MCR1 + MDPE	--	--	--	0.982	0.838	0.999
MCRG + PIRMD	0.987	0.250	0.986	0.984	0.897	0.999

Table C-4 - Percentage Difference Between Y-Intercepts from Blend Plots and Measured Values for Component A

Blend	Yield Stress			Break Strain			15% NCLS		
	Y-Inter	Measured	% Diff	Y-Inter	Measured	% Diff	Y-Inter	Measured	% Diff
VR1 + MCR1	3934	3688	+6.7	247	478	-48.3	37.2	45.8	-18.8
VR1 + MCRG	3564	3688	-3.4	552	478	+15.5	46.9	45.8	+2.4
VR2 + MCR1	3886	3924	-1.0	457	639	-28.4	55.4	38.5	+43.9
VR3 + MCR1	3779	3764	<1	490	647	-24.2	28.3	36.2	-21.8
MCRG + MDPE	3619	3527	+2.6	199	164	+21.3	2.9	7.6	-61.8
MCR1 + MDPE	3695	3620	+2.1	63	62.5	<1	4.2	7.6	-44.7
MCRG + PIRMD	3720	3527	+5.5	223	164	+36.0	5.7	7.6	-25.0

These results also show that the break strain values are not going to be accurate when contaminants are involved. One must be aware that the contaminants are going to reduce the expected elongation at break. The NCTL values are very different than predicted for three sets of results. The first one actually predicts a better resistance than the measured values. There is no obvious explanation for this except perhaps testing errors. The NCTL test is complicated and there are a variety of small errors that can lead to larger values. That is why the tests' interlaboratory scatter can be higher than 40%.

The other two large inaccuracies involve samples with MDPE in them. MDPE has a 15% NCTL time of thousands of hours, so it should not be surprising that it's difficult to accurately predict down to 8 hours time. In spite of some alarming scatter and prediction inaccuracies, overall the results show that trends do occur in predictable manners.

The results of the blending and testing with mixed color PCR HDPE have produced the following findings.

1. The maximum amount of mixed color PCR that can be blended with one of the pipe resins and meet 24 hours of stress crack resistance is about 20%. And, since the 15% NCTL is less aggressive than the NCLS test, a conservative number is closer to 15%.
2. At 15% added MCR, all the AASHTO requirements of pipe would be met.
3. The two different batches of mixed color PCR (MCR1, MCRG) behaved dramatically different. The latter produced much better correlation to theory and had a much higher break strain, suggesting that there were fewer contaminants in the sample.
4. The difference between the predicted and actual values of % strain-at-break might be used to evaluate the level of contamination in the recycled material.
5. Much greater stress crack resistance may be required to offset the deleterious effects of contamination.
6. The stress crack resistance can be dramatically improved by the addition MDPE to the mixed color PCR. A 50:50 blend would produce a resin with about 200 hours in the 15% NCTL test. The yield stress would be reduced to about 3250 psi, so this must be kept in balance to maintain adequate pipe stiffness.
7. The PIR-MD evaluated also improved the resistance to cracking, but not as much as the virgin MD.

## C.4 BLENDS MADE WITH NATURAL PCR

There were 27 blends made with natural PCR HDPE. They included:

VR2 + NAT @ 20, 40, 60 and 80%,  
 NAT + LLDPE @ 20, 40, 60 and 80%,  
 NAT + MDPE @ 20, 40, 60 and 80%,  
 VR1 + N10LL @ 20, 40, 60 and 80%,  
 VR2 + N10LL @ 20, 40, 60 and 80%,  
 VR1 + N35LL @ 20, 40, 60 and 80%,  
 50% NAT + 50% MDPE,  
 65% NAT + 35% PIR-LD, and  
 50% VR3 + 25% MDPE + 25% NAT.

The effect of recycled content on the yield strength for four blends of virgin pipe resins with natural PCR are shown in Figure C-4.

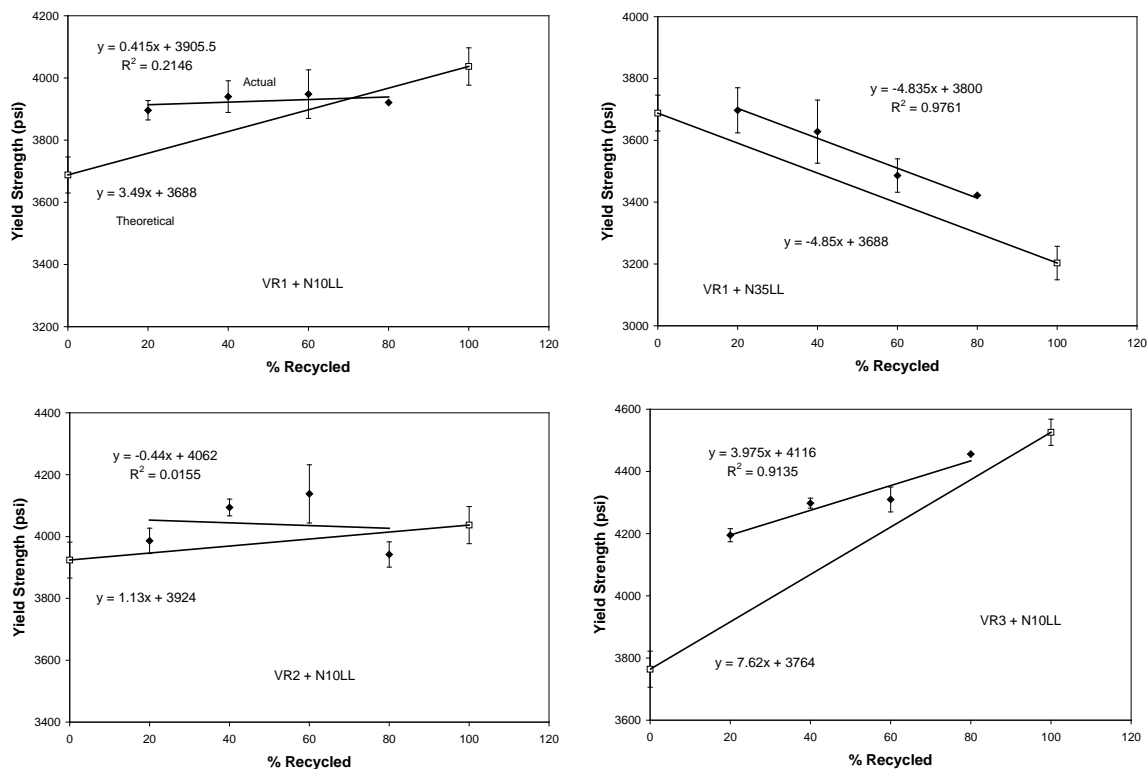


Figure C-4 - The Effect of Recycled Content on the Yield Strength of Blends of Virgin Pipe Resins and Natural PCR-HDPE

The N10LL and N35LL are natural PCR with added LLDPE at 10 and 35% by weight. The correlation coefficients for the lines and the agreement between the actual and theoretical are poor.

Similar plots for the breaking strain and the 15% NCTL stress crack resistance are shown in Figures C-5 and C-6.

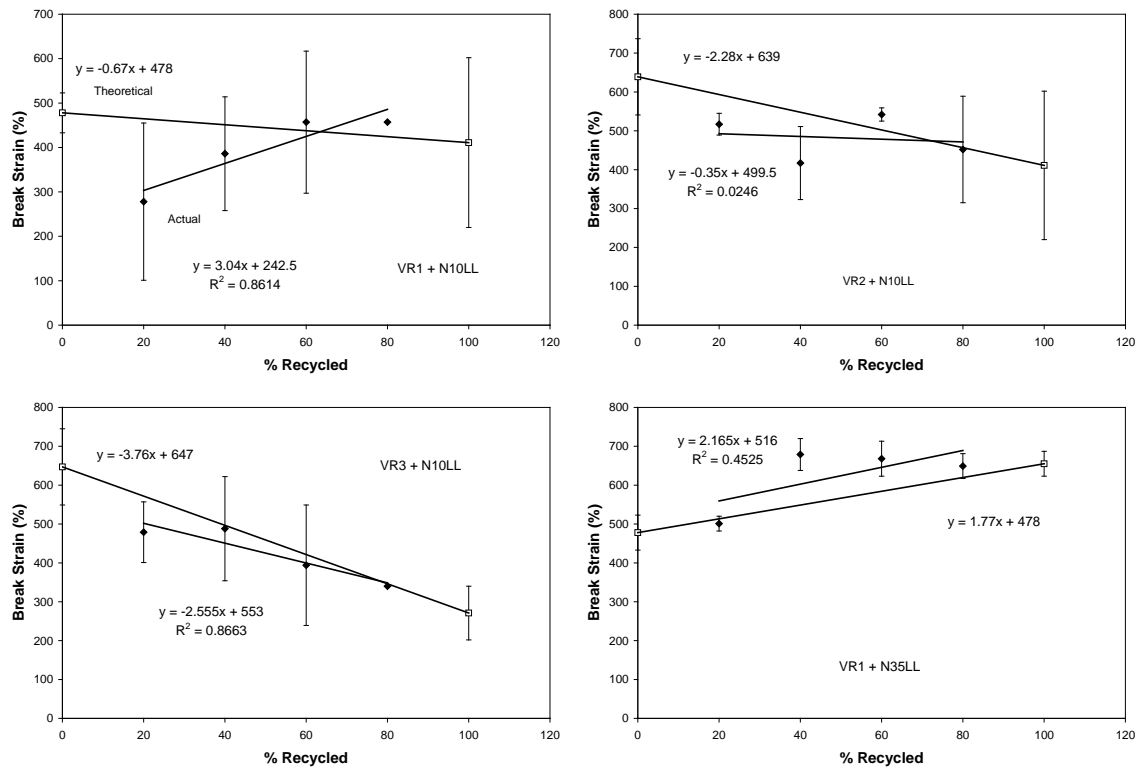


Figure C-5 - The Effect of Recycled Content on the Breaking Strain of Blends of Virgin Pipe Resins and Natural PCR-HDPE

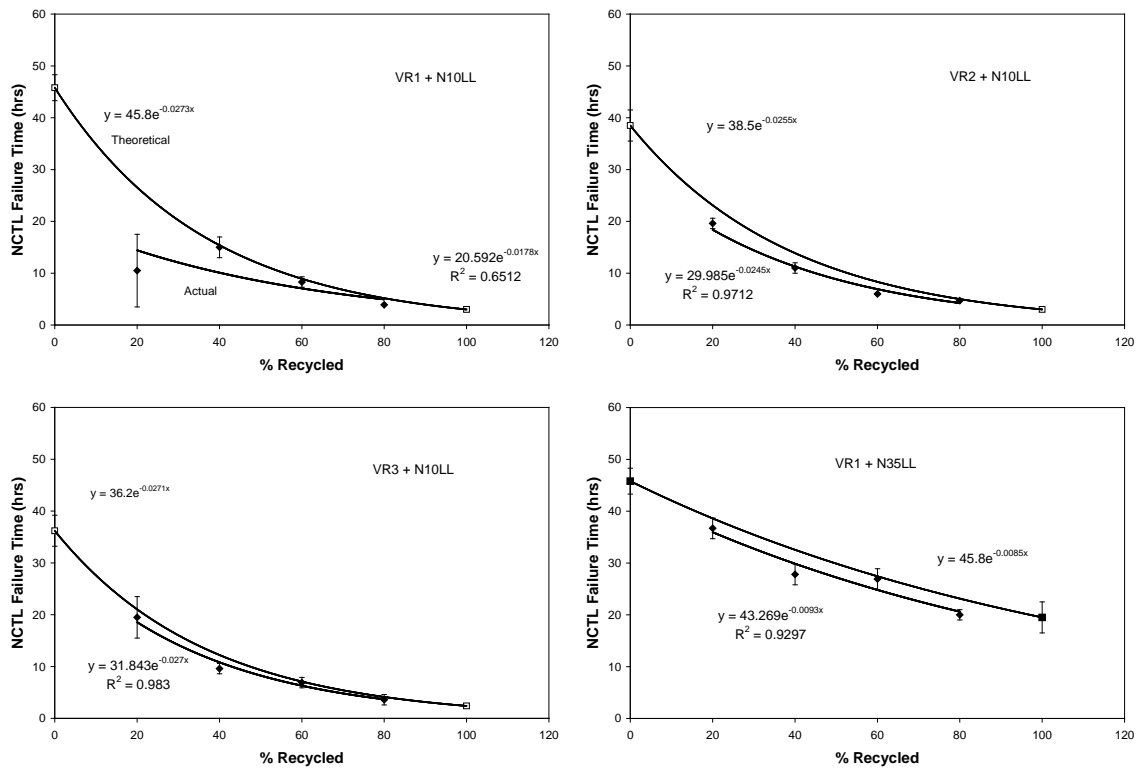


Figure C-6 - The Effect of Recycled Content on the 15% NCTL of Blends of Virgin Pipe Resins and Natural PCR-HDPE

Section C.9 contains summary tables for the blend series, plots of properties versus % recycled, and individual property reports for the 27 blends. Identical tables to Tables C-3 and C-4 are shown for these materials in Tables C-5 and C-6.

The poor correlation in the break strain for the NAT + LLDPE series is easily explained by contaminants. The NAT itself has a coefficient of variation of 38%, which is carried over into the blends with low amounts of LLDPE. The COVs for 5, 10 and 20% LLDPE were 33, 38, and 25% respectively. Interestingly, the series of NAT with MDPE also have high scatter, but the averages happen to fall in line so it doesn't present as dramatically as the NAT + LL results. The COVs for 20 and 40% MDPE were 36 and 28%.

Table C-5 - Correlation Coefficients ( $R^2$ ) from Blend Plots found in Section C.9

Blend	Density	Melt Index	Flow Ratio	Yield Stress	Break Strain	15% NCLS
VR2 + NAT	0.896	0.980	0.977	0.913	0.866	0.983
NAT + LLDPE	0.980	0.938	0.999	0.999	0.704	0.977
NAT + MDPE	0.924	0.995	0.999	0.998	0.963	0.989
VR1 + N10LL	0.968	0.989	0.994	0.215	0.861	0.651
VR2 + N10LL	0.600	0.955	0.980	0.015	0.025	0.971
VR1 + N35LL	--	--	--	0.976	0.452	0.930



Table C-6 - Percentage Difference Between Y-Intercepts from Blend Plots and Measured Values for Component A

Blend	Yield Stress			Break Strain			15% NCLS		
	Y-Inter	Measured	% Diff	Y-Inter	Measured	% Diff	Y-Inter	Measured	% Diff
VR2 + NAT	4116	3924	+4.9	553	639	-13.4	31.8	38.5	-17.4
NAT + LLDPE	4318	4525	-4.6	483	302	+60.0	1.3	2.3	-43.4
NAT + MDPE	4355	4525	-3.7	292	302	-3.3	1.0	2.3	-56.5
VR1 + N10LL	3905	3688	+5.9	243	478	-49.2	20.6	45.8	-55.0
VR2 + N10LL	4062	3924	+3.5	500	639	-21.7	30.0	38.5	-22.1
VR1 + N35LL	3800	3688	+3.0	516	478	+7.9	43.5	36.2	+20.2

The results of the blending and testing with natural PCR HDPE have produced the following findings.

1. Only about 10% of natural PCR HDPE can be added to virgin pipe resins and meet a 15% NCTL time of 24 hrs. However, the yield will be over 4000 psi, so the NCLS test will be less severe for this blend. That means that the limit might be closer to 15%.
2. Dramatic improvements in stress crack resistance can be obtained by blending the NAT with either LLDPE or MDPE. A failure time of 50 hrs in the 15% NCTL test can be obtained with around 45% of added LL and 55% of added MD.
3. Blends between NAT and MDPE are preferred because the yield stress remains higher for the MD blends. For example, the yield stress for 45% LL is around 2900 psi, while the yield stress for 55% MD is around 3400 psi. The AASHTO minimum density requirement for pipe resins is  $0.948 \text{ g/cm}^3$ , which correlates to a yield stress of around 3500 psi.
4. The addition of only 10% LLDPE does very little to improve the properties of resulting blends.
5. A blend of 50% VR3, 25% NAT and 25% MDPE has properties very close to a PPI certified pipe resin.

## **C.5 BLENDS MADE WITH PIR-HD**

A total of 12 blends were prepared with post-industrial HDPE. Section C.9 contains summary tables for the blend series, plots of properties versus % recycled, and individual property reports for the 12 blends. Tables containing correlation coefficients and predicted versus measured properties are found in Tables C-7 and C-8.

The Blends were:

VR1 + PIR-HD @ 20, 40, 60 AND 80%,  
VR2 + PIR-HD @ 20, 40, 60 AND 80%,  
VR3 + PIR-HD @ 20, 40, 60 AND 80%.

Table C-7 - Correlation Coefficients ( $R^2$ ) from Blend Plots found in Section C.10

Blend	Density	Melt Index	Color +Ash	Yield Stress	Break Strain	15% NCLS
VR1 + PIR-HD	0.890	0.996	0.999	0.931	0.933	0.918
VR2 + PIR-HD	0.966	0.164	0.999	0.994	0.101	0.888
VR3 + PIR-HD	0.985	0.880	0.999	0.897	0.592	0.841

Table C-8 - Percentage Difference Between Y-Intercepts from Blend Plots and Measured Values for Component A

Blend	Yield Stress			Break Strain			15% NCLS		
	Y-Inter	Measured	% Diff	Y-Inter	Measured	% Diff	Y-Inter	Measured	% Diff
VR1 + PIR-HD	3821	3688	+3.6	450	478	-5.9	39.4	45.8	-14.0
VR2 + PIR-HD	3907	3924	<1	635	639	<1	37.8	38.5	-1.8
VR3 + PIR-HD	3690	3764	-2.0	679	647	+4.9	34.6	36.2	-4.4

This series behaved more predictably. The PIR-HD had 3.9% color + ash but also a high break strain of 720%. The average yield stress of 3157 psi suggests its true density is around 0.943 g/cm<sup>3</sup> and its 15 % NCTL time is around 98 hours. This is a very good resin for blending because it seems to lack the type of contamination that produced the high scatter in the other blends. The low R<sup>2</sup> values in the table were due to the closeness in the values of c the VR2 and PIR-HD. The melt indices were 0.33 and 0.30 g/10 min and the break strains were 595 and 612%.

The results of blending and testing with PIR-HD have led to the following findings.

1. This PIR resin is apparently void of the contaminants found in PCR bottles that create high scatter in some properties, particularly break strain.
2. A resin with a base density of around 0.943 g/cm<sup>3</sup> is an excellent resin for blending because it has a yield stress of around 3150 psi and stress crack resistance around 100 hrs.
3. These test results served to validate the relationships found in the other blends.
4. Blends of virgin resins containing up to 40% PIR-HD had yield stresses around 3500 psi, break strains above 550% and 15% NCTL times greater than 40 hrs. This blend would meet the resin properties found in AASHTO M294 for pipe.

## **C.6 THE BAM STRESS CRACK TEST RESULTS**

The BAM test is a stress crack test that is run at 80°C on samples that are 0.5 in wide, by 6 in long, and is performed without a notch. The test is similar to the hydrostatic burst test for pipe. There is no flaw in either test and the test specimen fails at a location of the largest defect. The BAM test is complimentary to the NCLS or NCTL tests. Polyethylene resins have an inherent resistance to cracking. The notched tests basically measure the crack growth rate when a crack is initiated at a controlled flaw. The BAM test creates a situation where the specimen fails at the most significant flaw. Previous work by the PI showed that as the NCTL times grew longer, materials were better able to accommodate flaws. So, both the notched value and the BAM results are important for long-term durability. A more complete description of the BAM test is found in Appendix A, Section A.3.2. The results generated for the blends containing recycled were generated under an applied stress of 580 psi, at 80°C in deionized water.

The results on the blends that were tested are found in Table C-9 along with their break strain.

Table C-9 - BAM Test Results Under 580 psi  
At 80°C in Deionized Water

Sample	BAM Failure Time (hrs) <sup>1</sup>	% Strain-at-Break <sup>2</sup>
VR1	$>268 \pm 38$	$465 \pm 88$
VR2	$>300 \pm 97$	$625 \pm 118$
VR3	$>267 \pm 47$	$575 \pm 144$
VR3 + 20% MCR1	$87 \pm 33$	$461 \pm 65$
VR2 + 20% NAT	$93 \pm 32$	$534 \pm 120$
50% VR3 + 25% MD + 25% MCRG1	$>300$	$601 \pm 107$
50% VR3 + 25% MD + 25% NAT	$>206 \pm 89$	$631 \pm 188$
VR3 + 40% PIR-HD	$>242 \pm 100$	$643 \pm 97$
50% VR3 + 25% MD + 25% MCRG2	$40 \pm 26$	$331 \pm 145$

1 - Some specimens exceeded 300 hrs

2 - 10 replicates

Notice that the virgin resins and several of the blends exceeded 200 hours in the test. This is very encouraging since this test should be a good model for potential cracks in the field. Secondly, notice that the binary blends with 20% MCR1 and NAT had times close to 100 hours. These will help establish the minimum times when pipe is made. And finally, notice the last sample tested had MCRG2 in it. This was a recent batch of regrind that was obtained and apparently had more silicone rubber than had been seen before. This became obvious by examining the edges of the BAM test specimens that had been shaved. One could see rubber particles present along the edge. Not surprisingly, the BAM stress crack resistance was poor. The break strain was also tested to see if there was a correlation with the BAM results. There may not be enough data here to say for sure, but it appears as if there is a relationship. Regardless, anything one can do to reduce the presence of contaminants should improve the results of both the stress crack resistance and the breaking strain.

## C.7 RESIN FORMULATIONS FOR PIPE TRIALS

The last task in this phase of the project is to evaluate all the data generated and to select up to 10 blends for making trial corrugated pipe in at least 2 different pipe manufacturing plants. In an

effort to simplify the process, the focus will be on one virgin resin, and only PCR natural and mixed color resins. It is recognized that there are some differences between virgin resins, and that there are excellent PIR resins available. The main issue with the PIR is that it is difficult to find consistent supplies. It should also be mentioned again that this study has been limited by trying to add recycled to a virgin pipe resin with limited stress crack resistance. Better resins and resin blends are available with more than 100 hrs of stress crack resistance, as measured by the NCLS time. The use of these materials could produce much better formulations of equivalent formulations with more recycled HDPE in them.

The formulations presented were finalized after many hours of data analysis, and discussions with project personnel and consultants. It was decided that it is feasible to make blends that will meet AASHTO short-term requirements and contain significant amounts of recycled HDPE. The long-term properties of the pipe will be evaluated, and that information will allow for proper requirements to be placed on pipe resins containing recycled HDPE.

The two virgin resins, VR1 and MDPE, are consistent in their properties. The properties for the recycled resins will be an estimate, since there is some variability in these products.

Since there are two pipe plants available for manufacturing, it would be beneficial if they both made pipe from VR1 alone and 1 other formulation. So, there is a need for 7 formulations.

Table C-10 - Resins for Pipe Formulations

Resin	Yield Stress (psi)	Break Strain (%)	15% NCTL (hrs)
VR1	3688	478	45.8
MDPE	2732	771	>1000
PCR – MCR	3620	62.5	7.6
PCR – NAT	4525	302	2.3

Two obvious choices are simple 2-component blends with VR1 and 15% of PCR-MCR and PCR-NAT. With the use of the relationships obtained from the blend study, the resulting properties can be estimated:

The yield stress and break strain are linear functions:

$$\text{Blend Yield Stress} = (0.85 \times 3688) + (0.15 \times 3620) = 3678 \text{ psi for MCR,}$$

$$\text{Break Strain} = (0.85 \times 478) + (0.15 \times 62.5) = 416 \%,$$

The 15% NCTL is an exponential relationship:

$$15\% \text{ NCTL} = 45.8 e^{-0.018 \times 15} = 35.0 \text{ hrs.}$$

The values calculated in the same way for PCR-NAT are:

Yield Stress = 3814 psi,

Break Strain = 452 %

15% NCTL = 29.2 hrs

With the use of these equations, blends have been chosen that have a minimum yield stress of 3400 psi, a minimum break strain of 400% and a minimum 15% NCTL time of 29 hrs. Additionally, the blends have a recycled content from 15 to 60 percent.

The blends selected are shown in Table C-11 and their properties in Table C-12.

Table C-11 - Proposed Formulations for Pipe

Formulation #	VR1	Virgin MDPE	PCR-MCR	PCR-NAT	% Recycled
1	100				0
2	85		15		15
3	85			15	15
4	50	20	30		30
5	40	30		30	30
6	20	40	24	16	40
7		50		50	50
8		40	36	24	60

Table C-12 - Predicted Properties of Pipe Formulations

Formulation #	Yield Stress (psi)	% Break Strain	15% NCTL (hrs)
1	3688	478	45.8
2	3678	416	35.0
3	3818	452	29.2
4	3443	412	>49.5
5	3653	513	>47.1
6	3423	468	>63.3
7	3629	537	>48
8	3482	403	>40.1

The proposed formulations for making the trial pipe have a host of positive features. They include:

1. The minimum yield stress is 3420 psi, which is close to the yield stress of a 0.948 g/cm<sup>3</sup> resin, which is the minimum for AASHTO.
2. The 15% NCTL failure times are above 29 hrs, which is close to the minimum NCLS time of 24 hrs.
3. The break strains are above 400%, which should correspond to favorable BAM test results.
4. There is a wide range of percentage recycled represented (15-60%).
5. Both PCR mixed color and natural resins are represented in case the contaminants in the mixed color compromise the long-term properties of the blends.

The plan is to make 100 feet of 12" diameter pipe from each formulation. This will allow enough for testing under this project and retained pipe samples for future evaluations.

## **C.8 CONCLUSIONS**

A total of 66 blends were prepared and tested to find out how much recycled resin could be used in three PPI certified resins where the final product would still meet the AASHTO M294 resin requirements for corrugated pipe. It was determined that for simple, two component blends, the maximum amount of PCR HDPE is around 15%, while a specific PIR-HD obtained could be used in amounts up to 40%.

More importantly, it was found that through the relationships discovered during this task, other 2 and 3 component blends could be designed and optimized for the specific purpose of maximizing the amount of recycled HDPE used. This information will be invaluable to those developing new blends for improved short and long term properties of corrugated pipe resins. Contaminants like particles and silicone rubber seemed to affect the relationships in a negative way so the relationships are probably most useful as guidelines; some actual testing will still be required.

It also should be stated that much better recycled blends can be made than the ones described in this report. The results herein were limited by the fact that the recycled resins were blended with PPI certified pipe resins. The virgin resins only had around 50 hrs of NCLS time to begin with. Starting with similar resins with 100 or 150 hrs of NCLS time would allow for much more recycled to be used.

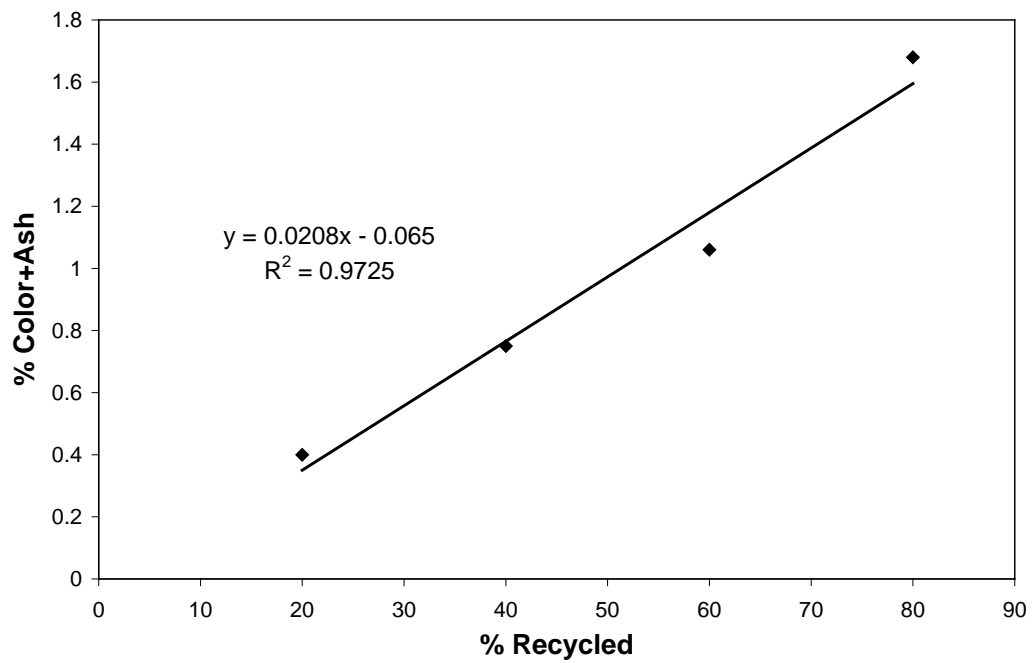
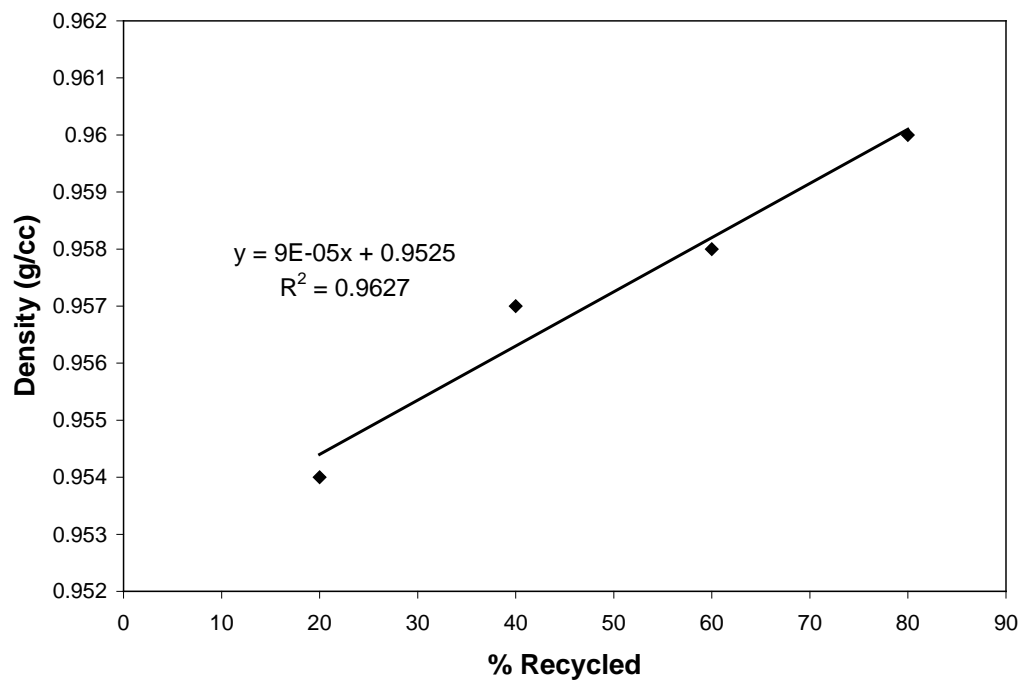


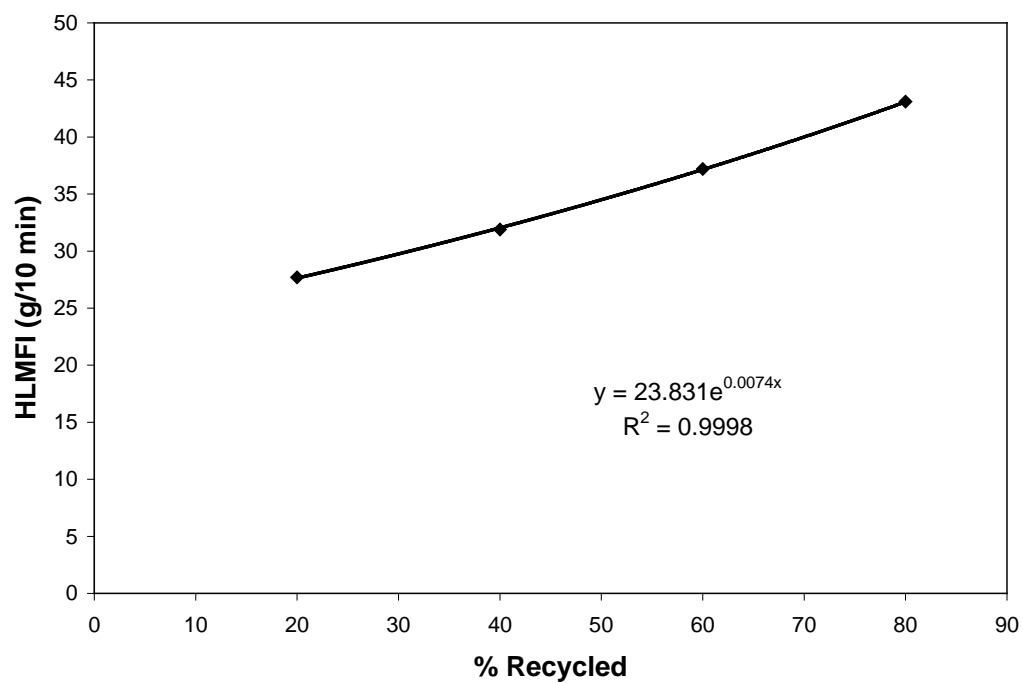
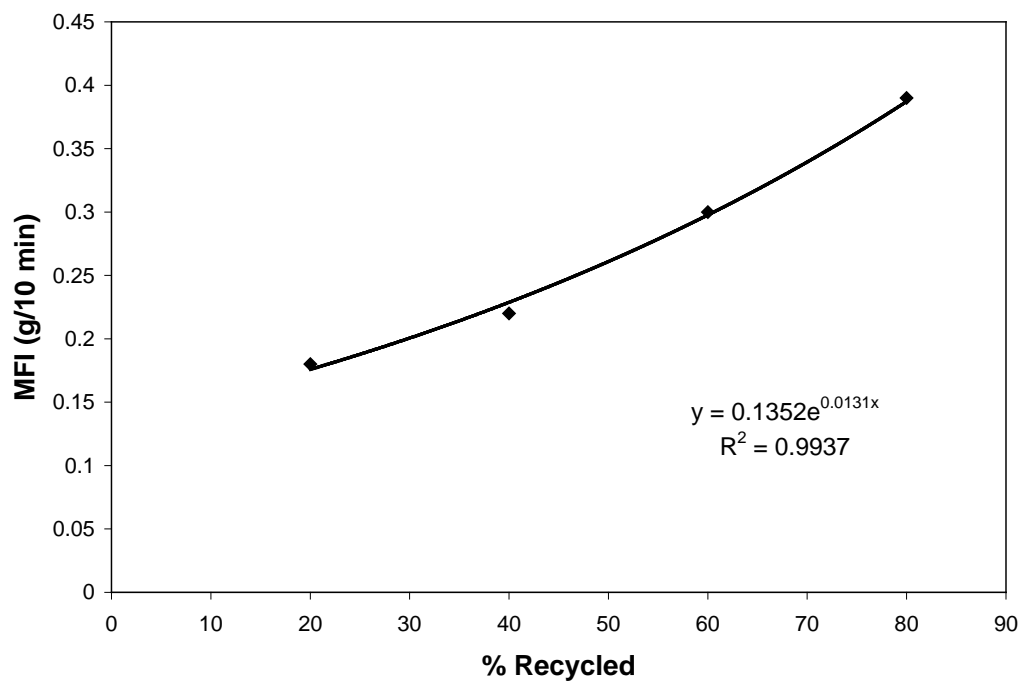
C.9 SUMMARY TABLES, GRAPHS, AND TEST REPORTS  
FOR BLENDS MADE WITH MIXED-COLOR,  
POST-CONSUMER, RECYCLED HDPE

### Virgin Resin 1 + Mixed Color Reprocessed

Property	Recycle Content					
	0% Recycle	20% Recycle	40% Recycle	60% Recycle	80% Recycle	100% Recycle
Density g/cm <sup>3</sup>		0.954	0.957	0.958	0.960	0.960
Melt Index g/10 min		0.18	0.22	0.30	0.39	0.54
Flow Rate g/10 min		27.7	31.9	37.2	43.1	45.2
MFR (21.6/2.16kg)		154	145	124	111	83
% Color + Ash		0.40	0.75	1.06	1.68	1.6
% PP		1.5	2.1	3.6	4.4	5.7
Yield Strength (psi)		3840	3796	3771	3607	3685
Break Strain (%)		199	219	127	124	46
NCTL-15% (hrs)		24.8	15.1	9.5	6.7	8.8
OIT (min)		17.6	17.3	15.5	13.0	12.2

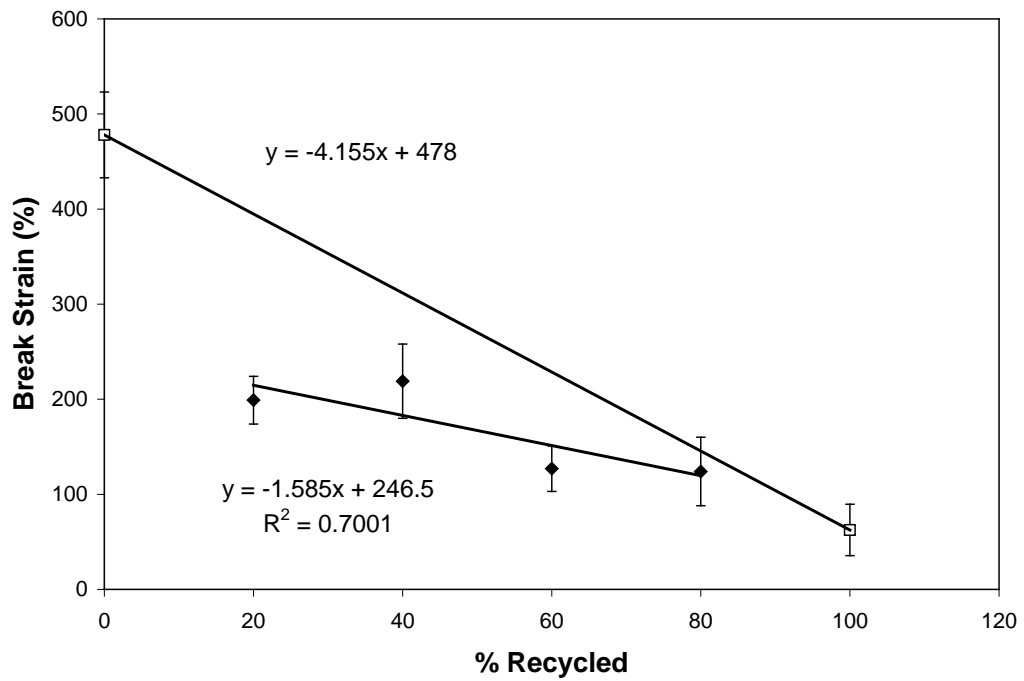
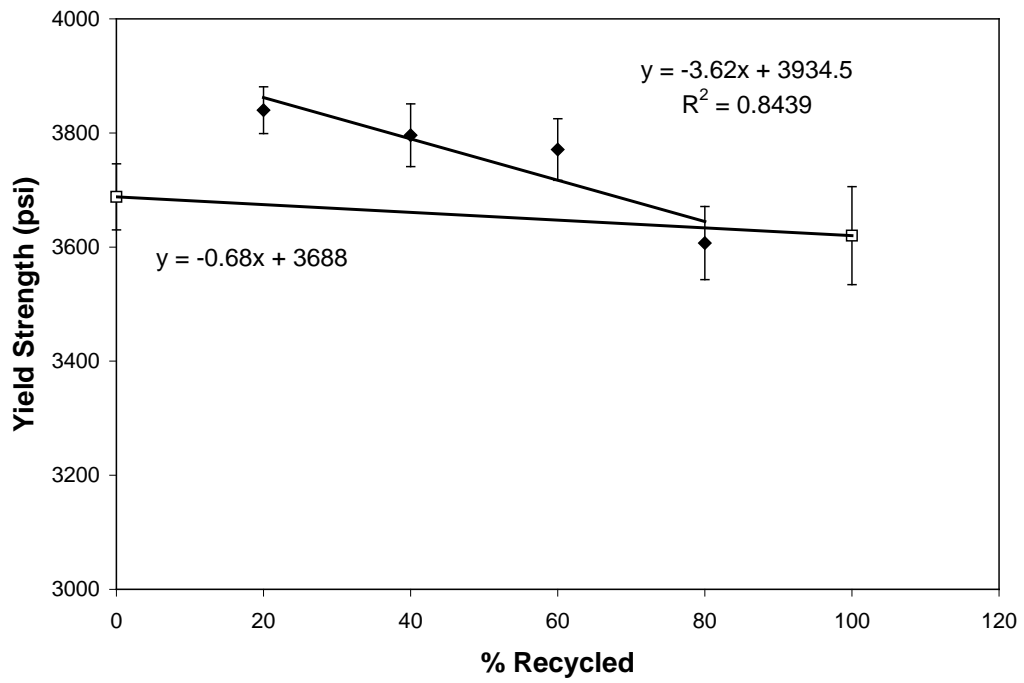
### Virgin Resin 1 + Mixed Color Reprocessed



