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Ravenna, OH 44266



Customer Washington State Department of Ecology
Test Report ID A24-1325-001
Customer Report ID Antioxidant/Antiozonant Sidewall Study

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Report Authorized by Doug Foster 10/22/2024



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Test Report Prepared for

Washington State Department of Ecology

Customer Request Summary

Mixing and testing of various antioxidants/antiozonants in sidewall formulation to study effects on ozone resistance

Sampling and Handling of Materials

Unless otherwise noted, all customer provided materials were stored at room temperature and treated as homogenous lots respectively. When called for, sampling from individual lots was performed at random.

Sample Reference Identification

ACE Sample ID	Customer ID/Description	Notes
A24-1325-001-08	Control (No AO)	Test specimens cure 9 minutes at 170°C
A24-1325-001-09	IPPD	Test specimens cure 8 minutes at 170°C
A24-1325-001-10	Antioxidant 1076	Test specimens cure 9 minutes at 170°C
A24-1325-001-11	Rambutan Peel Extract	Test specimens cure 8 minutes at 170°C
A24-1325-001-12	Alpha-Tocopherol (Vitamin E)	Test specimens cure 9 minutes at 170°C
A24-1325-001-13	Octyl Gallate	Test specimens cure 11 minutes at 170°C
A24-1325-001-14	6PPD	Test specimens cure 9 minutes at 170°C

Narrative

IPPD and 6PPD performed the best out of the compounds with cracking starting at 22 hours but breakage not occurring until after the 96 hour mark. Antioxidant 1076 and Vitamin E did not perform any better than the control compound. Rambutan Peel and Octyl Gallate performed worse than the control.

These studies were done at equal part loading. Higher loadings of potential 6PPD alternatives may or may not narrow the gap in performance.

Formulations

Material	A24-1325-001-08	A24-1325-001-09	A24-1325-001-10	A24-1325-001-11	A24-1325-001-12	A24-1325-001-13	A24-1325-001-14
Masterbatch							
Buna CB 24	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Natural Rubber SIR 10	50.00	50.00	50.00	50.00	50.00	50.00	50.00
Carbon Black N330	45.00	45.00	45.00	45.00	45.00	45.00	45.00
Zinc Oxide	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Extensoil 1996	5.00	5.00	5.00	5.00	5.00	5.00	5.00
Resinall R-1000	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Pepton 44	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Akrowax 195	1.50	1.50	1.50	1.50	1.50	1.50	1.50
Stearic Acid	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Akrochem 5073 Beads	1.50	1.50	1.50	1.50	1.50	1.50	1.50
TMQ	1.00	1.00	1.00	1.00	1.00	1.00	1.00
IPPD		2.00					
Antioxidant 1076			2.00				
Rambutan Peel Extract				2.00			
Alpha-Tocopherol					2.00		
Octyl Gallate						2.00	
6PPD							2.00
Final Pass							
Sulfur	1.00	1.00	1.00	1.00	1.00	1.00	1.00
TBBS	1.00	1.00	1.00	1.00	1.00	1.00	1.00
<i>Total phr</i>	<i>162.25</i>	<i>164.25</i>	<i>164.25</i>	<i>164.25</i>	<i>164.25</i>	<i>164.25</i>	<i>164.25</i>

Mixing Detail

Masterbatch (First Pass)

Time 0: Add Polymer and Peptizer
 Time 60 seconds: Add Carbon Black and Oil
 Temperature 200F: Sweep and add remaining materials
 Temperature 230F: Sweep
 Temperature 260F: Sweep
 Temperature 300F: Dump

Sample ID	Mix Time (min)	Dump Temp (F)	Probe Temp (F)	Yield
A24-1325-001-08	5.66	300	297	99.3
A24-1325-001-09	5.91	300	298	99.6
A24-1325-001-10	6.03	300	298	99.0
A24-1325-001-11	6.30	300	293	99.5
A24-1325-001-12	6.50	300	295	99.6
A24-1325-001-13	6.40	300	303	98.6
A24-1325-001-14	6.23	300	302	99.5