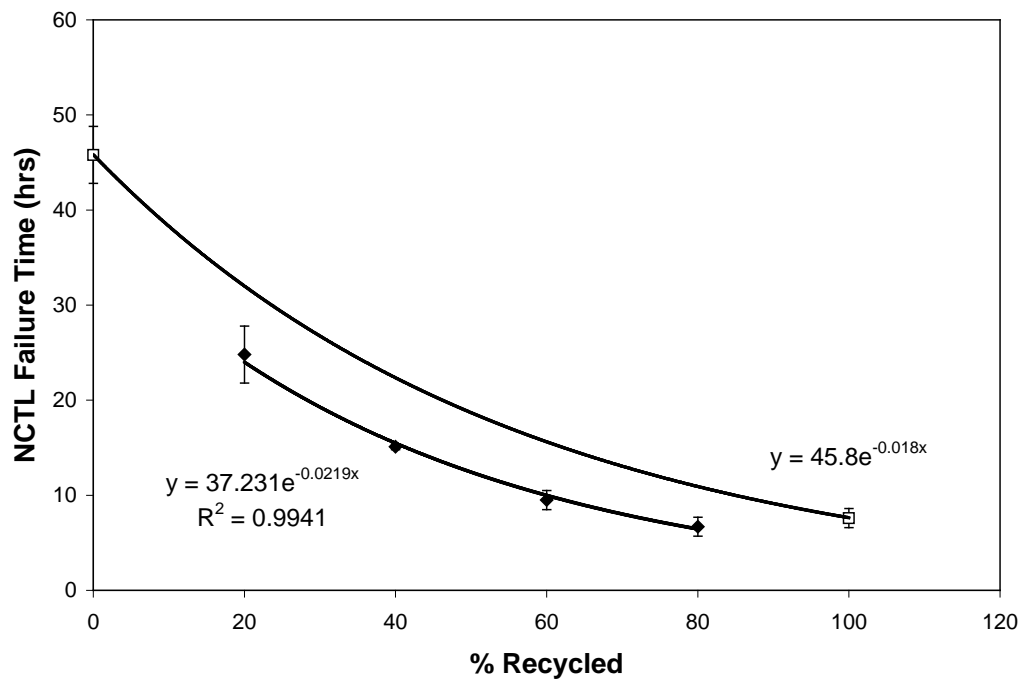


**Virgin Resin 1 + Mixed Color Reprocessed**

### Virgin Resin 1 + Mixed Color Reprocessed



### Virgin Resin 1 + Mixed Color Reprocessed



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Consumer Mixed Color Reprocessed**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 20% MCR1

Date: 9-Feb-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.954	0.954	0.954			0.954	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.17	0.18				0.18	
21.6 kg (g/10 min)	27.7	27.7				27.7	
Ratio						154	
<b>Composition</b>							
% Color/Ash	0.41	0.40	0.40			0.40	0.005
% PP	1.5					1.5	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3805	3779	3885	3867	3863	3840	41
Break Strain (%)	200	182	161	232	218	199	25
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	21.3	25.9	27.3	21.5	28.1	24.8	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	17.6					17.6	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Consumer Mixed Color Reprocessed**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 40% MCR1

Date: 9-Feb-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.957	0.957	0.957			0.957	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.22	0.22				0.22	
21.6 kg (g/10 min)	31.6	32.1				31.9	
Ratio						145	
<b>Composition</b>							
% Color/Ash	0.76	0.76	0.74			0.75	0
% PP	2.1					2.1	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3704	3773	3800	3859	3842	3796	55
Break Strain (%)	174	212	269	259	182	219	39
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	14.8	15.4	15.4	14.7	15.4	15.1	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	17.3					17.3	



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Consumer Mixed Color Reprocessed**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 60% MCR1

Date: 9-Feb-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.958	0.958	0.958			0.958	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.31	0.29				0.30	
21.6 kg (g/10 min)	37.0	37.4				37.2	
Ratio						124	
<b>Composition</b>							
% Color/Ash	1.06	1.08	1.05			1.06	0.012
% PP	3.6					3.6	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3719	3732	3843	3831	3732	3771	54
Break Strain (%)	157	100	154	106	119	127	24
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	11.2	10.1	10.2	8.3	7.7	9.5	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	15.5					15.5	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Consumer Mixed Color Reprocessed**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 80% MCR1

Date: 9-Feb-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.960	0.96	0.96			0.960	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.39	0.38				0.39	
21.6 kg (g/10 min)	43.8	42.4				43.1	
Ratio						111	
<b>Composition</b>							
% Color/Ash	1.62	1.68	1.73			1.68	0.045
% PP	4.4					4.4	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3685	3594	3657	3600	3500	3607	64
Break Strain (%)	194	120	108	95	102	124	36
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	7.6	7.6	6.4	6.2	5.7	6.7	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	13.0					13.0	

# TEST RESULTS

## Recycled HDPE Blend

### Post Consumer Mixed Color Reprocessed

### 100%

Material: Plaque from blended resin (MB 3X)  
Sample: 100% MCR1

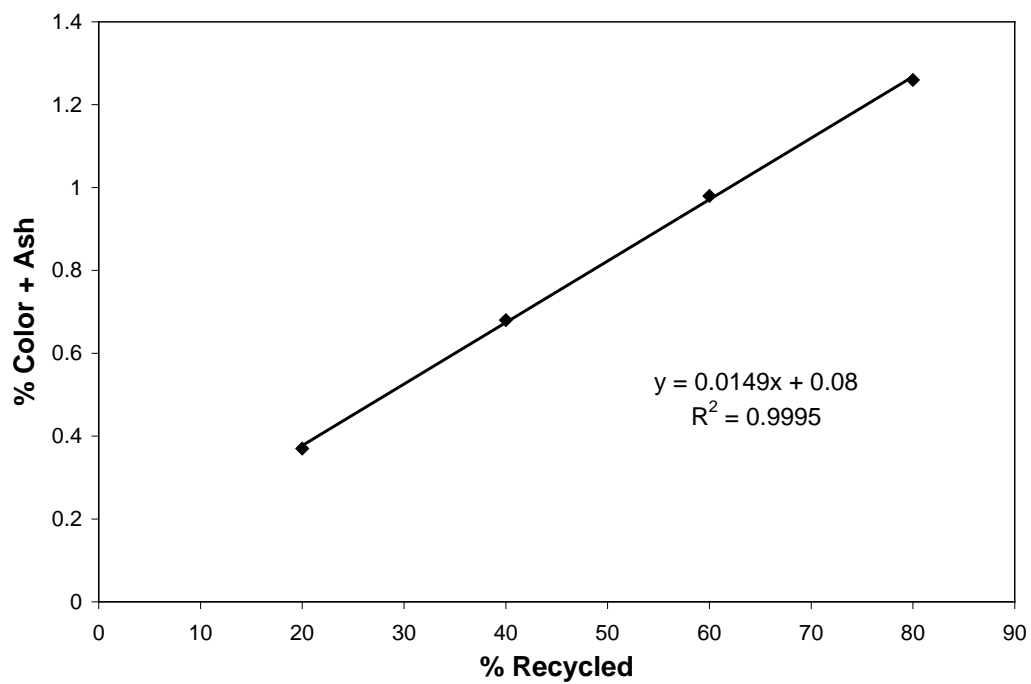
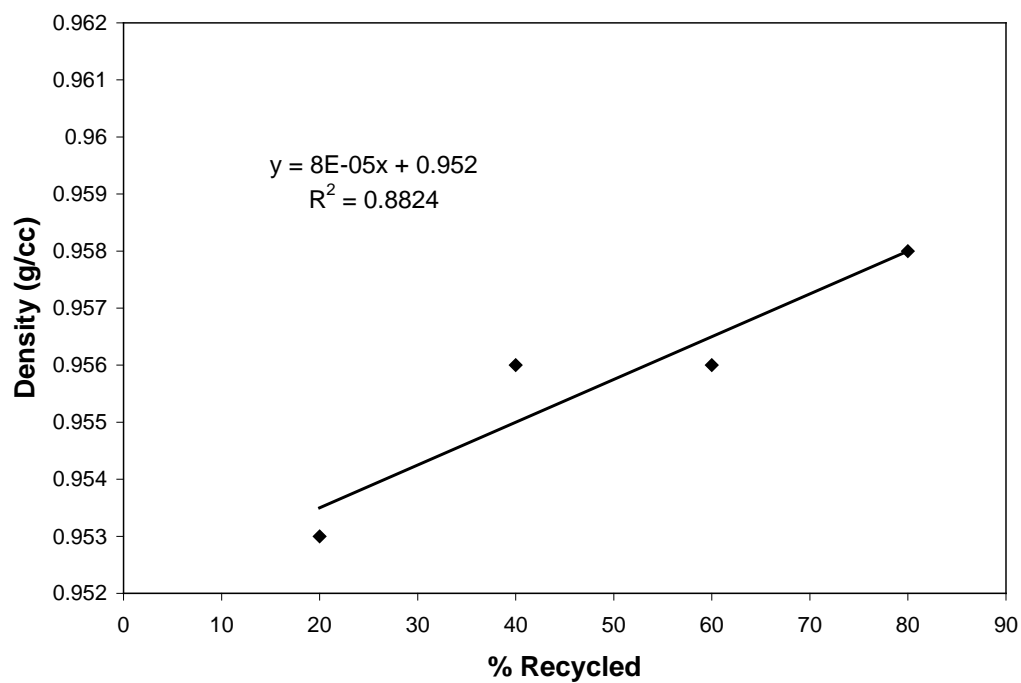
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TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.960	0.960	0.960			0.960	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.53	0.55				0.54	
21.6 kg (g/10 min)	46.9	43.6				45.2	
Ratio						83	
<b>Composition</b>							
% Color/Ash	1.61	1.67	1.39			1.56	0.120
% PP	5.7					5.7	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3591	3708	3724	3718	3684	3685	49
Break Strain (%)	80	31	33	18	68	46	24
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	10.9	10.4	7.8	7.0	8.1	8.8	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	12.2					12.2	

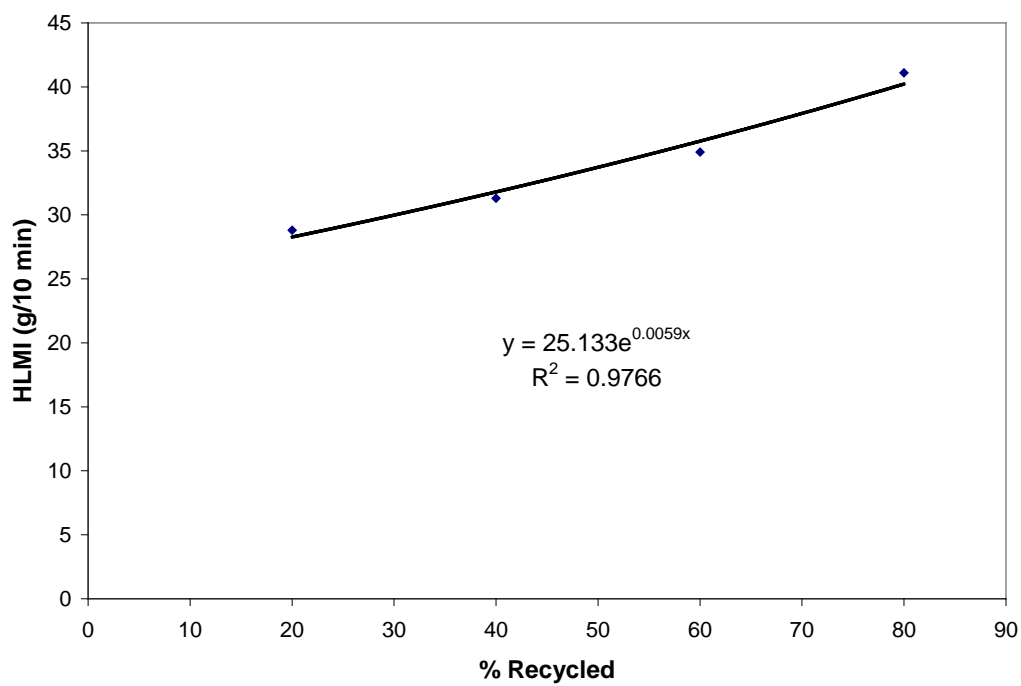
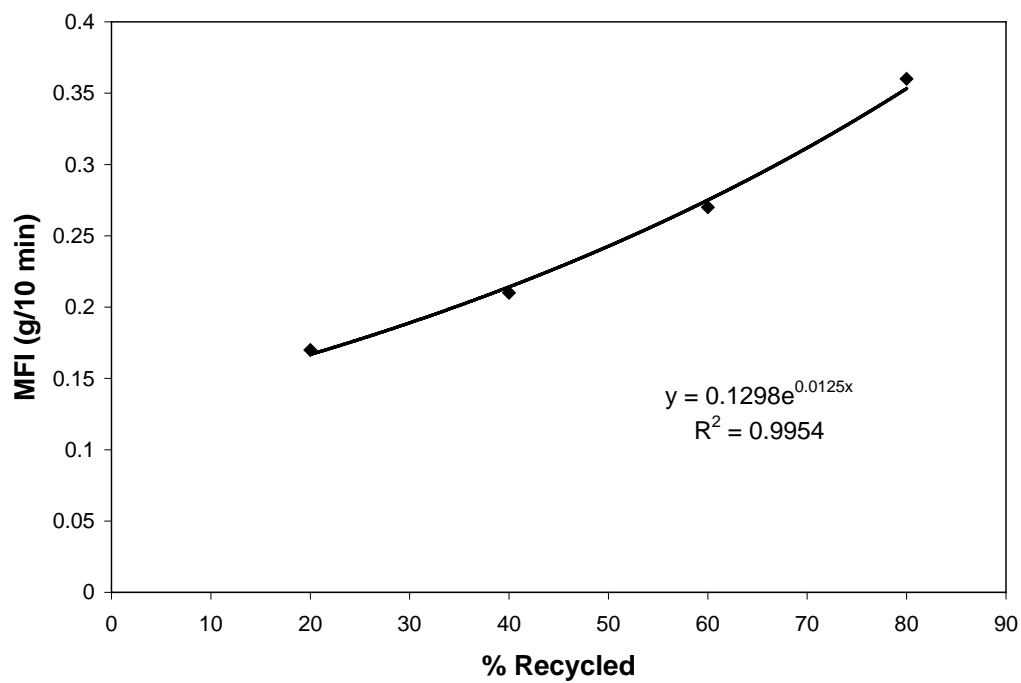
### Virgin Resin 1 + Mixed Color Regrind

Property	Recycle Content					
	0% Recycle	20% Recycle	40% Recycle	60% Recycle	80% Recycle	100% Recycle
Density g/cm <sup>3</sup>		0.953	0.956	0.956	0.958	0.960
Melt Index g/10 min		0.17	0.21	0.27	0.36	0.48
Flow Rate g/10 min		28.8	31.3	34.9	41.1	39.6
MFR (21.6/2.16kg)		169	152	129	114	83
% Color + Ash		0.37	0.68	0.98	1.26	1.57
% PP		0.8	1.2	2.1	3.1	3.2
Yield Strength (psi)		3574	3515	3499	3535	3441
Break Strain (%)		487	359	445	230	158
NCTL-15% (hrs)		32.4	19.1	15.2	9.1	8.0
OIT (min)		16.3	13.7	13.3	11.8	12.6

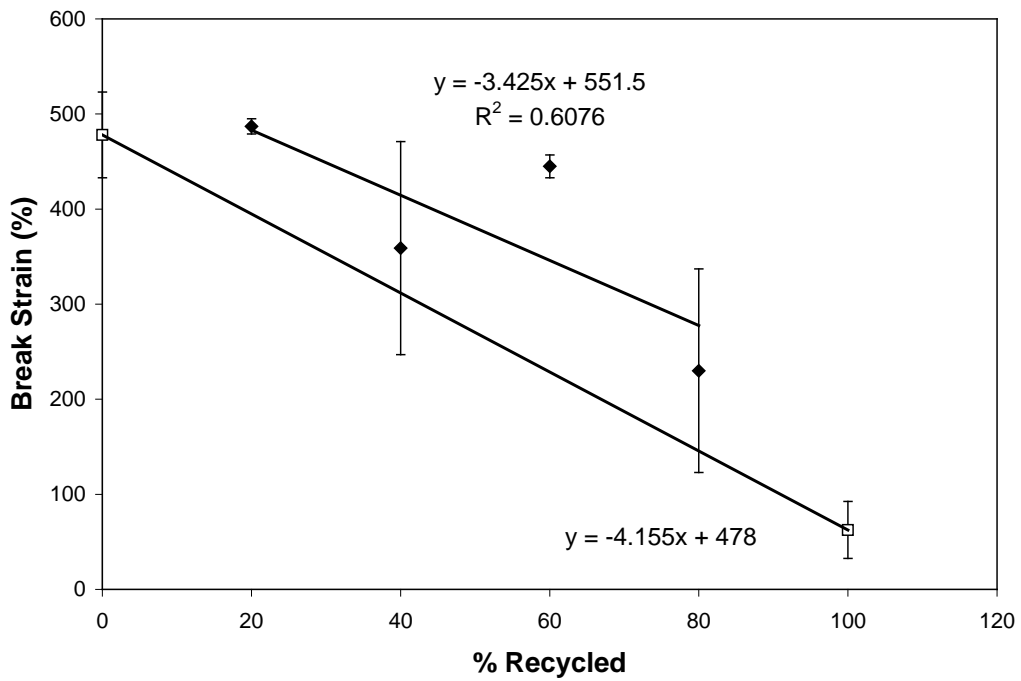
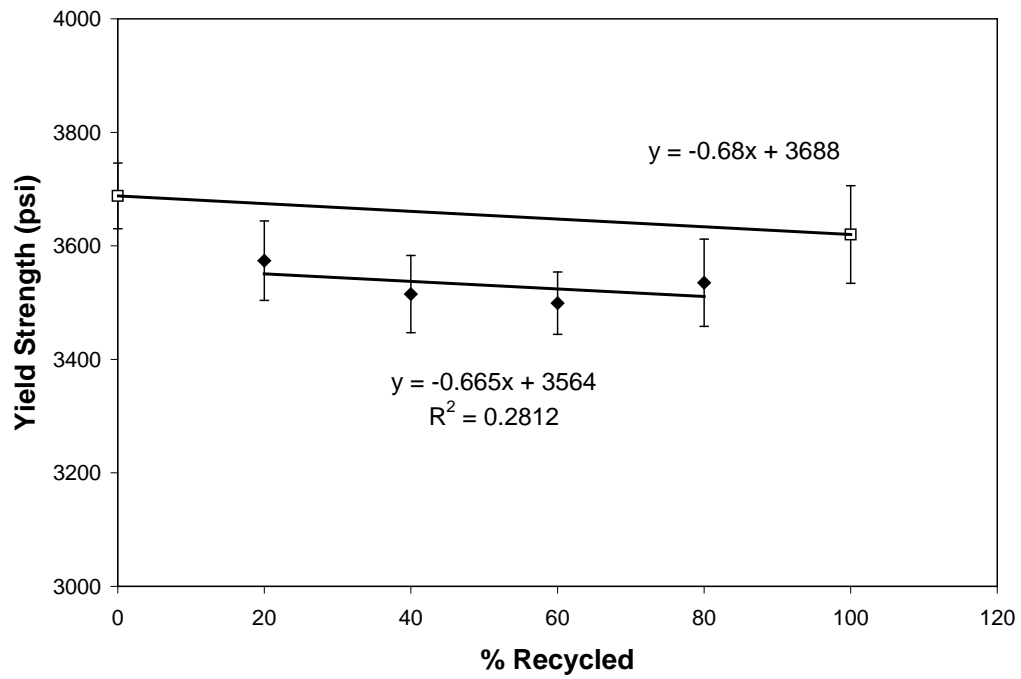
### Virgin Resin 1 + Mixed Color Regrind



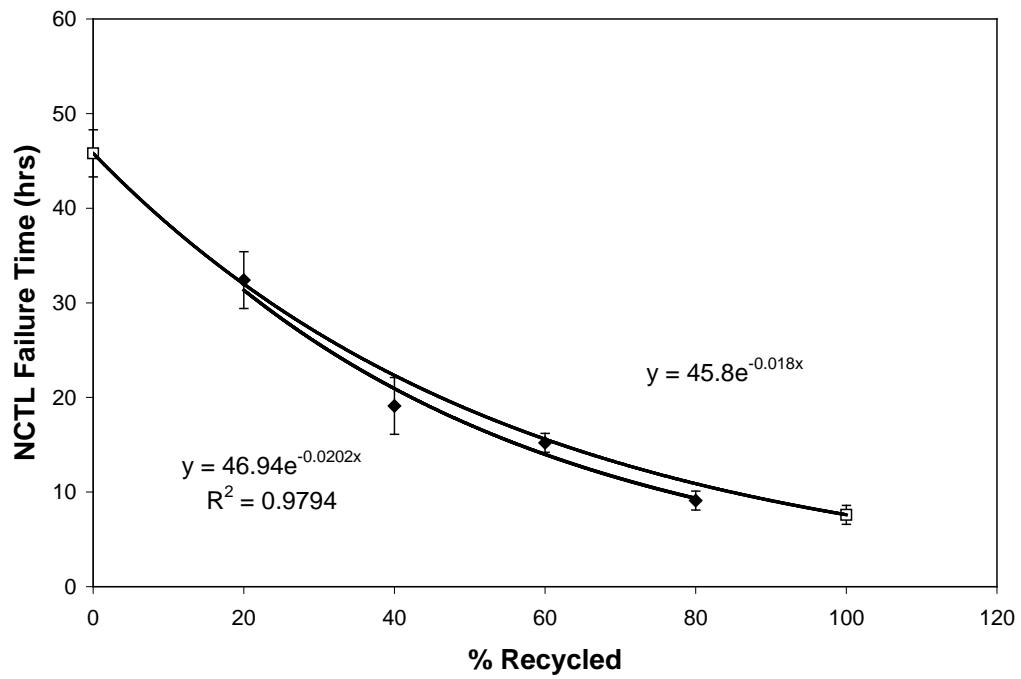
### Virgin Resin 1 + Mixed Color Regrind



### Virgin Resin 1 + Mixed Color Regrind



## Virgin Resin 1 + Mixed Color Regrind





**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Consumer Mixed Color Regrind**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 20% MCRG

Date: 19-Mar-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.952	0.953	0.954			0.953	0.001
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.17	0.17				0.17	
21.6 kg (g/10 min)	28.8	28.8				28.8	
Ratio						169	
<b>Composition</b>							
% Color/Ash	0.38	0.39	0.35			0.37	0.017
% PP	0.8					0.8	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3653	3643	3586	3500	3486	3574	70
Break Strain (%)	483	487	475	491	498	487	8
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	36.1	28.5	31.9	35.9	29.7	32.4	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	16.3					16.3	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Consumer Mixed Color Regrind**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 40% MCRG

Date: 19-Mar-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.956	0.956	0.956			0.956	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.21	0.20				0.21	
21.6 kg (g/10 min)	31.3	31.2				31.3	
Ratio						152	
<b>Composition</b>							
% Color/Ash	0.70	0.67	0.68			0.68	0.012
% PP	1.2					1.2	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3635	3465	3535	3500	3438	3515	68
Break Strain (%)	166	446	431	453	298	359	112
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	18.4	21.2	22.2	18.5	15.0	19.1	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	13.7					13.7	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Consumer Mixed Color Regrind**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 60% MCRG

Date: 19-Mar-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.956	0.956	0.956			0.956	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.27	0.27				0.27	
21.6 kg (g/10 min)	34.7	35.0				34.9	
Ratio						129	
<b>Composition</b>							
% Color/Ash	1.01	0.99	0.95			0.98	0.025
% PP	2.1					2.1	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3548	3513	3545	3494	3397	3499	55
Break Strain (%)	462	453	449	428	434	445	12
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	15.5	16.3	13.4	15.8	15.1	15.2	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	13.3					13.3	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Consumer Mixed Color Regrind**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 80% MCRG

Date: 19-Mar-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.958	0.958	0.959			0.958	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.35	0.37				0.36	
21.6 kg (g/10 min)	41.5	40.7				41.1	
Ratio						114	
<b>Composition</b>							
% Color/Ash	1.27	1.23	1.27			1.26	0.019
% PP	3.1					3.1	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3653	3533	3563	3514	3414	3535	77
Break Strain (%)	233	153	171	156	435	230	107
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	9.4	9.9	8.8	9.3	8.3	9.1	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	11.8					11.8	

# TEST RESULTS

## Recycled HDPE Blend

### Post Consumer Mixed Color Regrind

### 100%

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: 100% MCRG

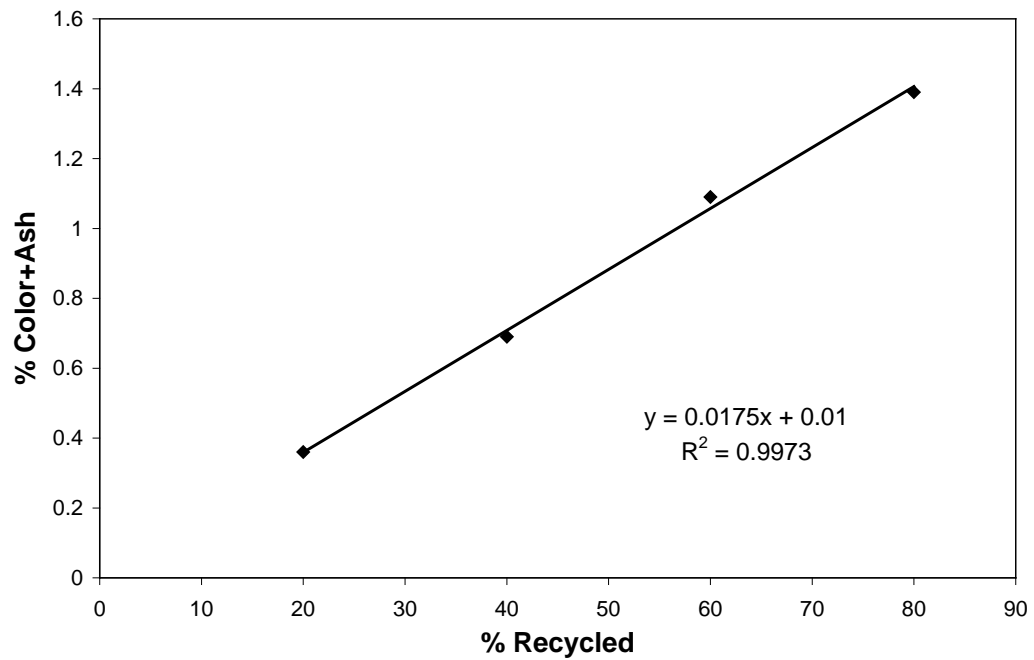
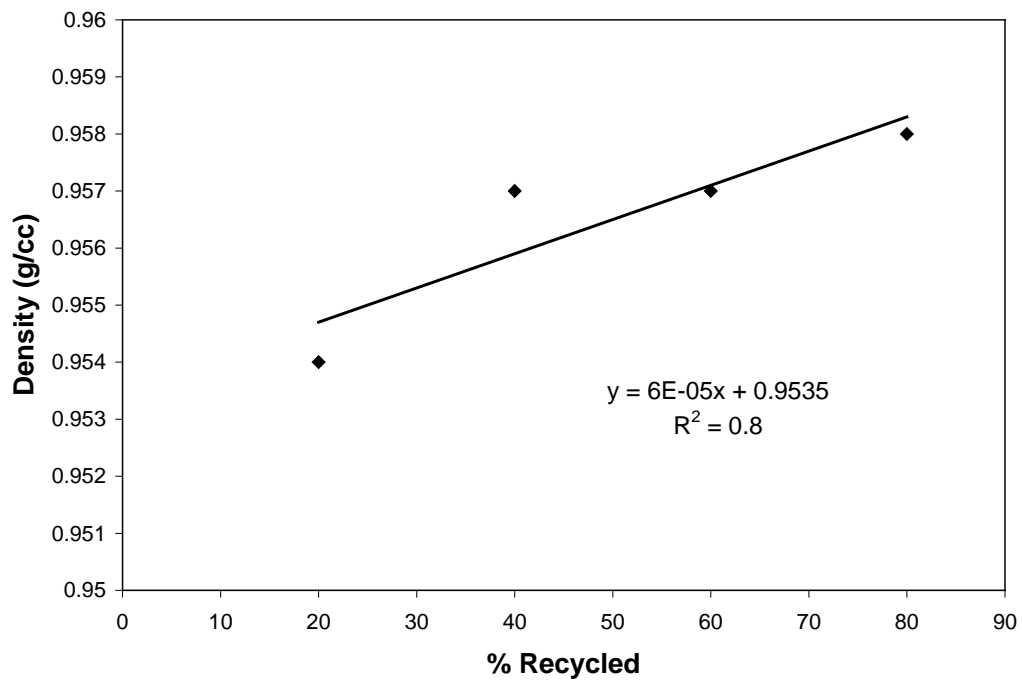
Date: 19-Mar-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.960	0.960	0.960			0.960	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.47	0.49				0.48	
21.6 kg (g/10 min)	39.3	39.9				39.6	
Ratio						83	
<b>Composition</b>							
% Color/Ash	1.58	1.58	1.55			1.57	0.014
% PP	3.2					3.2	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3486	3493	3443	3417	3366	3441	47
Break Strain (%)	128	223	132	140	166	158	35
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	7.8	8.6	7.2	7.7	8.6	8.0	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	12.6					12.6	

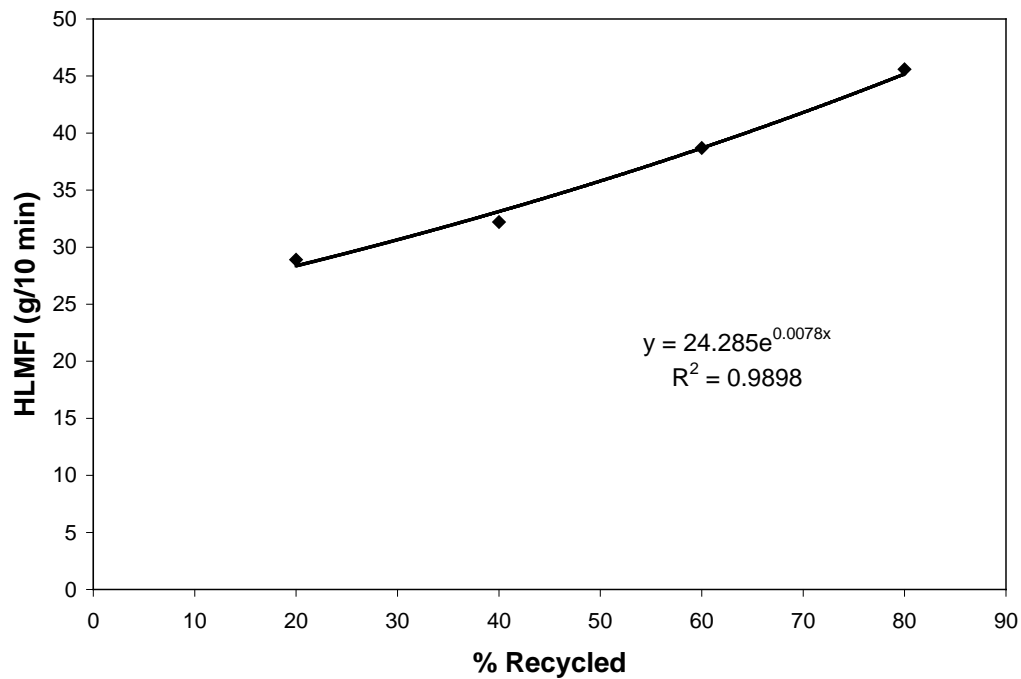
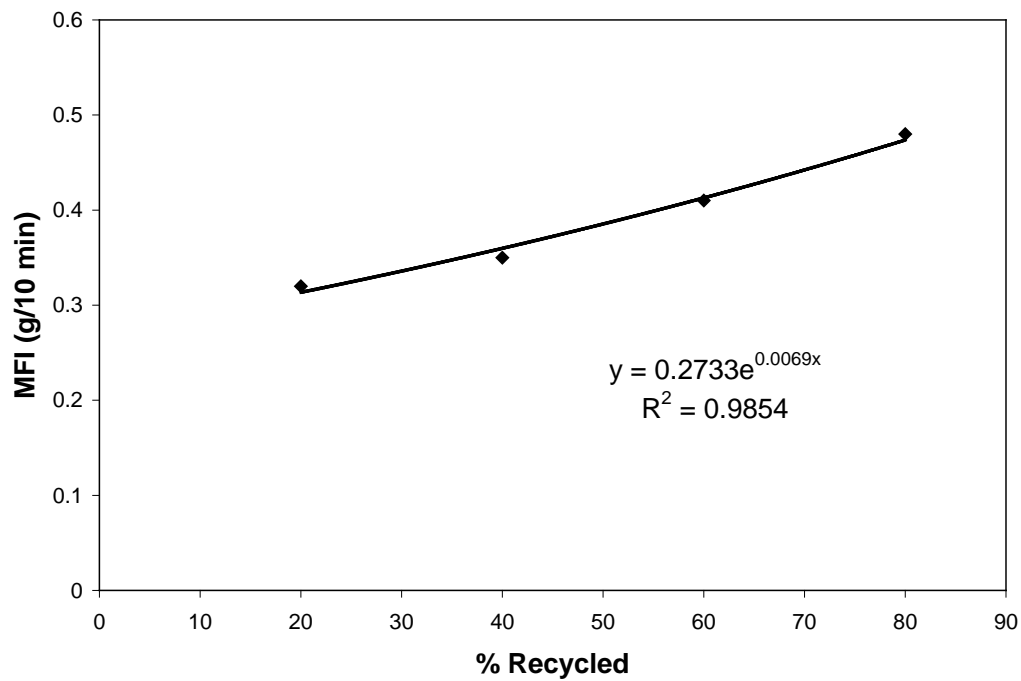
**Virgin Resin 2 + Mixed Color Reprocessed PCR**

Property	Supplier/Resin Type					
	0% Recycle	20% Recycle	40% Recycle	60% Recycle	80% Recycle	100% Recycle
Density g/cm <sup>3</sup>	0.956	0.954	0.957	0.957	0.958	0.960
Melt Index g/10 min	0.29	0.32	0.35	0.41	0.48	0.56
Flow Rate g/10 min	26.7	28.9	32.2	38.7	45.6	53.4
MFR (21.6/2.16kg)	93	91	92	95	95	95
% Ash	0.05	0.36	0.69	1.09	1.39	1.69
% PP	0	1.5	3.2	4.6	6.3	8.3
Yield Strength (psi)	3936	3825	3712	3628	3590	3556
Break Strain (%)	694	383	319	221	172	79
NCTL-15% (hrs)	39.2	35.0	26.8	13.8	10.7	6.4
OIT (min)	86	56	35	32	22	16

### Virgin Resin 2 + Mixed Color Reprocessed PCR

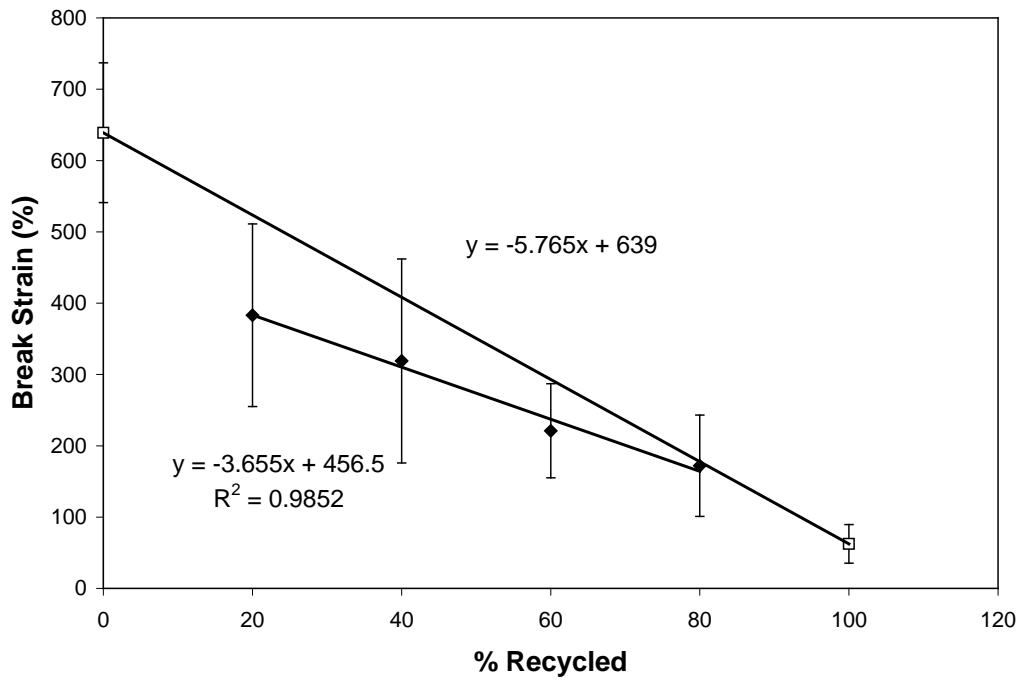
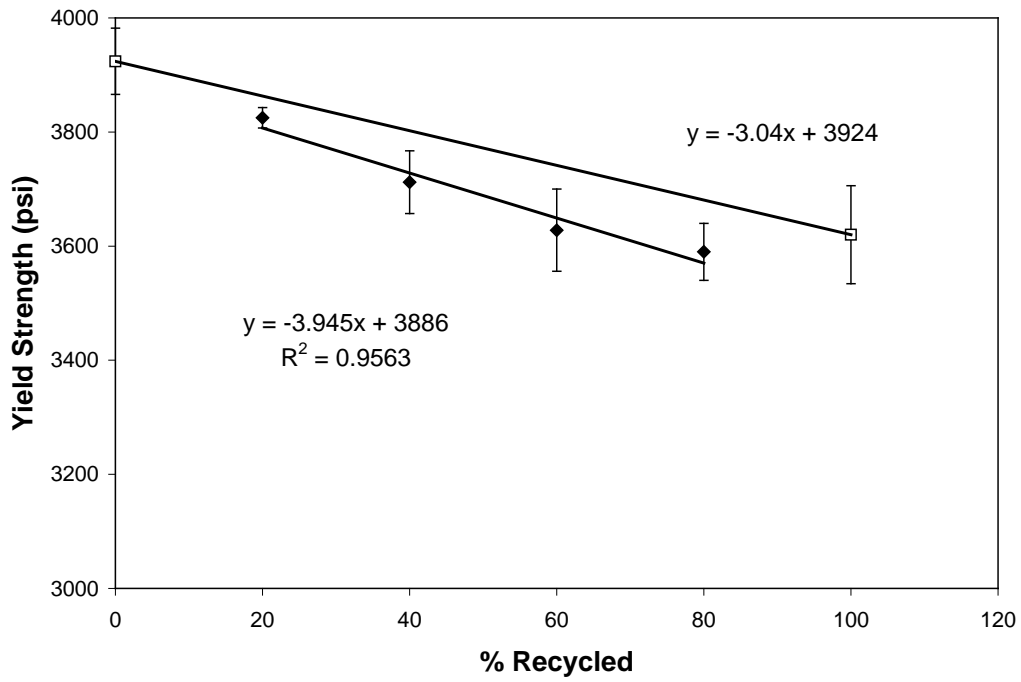


## Virgin Resin 2 + Mixed Color Reprocessed PCR

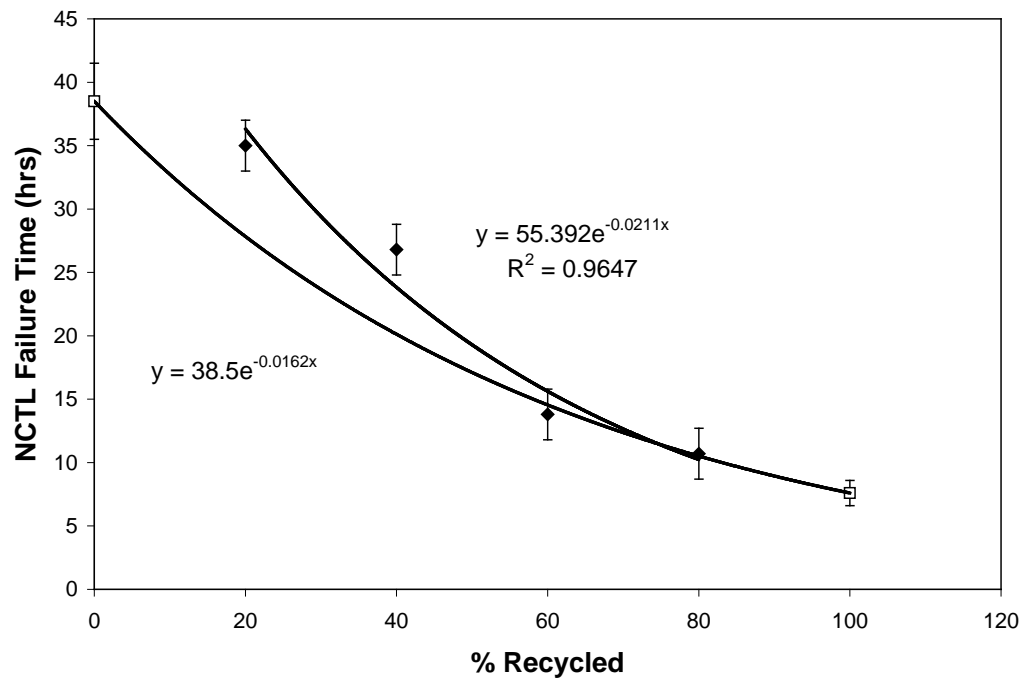




### Virgin Resin 2 + Mixed Color Reprocessed PCR



## Virgin Resin 2 + Mixed Color Reprocessed PCR



# TEST RESULTS

## Recycled HDPE Blend

### Virgin Resin 2

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% Virgin Resin 2

Date: 11-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.956	0.956	0.956			0.956	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.28	0.30				0.29	
21.6 kg (g/10 min)	26.9	26.5				26.7	
Ratio						93	
<b>Composition</b>							
% Color/Ash	0.04	0.04	0.07			0.05	0.014
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3932	3987	3961	3961	3840	3936	51
Break Strain (%)	708	731	596	687	749	694	53
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	39.5	39.1	34.8	45.8	36.8	39.2	4
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	86.2					86.2	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Consumer Mixed Color Reprocessed**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 80% VR2 + 20% MCR1

Date: 11-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.954	0.954	0.954			0.954	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.31	0.33				0.32	
21.6 kg (g/10 min)	28.9	28.9				28.9	
Ratio						91	
<b>Composition</b>							
% Color/Ash	0.35	0.37	0.37			0.36	0.009
% PP	1.8					1.8	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3843	3817	3851	3813	3803	3825	18
Break Strain (%)	236	217	488	476	496	383	128
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	34.1	38.1	33.2	34.1	35.6	35.0	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	55.7					55.7	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Consumer Mixed Color Reprocessed**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X)  
Sample: 60% VR2 + 40% MCR1

Date: 11-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.956	0.957	0.957			0.957	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.35	0.35				0.35	
21.6 kg (g/10 min)	31.9	32.5				32.2	
Ratio						92	
<b>Composition</b>							
% Color/Ash	0.70	0.69	0.68			0.69	0.008
% PP	3.2						
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3792	3704	3716	3730	3620	3712	55
Break Strain (%)	491	172	462	326	143	319	143
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	25.5	24.6	27.2	31.3	25.4	26.8	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	35.2					35.2	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Consumer Mixed Color Reprocessed**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 40% VR2 + 60% MCR1

Date: 11-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.957	0.957	0.957			0.957	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.41	0.41				0.41	
21.6 kg (g/10 min)	38.7	38.6				38.7	
Ratio						95	
<b>Composition</b>							
% Color/Ash	1.09	1.11	1.06			1.09	0.021
% PP	4.6					4.6	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3507	3648	3704	3690	3592	3628	72
Break Strain (%)	264	226	153	145	318	221	66
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	12.3	15.6	10.1	15.3	15.9	13.8	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	32.4					32.4	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Consumer Mixed Color Reprocessed**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X)  
Sample: 20% VR2 + 80% MCR1

Date: 11-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.958	0.958	0.958			0.958	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.49	0.48				0.49	
21.6 kg (g/10 min)	44.9	46.3				45.6	
Ratio						94	
<b>Composition</b>							
% Color/Ash	1.30	1.45	1.41			1.39	0.063
% PP	6.3					6.3	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3609	3594	3632	3623	3493	3590	50
Break Strain (%)	120	192	260	64	222	172	71
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	7.6	12.0	12.0	10.9	10.9	10.7	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	22.0					22.0	

# **TEST RESULTS** **Recycled HDPE Blend** **Post Consumer Mixed Color Reprocessed** **100%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: 100% MCR1

Date: 11-May-07  
TRI Log #: F7601

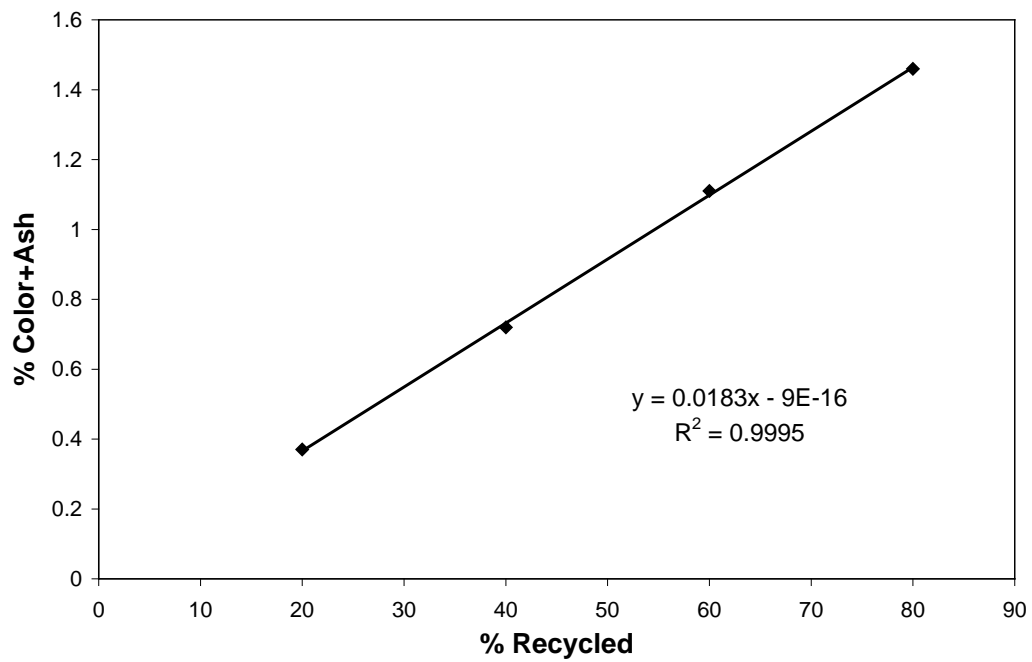
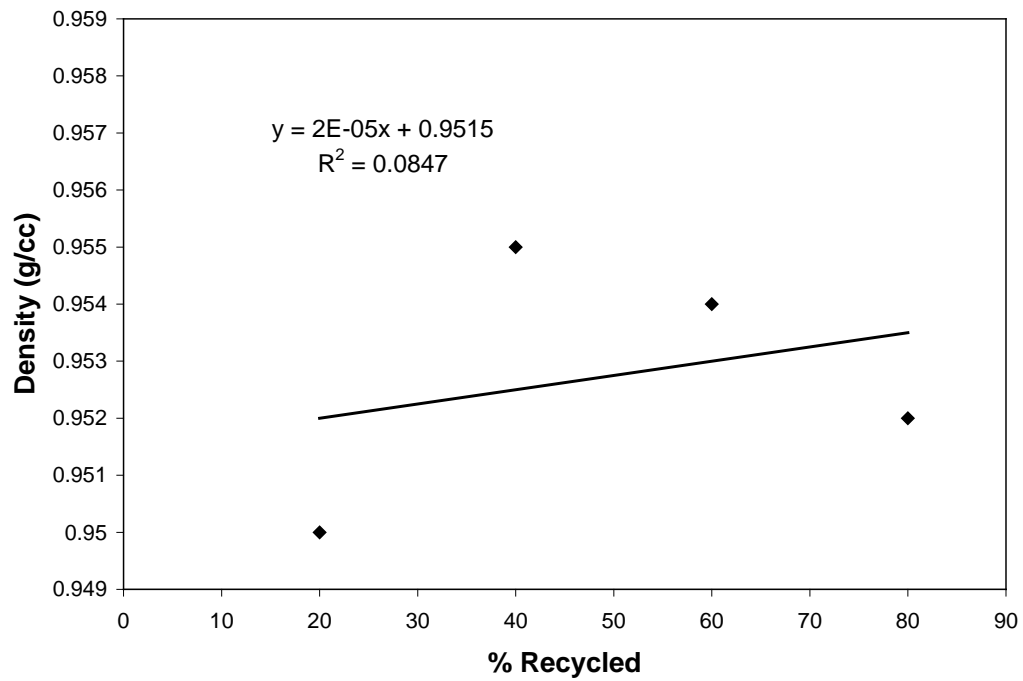
PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.960	0.96	0.96			0.960	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.55	0.57				0.56	
21.6 kg (g/10 min)	52.9	53.9				53.4	
Ratio						95	
<b>Composition</b>							
% Color/Ash	1.72	1.75	1.61			1.69	0.060
% PP	8.3					8.3	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3708	3647	3514	3565	3347	3556	124
Break Strain (%)	70	114	55	115	42	79	30
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	5.4	6.6	7.1	7.0	5.7	6.4	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	16.5					16.5	



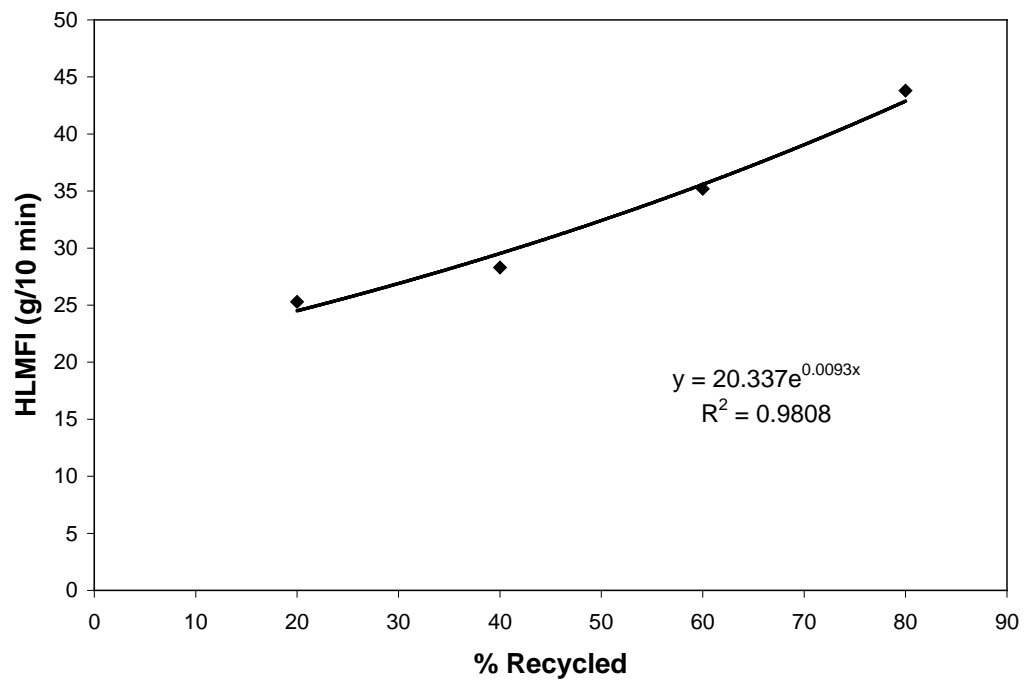
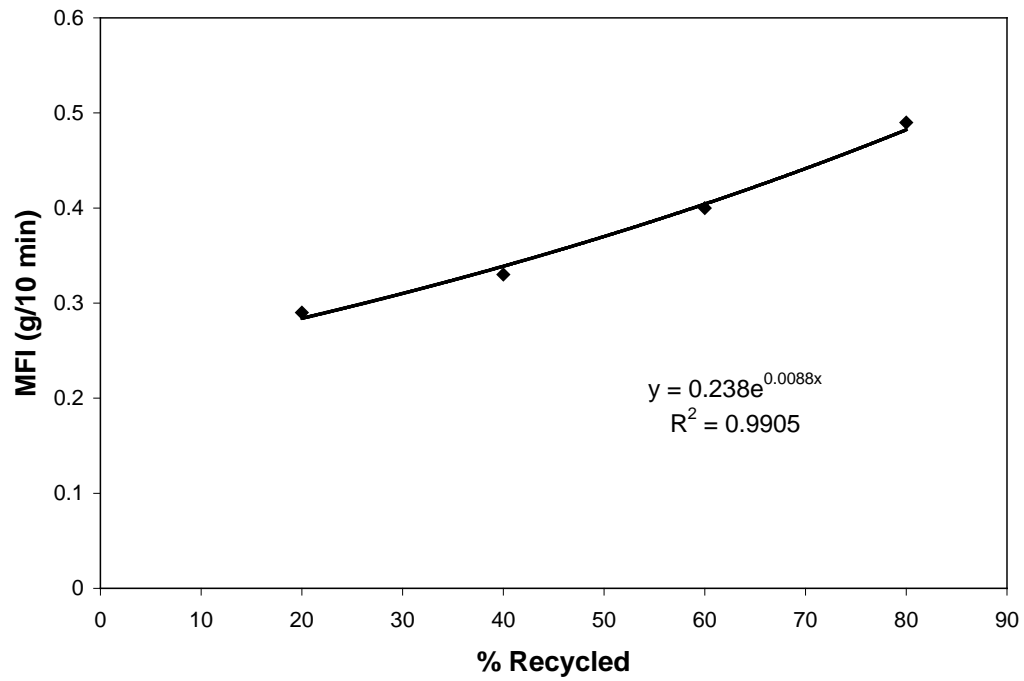
**Virgin Resin 3 + Mixed Color Reprocessed PCR-HD**

Property	Recycle Content					
	0% Recycle	20% Recycle	40% Recycle	60% Recycle	80% Recycle	100% Recycle
Density g/cm <sup>3</sup>	0.949	0.950	0.955	0.954	0.952	
Melt Index g/10 min	0.28	0.29	0.33	0.40	0.49	
Flow Rate g/10 min	23.2	25.3	28.3	35.2	43.8	
MFR (21.6/2.16kg)	83	88	86	87	89	
% Ash	0.04	0.37	0.72	1.11	1.46	
% PP	0	1.8	3.1	3.6	7.6	
Yield Strength (psi)	3804	3778	3726	3758	3724	
Break Strain (%)	667	320	441	237	101	
NCTL-15% (hrs)	44	17.6	15.3	9.5	5.9	
OIT (min)	33.8	33.6	28.2	23.1	18.4	

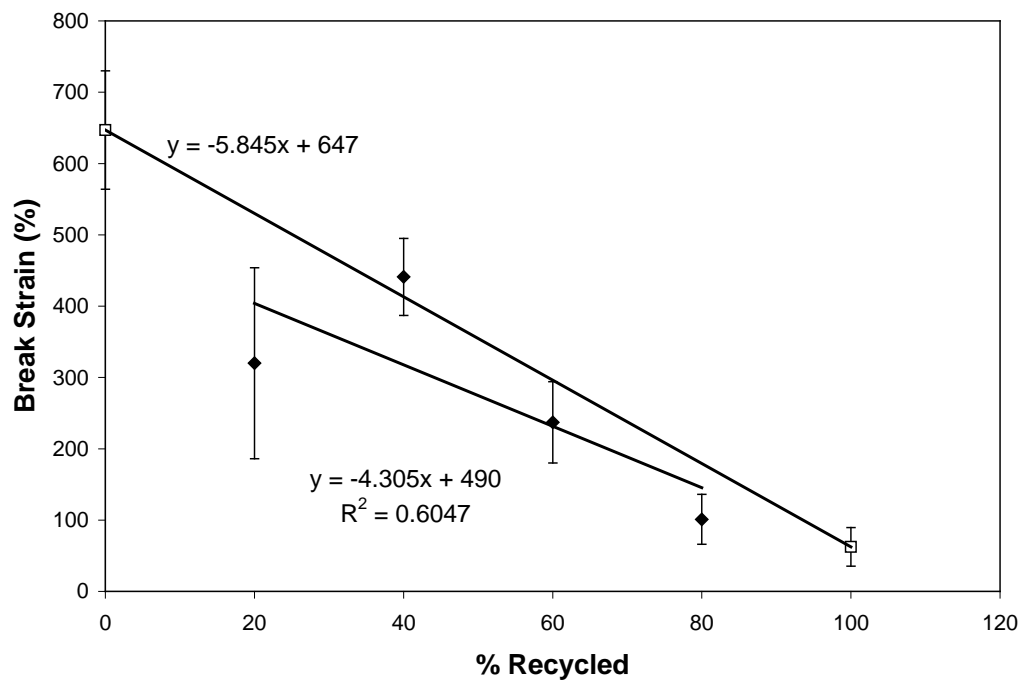
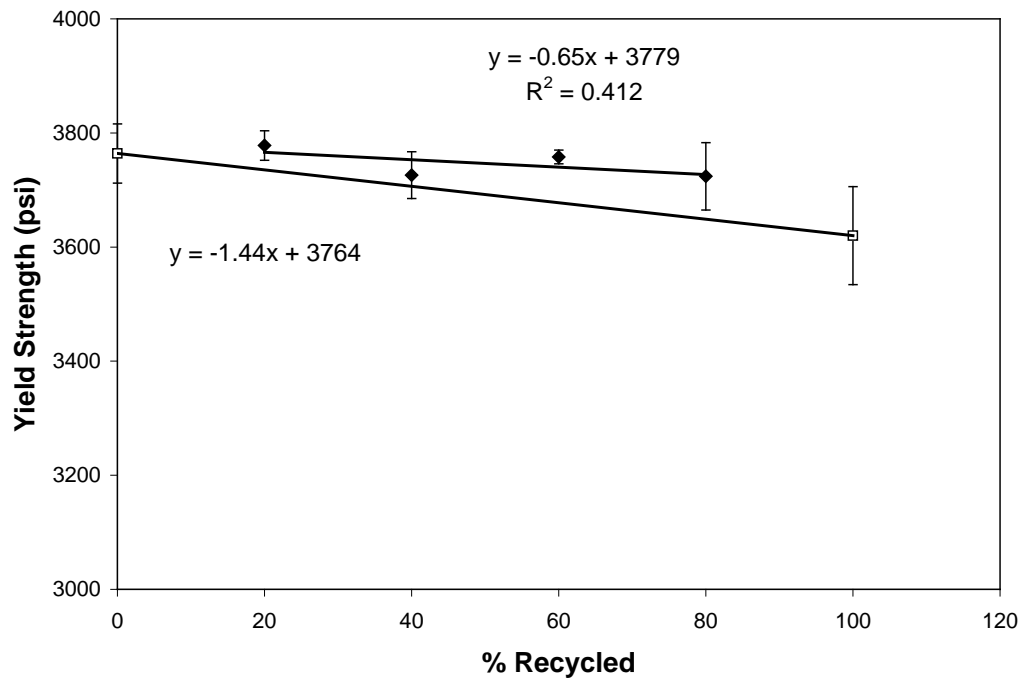
## Virgin Resin 3 + Mixed Color Reprocessed PCR-HDPE



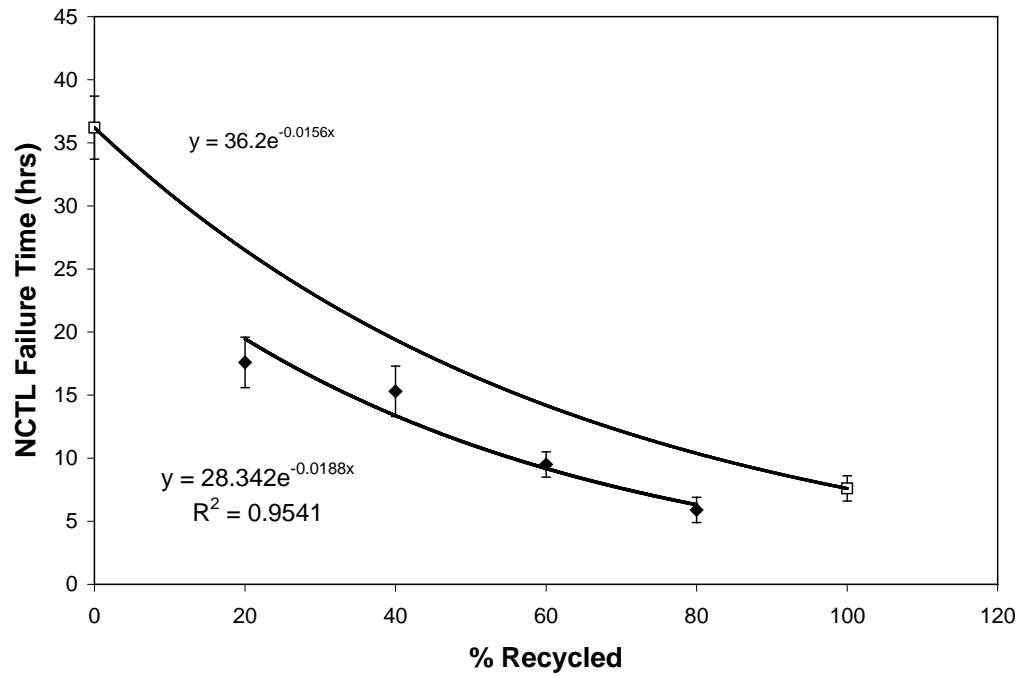
### Virgin Resin 3 + Mixed Color Reprocessed PCR-HDPE



### Virgin Resin 3 + Mixed Color Reprocessed PCR-HDPE



### Virgin Resin 3 + Mixed Color Reprocessed PCR-HDPE



# TEST RESULTS

## Recycled HDPE Blend

### Virgin Resin 3

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% VR3

Date: 25-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.948	0.949	0.949			0.949	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.28	0.28				0.28	
21.6 kg (g/10 min)	22.6	23.7				23.2	
Ratio						83	
<b>Composition</b>							
% Color/Ash	0.08	0.03	0.01			0.04	0.029
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3875	3827	3767	3818	3733	3804	49
Break Strain (%)	731	479	733	701	693	667	96
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	39.1	48.0	45.3	47.1	42.6	44.4	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	33.8					33.8	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + Post Consumer Mixed Color Reprocessed**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 80% VR3 + 20% MCR1

Date: 25-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.950	0.950	0.950			0.950	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.28	0.29				0.29	
21.6 kg (g/10 min)	25.1	25.4				25.3	
Ratio						88	
<b>Composition</b>							
% Color/Ash	0.38	0.36	0.36			0.37	0.009
% PP	1.8					1.8	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3789	3797	3736	3760	3808	3778	26
Break Strain (%)	480	248	246	148	476	320	134
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	15.2	19.0	17.3	19.5	17.2	17.6	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	33.6					33.6	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + Post Consumer Mixed Color Reprocessed**  
**60% + 40%**

Material: Plaque from blended resin  
Sample: 60% VR3 + 40% MCR1

Date: 25-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.955	0.955	0.955			0.955	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.33	0.33				0.33	
21.6 kg (g/10 min)	28.1	28.5				28.3	
Ratio						86	
<b>Composition</b>							
% Color/Ash	0.73	0.73	0.69			0.72	0.019
% PP	3.1					3.1	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3767	3747	3750	3711	3653	3726	41
Break Strain (%)	466	467	475	332	463	441	54
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	14.4	17.2	13.5	18.6	12.7	15.3	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	28.2					28.2	



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + Post Consumer Mixed Color Reprocessed**  
**40% + 60%**

Material: Plaque from blended resin  
Sample: 40% VR3 + 60% MCR1

Date: 25-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.953	0.954	0.954			0.954	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.40	0.40				0.40	
21.6 kg (g/10 min)	34.9	35.4				35.2	
Ratio						87	
<b>Composition</b>							
% Color/Ash	1.13	1.09	1.12			1.11	0.017
% PP	3.6					3.1	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3770	3764	3736	3763	3757	3758	12
Break Strain (%)	176	208	207	341	251	237	57
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	9.9	8.8	9.9	8.9	9.8	9.5	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	23.1					23.1	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + Post Consumer Mixed Color Reprocessed**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 20% VR3 + 80% MCR1

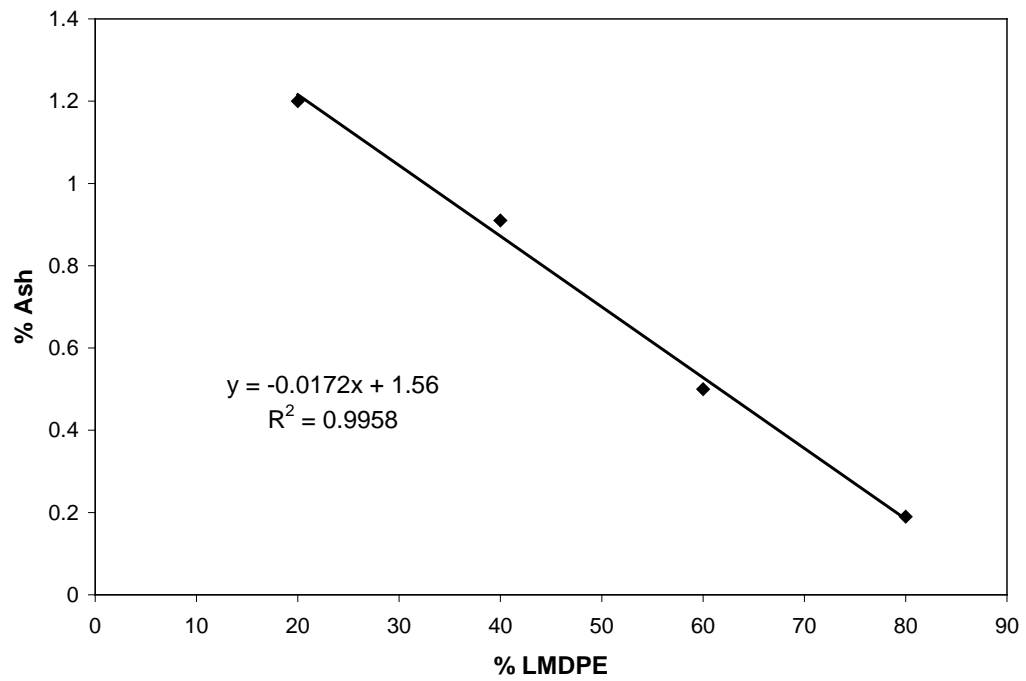
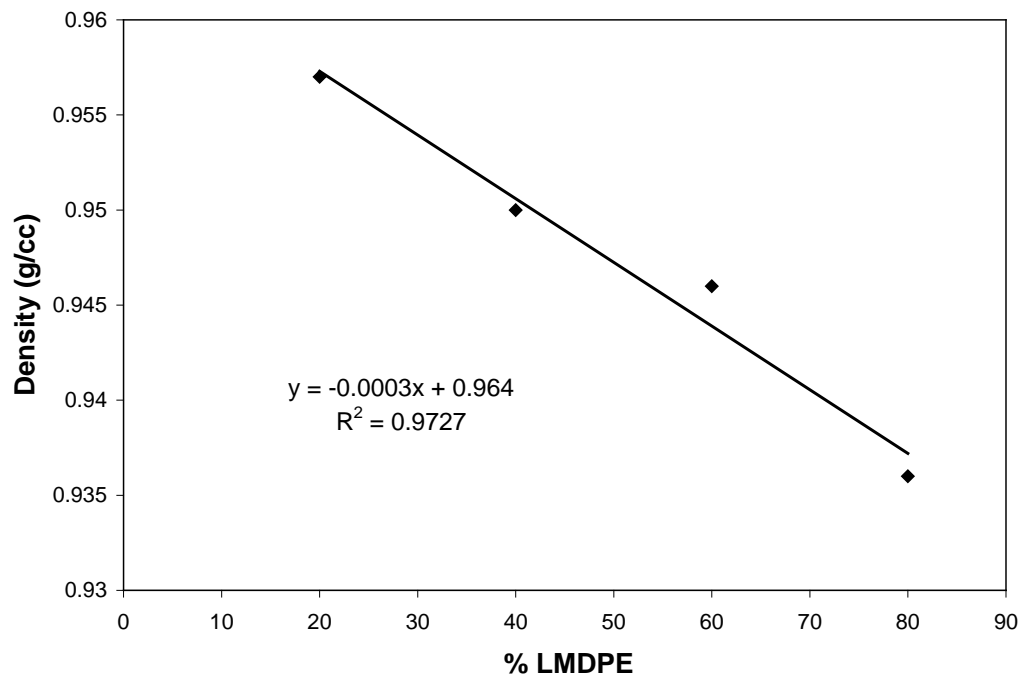
Date: 25-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.952	0.952	0.952			0.952	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.49	0.49				0.49	
21.6 kg (g/10 min)	43.9	43.6				43.8	
Ratio						89	
<b>Composition</b>							
% Color/Ash	1.42	1.47	1.49			1.46	0.029
% PP	7.6					3.1	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3614	3764	3783	3726	3732	3724	59
Break Strain (%)	152	48	91	88	124	101	35
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	6.1	5.9	5.9	5.0	6.6	5.9	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	18.4					18.4	

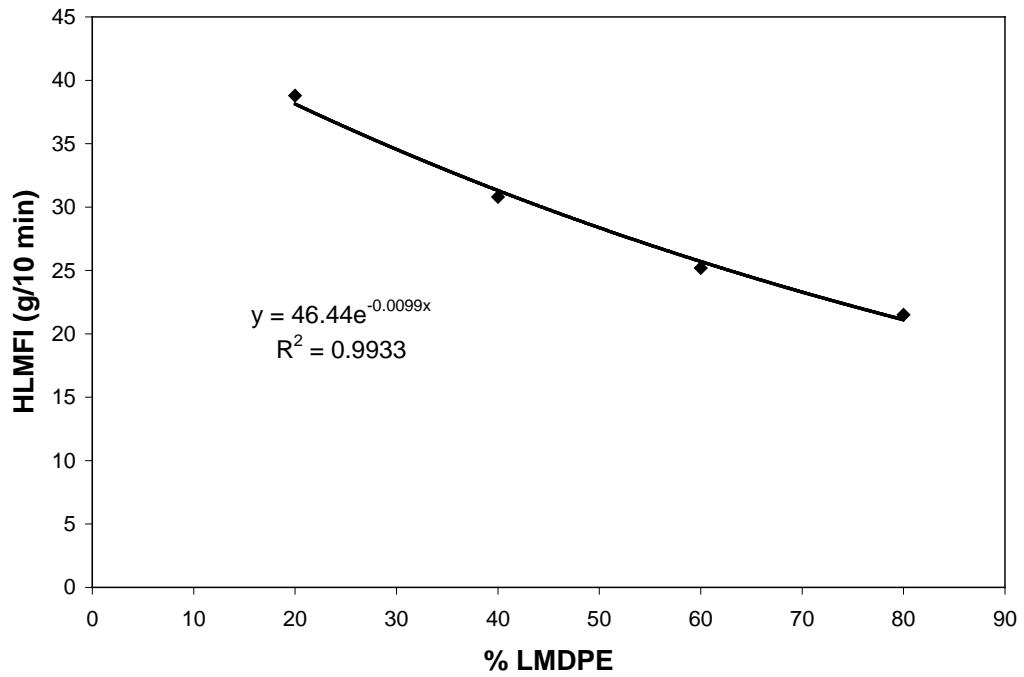
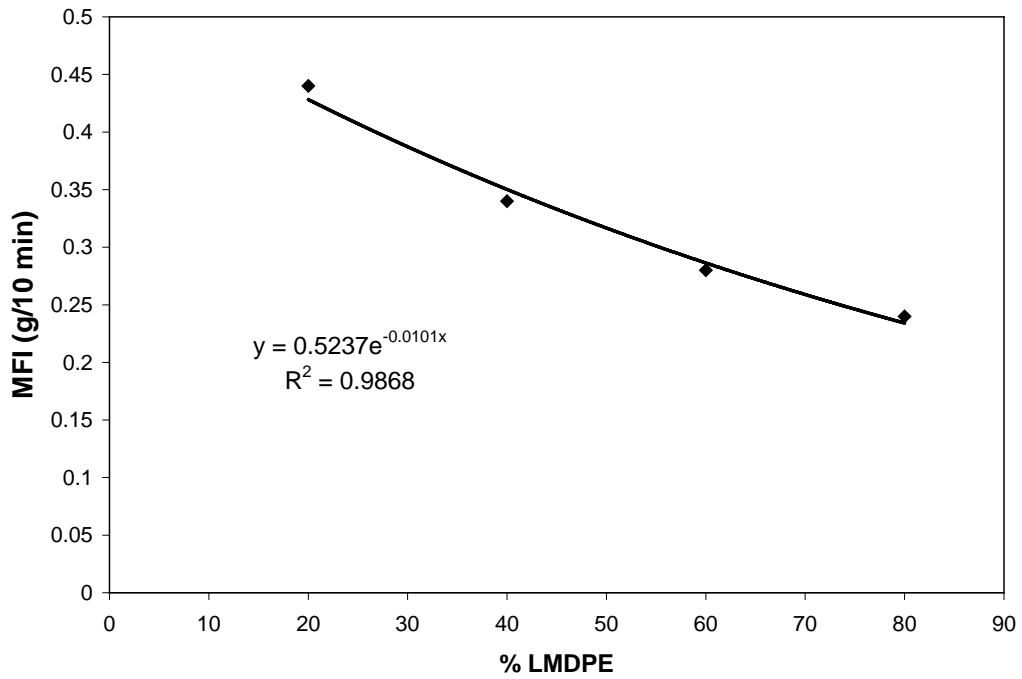
### Mixed Color Regrind + Virgin MDPE

Property	Virgin MDPE Content					
	0% MDPE	20% MDPE	40% MDPE	60% MDPE	80% MDPE	100% MDPE
Density g/cm <sup>3</sup>	0.960	0.957	0.950	0.946	0.936	
Melt Index g/10 min	0.52	0.44	0.34	0.28	0.24	
Flow Rate g/10 min	50.8	38.8	30.8	25.2	21.5	
MFR (21.6/2.16kg)	97	89	91	90	89	
Ash	1.46	1.20	0.91	0.50	0.19	
Yield Strength (psi)	3613	3432	3278	2951	2904	
Break Strain (%)	171	292	504	651	690	
NCTL-15% (hrs)	7.1	19.3	58.8	583	>1000	
OIT (min)	12.1	38.7	77.9	117	168	

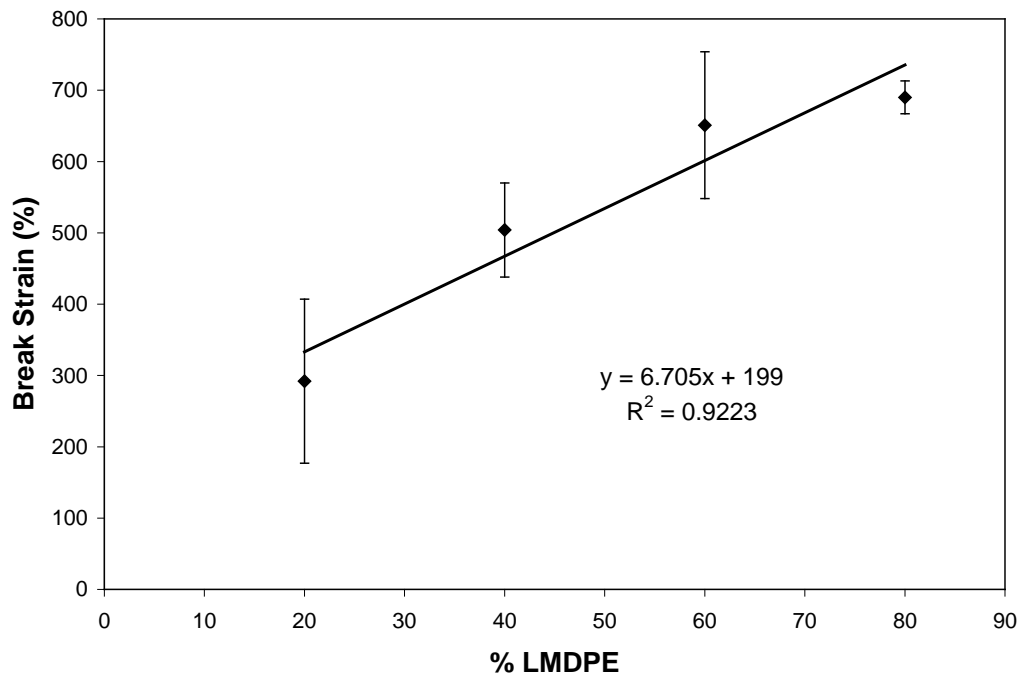
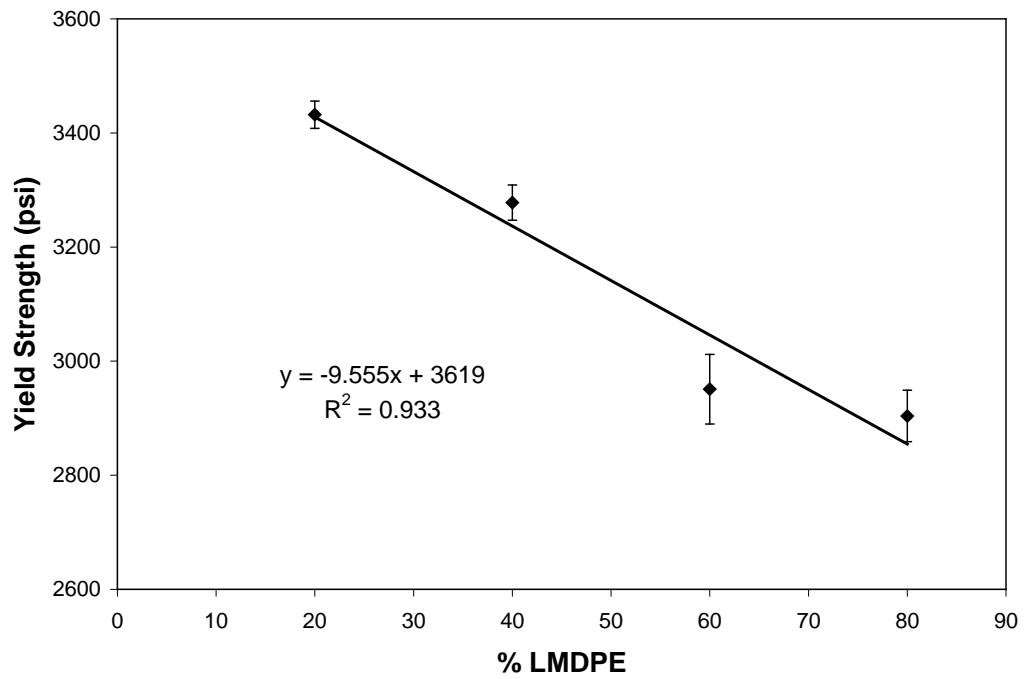
### Mixed Color Regrind + Virgin MDPE



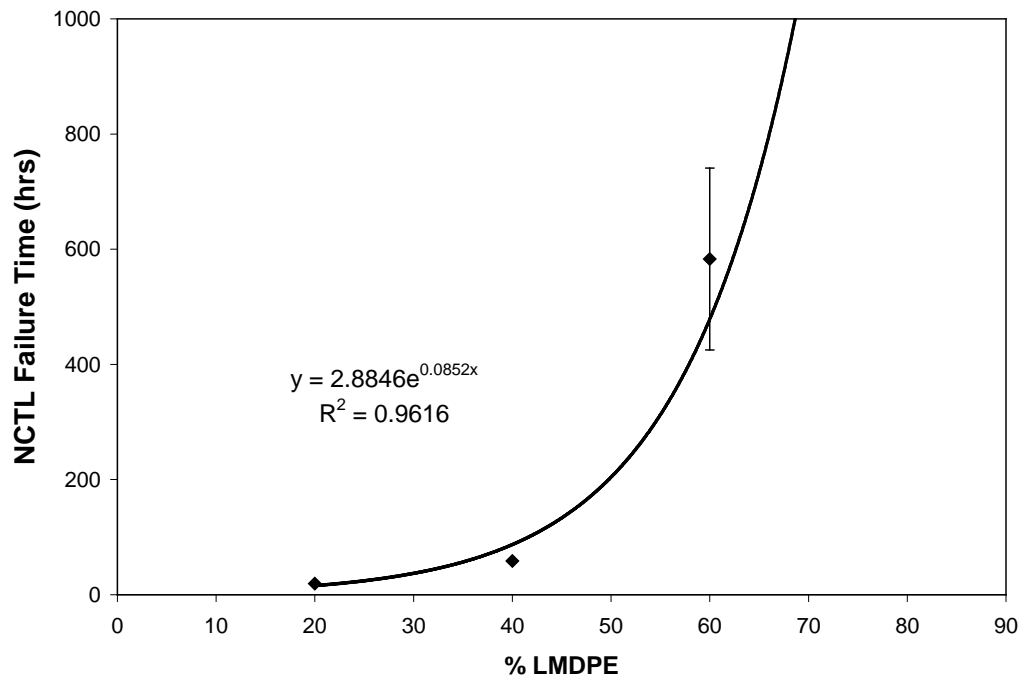
### Mixed Color Regrind + Virgin MDPE



### Mixed Color Regrind + Virgin MDPE



### Mixed Color Regrind + Virgin MDPE



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Mixed Color Regrind + Virgin LMDPE**  
**100% + 0%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% Mixed Color Regrind