Final Pass

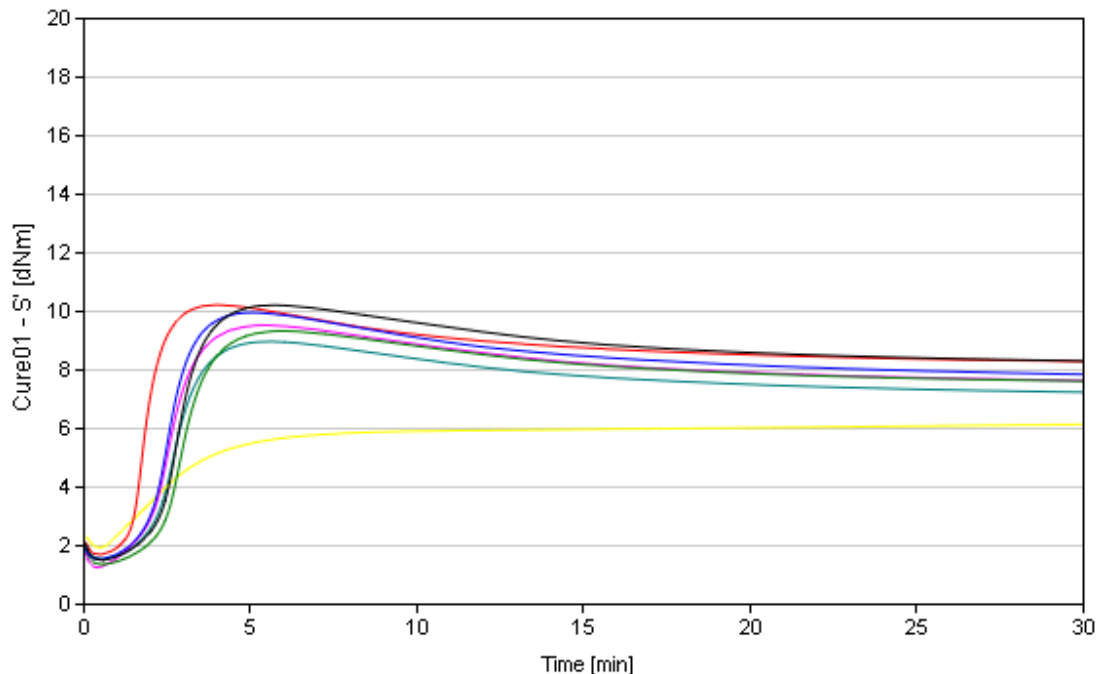
Time 0: Add ½ Polymer, Curatives, and ½ Polymer (Sandwich loading)
 Temperature 180F: Sweep
 Temperature 215F: Dump

Sample ID	Mix Time (min)	Dump Temp (F)	Probe Temp (F)	Yield
A24-1325-001-08	1.85	215	226	100.0
A24-1325-001-09	2.32	215	233	100.0
A24-1325-001-10	3.18	215	229	100.0
A24-1325-001-11	2.13	215	228	99.9
A24-1325-001-12	2.18	215	231	99.9
A24-1325-001-13	1.75	215	235	100.0
A24-1325-001-14	1.95	215	234	100.0

Testing Detail

ASTM D5289 - MDR

30 minutes @ 170°C



Sample ID	Color	Max (dNm)	Min (dNm)	Ts2 (min)	Tc90 (min)
A24-1325-001-08	Black	10.22	1.51	2.43	3.84
A24-1325-001-09	Blue	9.96	1.55	2.15	3.45
A24-1325-001-10	Green	9.34	1.36	2.59	4.03
A24-1325-001-11	Red	10.22	1.70	1.60	2.60
A24-1325-001-12	Fuchsia	9.53	1.26	2.12	3.57
A24-1325-001-13	Yellow	6.15	1.94	2.41	6.36
A24-1325-001-14	Teal	8.98	1.56	2.37	3.76

ASTM D1149 – Dynamic Ozone

Test slabs prepared utilizing tc90 + 8 minutes at 170°C





Specimens conditioned a minimum of 24 hours at standard laboratory conditions prior to testing