Date: 16-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.960	0.960	0.960			0.960	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.55	0.49				0.52	
21.6 kg (g/10 min)	50.3	51.2				50.8	
Ratio						97	
<b>Composition</b>							
% Ash	1.45	1.46				1.46	0.005
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3708	3613	3623	3626	3493	3613	69
Break Strain (%)	158	183	215	158	142	171	26
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	7.1	7.9	7.1	7.1	6.3	7.1	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	12.1					12.1	



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Mixed Color Regrind + Virgin LMDPE**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Mixed Color Regrind + 20% LMDPE

Date: 16-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.957	0.957	0.957			0.957	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.44	0.43				0.44	
21.6 kg (g/10 min)	38.2	39.3				38.8	
Ratio						89	
<b>Composition</b>							
% Ash	1.15	1.24				1.20	0.045
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3425	3410	3475	3437	3412	3432	24
Break Strain (%)	164	403	312	427	156	292	115
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	21.2	22.0	18.5	18.1	16.9	19.3	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	38.7					38.7	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Mixed Color Regrind + Virgin LMDPE**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Mixed Color Regrind + 40% LMDPE

Date: 16-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.950	0.950	0.950			0.950	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.33	0.34				0.34	
21.6 kg (g/10 min)	30.9	30.6				30.8	
Ratio						91	
<b>Composition</b>							
% Ash	0.94	0.87				0.91	0.035
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3333	3244	3274	3285	3253	3278	31
Break Strain (%)	453	550	420	604	491	504	66
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	62.2	58.7	57.8	57.5	57.6	58.8	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	77.9					77.9	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Mixed Color Regrind + Virgin LMDPE**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Mixed Color Regrind + 60% LMDPE

Date: 16-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.946	0.946	0.946			0.946	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.28	0.28				0.28	
21.6 kg (g/10 min)	25.2	25.2				25.2	
Ratio						90	
<b>Composition</b>							
% Ash	0.48	0.52				0.50	0.020
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	2993	2906	3031	2966	2861	2951	61
Break Strain (%)	703	446	687	712	705	651	103
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	503	823	626	619	342	583	158
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	117					117	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Mixed Color Regrind + Virgin LMDPE**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Mixed Color Regrind + 80% LMDPE

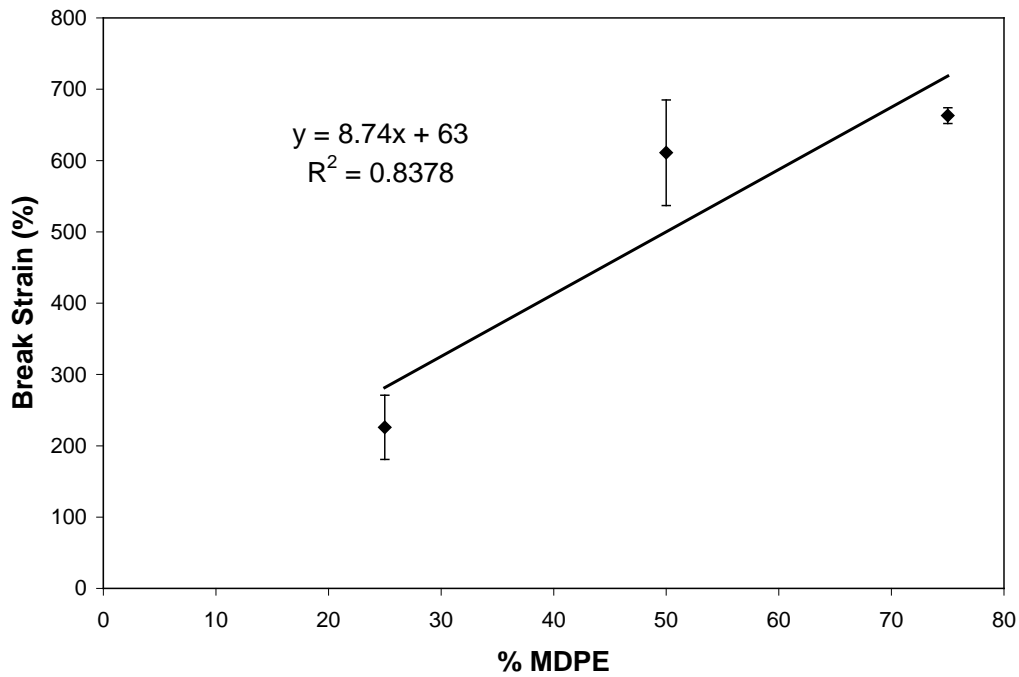
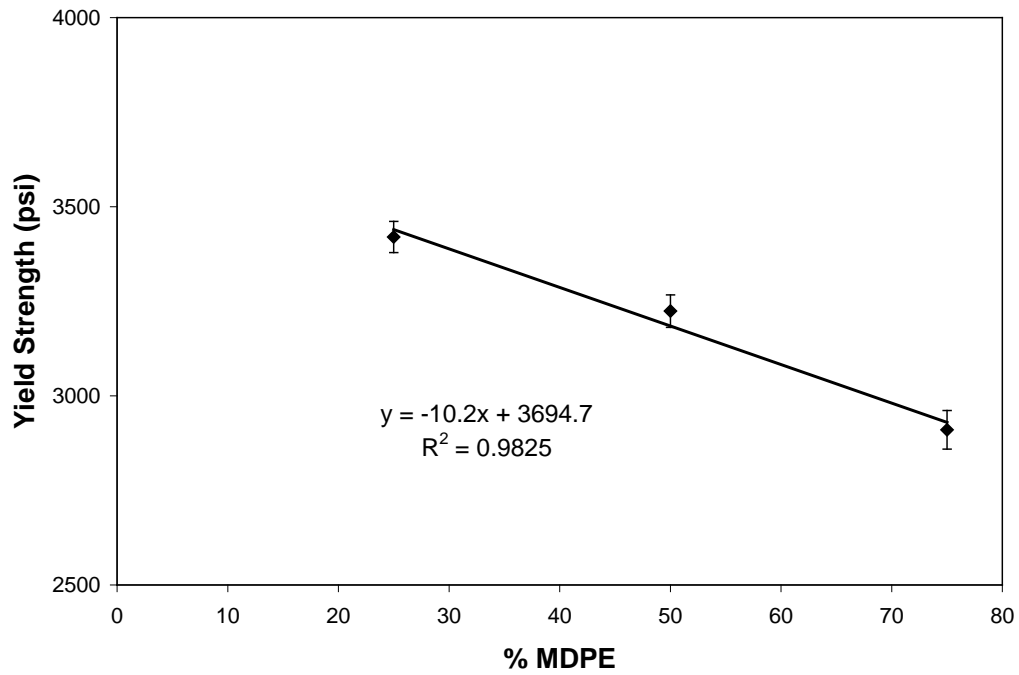
Date: 16-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.936	0.936	0.937			0.936	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.25	0.24				0.24	
21.6 kg (g/10 min)	21.4	21.6				21.5	
Ratio						89	
<b>Composition</b>							
% Ash	0.15	0.22				0.19	0.035
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	2980	2853	2908	2914	2863	2904	45
Break Strain (%)	672	726	705	680	665	690	23
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	>1000	>1000	>1000	>1000	>1000	>1000	
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	168					168	

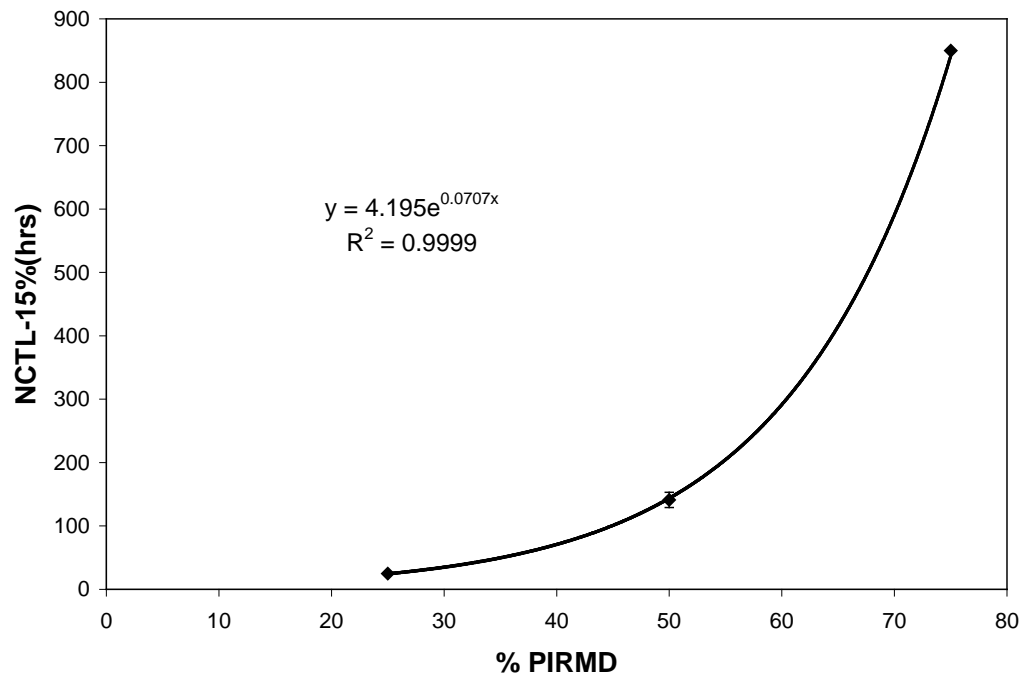
**Mixed Color Regrind + Virgin MDPE (Repeat)**

Property	Virgin MDPE Content					
	0% MDPE	25% MDPE	50% MDPE	75% MDPE	100% MDPE	
Density g/cm <sup>3</sup>						
Melt Index g/10 min						
Flow Rate g/10 min						
MFR (21.6/2.16kg)						
% Color						
% Ash						
Yield Strength (psi)		3420	3224	2910		
Break Strain (%)		226	611	663		
NCTL-15% (hrs)		24.8	141	>850		
OIT (min)						

### Mixed Color Regrind + Virgin MDPE (Repeat)



### Mixed Color Regrind + Virgin MDPE (Repeat)



# TEST RESULTS

## Recycled HDPE Blend

### Post Consumer Mixed Color Regrind + Virgin LMDPE

### 75% + 25%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Mixed Color Regrind + 25% LMDPE

Date: 20-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density</b> <b>(ASTM D 1505)</b>							
Density (g/cm3)						<div></div>	
<b>Melt Flow Index</b> <b>(ASTM D 1238)</b>							
2.16 kg (g/10min)						<div></div>	
21.6 kg (g/10 min)						<div></div>	
Ratio						<div></div>	
<b>Composition</b>							
% Ash						<div></div>	
<b>Tensile Properties</b> <b>(ASTM D 638)</b>							
Yield Strength (psi)	3389	3391	3419	3500	3403	<div>3420</div>	41
Break Strain (%)	257	245	283	172	174	<div>226</div>	45
<b>Environmental Stress Crack Resistance</b> <b>(ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	25.8	24.3	25.3	25.3	23.4	<div>24.8</div>	0.9
<b>Oxidative Stability</b> <b>(ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						<div></div>	



# TEST RESULTS

## Recycled HDPE Blend

### Post Consumer Mixed Color Regrind + Virgin LMDPE

### 50% + 50%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Mixed Color Regrind + 50% LMDPE

Date: 20-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density</b> <b>(ASTM D 1505)</b>							
Density (g/cm3)						<div></div>	
<b>Melt Flow Index</b> <b>(ASTM D 1238)</b>							
2.16 kg (g/10min)						<div></div>	
21.6 kg (g/10 min)						<div></div>	
Ratio						<div></div>	
<b>Composition</b>							
% Ash						<div></div>	
<b>Tensile Properties</b> <b>(ASTM D 638)</b>							
Yield Strength (psi)	3286	3159	3254	3214	3208	<div>3224</div>	43
Break Strain (%)	697	475	641	605	639	<div>611</div>	74
<b>Environmental Stress Crack Resistance</b> <b>(ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	131	145	125	151	155	<div>141</div>	12
<b>Oxidative Stability</b> <b>(ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						<div></div>	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Mixed Color Regrind + Virgin LMDPE**  
**25% + 75%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Mixed Color Regrind + 75% LMDPE

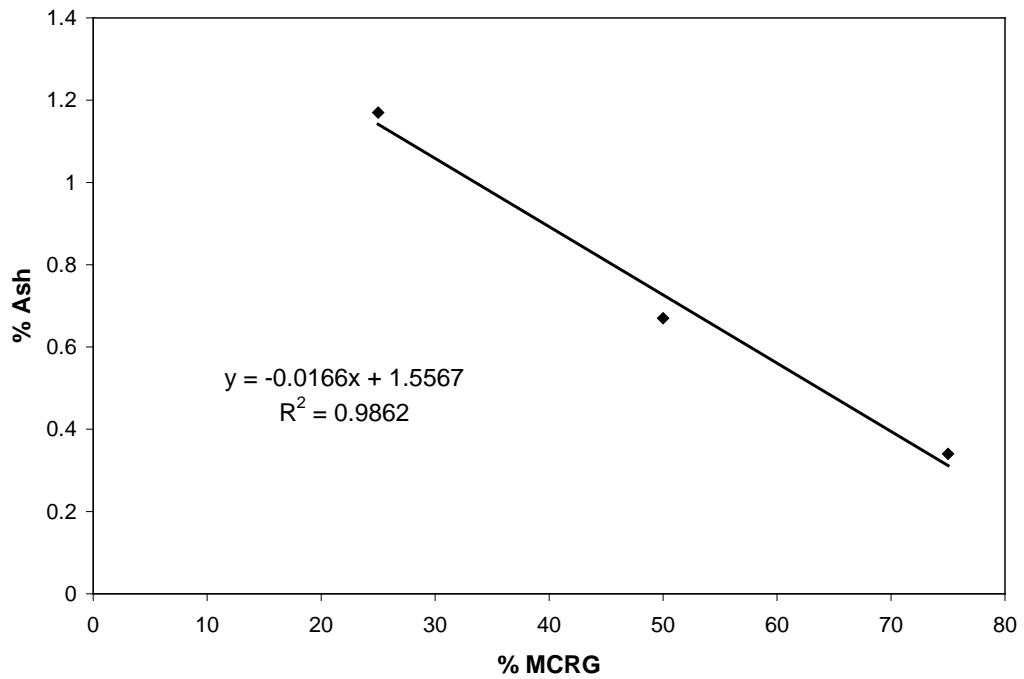
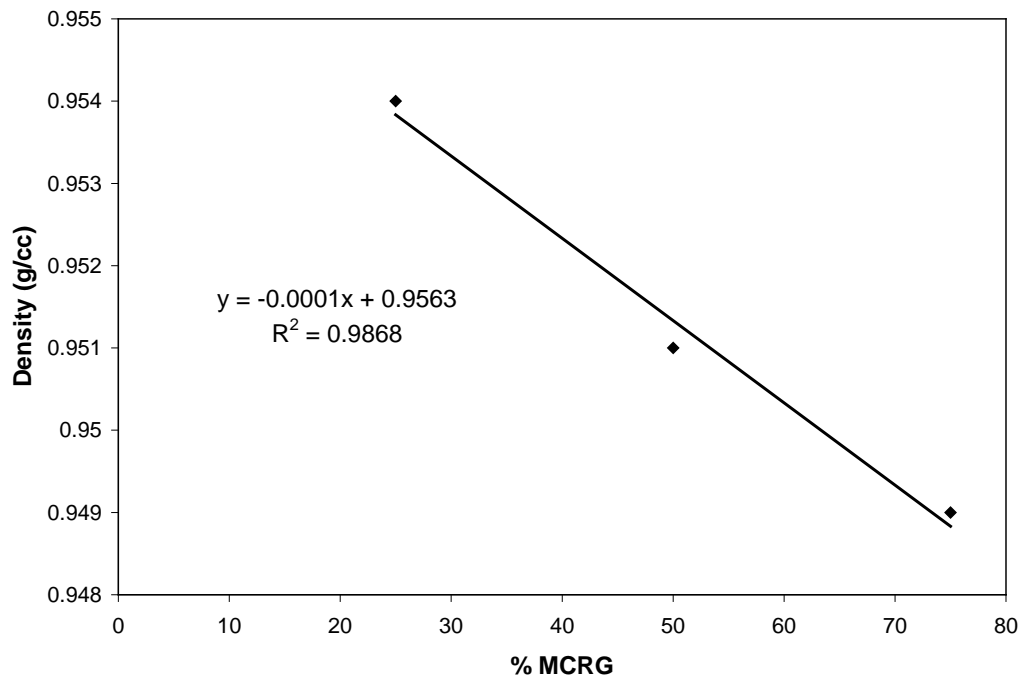
Date: 20-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density</b> <b>(ASTM D 1505)</b>							
Density (g/cm3)						<div></div>	
<b>Melt Flow Index</b> <b>(ASTM D 1238)</b>							
2.16 kg (g/10min)						<div></div>	
21.6 kg (g/10 min)						<div></div>	
Ratio						<div></div>	
<b>Composition</b>							
% Ash						<div></div>	
<b>Tensile Properties</b> <b>(ASTM D 638)</b>							
Yield Strength (psi)	2959	2827	2875	2945	2943	<div>2910</div>	51
Break Strain (%)	666	677	673	648	652	<div>663</div>	11
<b>Environmental Stress Crack Resistance</b> <b>(ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	>850	>850	>850	>850	>850	>850	
<b>Oxidative Stability</b> <b>(ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						<div></div>	

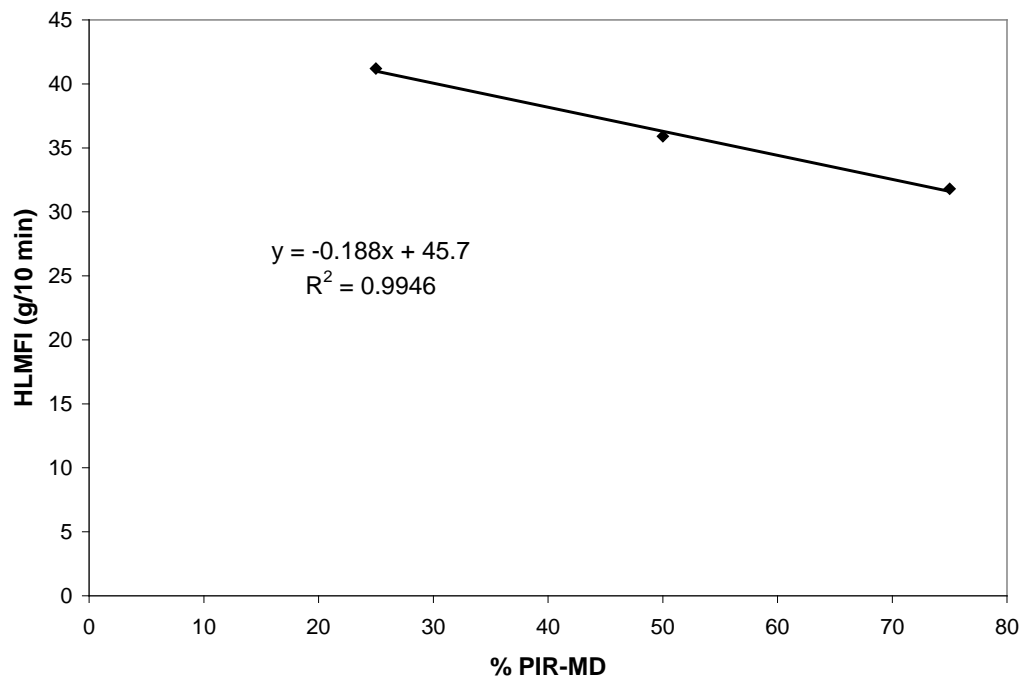
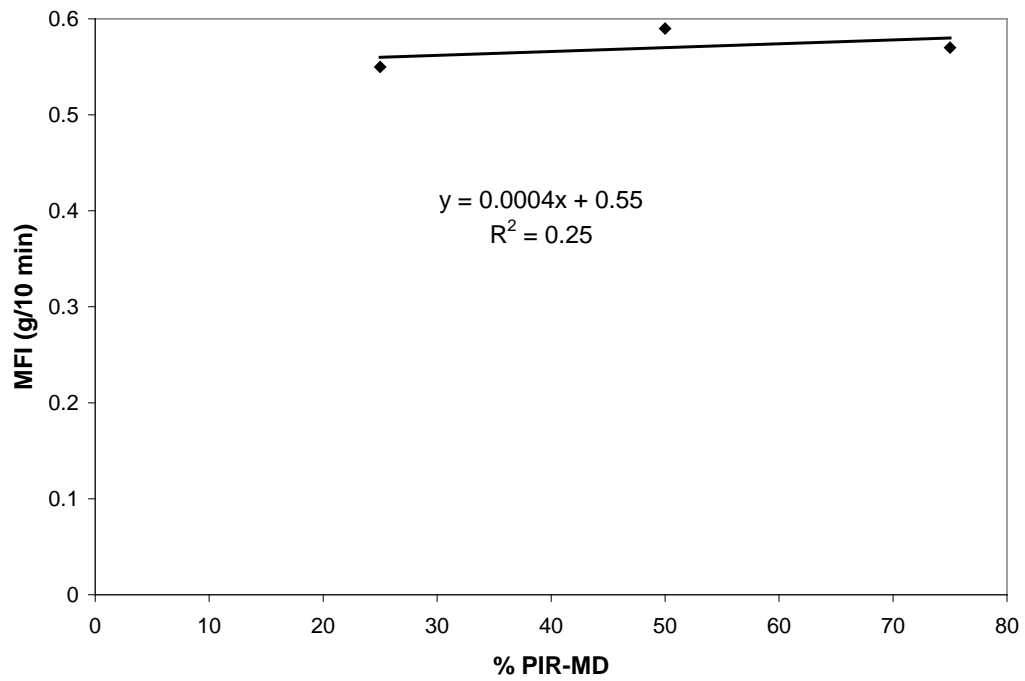
**Mixed Color Regrind + PIR-MDPE**

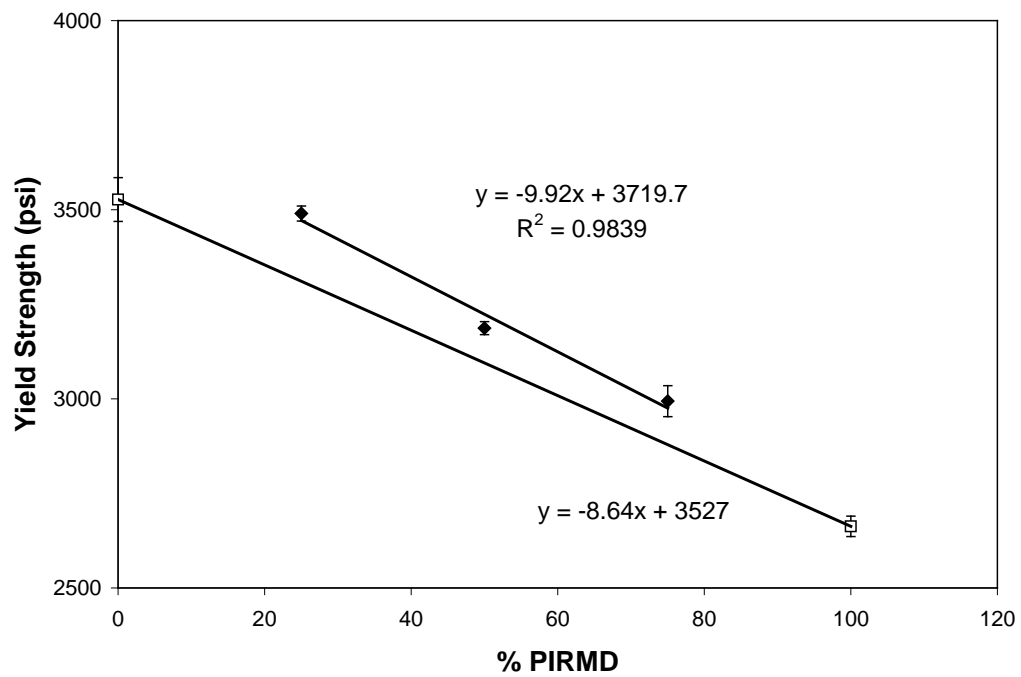
Property	Virgin MDPE Content					
	0% PIR-MD	25% PIR-MD	50% PIR-MD	75% PIR-MD	100% PIR-MD	
Density g/cm <sup>3</sup>		0.954	0.951	0.949		
Melt Index g/10 min		0.55	0.59	0.57		
Flow Rate g/10 min		41.2	35.9	31.8		
MFR (21.6/2.16kg)		75	61	56		
% Color		1.62	1.69	1.78		
% Ash		1.17	0.67	0.34		
Yield Strength (psi)		3490	3187	2994		
Break Strain (%)		363	640	712		
NCTL-15% (hrs)		15.9	44.5	124		
OIT (min)		23.3	35.3	47.6		

### Mixed Color Regrind + PIR-MDPE

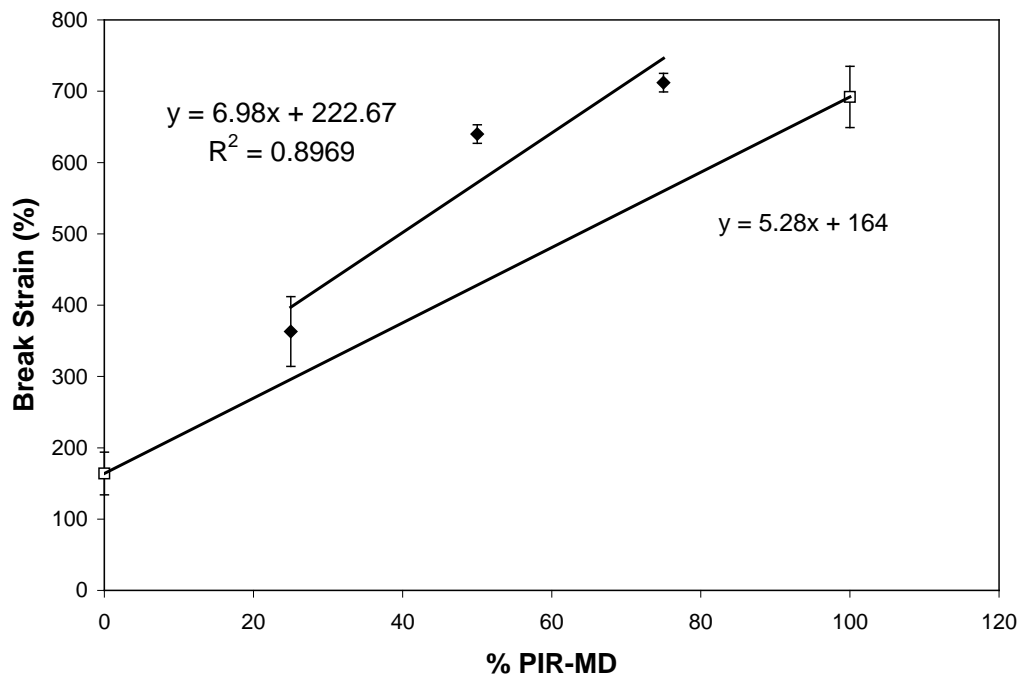
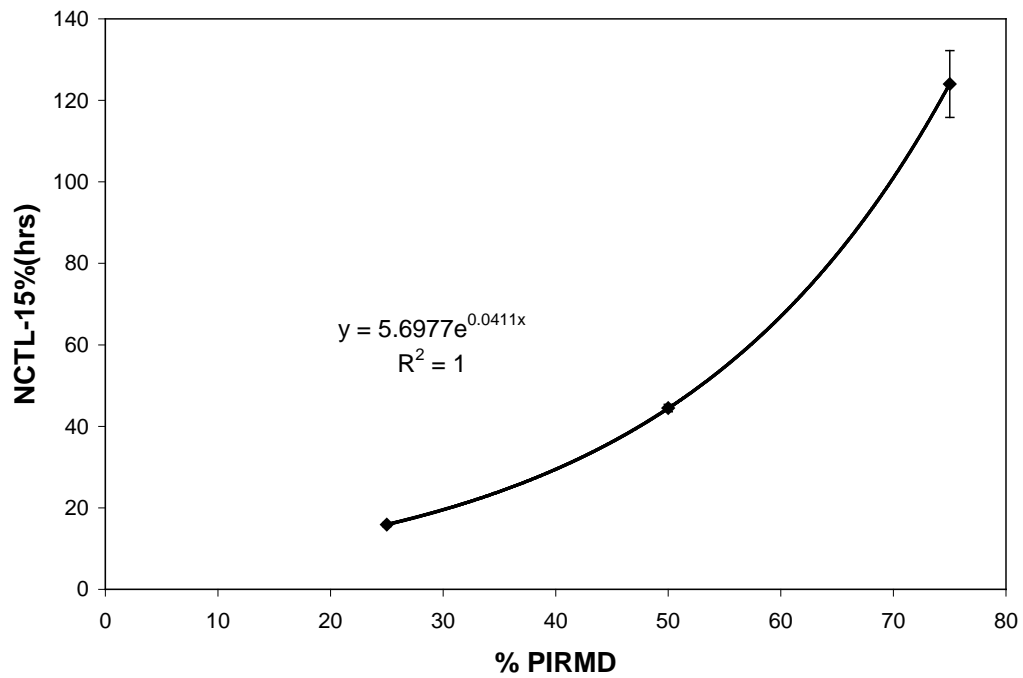


### Mixed Color Regrind + PIR-MDPE





**Mixed Color Regrind + PIR-MDPE**



Mixed Color Regrind + PIR-MDPE

**TEST RESULTS**  
**Recycled HDPE Blend**  
**PCR Mixed Color Regrind + PIR Regrind MD**  
**75% + 25%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 75% MCRG + 25% PIR-MD

Date: 16-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
Density (ASTM D 1505)							
Density (g/cm3)	0.954	0.954	0.954				
Melt Flow Index (ASTM D 1238)							
2.16 kg (g/10min)	0.54	0.55				0.55	
21.6 kg (g/10 min)	41	41.5				41.25	
Ratio						75	
Composition							
% Volatiles							
% Color	1.58	1.66				1.62	
% Ash	1.16	1.17				1.17	
Tensile Properties (ASTM D 638)							
Yield Strength (psi)	3478	3486	3514	3465	3507	3490	20
Break Strain (%)	463	357	243	330	420	363	49
Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)							
Failure Time (hours)	17.8	16.2	15.5	15.0	14.9	15.9	0.5
Oxidative Stability (ASTM D 3895)							
Induction Time (min) (ASTM D3895)						23.3	



**TEST RESULTS**  
**Recycled HDPE Blend**  
**PCR Mixed Color Regrind + PIR Regrind MD**  
**50% + 50%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 50% MCRG + 50% PIR-MD

Date: 16-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.951	0.951	0.951			<div>0.95</div>	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.60	0.57				<div>0.59</div>	
21.6 kg (g/10 min)	35.8	35.9				<div>35.85</div>	
Ratio						<div>61</div>	
<b>Composition</b>							
% Volatiles						<div></div>	
% Color	1.67	1.71				<div>1.69</div>	
% Ash	0.63	0.7				<div>0.67</div>	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3135	3183	3197	3225	3197	<div>3187</div>	17
Break Strain (%)	667	667	667	640	557	<div>640</div>	13
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	35.2	49.3	47.6	49.8	40.8	<div>44.5</div>	0.9
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						<div>35.3</div>	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**PCR Mixed Color Regrind + PIR Regrind MD**  
**25% + 75%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 25% MCRG + 75% PIR-MD

Date: 16-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.949	0.949	0.949			0.95	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.56	0.58				0.57	
21.6 kg (g/10 min)	32	31.6				31.80	
Ratio						56	
<b>Composition</b>							
% Volatiles							
% Color	1.79	1.76				1.78	
% Ash	0.36	0.31				0.34	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	2985	3057	2957	3014	2957	2994	41
Break Strain (%)	734	721	700	691	716	712	13
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	108	124	115	135	138	124	8.2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						47.6	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**PCR Mixed Color Reprocessed + PIR Reprocessed HD**  
**75% + 25%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 75% MCR1 + 25% PIR-HD

Date: 24-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
Density (ASTM D 1505)							
Density (g/cm3)	0.960	0.961	0.961			0.961	0.000
Melt Flow Index (ASTM D 1238)							
2.16 kg (g/10min)	0.51	0.51				0.51	
21.6 kg (g/10 min)	46.4	45.9				46.2	
Ratio						91	
Composition							
% Volatiles							
% Color	2.28	2.3	2.17			2.25	0.057
% Ash						#DIV/0!	#DIV/0!
Tensile Properties (ASTM D 638)							
Yield Strength (psi)	3614	3554	3586	3649	3521	3585	39
Break Strain (%)	140	81	125	91	104	108	19
Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)							
Failure Time (hours)	7.9	8.9	7.9	10.0	8.0	8.5	0.9
Oxidative Stability (ASTM D 3895)							
Induction Time (min) (ASTM D3895)	18.2					18.2	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + PCR Mixed Color Reprocessed + Virgin MDPE**  
**50% + 25% + 25%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: VR3 + 25% MCR1 + 25% MDPE

Date: 20-Jun-07  
TRI Log #: F7601

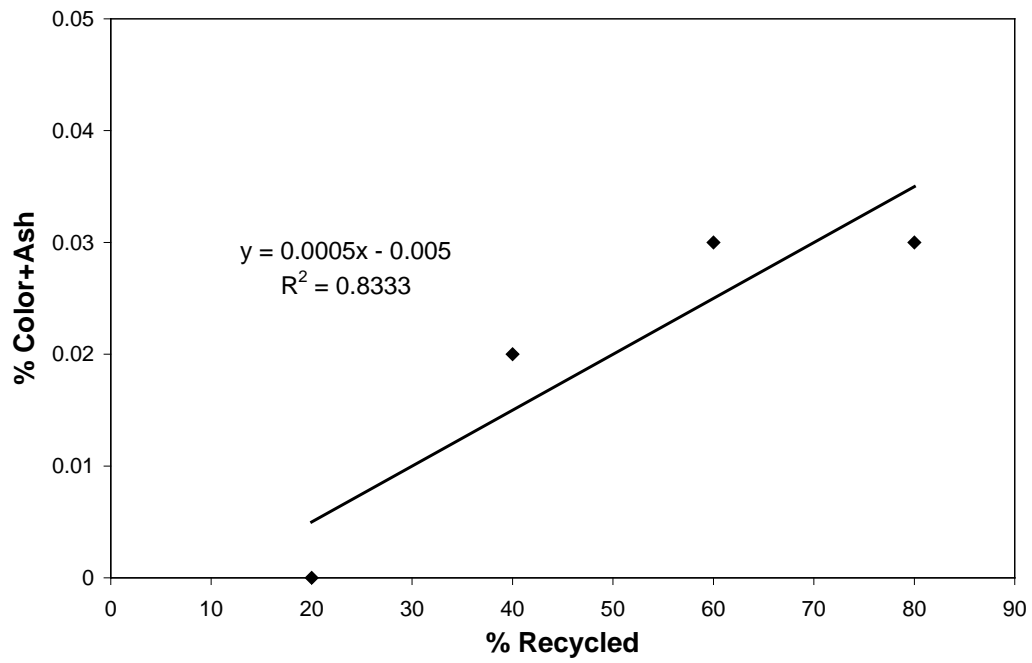
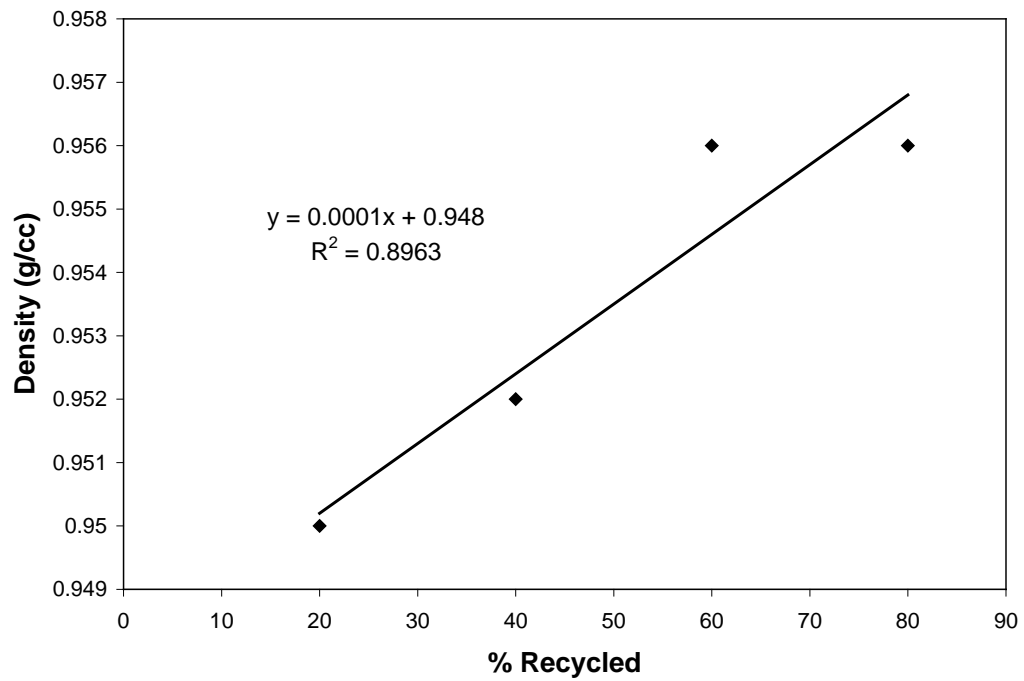
PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.941	0.942	0.942			0.942	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.30	0.30				0.30	
21.6 kg (g/10 min)	24.4	23.9				24.2	
Ratio						81	
<b>Composition</b>							
% Color/Ash	0.42	0.42	0.42			0.42	0.000
% PP							
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3507	3575	3563	3649	3575	3574	45
Break Strain (%)	604	510	459	526	583	536	52
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	39.3	50.3	38.3	32.1	42.6	40.5	6
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	63.4					63.4	

## C.9 SUMMARY TABLES, GRAPHS, AND TEST REPORTS FOR BLENDS MADE WITH NATURAL, POST-CONSUMER, RECYCLED HDPE

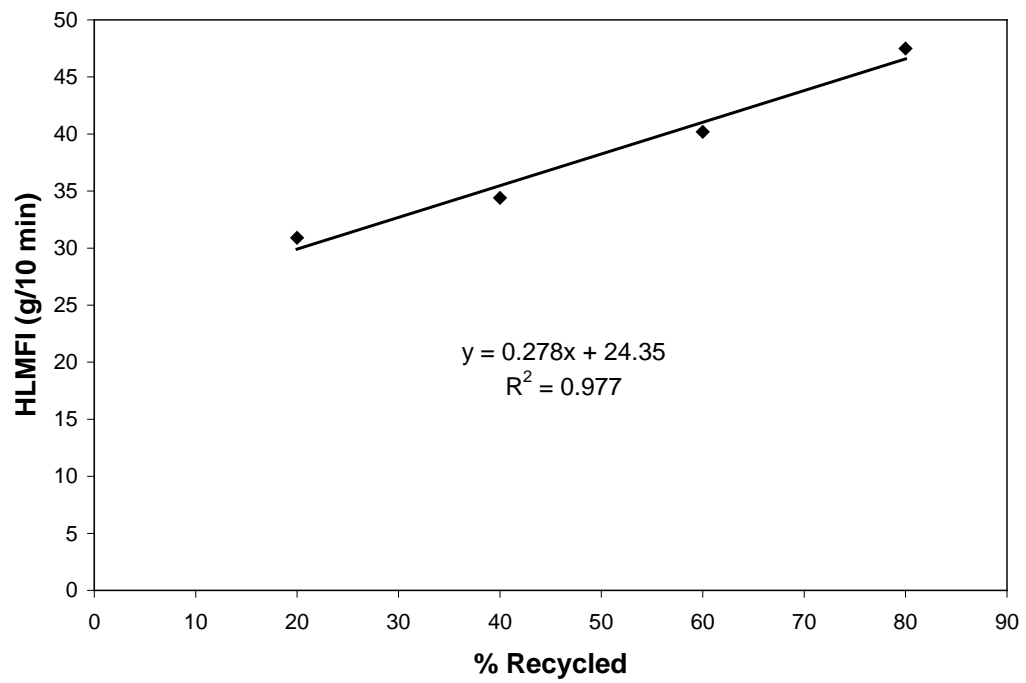
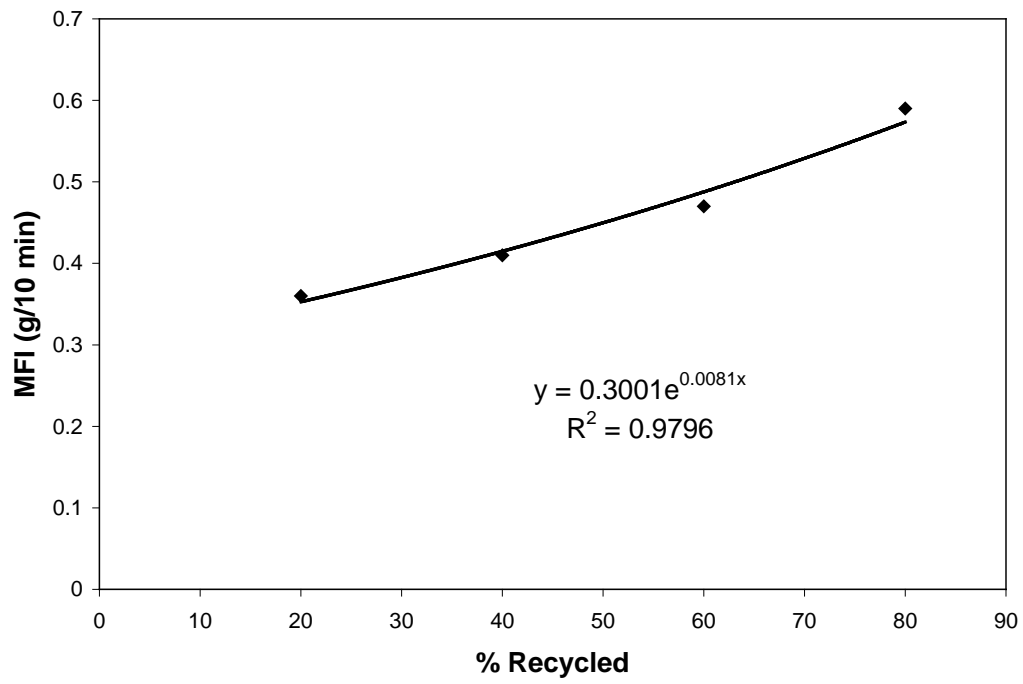
### Virgin Resin 2 + Natural Reprocessed PCR

Property	Recycled Content					
	0% Recycle	20% Recycle	40% Recycle	60% Recycle	80% Recycle	100% Recycle
Density g/cm <sup>3</sup>		0.950	0.952	0.956	0.956	0.959
Melt Index g/10 min		0.36	0.41	0.47	0.59	0.77
Flow Rate g/10 min		30.9	34.4	40.2	47.5	58.2
MFR (21.6/2.16kg)		86	85	85	81	76
% Ash		0.00	0.02	0.03	0.03	0.03
Yield Strength (psi)		4195	4298	4310	4456	4564
Break Strain (%)		479	488	394	340	313
NCTL-15% (hrs)		19.5	9.6	6.9	3.6	3.0
OIT (min)		65.7	47.9	36.5	23.6	15.7

### Virgin Resin 2 + Natural Reprocessed PCR

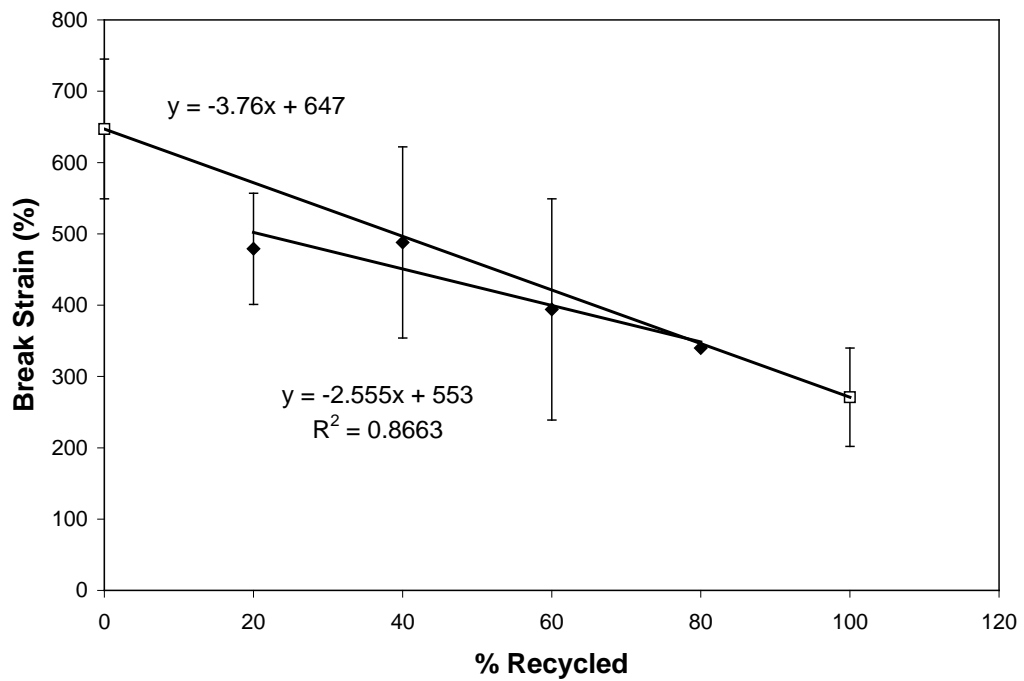
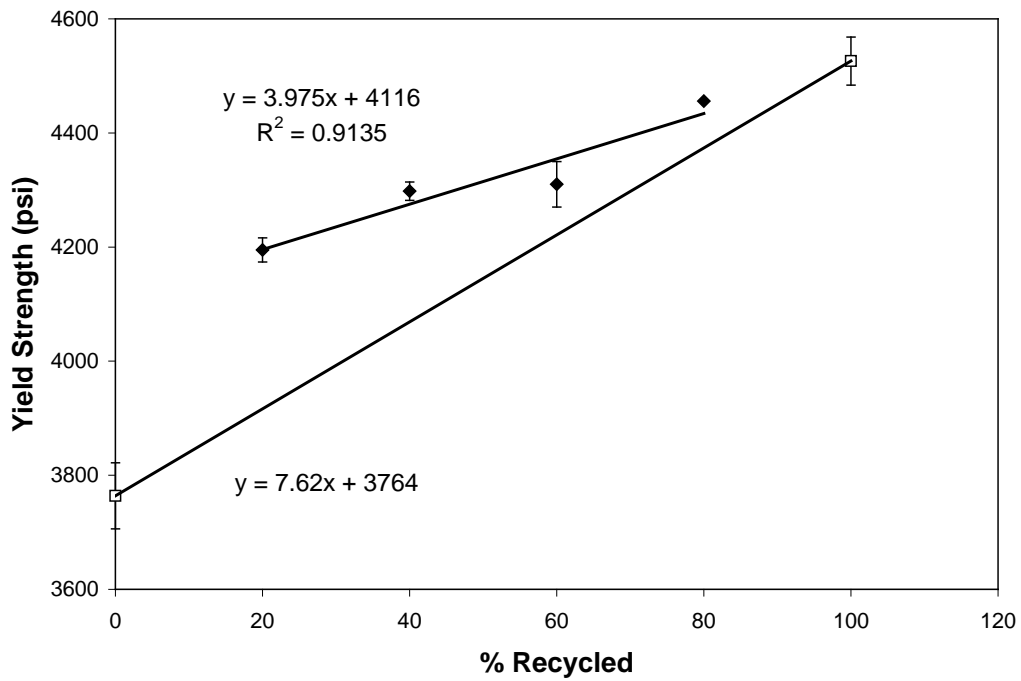


### Virgin Resin 2 + Natural Reprocessed PCR

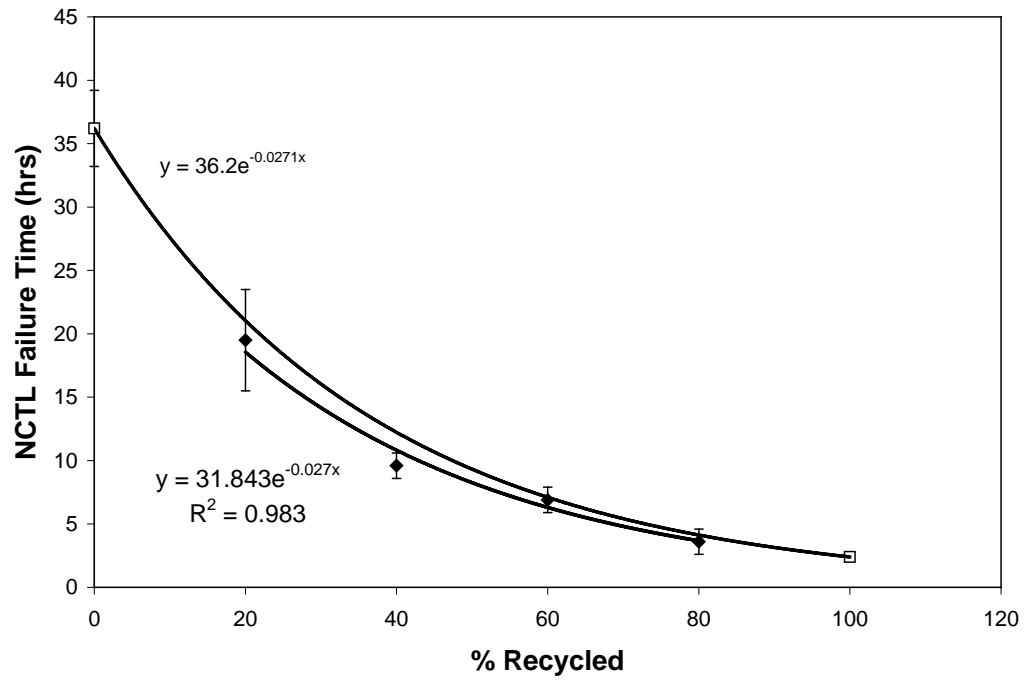




## Virgin Resin 2 + Natural Reprocessed PCR



## Virgin Resin 2 + Natural Reprocessed PCR



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Consumer Natural Reprocessed**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 80% Virgin Resin 2 + 20% Nat PCR

Date: 17-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.950	0.95	0.95			0.950	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.36	0.36				0.36	
21.6 kg (g/10 min)	31	30.8				30.9	
Ratio						86	
<b>Composition</b>							
% Color/Ash	0.00	0.00	0.00			0.00	0.000
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4297	4153	4243	4066	4216	4195	79
Break Strain (%)	450	600	499	455	391	479	70
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	11.9	23.3	19.4	21.1	21.7	19.5	4
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	65.7					65.7	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Consumer Natural Reprocessed**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 60% Virgin Resin 2 + 40% Nat. PCR

Date: 17-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.952	0.952	0.953			0.952	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.40	0.41				0.41	
21.6 kg (g/10 min)	34.7	34				34.4	
Ratio						85	
<b>Composition</b>							
% Color/Ash	0.02	0.02	0.02			0.02	0.000
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4297	4315	4300	4319	4261	4298	21
Break Strain (%)	333	521	549	516	522	488	78
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	9.4	9.4	9.4	10.4	9.4	9.6	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	47.9					47.9	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Consumer Natural Reprocessed**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 40% Virgin Resin 2 + 60% Nat. PCR

Date: 17-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.955	0.956	0.956			0.956	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.47	0.47				0.47	
21.6 kg (g/10 min)	40	40.3				40.2	
Ratio						85	
<b>Composition</b>							
% Color/Ash	0.04	0.02	0.03			0.03	0.008
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4301	4333	4315	4315	4286	4310	16
Break Strain (%)	422	277	538	202	529	394	134
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	6.4	6.9	7.1	6.7	7.3	6.9	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	36.5					36.5	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Consumer Natural Reprocessed**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 20% Virgin Resin 2 + 80% Nat. PCR

Date: 17-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.956	0.956	0.957			0.956	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.60	0.58				0.59	
21.6 kg (g/10 min)	47.7	47.3				47.5	
Ratio						81	
<b>Composition</b>							
% Color/Ash	0.04	0.04	0.02			0.03	0.009
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4442	4397	4520	4446	4474	4456	40
Break Strain (%)	605	143	381	326	247	340	155
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	3.4	3.8	3.4	4.1	3.2	3.6	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	23.6					23.6	

# TEST RESULTS

## Recycled HDPE Blend

### Reprocessed Post Consumer Natural HD

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% Nat PCR

Date: 17-May-07  
TRI Log #: F7601

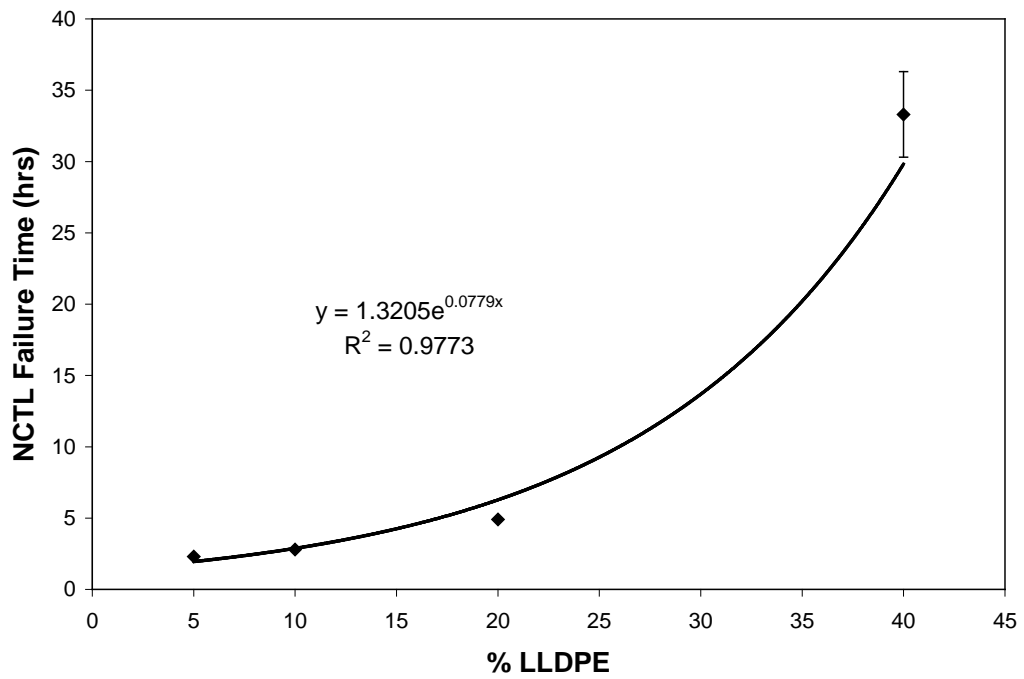
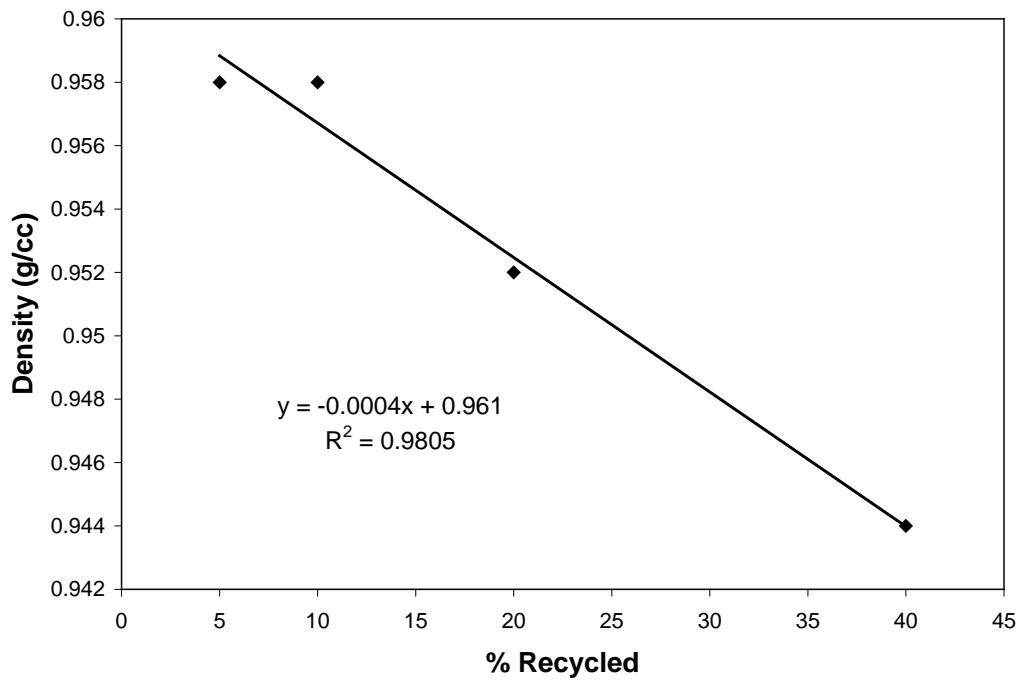
PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.960	0.959	0.959			0.959	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.76	0.77				0.77	
21.6 kg (g/10 min)	58.6	57.7				58.2	
Ratio						76	
<b>Composition</b>							
% Color/Ash	0.06	0.04	0.00			0.03	0.025
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4575	4644	4549	4597	4457	4564	62
Break Strain (%)	323	214	334	295	397	313	60
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	3.3	3.2	3.2	3.0	2.4	3.0	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	15.7					15.7	

### Natural Reprocessed + LLDPE

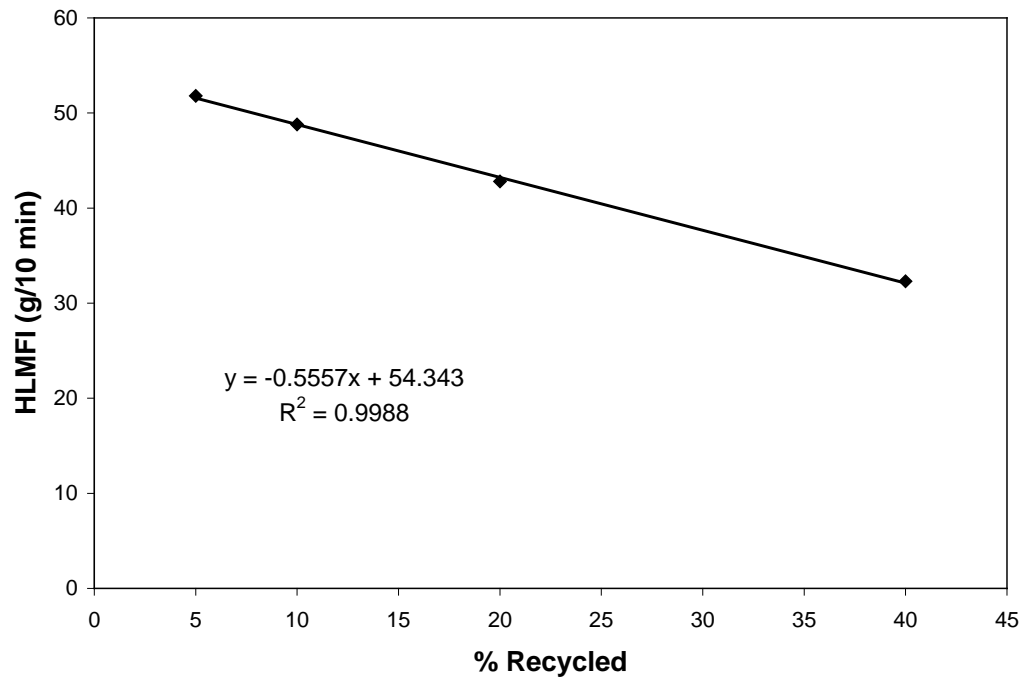
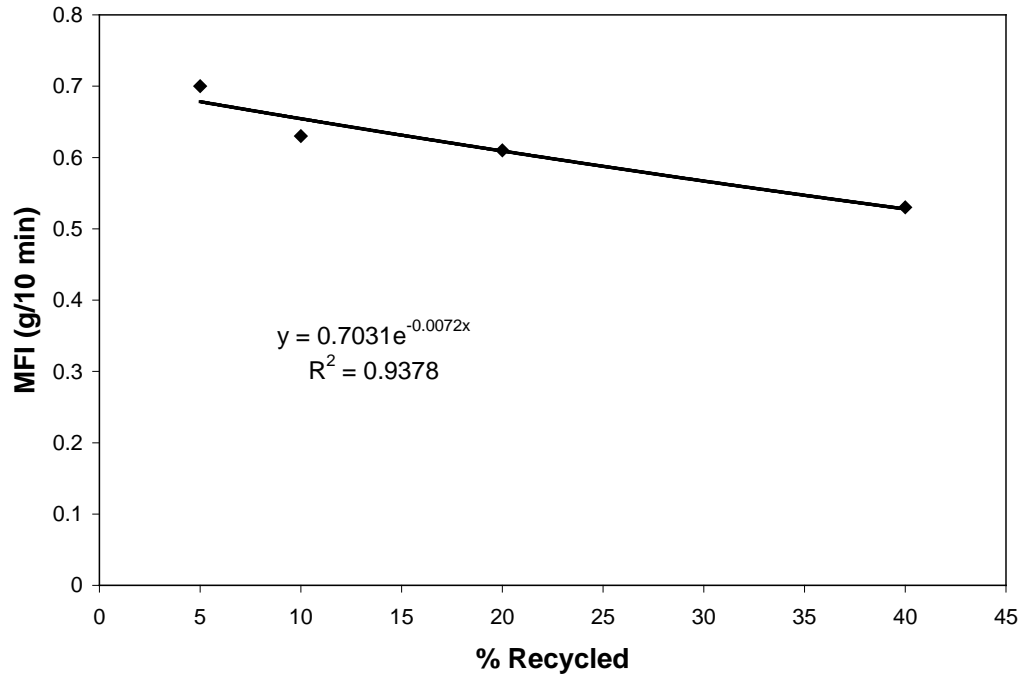
Property	LLDPE Content					
	0% LL	5% LL	10% LL	20% LL	40% LL	100% LL
Density g/cm <sup>3</sup>	0.960	0.958	0.958	0.952	0.944	
Melt Index g/10 min	0.79	0.70	0.63	0.61	0.53	
Flow Rate g/10 min	56.0	51.8	48.8	42.8	32.3	
MFR (21.6/2.16kg)	71	74	77	70	61	
Yield Strength (psi)	4523	4172	3976	3677	3029	
Break Strain (%)	365	492	496	616	615	
NCTL-15% (hrs)	2.0	2.3	2.8	4.9	33.3	
OIT (min)	15.6					



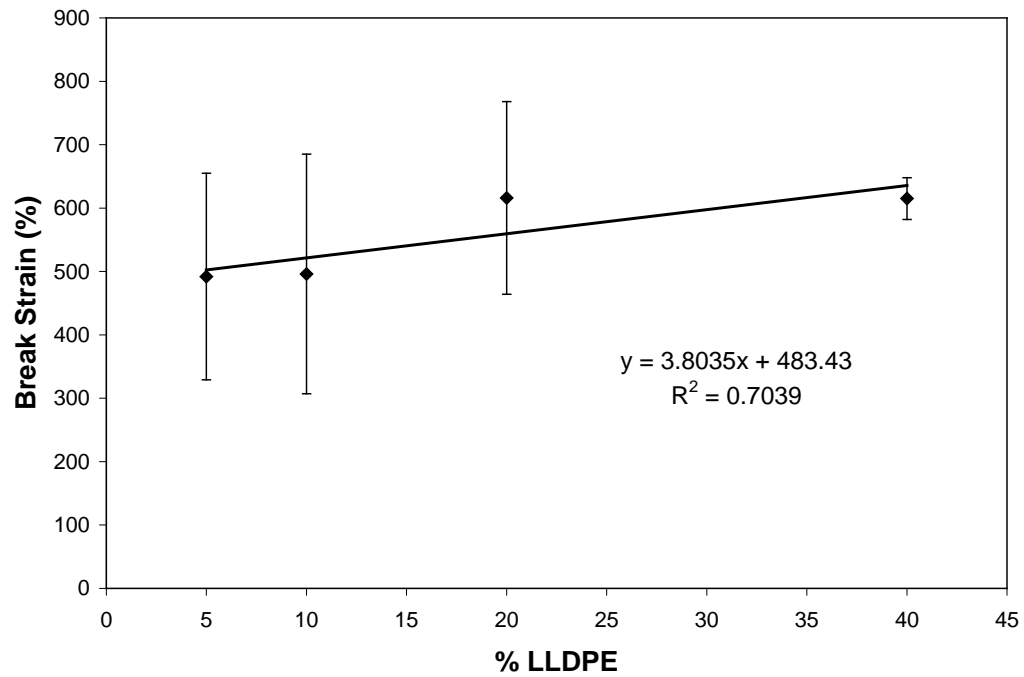
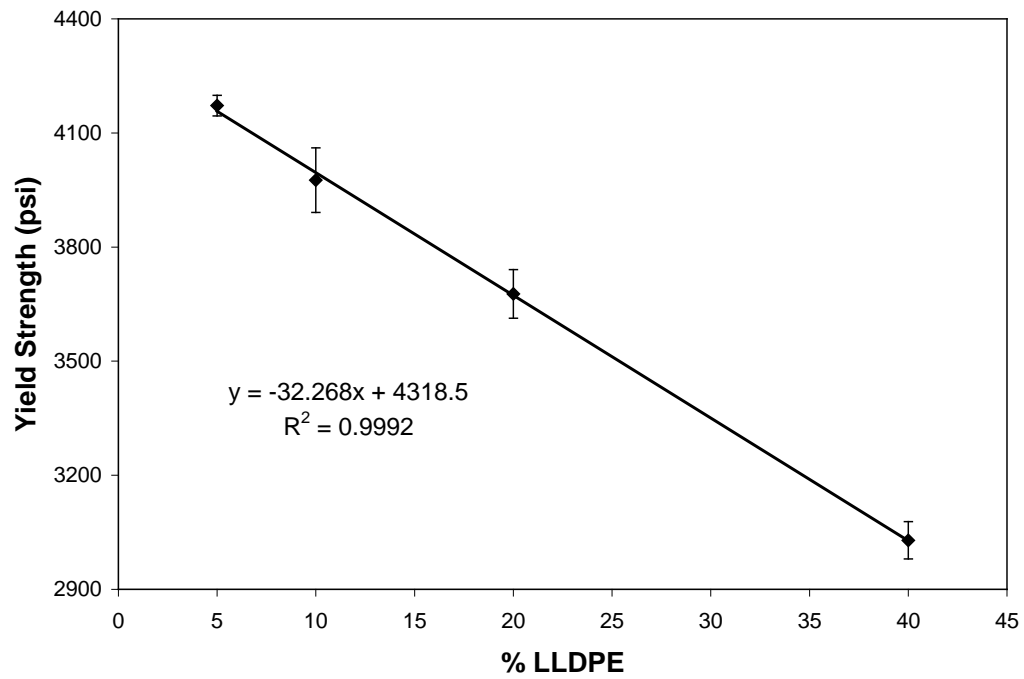
### Natural Reprocessed + LLDPE



## Natural Reprocessed + LLDPE



### Natural Reprocessed + LLDPE



# **TEST RESULTS** **Recycled HDPE Classification** **PCR Natural Reprocessed** **Prepared by TRI**

Material: Plaque from blended resin (MB 2X @ 100 Mesh)  
Sample: 100% Natural Repro

Date: 13-Feb-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.960	0.96	0.96			0.960	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.71	0.87				0.79	
21.6 kg (g/10 min)	52.7	59.3				56.0	
Ratio						71	
<b>Composition</b>							
% Volatiles	0.08					0.08	
% Color/Ash	0.06	0.05				0.06	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4543	4507	4515	4536	4514	4523	14
Break Strain (%)	70	194	496	638	427	365	206
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	2.0	2.0	2.0	2.1	1.7	2.0	0.1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)							

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Natural Reprocessed + LLDPE**  
**95% + 5%**

Material: Plaque from blended resin  
Sample: 95% Natural Repro + 5% LLDPE

Date: 23-Feb-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
Density (ASTM D 1505)							
Density (g/cm3)	0.958	0.958	0.958			0.958	0.000
Melt Flow Index (ASTM D 1238)							
2.16 kg (g/10min)	0.70	0.71				0.70	
21.6 kg (g/10 min)	52.8	50.9				51.9	
Ratio						74	
Composition							
% Volatiles							
% Color/Ash							
Tensile Properties (ASTM D 638)							
Yield Strength (psi)	4217	4132	4162	4176	4171	4172	27
Break Strain (%)	255	601	629	638	335	492	163
Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)							
Failure Time (hours)	2.8	2.3	2.3	2.1	2.2	2.3	0
Oxidative Stability (ASTM D 3895)							
Induction Time (min) (ASTM D3895)							

# **TEST RESULTS** **Recycled HDPE Blend** **Natural Reprocessed + LLDPE** **90% + 10%**

Material: Plaque from blended resin  
Sample: 90% Natural Repro + 10% LLDPE

Date: 23-Feb-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.958	0.958	0.958			0.958	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.63	0.63				0.63	
21.6 kg (g/10 min)	49.1	48.6				48.9	
Ratio						77	
<b>Composition</b>							
% Volatiles							
% Color/Ash	1.02	1.01	1.00			1.01	0.009
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4127	3986	3960	3935	3870	3976	85
Break Strain (%)	379	728	599	581	191	496	189
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	2.7	2.7	2.6	3.4	2.8	2.8	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)							

# **TEST RESULTS** **Recycled HDPE Blend** **Natural Reprocessed + LLDPE** **80% + 20%**

Material: Plaque from blended resin  
Sample: 80% Natural Repro + 20% LLDPE

Date: 23-Feb-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.951	0.952	0.952			0.952	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.61	0.61				0.61	
21.6 kg (g/10 min)	42.6	43.0				42.8	
Ratio						70	
<b>Composition</b>							
% Volatiles							
% Color/Ash	1.00	1.02	1.02			1.01	0.009
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3792	3608	3697	3658	3632	3677	64
Break Strain (%)	665	349	754	755	561	617	152
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	4.3	5.4	5.2	4.7	4.9	4.9	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)							

# **TEST RESULTS** **Recycled HDPE Blend** **Natural Reprocessed + LLDPE** **60% + 40%**

Material: Plaque from blended resin  
Sample: 60% Natural Repro + 40% LLDPE

Date: 23-Feb-07  
TRI Log #: F7601

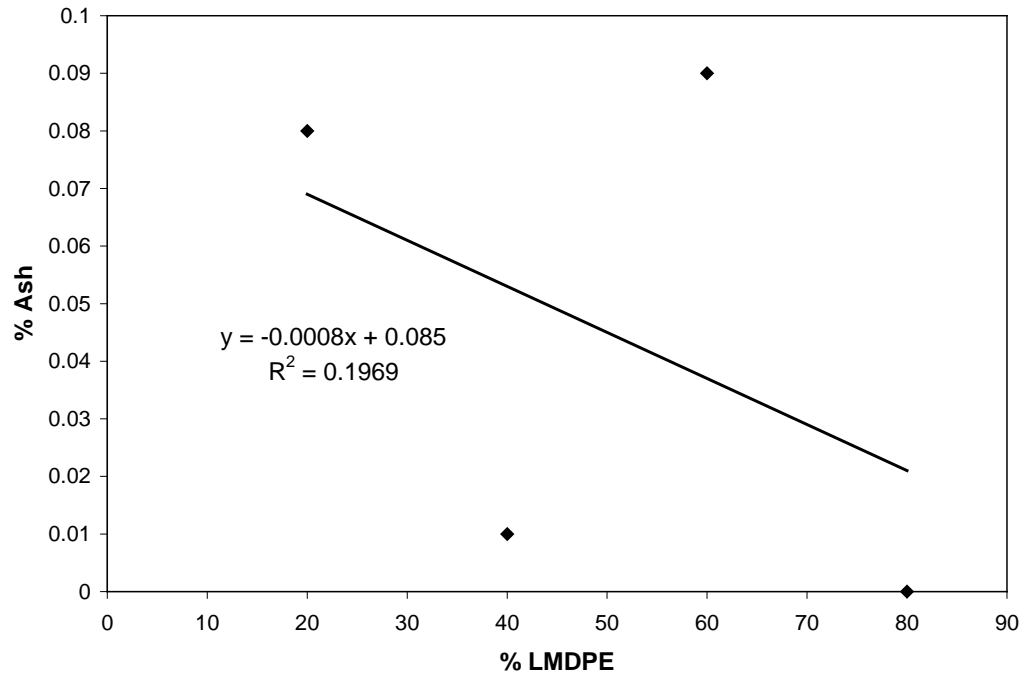
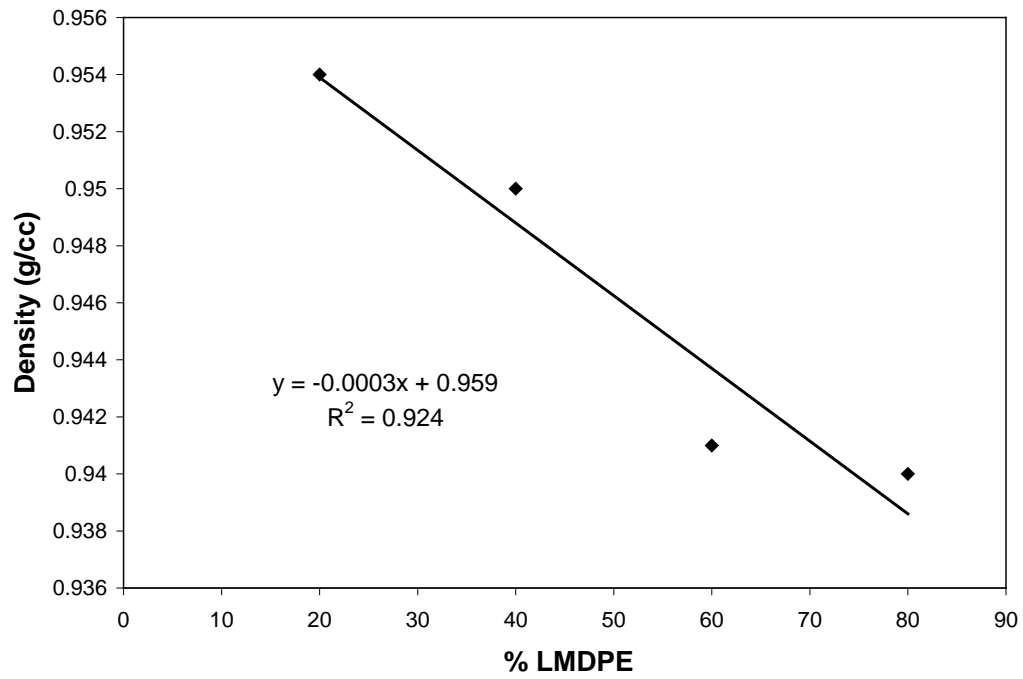
PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.944	0.944	0.945			0.944	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.52	0.53				0.53	
21.6 kg (g/10 min)	32.4	32.3				32.4	
Ratio						61	
<b>Composition</b>							
% Volatiles							
% Color/Ash							
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3098	3029	3029	3043	2944	3029	49
Break Strain (%)	596	665	636	571	608	615	33
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	31.1	31.8	34.5	39.4	29.5	33.3	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)							



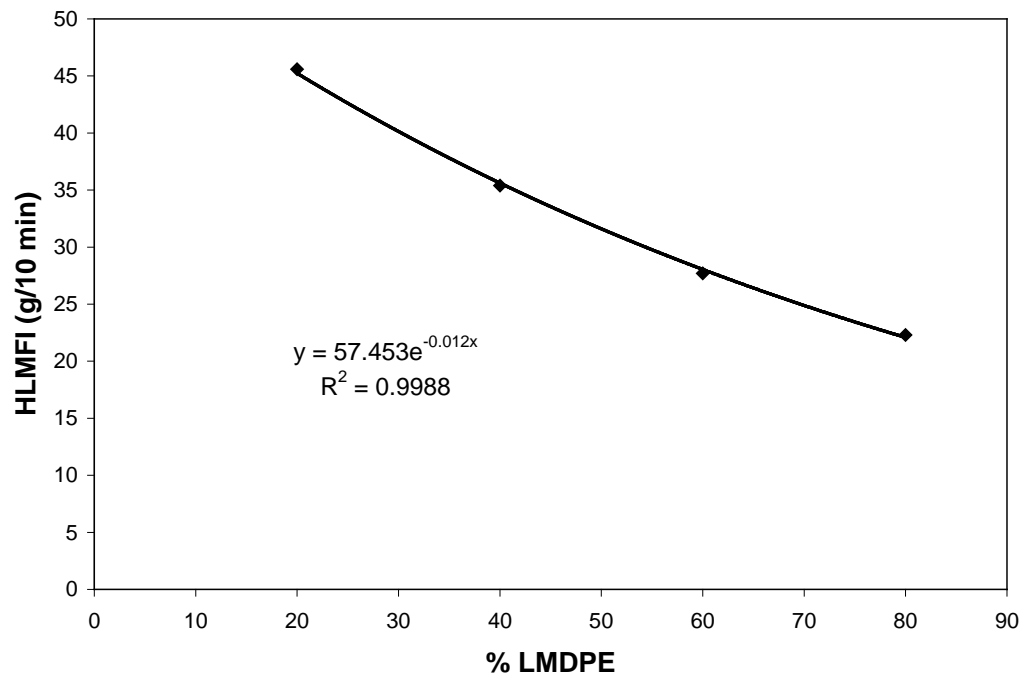
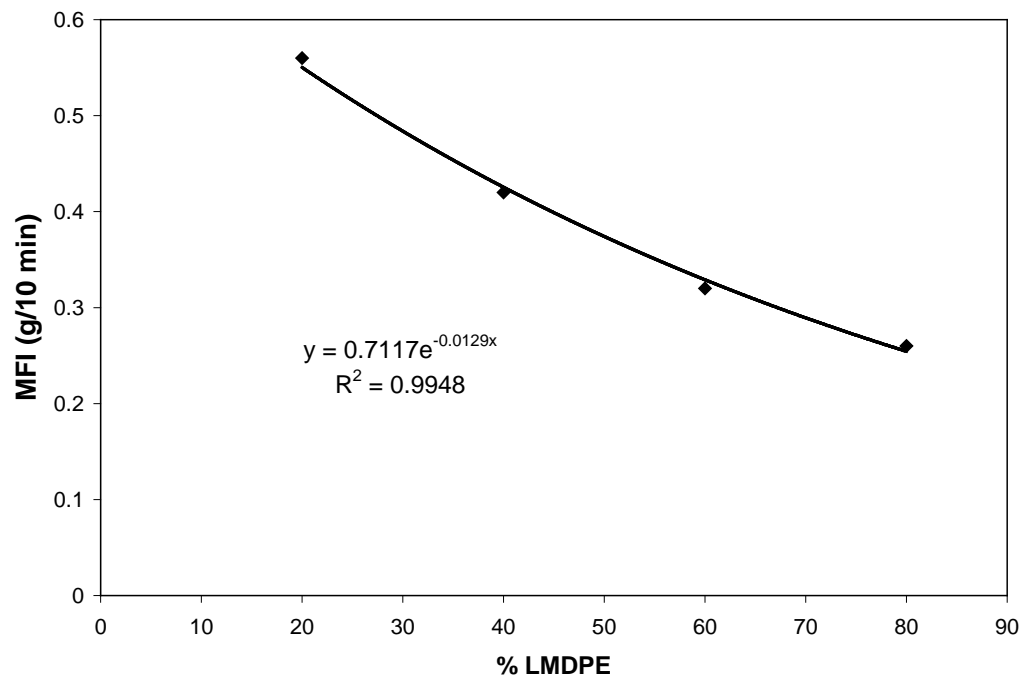
### Natural Reprocessed + Virgin MDPE