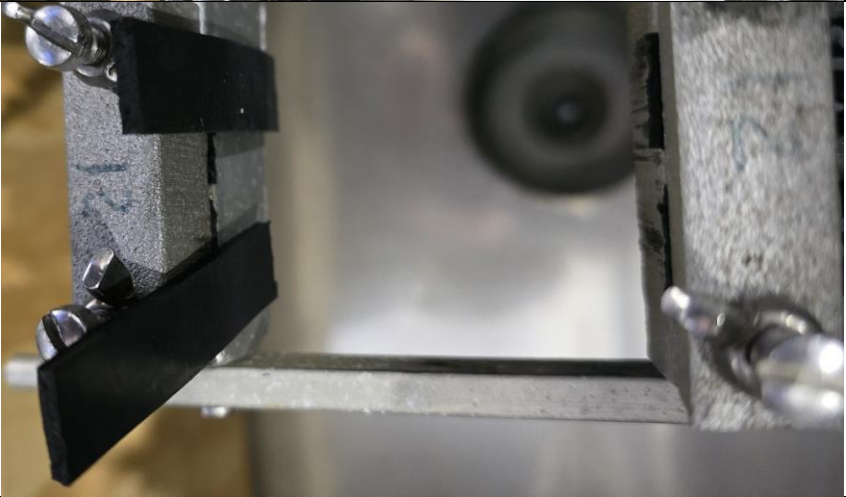

240 hours at 40°C/50pphm and 25% dynamic ozone at 30 cpm

Imagery on following page



Sample ID	Notes and observations
A24-1325-001-08	Observed fully broken at 22 hours exposure
A24-1325-001-09	Cracking at 22 hours, full break occurred between 96 hr and 168 hr check
A24-1325-001-10	Observed fully broken at 22 hours exposure
A24-1325-001-11	Observed fully broken at 7 hours exposure
A24-1325-001-12	Observed fully broken at 22 hours exposure
A24-1325-001-13	Observed fully broken at 7 hours exposure
A24-1325-001-14	Cracking at 22 hours, full break occurred between 96 hr and 168 hr check

24 hour check

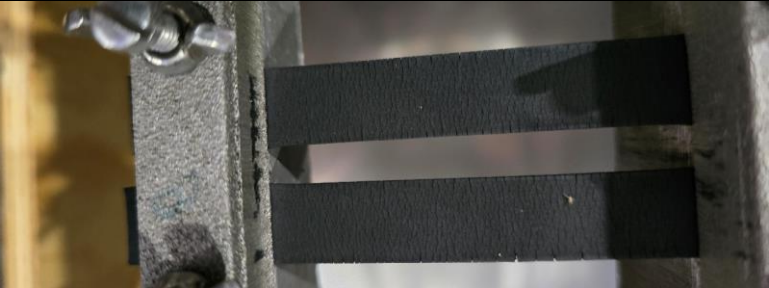
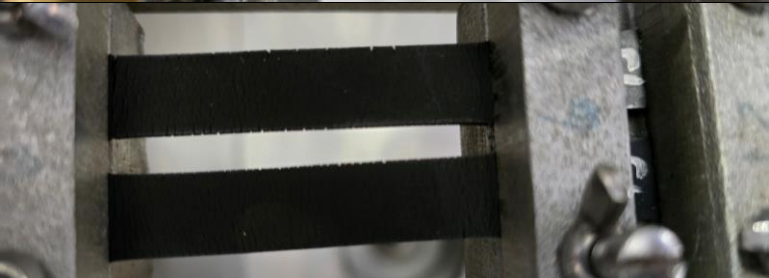
Sample ID	Imagery
A24-1325-001-08	
A24-1325-001-09	
A24-1325-001-10	
A24-1325-001-11	

A24-1325-001-12	
A24-1325-001-13	
A24-1325-001-14	


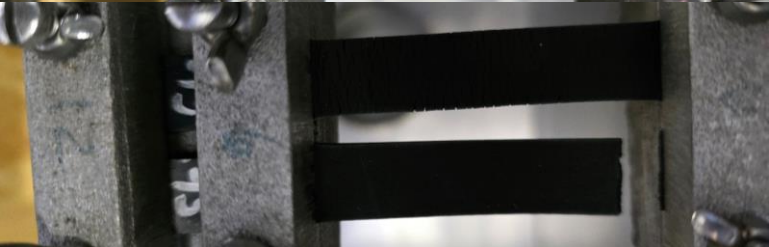
48 hour check

Sample ID	Imagery
A24-1325-001-09	
A24-1325-001-14	

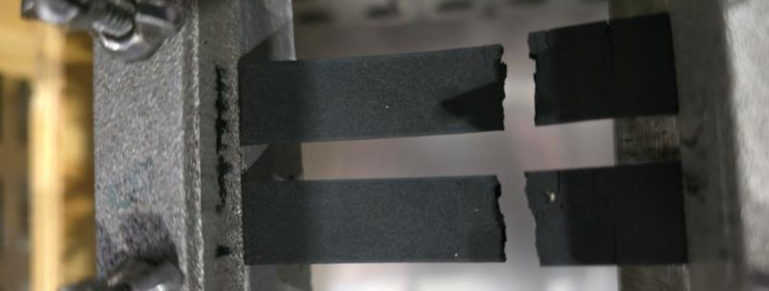
72 hour check

Sample ID	Imagery
A24-1325-001-09	
A24-1325-001-14	

96 hour check

Sample ID	Imagery
A24-1325-001-09	
A24-1325-001-14	

168 hour check

Sample ID	Imagery
A24-1325-001-09	
A24-1325-001-14	