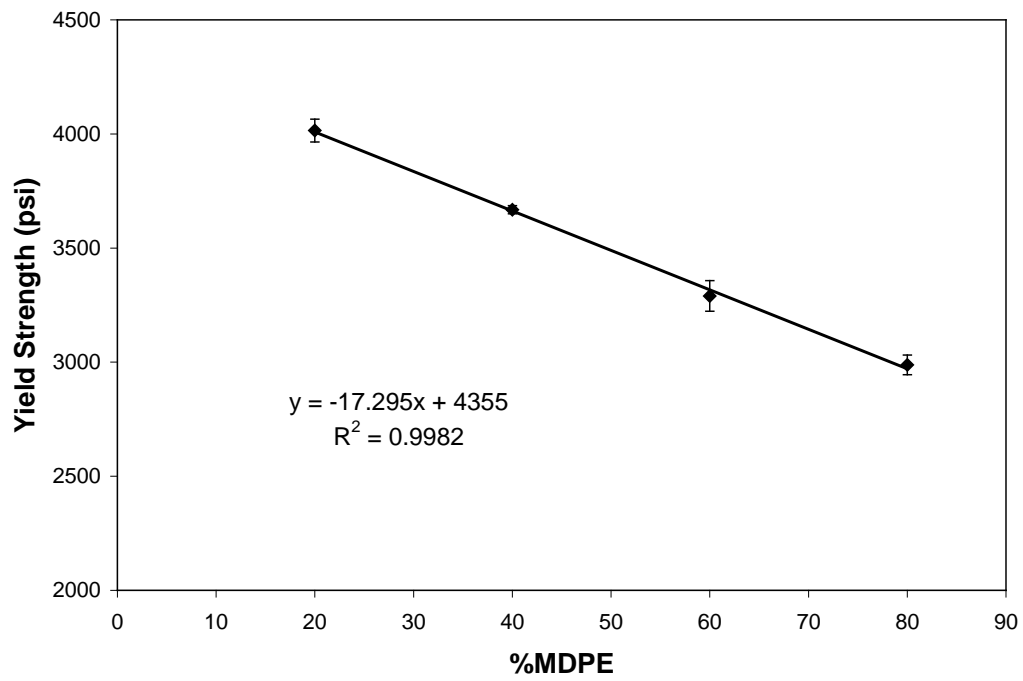
Property	Virgin MDPE Content					
	0% MDPE	20% MDPE	40% MDPE	60% MDPE	80% MDPE	100% MDPE
Density g/cm <sup>3</sup>	0.960	0.954	0.950	0.941	0.940	
Melt Index g/10 min	0.81	0.56	0.42	0.32	0.26	
Flow Rate g/10 min	61.9	45.6	35.4	27.7	22.3	
MFR (21.6/2.16kg)	76	82	83	85	85	
Ash	0.05	0.08	0.01	0.09	0.0	
Yield Strength (psi)	4489	4015	3668	3290	2988	
Break Strain (%)	229	374	507	624	672	
NCTL-15% (hrs)	1.8	4.6	14.4	75.2	>750	
OIT (min)	9.0	33.8	72.0	125	176	

## Natural Reprocessed + Virgin MDPE

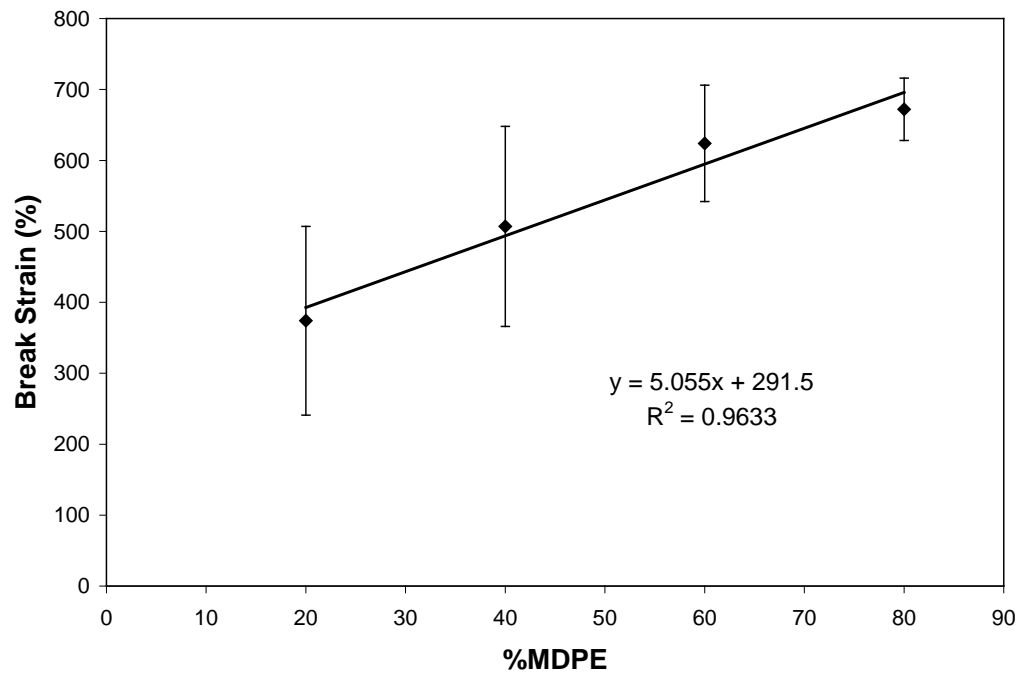


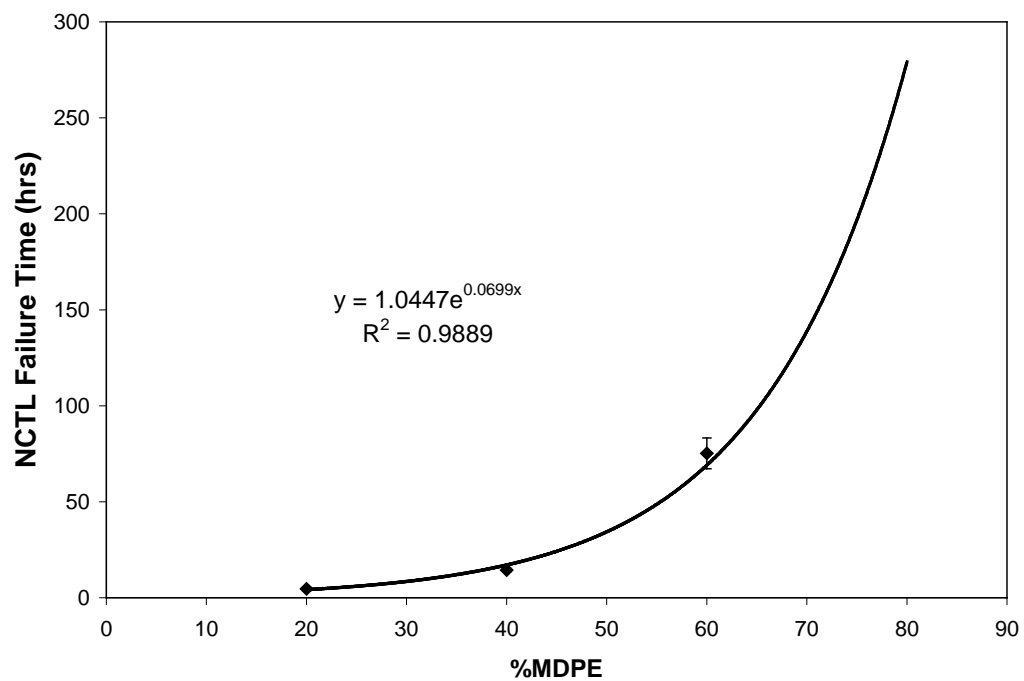
### Natural Reprocessed + Virgin MDPE





**Natural Reprocessed + Virgin MDPE**





**Natural Reprocessed + Virgin MDPE**

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Natural Reprocessed + Virgin LMDPE**  
**100% + 0%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Nat Repro

Date: 22-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.960	0.96	0.96			0.960	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.80	0.82				0.81	
21.6 kg (g/10 min)	62.5	61.2				61.9	
Ratio						76	
<b>Composition</b>							
% Ash	0.02	0.03	0.10			0.05	0.036
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4396	4539	4495	4492	4522	4489	50
Break Strain (%)	169	127	245	354	249	229	78
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	1.8	1.8	1.8	1.8	1.8	1.8	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	9					9	

# TEST RESULTS

## Recycled HDPE Blend

### Post Consumer Natural Reprocessed + Virgin LMDPE

### 80% + 20%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Nat Repro + 20% LMDPE

Date: 22-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.954	0.954	0.954			0.954	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.56	0.55				0.56	
21.6 kg (g/10 min)	45.3	45.8				45.6	
Ratio						82	
<b>Composition</b>							
% Ash	0.07	0.09				0.08	0.010
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3927	4027	4070	4053	3997	4015	50
Break Strain (%)	228	559	269	505	309	374	133
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	4.7	4.5	4.6	4.8	4.5	4.6	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	33.8					33.8	

# TEST RESULTS

## Recycled HDPE Blend

### Post Consumer Natural Reprocessed + Virgin LMDPE

### 60% + 40%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Nat Repro + 40% LMDPE

Date: 22-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.950	0.950	0.950			0.950	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.43	0.42				0.42	0.004
21.6 kg (g/10 min)	35.2	35.5				35.4	
Ratio						83	
<b>Composition</b>							
% Ash	0.01	0.01				0.01	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3683	3655	3650	3695	3655	3668	18
Break Strain (%)	242	658	515	574	547	507	141
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	14.2	14.6	14.2	14.3	14.8	14.4	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	72.0					72.0	



# TEST RESULTS

## Recycled HDPE Blend

### Post Consumer Natural Reprocessed + Virgin LMDPE

### 40% + 60%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Nat Repro + 60% LMDPE

Date: 22-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.941	0.941	0.941			0.941	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.32	0.33				0.32	
21.6 kg (g/10 min)	27.6	27.7				27.7	
Ratio						85	
<b>Composition</b>							
% Ash	0.07	0.10				0.09	0.015
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3227	3212	3373	3364	3273	3290	67
Break Strain (%)	661	464	701	646	647	624	82
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	78.6	82.8	82.9	71.2	60.6	75.2	8
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	125.0					125.0	

# TEST RESULTS

## Recycled HDPE Blend

### Post Consumer Natural Reprocessed + Virgin LMDPE

### 20% + 80%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Nat Repro + 60% LMDPE

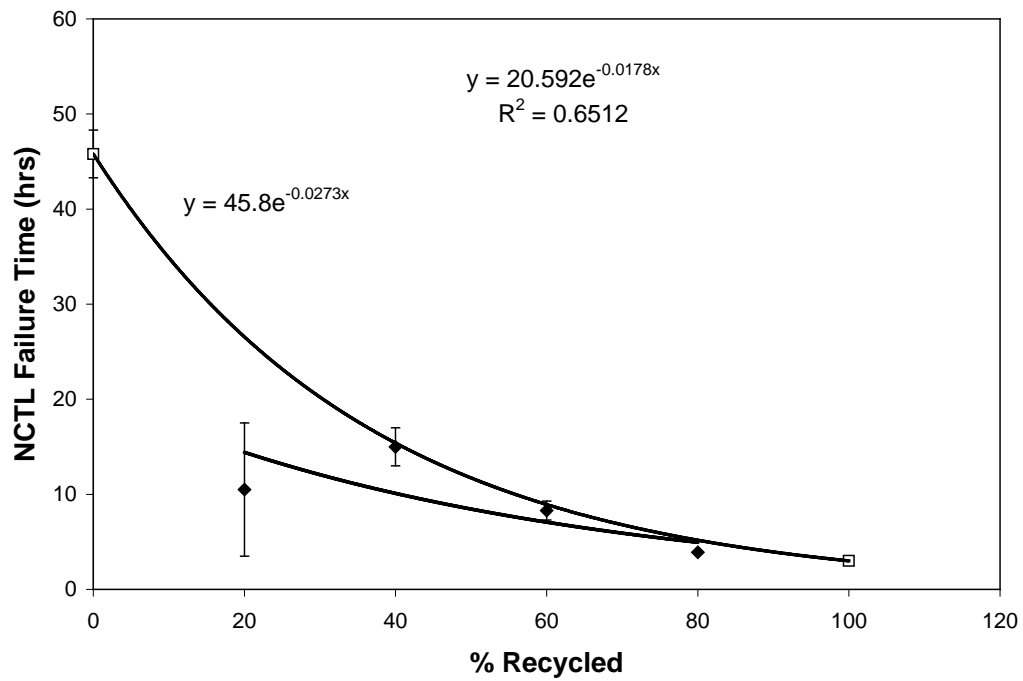
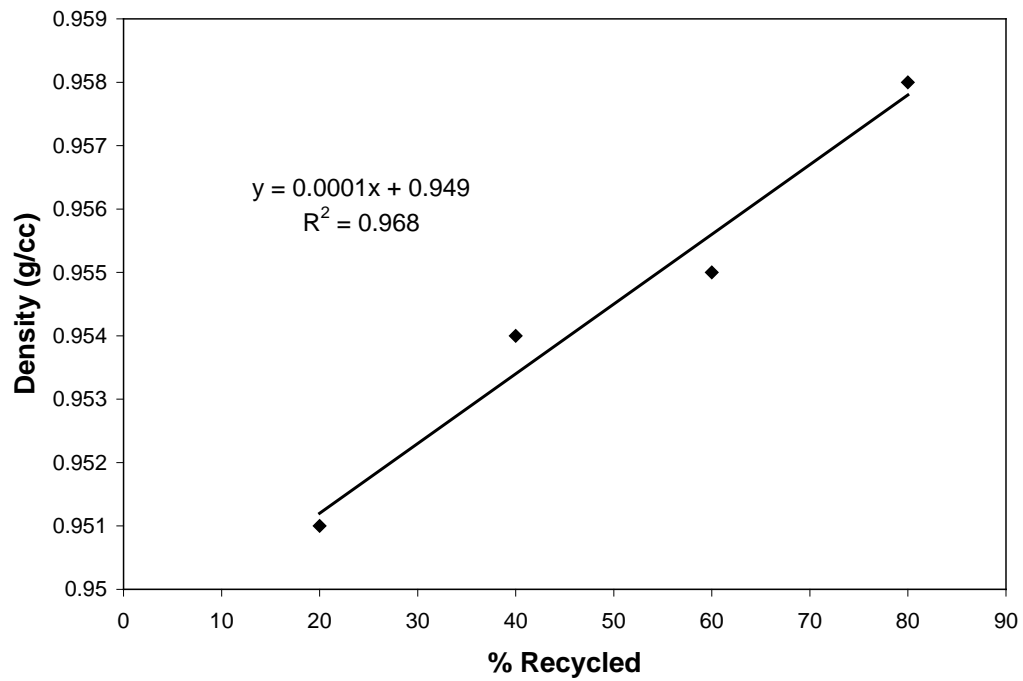
Date: 22-Oct-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.940	0.940	0.940			0.940	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.25	0.27				0.26	
21.6 kg (g/10 min)	22.2	22.3				22.3	
Ratio						85	
<b>Composition</b>							
% Ash	0.00	0.00				0.00	0.000
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	2945	2954	3018	3057	2968	2988	43
Break Strain (%)	688	704	705	677	586	672	44
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	>750	>750	>750	>750	>750	>750	
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	176.0					176.0	

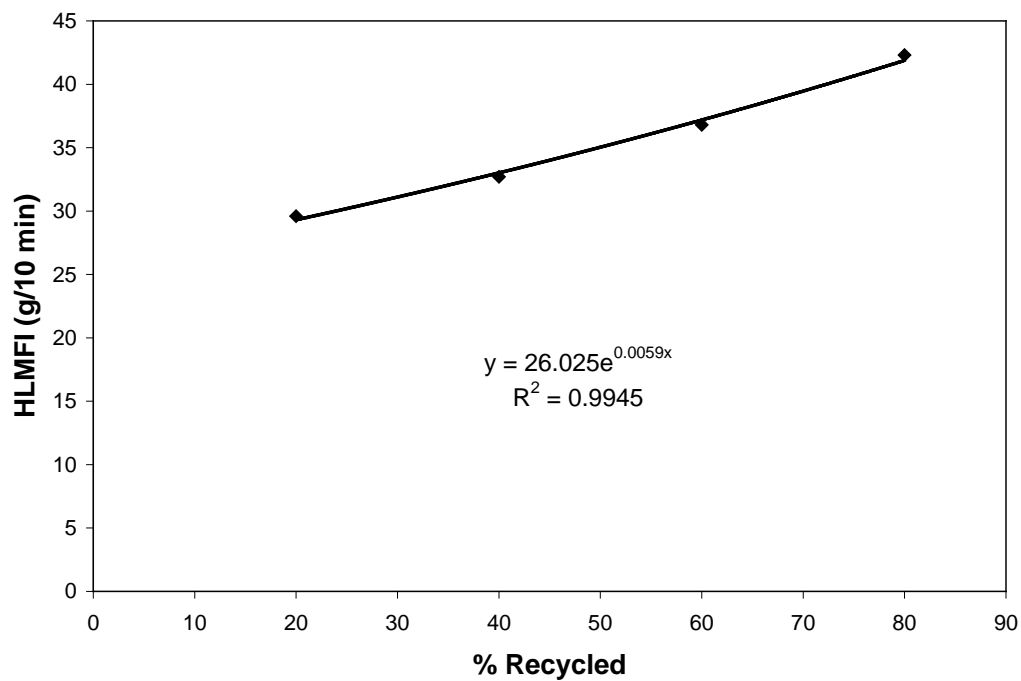
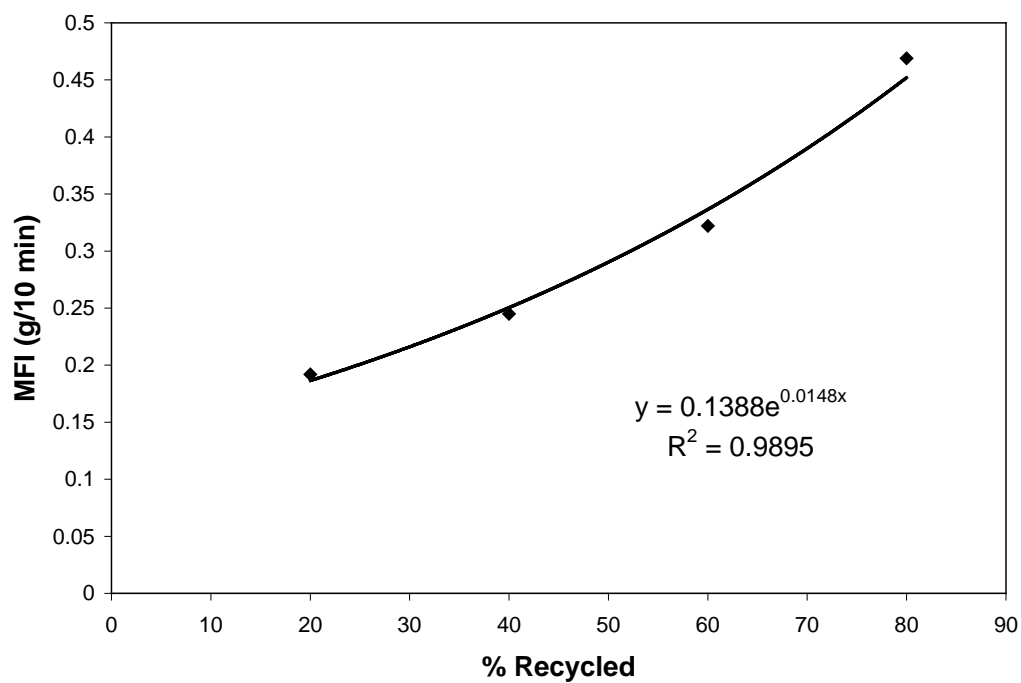
**Virgin Resin 1 + (Natural Reprocessed PCR + 10% Virgin LLDPE)**

Property	Recycle Content					
	0% Recycle	18% Recycle	36% Recycle	54% Recycle	72% Recycle	100% Recycle
Density g/cm <sup>3</sup>		0.951	0.954	0.955	0.958	0.958
Melt Index g/10 min		0.192	0.245	0.322	0.469	0.632
Flow Rate g/10 min		29.7	32.7	36.8	42.3	48.8
MFR (21.6/2.16kg)		155	133	114	90	77.2
Yield Strength (psi)		3896	3940	3948	3921	3976
Break Strain (%)		278	386	457	457	496
NCTL-15% (hrs)		10.5	15.0	8.3	3.9	3.2
OIT (min)						

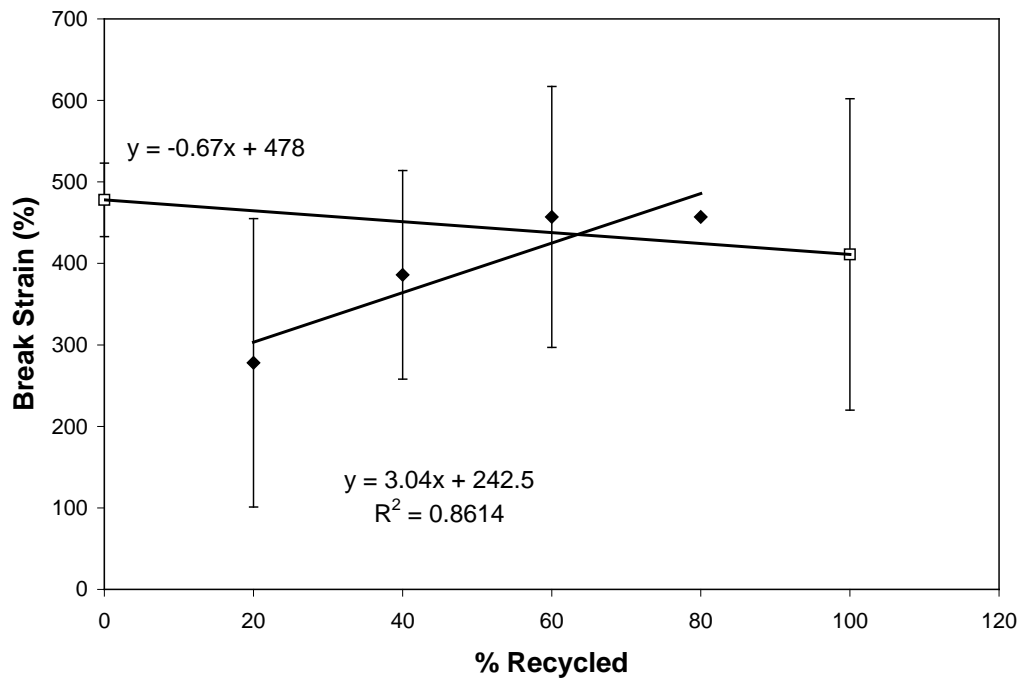
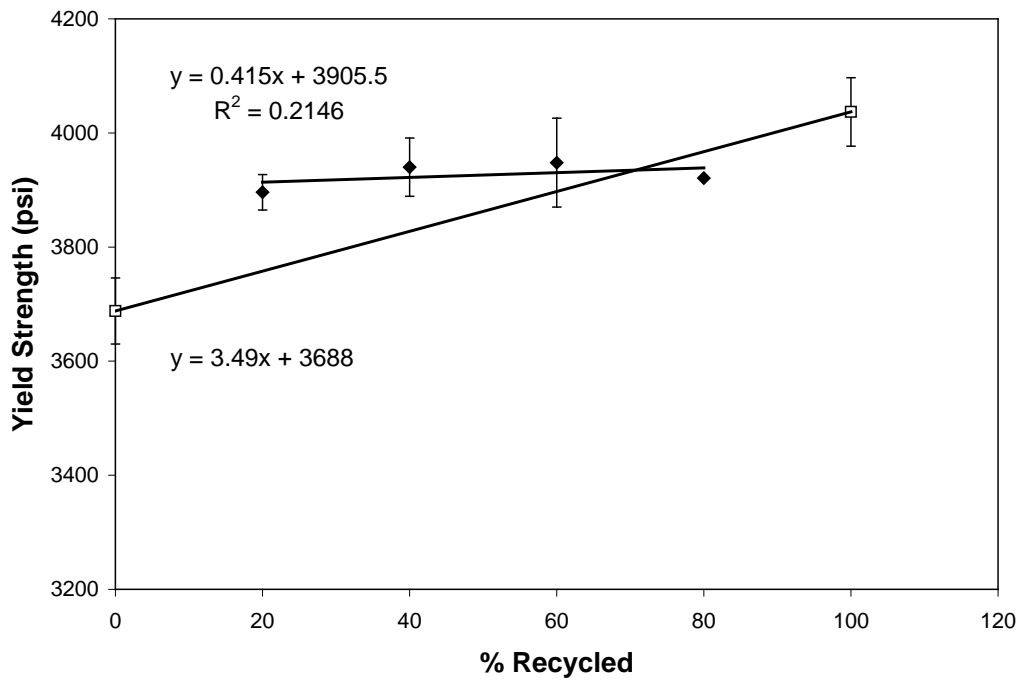
### Virgin Resin 1 + (Natural Reprocessed + 10% LLDPE)



### Virgin Resin 1 + (Natural Reprocessed + 10% LLDPE)



### Virgin Resin 1 + (Natural Reprocessed + 10% LLDPE)



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + (Post Consumer Natural Reprocessed + 10% Virgin LLDPE)**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 20% (Nat + 10% LL)

Date: 5-Mar-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.950	0.951	0.951			0.951	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.19	0.20				0.19	
21.6 kg (g/10 min)	29.3	30.1				29.7	
Ratio						155	
<b>Composition</b>							
% Ash							
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3959	3882	3962	3936	3743	3896	82
Break Strain (%)	499	25	80	484	304	278	198
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	21.9	15.0	8.2	3.8	3.6	10.5	7
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)							

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + (Post Consumer Natural Reprocessed + 10% Virgin LLDPE)**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 40% (Nat + 10% LL)

Date: 5-Mar-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.954	0.954	0.954			0.954	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.24	0.25				0.25	
21.6 kg (g/10 min)	32.9	32.6				32.8	
Ratio						133	
<b>Composition</b>							
% Ash							
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3986	3907	3934	3909	3963	3940	31
Break Strain (%)	498	539	550	198	143	386	177
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	14.6	13.9	17.2	17.1	12.2	15.0	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)							



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + (Post Consumer Natural Reprocessed + 10% Virgin LLDPE)**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 60% (Nat + 10% LL)

Date: 5-Mar-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
Density (ASTM D 1505)							
Density (g/cm3)	0.955	0.955	0.955			0.955	0.000
Melt Flow Index (ASTM D 1238)							
2.16 kg (g/10min)	0.31	0.33				0.32	
21.6 kg (g/10 min)	36.7	37.0				36.9	
Ratio						114	
Composition							
% Ash							
Tensile Properties (ASTM D 638)							
Yield Strength (psi)	4014	3958	3986	3913	3870	3948	51
Break Strain (%)	535	550	211	538	450	457	128
Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)							
Failure Time (hours)	8.0	7.9	8.5	7.7	9.2	8.3	1
Oxidative Stability (ASTM D 3895)							
Induction Time (min) (ASTM D3895)							

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + (Post Consumer Natural Reprocessed + 10% Virgin LLDPE)**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 80% (Nat + 10% LL)

Date: 5-Mar-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.958	0.958	0.958			0.958	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.46	0.48				0.47	
21.6 kg (g/10 min)	42.1	42.5				42.3	
Ratio						90	
<b>Composition</b>							
% Ash							
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4041	3930	3956	3867	3812	3921	78
Break Strain (%)	573	569	532	146	464	457	160
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	3.4	4.2	3.8	3.8	4.2	3.9	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)							

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Natural Reprocessed + 10% Virgin LLDPE**  
**100%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: 100% (Nat + 10% LL)

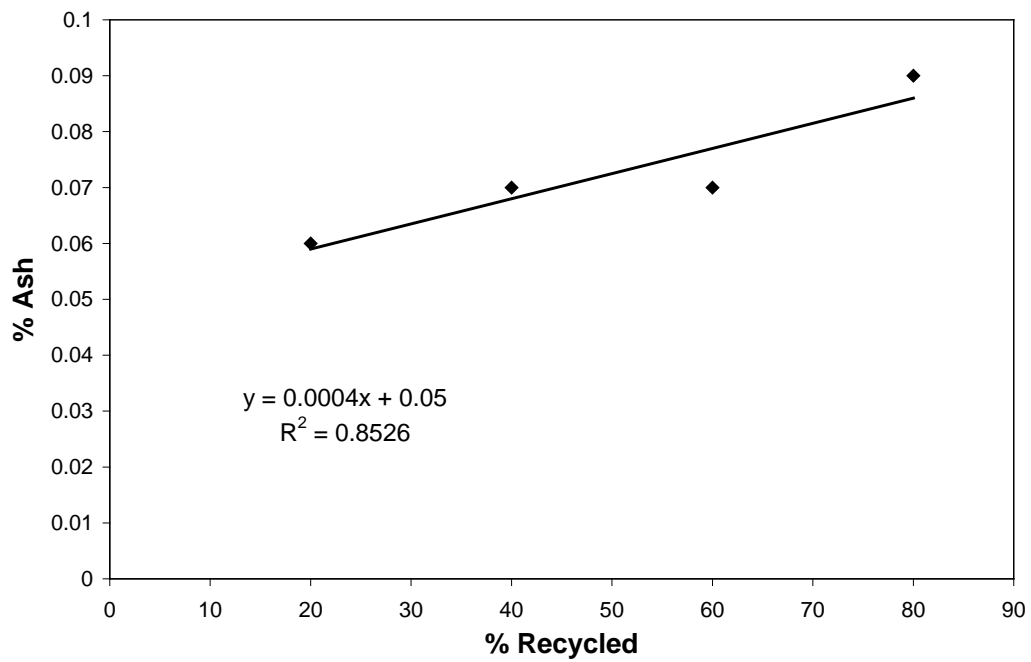
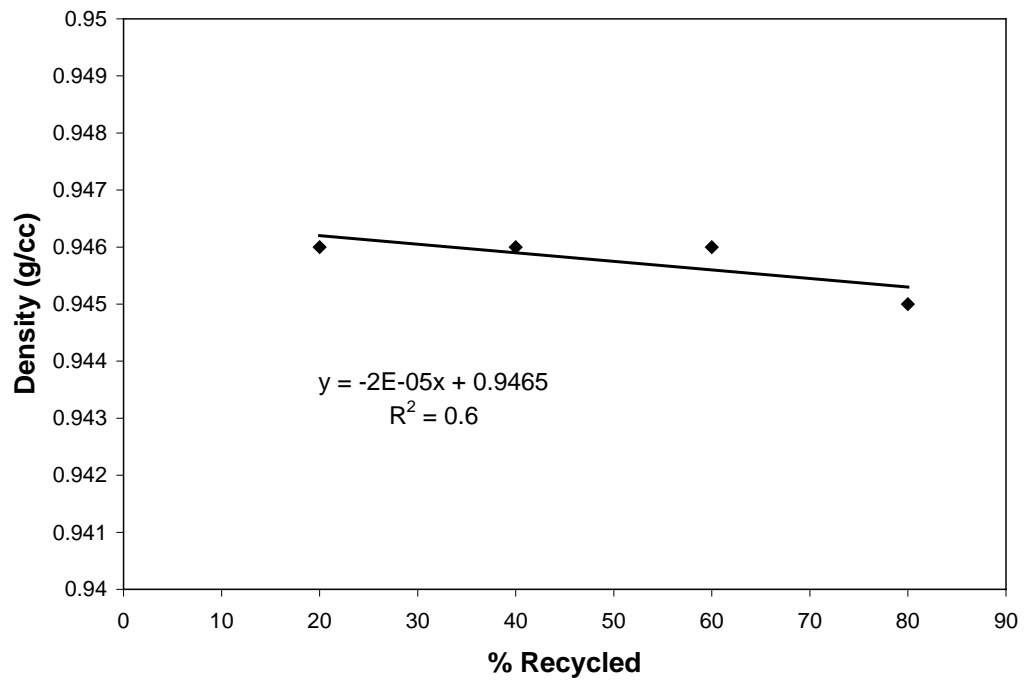
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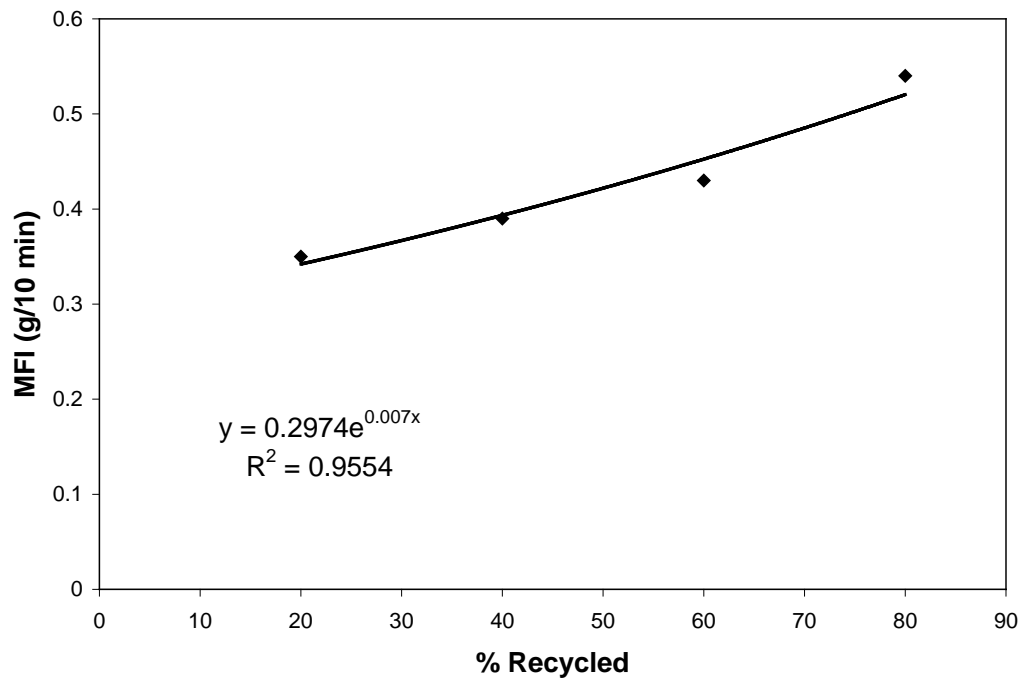
PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.958	0.957	0.958			0.958	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.63	0.63				0.63	
21.6 kg (g/10 min)	48.6	49.1				48.9	
Ratio						77	
<b>Composition</b>							
% Ash	0.06	0.05				0.06	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4127	3986	3960	3935	3870	3976	85
Break Strain (%)	379	728	599	581	191	496	189
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	3.1	3.5	3.2	3.3	3.1	3.2	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)							

**Virgin Resin 2 + (Natural Reprocessed PCR + 10% Virgin LLDPE)**

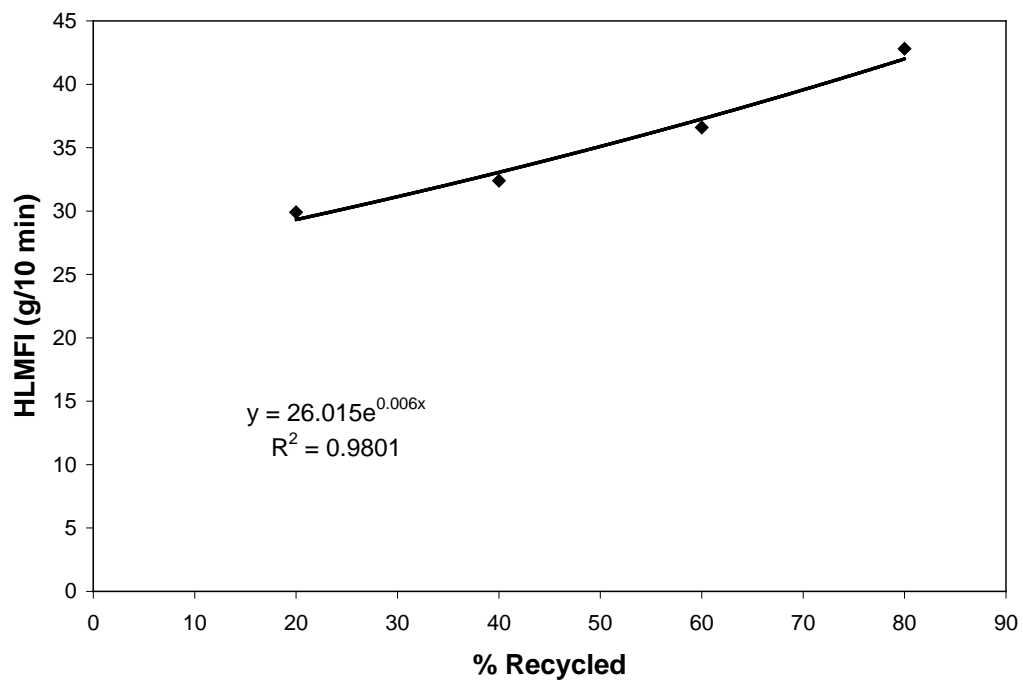
Property	Recycled Content					
	0% Recycle	18% Recycle	36% Recycle	54% Recycle	72% Recycle	100% Recycle
Density g/cm <sup>3</sup>	0.952	0.946	0.946	0.946	0.945	0.956
Melt Index g/10 min	0.33	0.35	0.39	0.43	0.54	0.66
Flow Rate g/10 min	28.3	29.9	32.4	36.6	42.8	46.7
MFR (21.6/2.16kg)	87	81	84	86	80	71
% Ash	0.04	0.06	0.07	0.07	0.09	0.12
Yield Strength (psi)	4021	3986	4094	4138	3942	4099
Break Strain (%)	675	517	417	542	452	327
NCTL-15% (hrs)	42.4	19.6	11.0	6.0	4.7	2.7
OIT (min)	83.0	55.4	44.3	37.5	31.3	24.2

**Virgin Resin 2 + (Natural Reprocessed PCR + 10% Virgin LLDPE)**

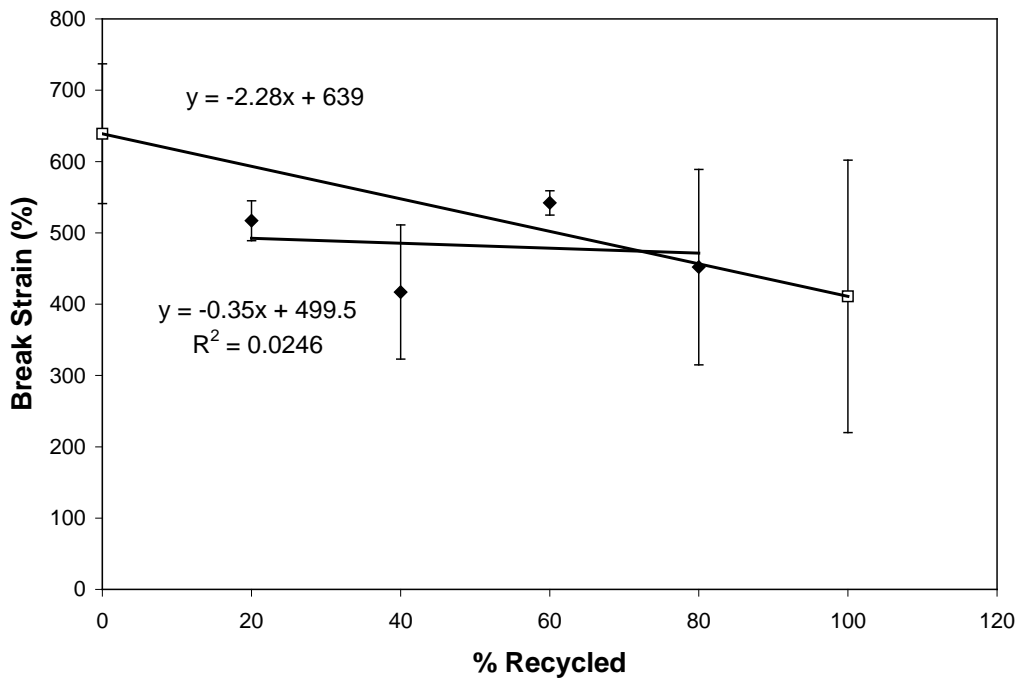
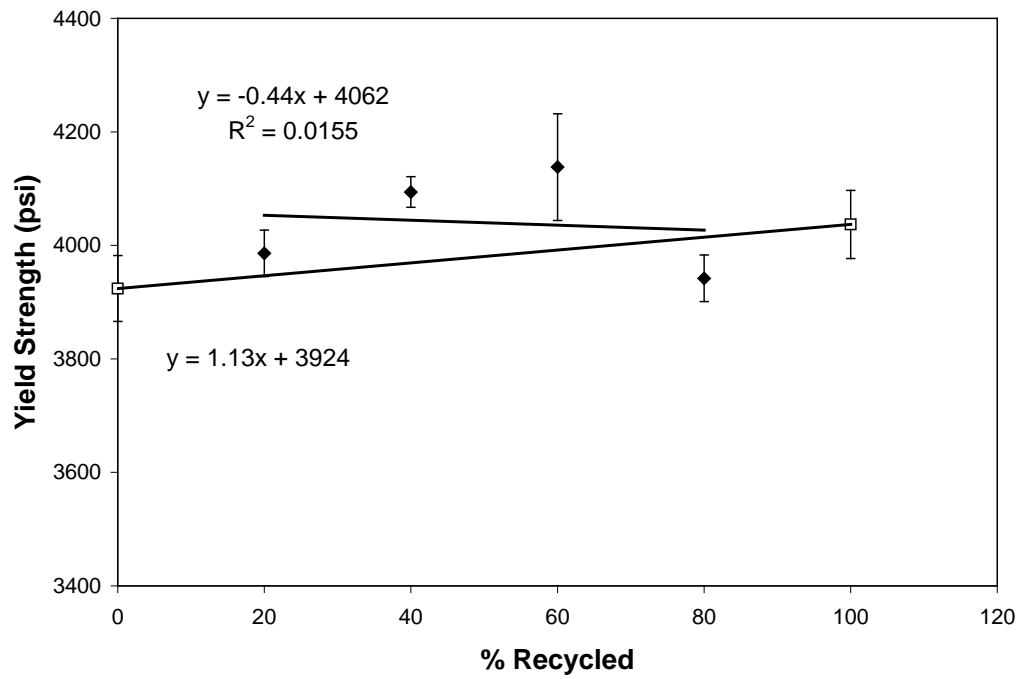


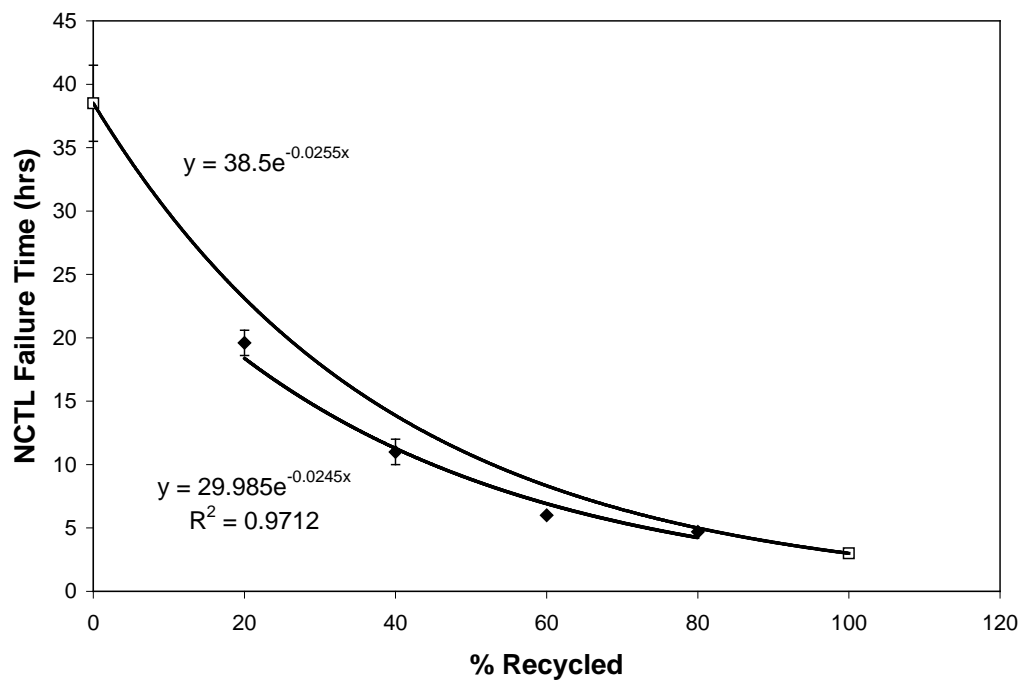


**Virgin Resin 2 + (Natural Reprocessed PCR + 10% Virgin LLDPE)**



**Virgin Resin 2 + (Natural Reprocessed PCR + 10% Virgin LLDPE)**





**Virgin Resin 2 + (Natural Reprocessed PCR + 10% Virgin LLDPE)**



# TEST RESULTS

## Recycled HDPE Blend

### Virgin Resin 2

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% Virgin Resin 2

Date: 28-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.952	0.952	0.952			0.952	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.33	0.32				0.33	
21.6 kg (g/10 min)	28.3	28.3				28.3	
Ratio						87	
<b>Composition</b>							
% Color/Ash	0.03	0.04	0.05			0.04	0.008
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3986	3932	4067	4092	4027	4021	57
Break Strain (%)	741	825	835	409	567	675	164
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	45.8	37.4	41.6	41.9	45.5	42.4	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	83.0					83.0	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + (Post Consumer Natural Reprocessed + 10% Virgin LLDPE)**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 80% Virgin Resin 2 + 20% (Nat. PCR + 10% LL)

Date: 28-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.946	0.946	0.946			0.946	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.35	0.35				0.35	
21.6 kg (g/10 min)	29.9	27.5				28.7	
Ratio						81	
<b>Composition</b>							
% Color/Ash	0.09	0.05	0.05			0.06	0.019
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3986	4043	3985	4000	3917	3986	41
Break Strain (%)	541	541	514	525	464	517	28
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	18.7	21.3	19.0	19.9	19.3	19.6	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	55.4					55.4	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + (Post Consumer Natural Reprocessed + 10% Virgin LLDPE)**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X)  
Sample: 60% Virgin Resin 2 + 40% (Nat. PCR + 10% LL)

Date: 28-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.946	0.946	0.946			0.946	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.38	0.39				0.39	
21.6 kg (g/10 min)	32.5	32.3				32.4	
Ratio						84	
<b>Composition</b>							
% Color/Ash	0.06	0.09	0.07			0.07	0.012
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4129	4100	4069	4116	4057	4094	27
Break Strain (%)	503	270	400	380	533	417	94
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	10.7	12.0	10.8	10.7	10.8	11.0	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	44.3					44.3	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + (Post Consumer Natural Reprocessed + 10% Virgin LLDPE)**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 40% Virgin Resin 2 + 60% (Nat. PCR + 10% LL)

Date: 28-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.946	0.946	0.946			0.946	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.42	0.44				0.43	
21.6 kg (g/10 min)	36.5	36.6				36.6	
Ratio						86	
<b>Composition</b>							
% Color/Ash	0.08	0.07	0.06			0.07	0.008
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4133	3960	4173	4208	4216	4138	94
Break Strain (%)	564	542	541	512	550	542	17
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	6.2	5.9	5.9	5.9	5.9	6.0	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	37.5					37.5	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + ( Post Consumer Natural Reprocessed + 10% Virgin LLDPE)**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X)  
Sample: 20% Virgin Resin 2 + 80% (Nat. PCR + 10% LL)

Date: 28-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.945	0.945	0.945			0.945	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.52	0.55				0.54	
21.6 kg (g/10 min)	43.3	42.3				42.8	
Ratio						80	
<b>Composition</b>							
% Color/Ash	0.10	0.09	0.08			0.09	0.008
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4014	3928	3958	3914	3897	3942	41
Break Strain (%)	535	478	185	503	561	452	137
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	4.7	5.2	4.5	4.6	4.7	4.7	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	31.3					31.3	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Natural Reprocessed + 10% Virgin LLDPE**  
**100%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: 100% (Nat. PCR + 10% LL)

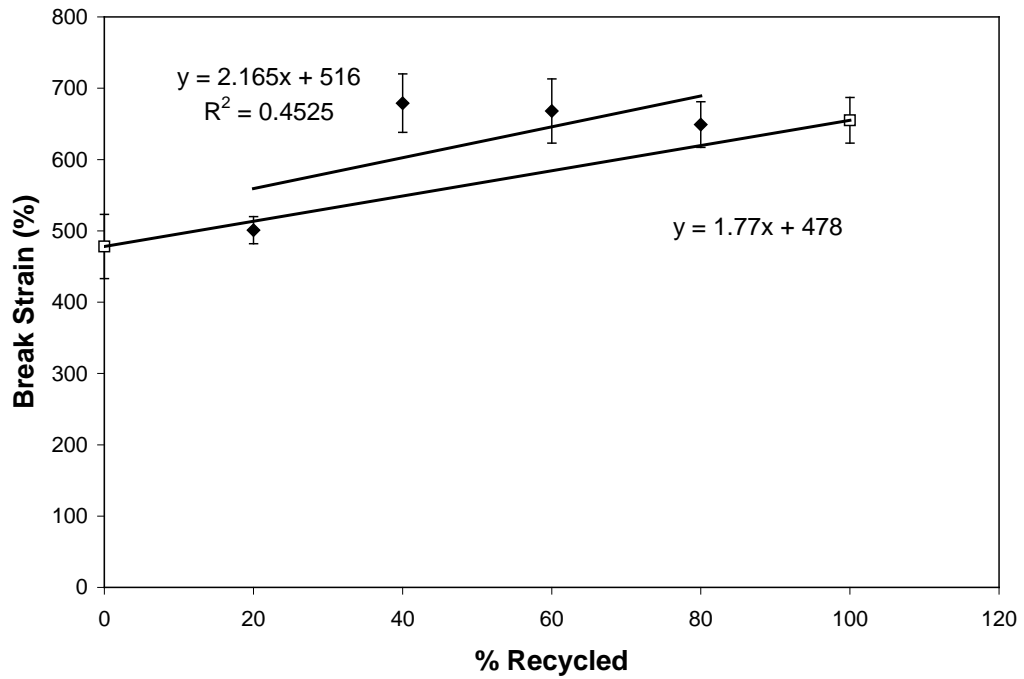
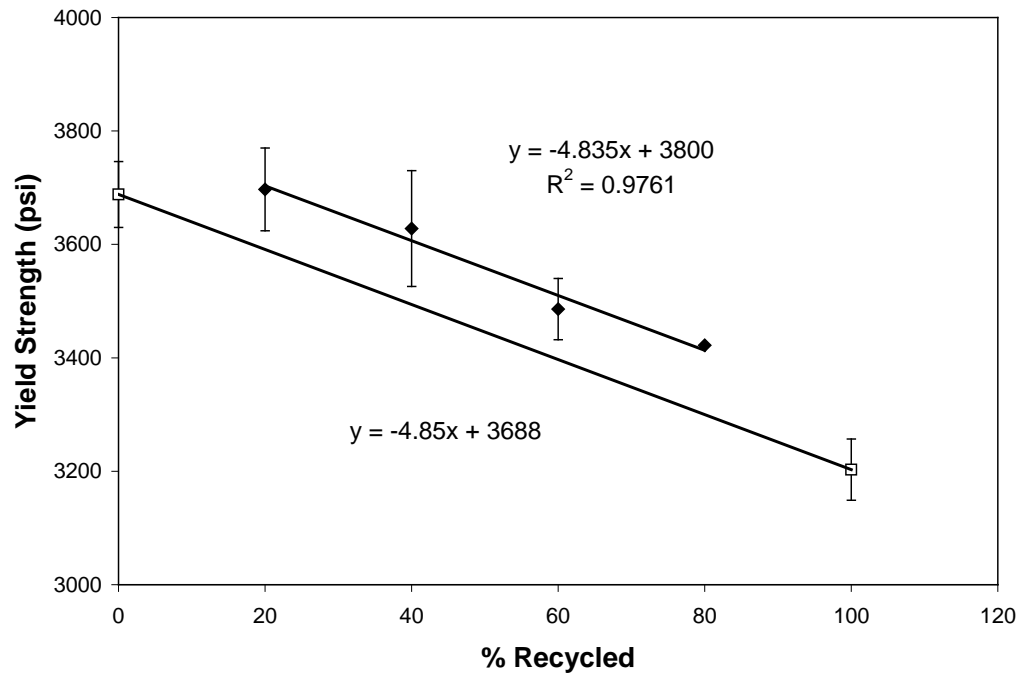
Date: 28-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.956	0.956	0.956			0.956	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.65	0.67				0.66	
21.6 kg (g/10 min)	45.8	47.6				46.7	
Ratio						71	
<b>Composition</b>							
% Color/Ash	0.10	0.16	0.11			0.12	0.026
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	4104	4042	4125	4145	4081	4099	36
Break Strain (%)	208	100	547	568	210	327	193
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	2.6	2.7	2.7	2.6	2.7	2.7	0
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	24.2					24.2	

**Virgin Resin 1 + (Natural Reprocessed PCR + 35% LLDPE)**

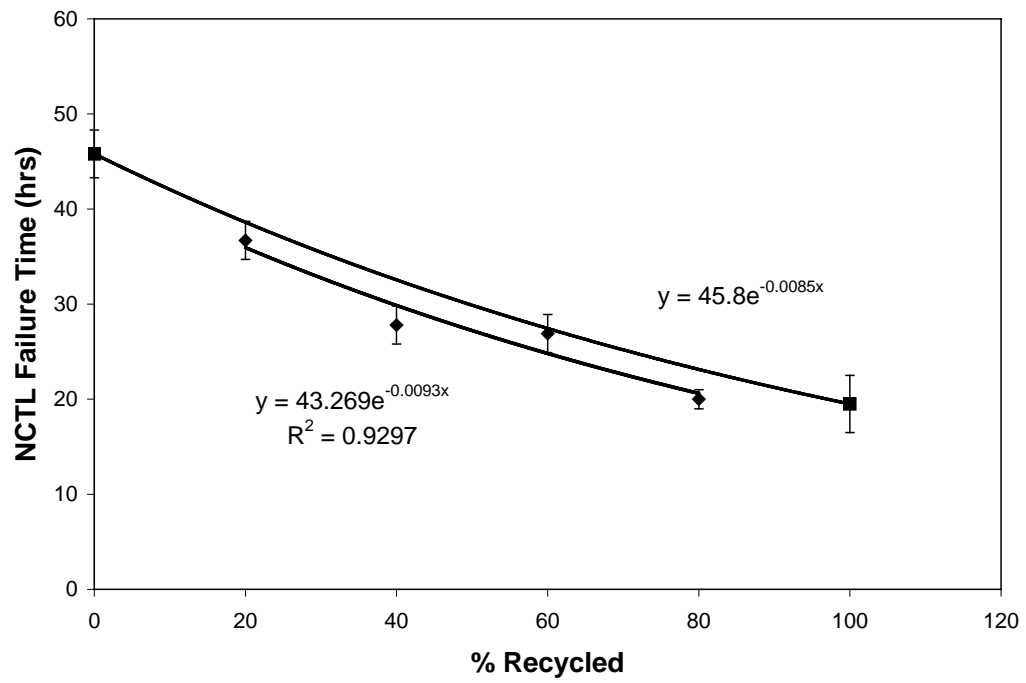
Property	Recycle Content					
	0% Recycle	13% Recycle	26% Recycle	39% Recycle	52% Recycle	65% Recycle
Density g/cm <sup>3</sup>						
Melt Index g/10 min						
Flow Rate g/10 min						
MFR (21.6/2.16kg)						
% Color + Ash						
% PP						
Yield Strength (psi)		3697	3628	3486	3422	3203
Break Strain (%)		501	679	668	649	655
NCTL-15% (hrs)		36.7	27.8	26.9	20.0	19.5
OIT (min)						

**Virgin Resin 1 + (Natural Reprocessed PCR + 35% LLDPE)**





**Virgin Resin 1 + (Natural Reprocessed PCR + 35% LLDPE)**



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + (PCR Natural + 35% LLDPE)**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 20% N35LL

Date: 24-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)						<div></div>	
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)						<div></div>	
21.6 kg (g/10 min)						<div></div>	
Ratio						<div></div>	
<b>Composition</b>							
% Color/Ash						<div></div>	
% PP						<div></div>	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3685	3618	3693	3781	3708	<div>3697</div>	52
Break Strain (%)	458	553	518	475		<div>501</div>	37
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	34.6	34.7	36.5	41.1	36.6	<div>36.7</div>	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						<div></div>	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + (PCR Natural + 35% LLDPE)**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 40% N35LL (26% Recycled)

Date: 24-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)						<div></div>	
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)						<div></div>	
21.6 kg (g/10 min)						<div></div>	
Ratio						<div></div>	
<b>Composition</b>							
% Color/Ash						<div></div>	
% PP						<div></div>	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3678	3620	3630	3714	3500	<div>3628</div>	73
Break Strain (%)	685	662	699	698	652	<div>679</div>	19
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	27.4	31.2	26.5	26.3	27.6	<div>27.8</div>	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						<div></div>	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + (PCR Natural + 35% LLDPE)**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 60% N35LL (39% Recycled)

Date: 24-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)						<div></div>	
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)						<div></div>	
21.6 kg (g/10 min)						<div></div>	
Ratio						<div></div>	
<b>Composition</b>							
% Color/Ash						<div></div>	
% PP						<div></div>	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3597	3575	3438	3315	3507	<div>3486</div>	102
Break Strain (%)	667	716	712	629	616	<div>668</div>	41
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	26.5	26.5	24.6	26.3	30.4	<div>26.9</div>	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						<div></div>	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + (PCR Natural + 35% LLDPE)**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: VR1 + 80% N35LL (52% Recycled)

Date: 24-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)						<div></div>	
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)						<div></div>	
21.6 kg (g/10 min)						<div></div>	
Ratio						<div></div>	
<b>Composition</b>							
% Color/Ash						<div></div>	
% PP						<div></div>	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3458	3408	3366	3507	3371	<div>3422</div>	54
Break Strain (%)	713	630	577	675	649	<div>649</div>	45
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	18.9	21.9	20.4	20.4	18.5	<div>20.0</div>	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						<div></div>	

# TEST RESULTS

## Recycled HDPE Blend

### PCR Natural + 35% LLDPE

Material: Plaque from blended resin (MB 3X @ 100 Mesh)  
Sample: 100% N35LL (65% Recycled)

Date: 24-Aug-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)						<div></div>	
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)						<div></div>	
21.6 kg (g/10 min)						<div></div>	
Ratio						<div></div>	
<b>Composition</b>							
% Color/Ash						<div></div>	
% PP						<div></div>	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3233	3111	3176	3268	3226	<div>3203</div>	54
Break Strain (%)	607	678	632	660	696	<div>655</div>	32
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	15.4	23.7	17.5	20.5	20.5	<div>19.5</div>	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)						<div></div>	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Post Consumer Natural Reprocessed + Virgin LMDPE**  
**50% + 50%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: Nat Repro + 50% MDPE

Date: 13-Feb-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.947	0.947	0.947			0.947	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.36	0.35				0.35	
21.6 kg (g/10 min)	30.9	31.0				31.0	
Ratio						88	
<b>Composition</b>							
% Ash	0.05	0.07	0.10			0.07	0.021
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3429	3480	3443	3368	3386	3421	40
Break Strain (%)	733	224	643	661	464	545	183
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	36.7	26.9	36.0	31.5	30.0	32.2	4
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	113					113	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**PCR Natural Reprocessed + PIR Reprocessed LD**  
**65% + 35%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 65% PCR Nat + 35% PIR-LD

Date: 24-May-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.956	0.957	0.957			0.957	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.74	0.74				0.74	
21.6 kg (g/10 min)	42.2	41.7				42.0	
Ratio						57	
<b>Composition</b>							
% Volatiles							
% Color	1.46	1.46	2.11			1.68	0.306
% Ash						#DIV/0!	#DIV/0!
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3410	3400	3329	3486	3423	3410	64
Break Strain (%)	548	639	587	668		611	34
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	7.6	9.2	8.2	6.9	7.0	7.8	0.9
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	12.1					12.1	



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + Post Consumer Natural Reprocessed + Virgin MD**  
**50% + 25% + 25%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 50% VR3 + 25% Nat Repro + 25% MDPE

Date: 25-May-07  
TRI Log #: F7601

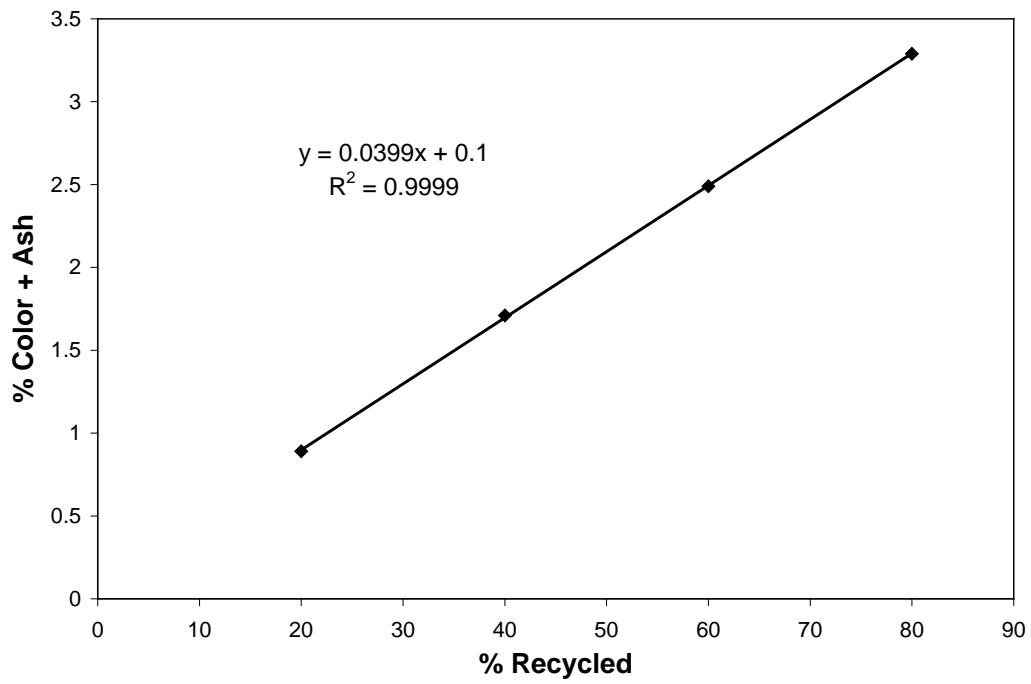
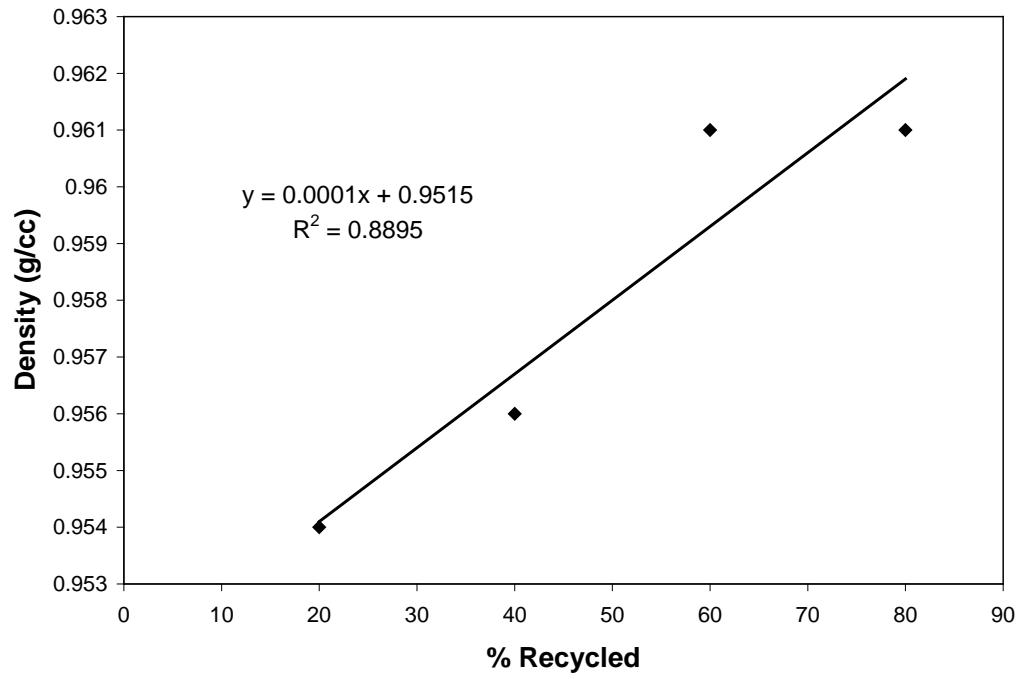
PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.942	0.942	0.942			0.942	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.33	0.31				0.32	
21.6 kg (g/10 min)	26.6	26.3				26.5	
Ratio						83	
<b>Composition</b>							
% Ash	0.08	0.04	0.06			0.06	0.016
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3507	3535	3430	3455	3366	3459	59
Break Strain (%)	661	483	653	669	665	626	72
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	33.7	36.7	38.0	34.0	35.6	35.6	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	65.9					65.9	

**C.10 SUMMARY TABLES, GRAPHS, AND TEST REPORTS  
FOR BLENDS MADE WITH POST-INDUSTRIAL  
RECYCLED HDPE**

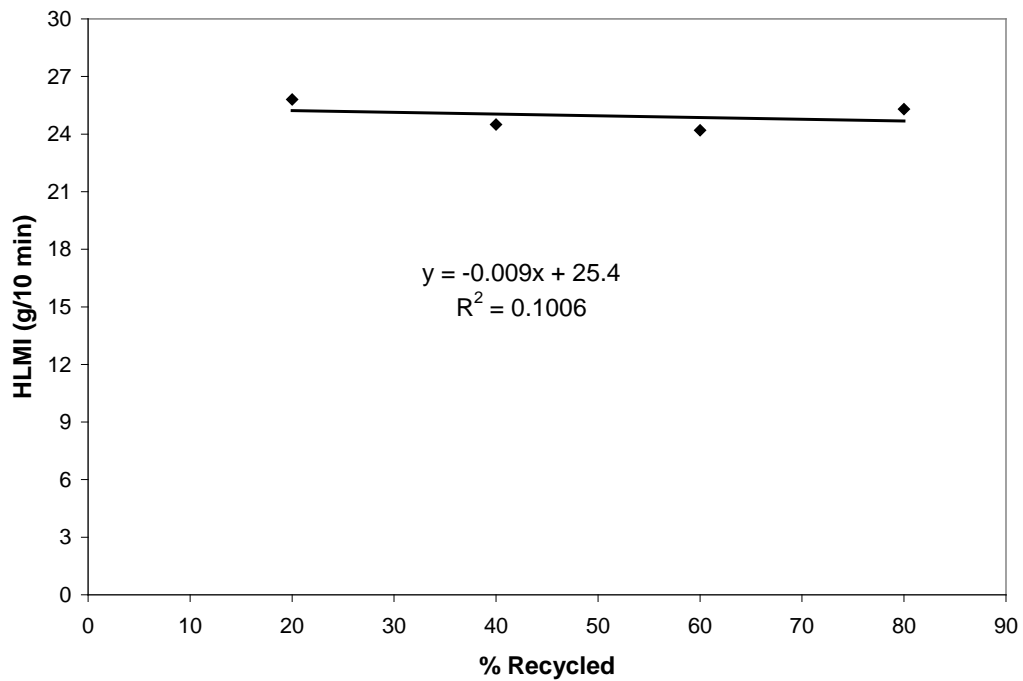
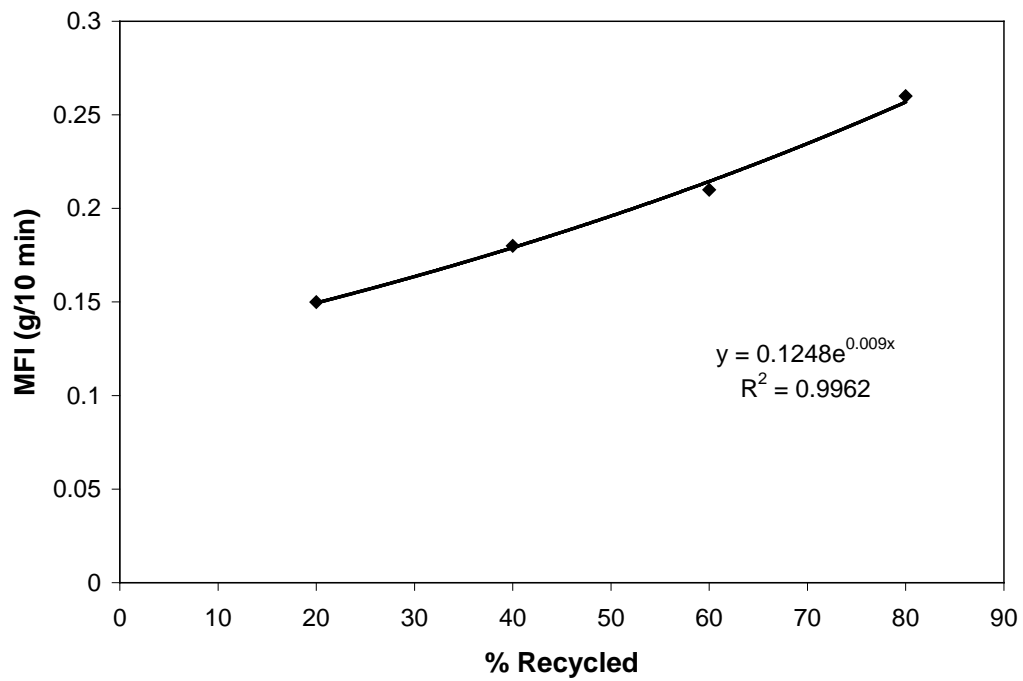
**Virgin Resin 1 + Post Industrial HD**

Property	Recycle Content					
	0% Recycle	20% Recycle	40% Recycle	60% Recycle	80% Recycle	100% Recycle
Density g/cm <sup>3</sup>	0.949	0.954	0.956	0.961	0.961	0.965
Melt Index g/10 min	0.15	0.15	0.18	0.21	0.26	0.31
Flow Rate g/10 min	25.9	25.8	24.5	24.2	25.3	26.0
MFR (21.6/2.16kg)	179	172	137	114	98	85
% Color + Ash	0.06	0.89	1.71	2.49	3.29	3.91
Yield Strength (psi)	3555	3723	3578	3406	3383	3087
Break Strain (%)	484	500	512	584	613	720
NCTL-15% (hrs)	47.6	43.6	59.6	64.6	72.9	91.1
OIT (min)	21.0	18.2	20.0	21.1	16.9	16.9

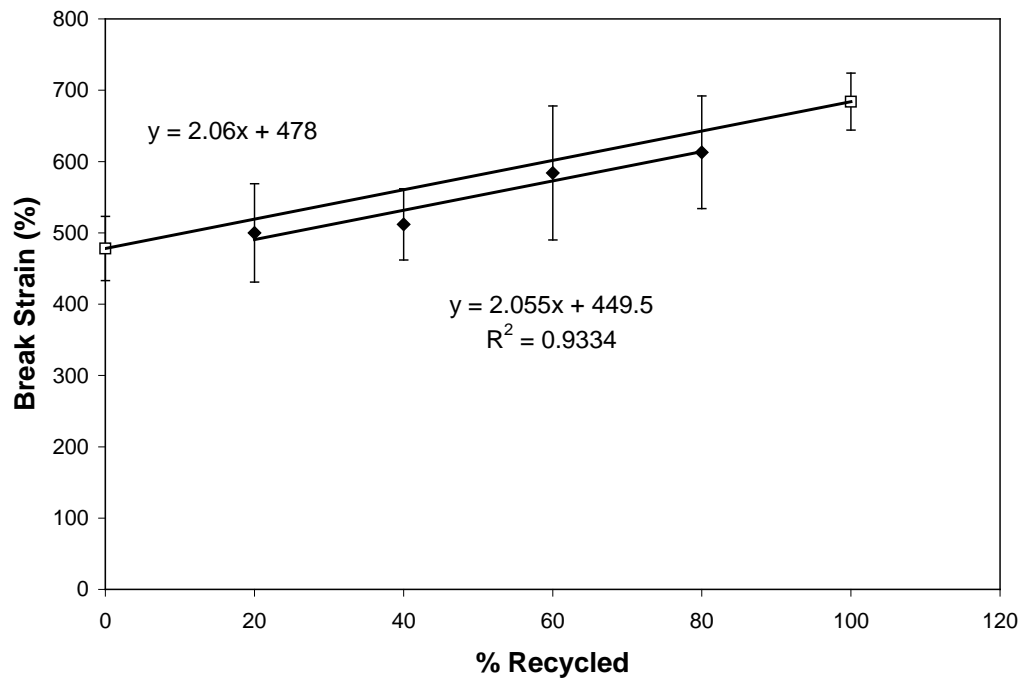
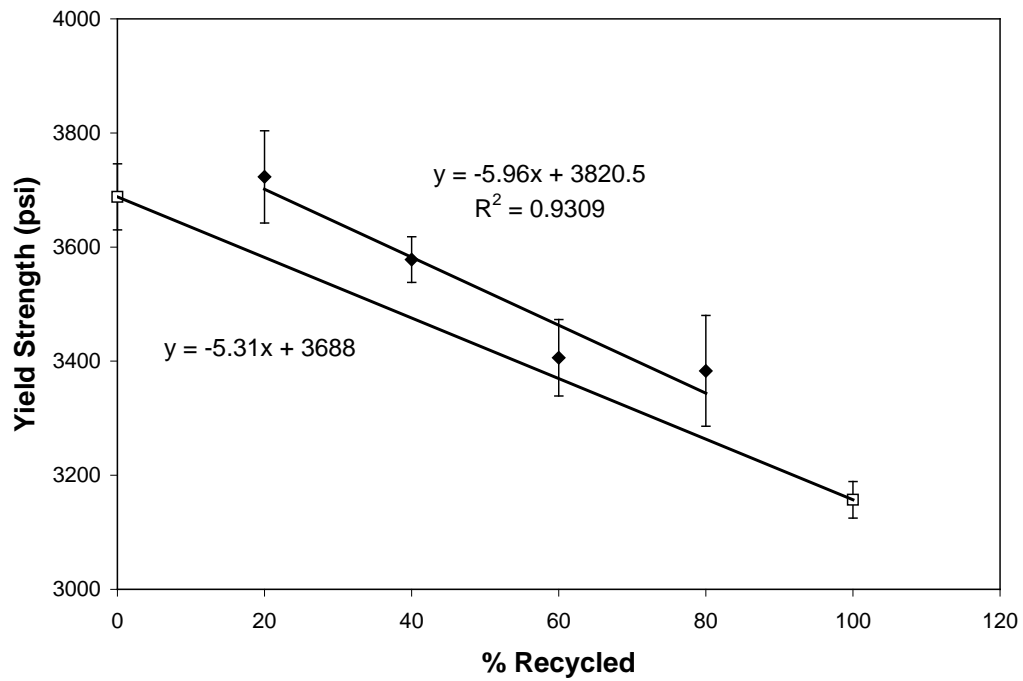
## Virgin Resin 1 + Post Industrial HD

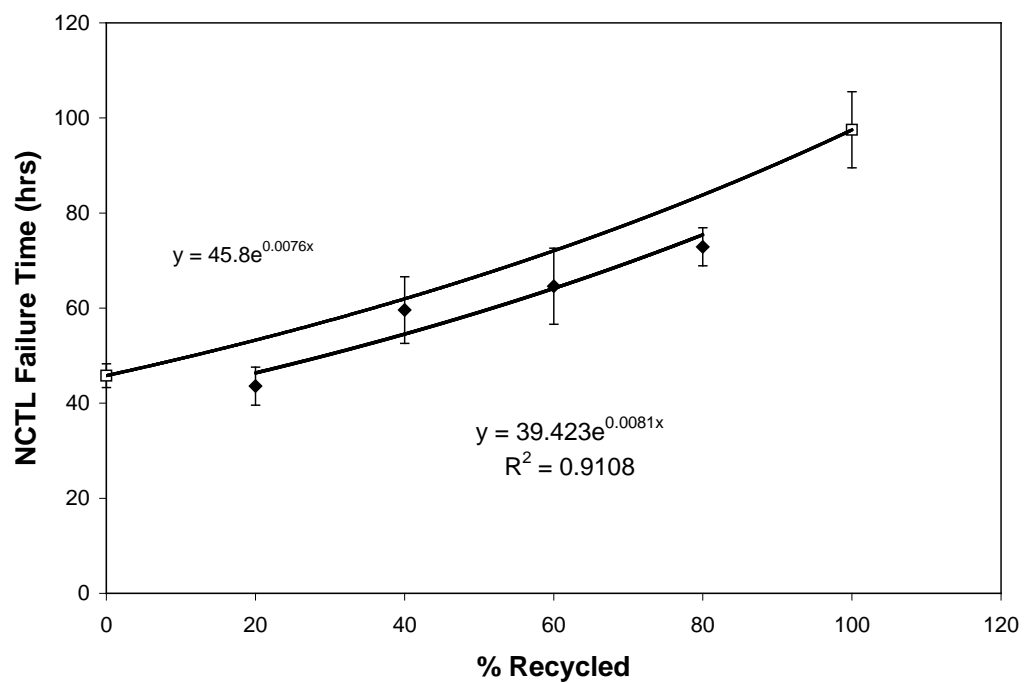


### Virgin Resin 1 + Post Industrial HD



### Virgin Resin 1 + Post Industrial HD





**Virgin Resin 1 + Post Industrial HD**

# TEST RESULTS

## Recycled HDPE Blend

### Virgin Resin 1

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% VR1

Date: 19-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.949	0.949	0.949			0.949	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.15	0.15				0.15	
21.6 kg (g/10 min)	25.9	25.9				25.9	
Ratio						179	
<b>Composition</b>							
% Color/Ash	0.05	0.03	0.09			0.06	0.025
% PP	0					0.0	
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3592	3535	3586	3535	3528	3555	28
Break Strain (%)	513	491	479	445	493	484	22
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	49.3	50.1	45.8	42.2	50.4	47.6	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	21.0					21.0	



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Industrial Reprocessed HD)**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: VR1 + 20% PIR-HD

Date: 19-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.954	0.954	0.954			0.954	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.15					0.15	
21.6 kg (g/10 min)	25.9	25.7				25.8	
Ratio						172	
<b>Composition</b>							
% Color/Ash	0.92	0.88	0.87			0.89	0.022
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3625	3693	3681	3865	3750	3723	81
Break Strain (%)	449	471	633	498	449	500	69
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	39.1	39.4	42.5	47.0	50.1	43.6	4
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	18.2					18.2	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Industrial Reprocessed HD**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: VR1 + 40% PIR-HD

Date: 19-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.955	0.956	0.956			0.956	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.18	0.18				0.18	
21.6 kg (g/10 min)	24.6	24.3				24.5	
Ratio						137	
<b>Composition</b>							
% Color/Ash	1.71	1.71	1.71			1.71	0.000
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3535	3527	3597	3627	3603	3578	40
Break Strain (%)	450	601	514	481	512	512	50
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	55.6	53.1	70.9	64.4	53.9	59.6	7
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	20.0					20.0	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Industrial Reprocessed HD**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: VR1 + 60% PIR-HD

Date: 19-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.961	0.961	0.961			0.961	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.21	0.22				0.21	
21.6 kg (g/10 min)	24.3	24.0				24.2	
Ratio						114	
<b>Composition</b>							
% Color/Ash	2.44	2.51	2.51			2.49	0.033
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3514	3361	3438	3397	3320	3406	67
Break Strain (%)	613	414	561	689	641	584	94
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	68.0	70.1	73.4	56.8	54.5	64.6	8
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	21.1					21.1	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 1 + Post Industrial Reprocessed HD**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: VR1 + 80% PIR-HD

Date: 19-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.961	0.961	0.961			0.961	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.26	0.26				0.26	
21.6 kg (g/10 min)	25.1	25.4				25.3	
Ratio						98	
<b>Composition</b>							
% Color/Ash	3.18	3.35	3.33			3.29	0.076
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3507	3382	3466	3324	3236	3383	97
Break Strain (%)	608	611	719	649	477	613	79
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	64.6	73.5	77.7	73.3	75.2	72.9	4
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	16.9					16.9	

# TEST RESULTS

## Recycled HDPE Blend

### Post Industrial Reprocessed HD

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% PIR-HD

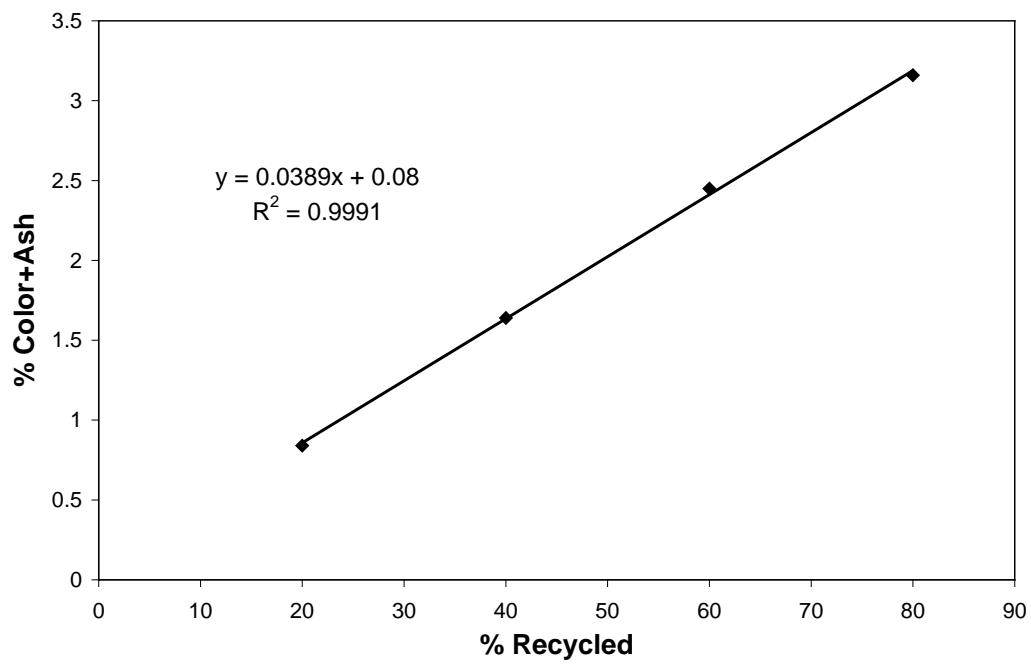
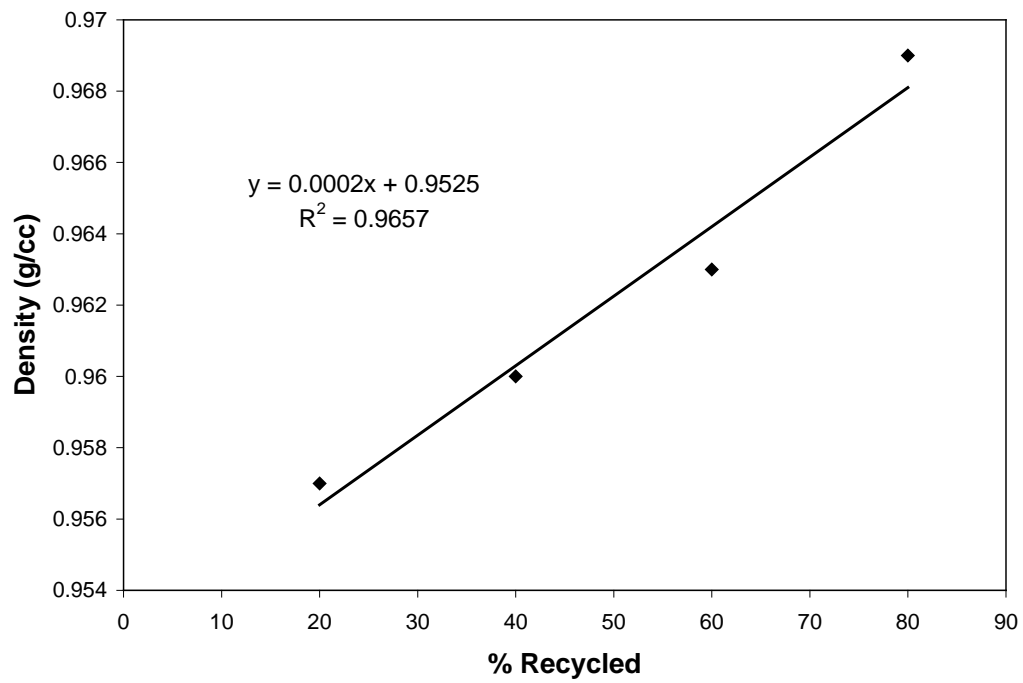
Date: 19-Jun-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.965	0.965	0.965			0.965	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.30	0.31				0.31	
21.6 kg (g/10 min)	25.7	26.3				26.0	
Ratio						85	
<b>Composition</b>							
% Color/Ash	3.94	3.94	3.86			3.91	0.038
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3132	3098	3097	3042	3068	3087	30
Break Strain (%)	720	736	717	712	714	720	9
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	77.3	82.3	98.0	101.1	96.6	91.1	9
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	16.9					16.9	

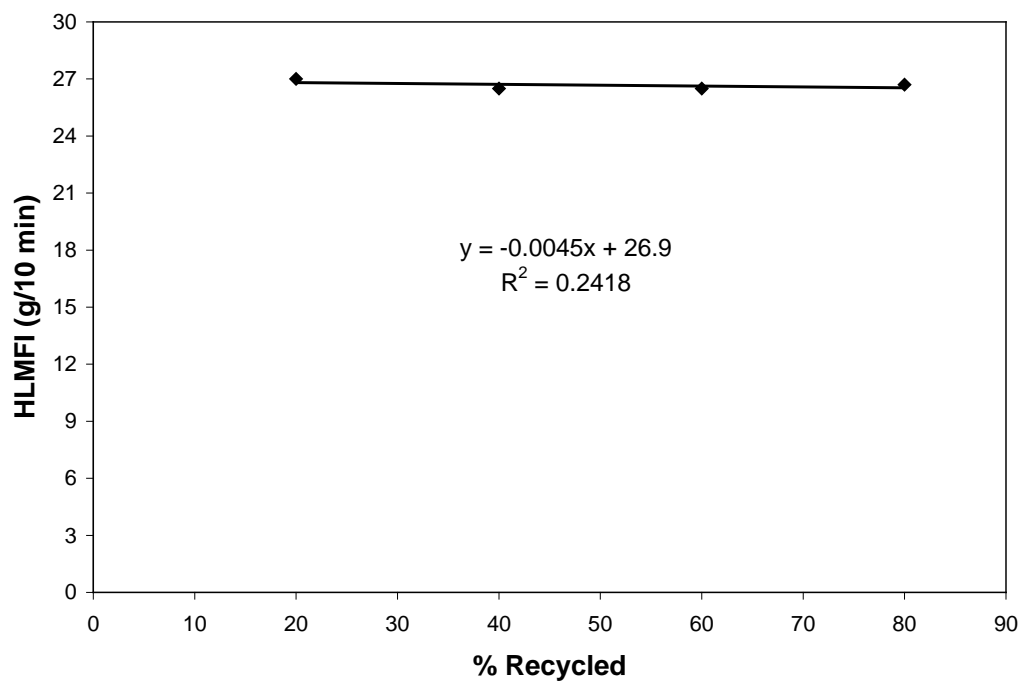
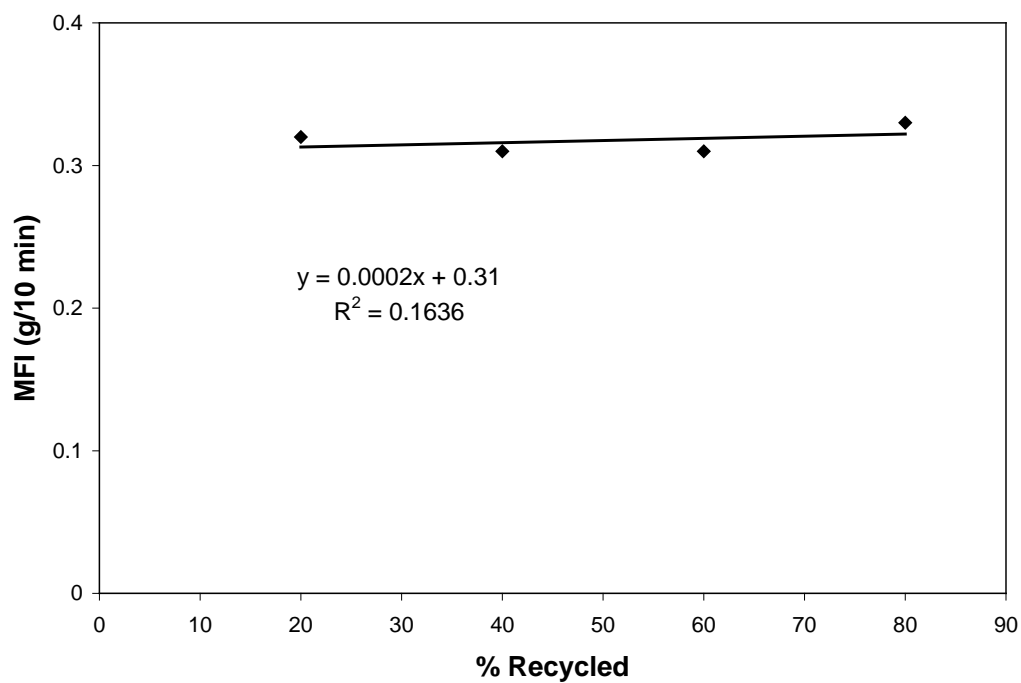
### Virgin Resin 2 + Reprocessed Post Industrial HD

Property	Recycled Content					
	0% Recycle	20% Recycle	40% Recycle	60% Recycle	80% Recycle	100% Recycle
Density g/cm <sup>3</sup>	0.952	0.957	0.960	0.963	0.969	0.970
Melt Index g/10 min	0.33	0.32	0.31	0.31	0.33	0.30
Flow Rate g/10 min	27.8	27.0	26.5	26.5	26.7	26.7
MFR (21.6/2.16kg)	84.2	84.5	85.8	85.5	80.9	89
% Black	0.02	0.84	1.64	2.45	3.16	3.84
Yield Strength (psi)	3834	3736	3592	3387	3249	3296
Break Strain (%)	595	569	678	603	547	612
NCTL-15% (hrs)	34.6	42.1	52.0	64.7	64.5	115
OIT (min)	80	66	46	34	22	19

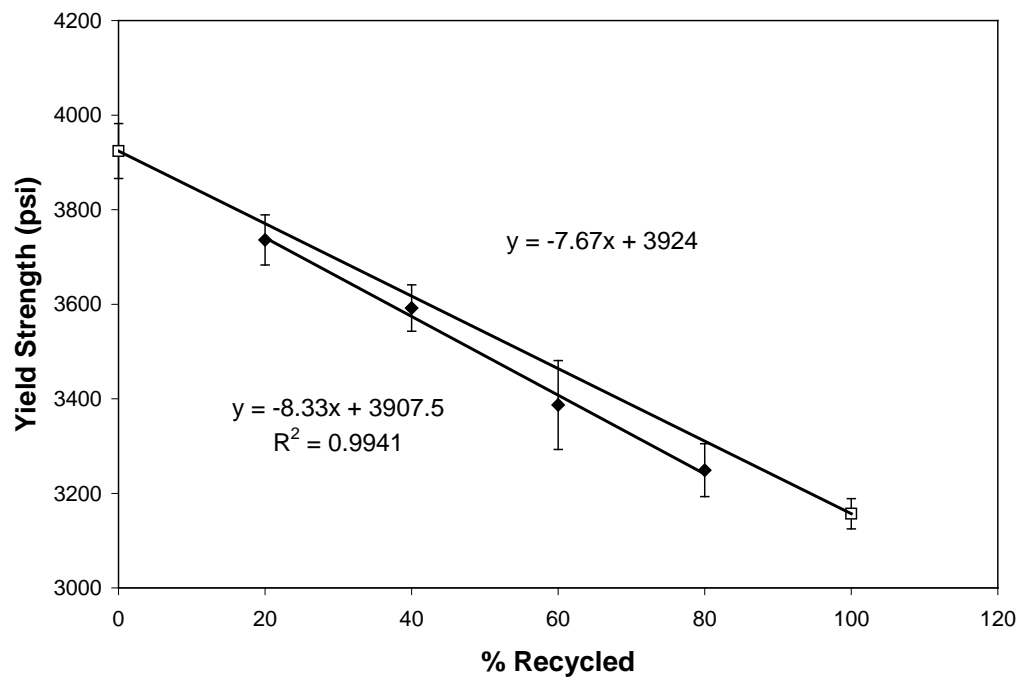
## Virgin Resin 2 + Reprocessed Post Industrial HD



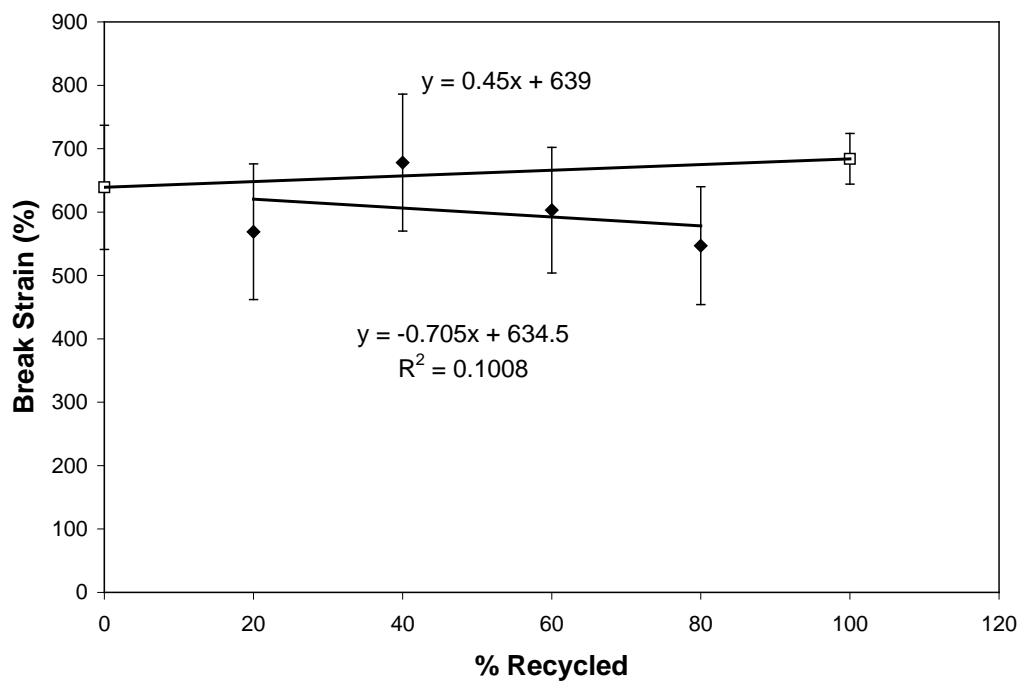
### Virgin Resin 2 + Reprocessed Post Industrial HD

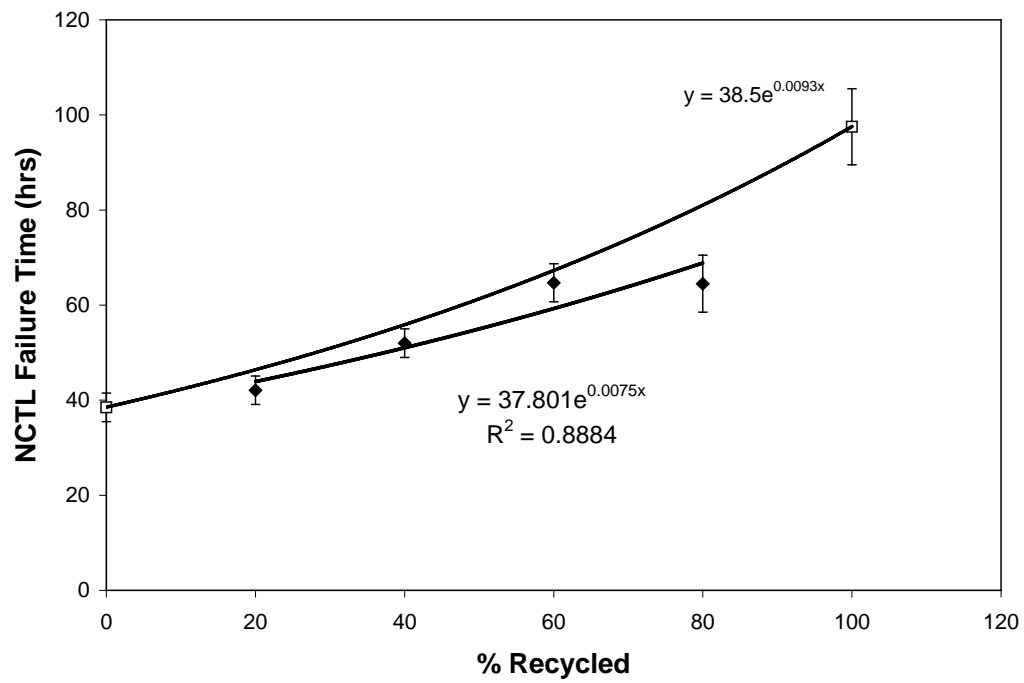






**Virgin Resin 2 + Reprocessed Post Industrial HD**





**Virgin Resin 2 + Reprocessed Post Industrial HD**

# TEST RESULTS

## Recycled HDPE Blend

### Virgin Resin 2

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% Virgin Resin 2

Date: 5-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.952	0.952	0.952			0.952	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.33	0.33				0.33	
21.6 kg (g/10 min)	27.8	27.9				27.9	
Ratio						84	
<b>Composition</b>							
% Color/Ash	0.02	0.02	0.02			0.02	0.000
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3959	3800	3908	3818	3684	3834	95
Break Strain (%)	693	714	485	489		595	109
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	34.9	34.4	32.8	35.5	35.5	34.6	1
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	80.5					80.5	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Industrial Reprocessed HD**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 80% VR2 + 20% PIR-HD

Date: 5-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.957	0.957	0.957			0.957	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.32	0.32				0.32	
21.6 kg (g/10 min)	36.9	27.2				32.1	
Ratio						101	
<b>Composition</b>							
% Color/Ash	0.89	0.80	0.82			0.84	0.039
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3817	3712	3773	3718	3662	3736	53
Break Strain (%)	465	696	695	454	536	569	107
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	44.7	40.8	46.3	39.1	39.8	42.1	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	65.7					65.7	

# TEST RESULTS

## Recycled HDPE Blend

### Virgin Resin 2 + Post Industrial Reprocessed HD 60% + 40%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 60% VR2 + 40% PIRHD

Date: 5-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.960	0.960	0.960			0.960	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.31	0.31				0.31	
21.6 kg (g/10 min)	26.8	26.3				26.6	
Ratio						86	
<b>Composition</b>							
% Color/Ash	1.56	1.75	1.61			1.64	0.080
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3643	3614	3592	3611	3500	3592	49
Break Strain (%)	720	747	657	478	786	678	108
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	51.8	47.5	50.7	53.9	56.3	52.0	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	46.2					46.2	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 2 + Post Industrial Reprocessed HD**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 40% VR2 + 60% PIR-HD

Date: 5-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.963	0.963	0.963			0.963	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.31	0.31				0.31	
21.6 kg (g/10 min)	26.4	26.6				26.5	
Ratio						85	
<b>Composition</b>							
% Color/Ash	2.38	2.49	2.49			2.45	0.052
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3487	3397	3487	3308	3254	3387	94
Break Strain (%)	572	517	491	684	751	603	99
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	67.2	71.5	58.8	62.8	63.1	64.7	4
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	34.3					34.3	

# TEST RESULTS

## Recycled HDPE Blend

### Virgin Resin 2 + Post Industrial Reprocessed HD 20% + 80%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 20% VR2 + 80% PIR-HD

Date: 5-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.968	0.968	0.968			0.968	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.34	0.33				0.33	
21.6 kg (g/10 min)	26.6	26.8				26.7	
Ratio						80	
<b>Composition</b>							
% Color/Ash	3.19	3.14	3.15			3.16	0.022
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3338	3222	3230	3280	3174	3249	56
Break Strain (%)	632	466	471	480	685	547	93
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	67.4	72.1	53.7	67.0	62.4	64.5	6
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	22.1					22.1	

# TEST RESULTS

## Recycled HDPE Blend

### Post Industrial Reprocessed HD

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% PIR-HD

Date: 5-Jul-07  
TRI Log #: F7601

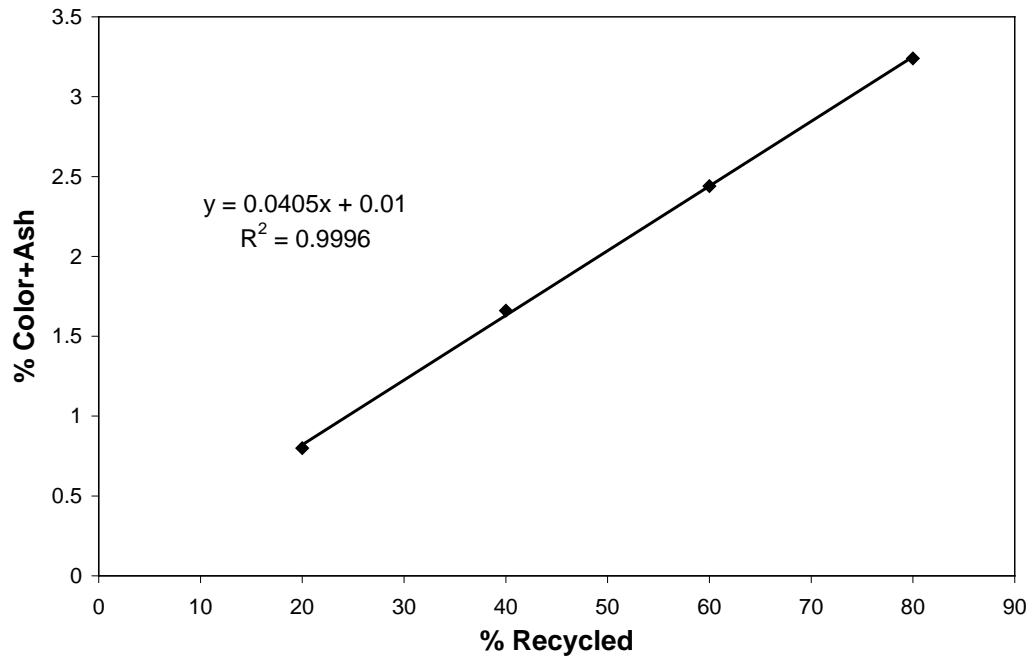
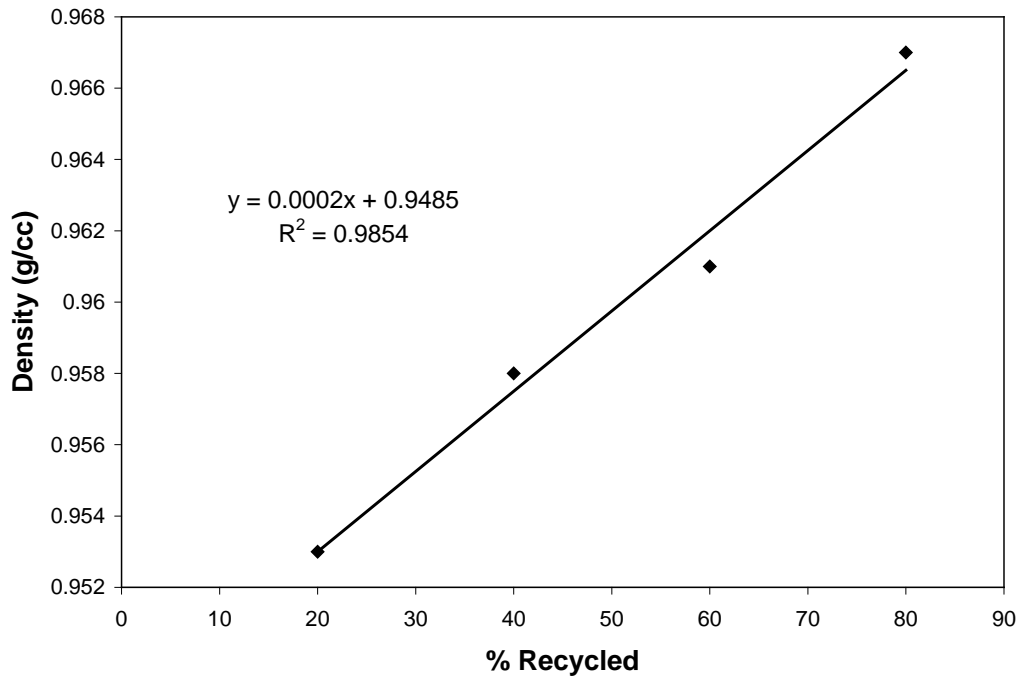
PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.970	0.970	0.970			0.970	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.30	0.31				0.31	
21.6 kg (g/10 min)	26.5	27.0				26.8	
Ratio						88	
<b>Composition</b>							
% Color/Ash	3.89	3.83	3.79			3.84	0.041
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3303	3233	3312	3333	3300	3296	34
Break Strain (%)	588	684	424	697	669	612	102
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	108.0	110.0	127.0	108.0	120.0	114.6	8
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	18.8					18.8	



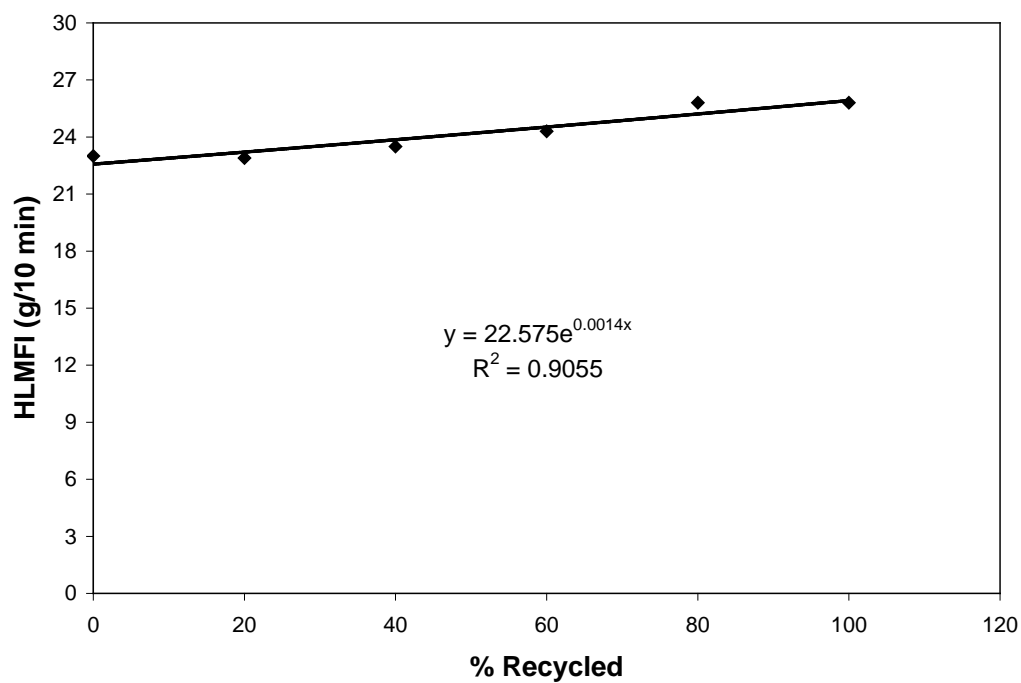
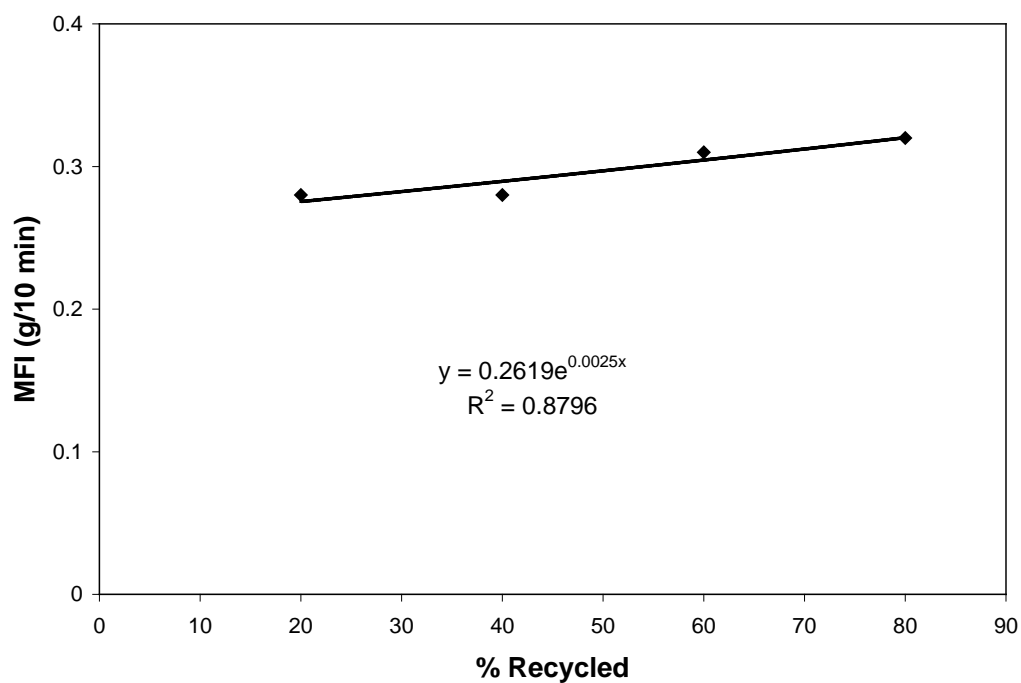
**Virgin Resin 3 + Post Industrial Reprocessed HDPE**

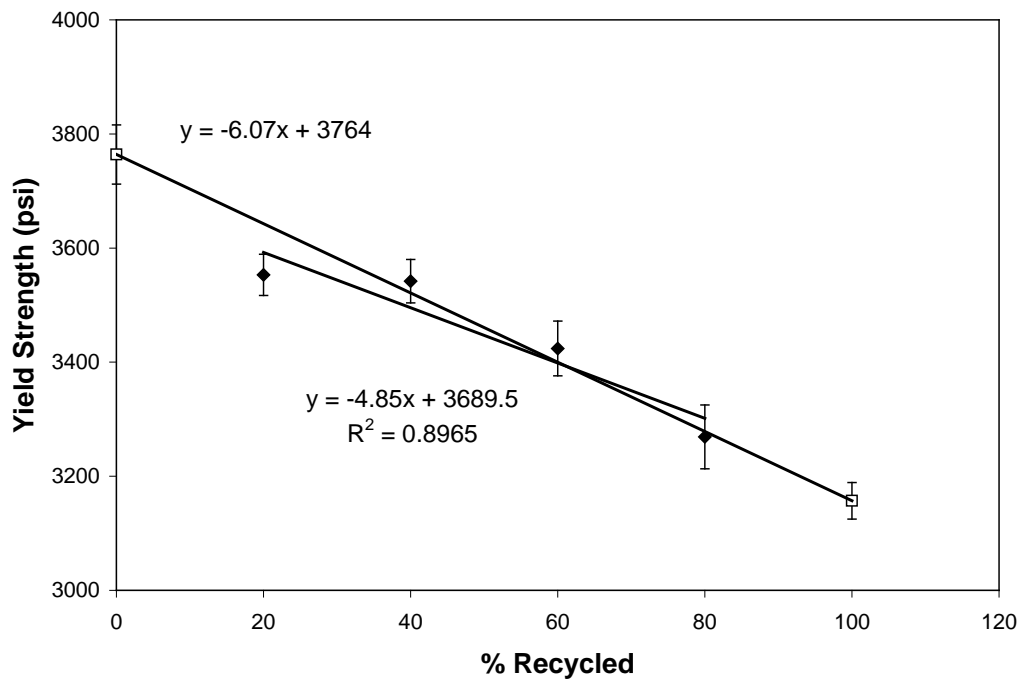
Property	Recycle Content					
	0% Recycle	20% Recycle	40% Recycle	60% Recycle	80% Recycle	100% Recycle
Density g/cm <sup>3</sup>	0.949	0.953	0.958	0.961	0.967	0.970
Melt Index g/10 min	0.27	0.28	0.28	0.31	0.32	0.31
Flow Rate g/10 min	23.0	22.9	23.5	24.3	25.8	25.8
MFR (21.6/2.16kg)	84	80	83	78	80	84
% Black	0.05	0.80	1.66	2.44	3.24	4.10
Yield Strength (psi)	3849	3553	3542	3424	3269	3088
Break Strain (%)	641	733	769	737	765	720
NCTL-15% (hrs)	28	43.3	41.4	55.6	64.8	86.5
OIT (min)	43.0	38.1	32.5	31.8	19.6	18.7

### Virgin Resin 3 + Post Industrial Reprocessed HDPE

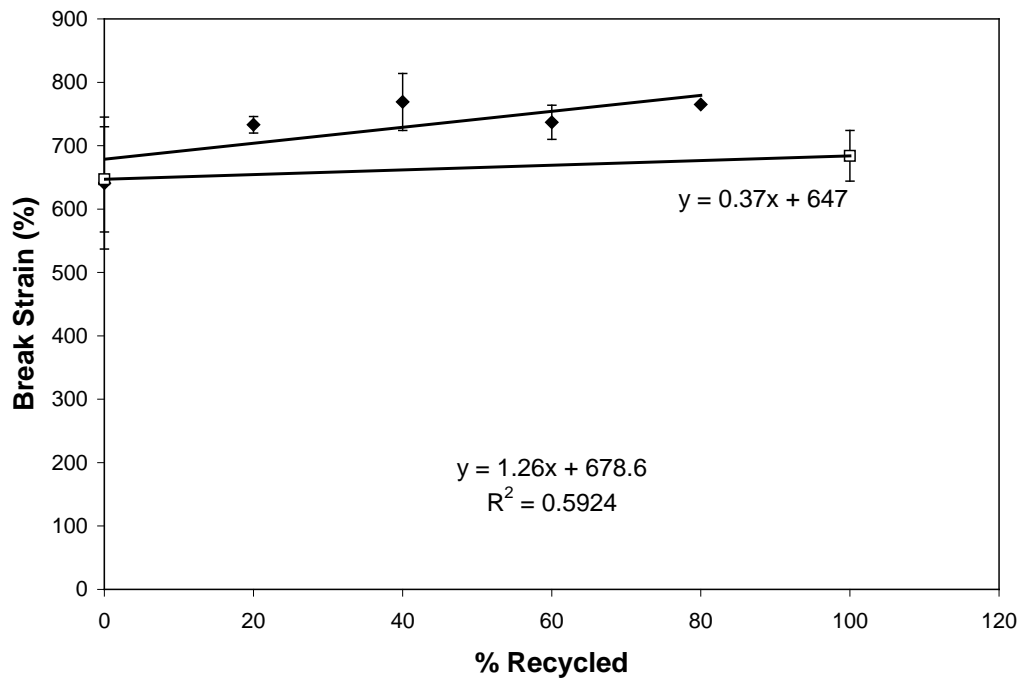


### Virgin Resin 3 + Post Industrial Reprocessed HDPE

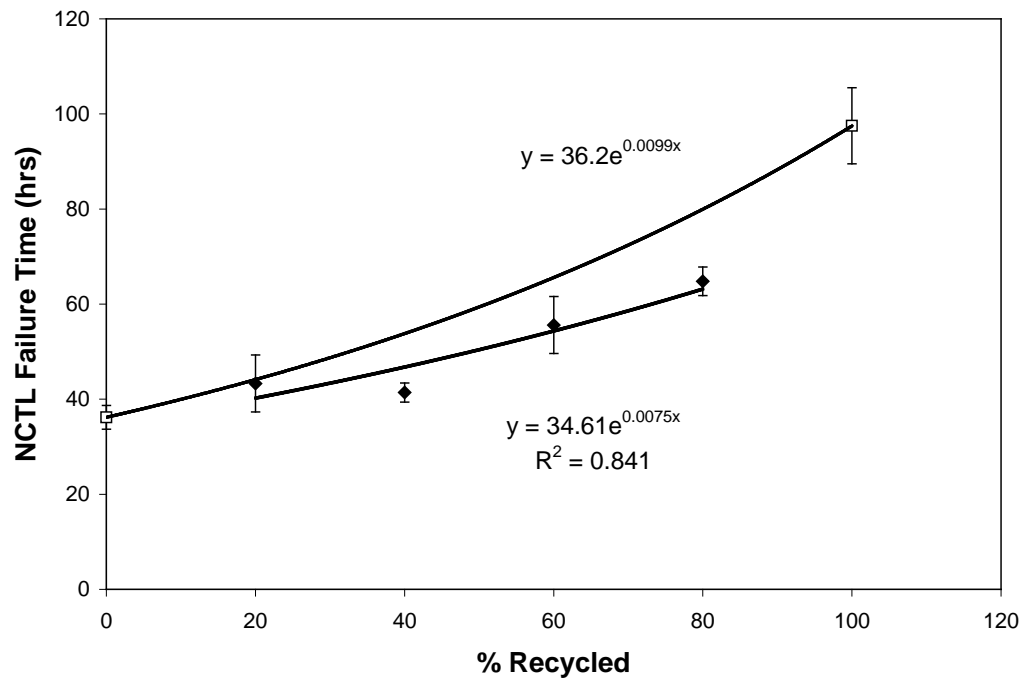




**Virgin Resin 3 + Post Industrial Reprocessed HDPE**



# Virgin Resin 3 + Post Industrial Reprocessed HDPE



# TEST RESULTS

## Recycled HDPE Blend

### Virgin Resin 3

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% VR3

Date: 10-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.948	0.949	0.949			0.949	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.27	0.27				0.27	
21.6 kg (g/10 min)	23.1	22.8				23.0	
Ratio						84	
<b>Composition</b>							
% Color/Ash	0.06	0.06	0.02			0.05	0.019
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3810	3853	3904	3865	3814	3849	35
Break Strain (%)	740	690	659	571	547	641	72
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	28.4	28.0	24.0	28.3	31.5	28.0	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	43.0					43.0	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + Post Industrial Reprocessed HD**  
**80% + 20%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: VR3 + 20% PIR-HD

Date: 10-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.953	0.954	0.954			0.954	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.28	0.29				0.28	
21.6 kg (g/10 min)	22.9	22.9				22.9	
Ratio						80	
<b>Composition</b>							
% Color/Ash	0.79	0.81	0.80			0.80	0.008
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3592	3526	3597	3544	3505	3553	36
Break Strain (%)	806	527	777	786	767	733	104
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	40.9	38.0	41.8	40.8	54.8	43.3	6
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	38.1					38.1	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + Post Industrial Reprocessed HD**  
**60% + 40%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: VR3 + 40% PIR-HD

Date: 10-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.958	0.958	0.958			0.958	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.28	0.29				0.28	
21.6 kg (g/10 min)	23.5	23.5				23.5	
Ratio						83	
<b>Composition</b>							
% Color/Ash	1.63	1.68	1.66			1.66	0.021
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3487	3535	3521	3584	3584	3542	38
Break Strain (%)	758	791	776	766	754	769	13
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	42.7	42.7	39.5	39.2	43.1	41.4	2
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	32.5					32.5	



**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + Post Industrial Reprocessed HD**  
**40% + 60%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: VR3 + 60% PIR-HD

Date: 10-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.961	0.961	0.961			0.961	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.31	0.31				0.31	
21.6 kg (g/10 min)	24.2	24.3				24.3	
Ratio						78	
<b>Composition</b>							
% Color/Ash	2.43	2.47	2.41			2.44	0.025
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3429	3453	3423	3479	3338	3424	48
Break Strain (%)	779	776	722	656	750	737	45
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	57.6	66.2	52.8	52.0	49.6	55.6	6
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	31.8					31.8	

**TEST RESULTS**  
**Recycled HDPE Blend**  
**Virgin Resin 3 + Post Industrial Reprocessed HD**  
**20% + 80%**

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: VR3 + 80% PIR-HD

Date: 10-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.967	0.967	0.967			0.967	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.32	0.32				0.32	
21.6 kg (g/10 min)	25.8	25.7				25.8	
Ratio						80	
<b>Composition</b>							
% Color/Ash	3.24	3.31	3.16			3.24	0.061
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3371	3286	3243	3222	3225	3269	56
Break Strain (%)	786	800	752	724	763	765	27
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	64.0	62.7	69.8	62.7	64.8	64.8	3
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	19.6					19.6	

# TEST RESULTS

## Recycled HDPE Blend

### Reprocessed Post Industrial HD

### 100%

Material: Plaque from blended resin (MB 3X @ 150 Mesh)  
Sample: 100% PIR-HD

Date: 10-Jul-07  
TRI Log #: F7601

PARAMETER	Test Replicate Number					Mean	STD
	1	2	3	4	5		
<b>Density (ASTM D 1505)</b>							
Density (g/cm3)	0.970	0.970	0.970			0.970	0.000
<b>Melt Flow Index (ASTM D 1238)</b>							
2.16 kg (g/10min)	0.29	0.32				0.31	
21.6 kg (g/10 min)	25.9	25.7				25.8	
Ratio						84	
<b>Composition</b>							
% Color/Ash	3.83	4.08	4.38			4.10	0.225
<b>Tensile Properties (ASTM D 638)</b>							
Yield Strength (psi)	3132	3099	3097	3042	3068	3088	31
Break Strain (%)	720	736	717	712	714	720	9
<b>Environmental Stress Crack Resistance (ASTM D5397 @ 15% of Yield)</b>							
Failure Time (hours)	88.8	95.7	93.1	69.5	85.6	86.5	9
<b>Oxidative Stability (ASTM D 3895)</b>							
Induction Time (min) (ASTM D3895)	18.7					18.7	