

Ester Plasticizers in Hydrin

Recipe KS11-137

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6*</u>	<u>7</u>
Hydrin C2000L	100.0	100.0	100.0	100.0	100.0	100.0	100.0
N-330	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Stearic Acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Naugard 445	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vanox MTI	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Plasthall® 7006	20.0	-	-	-	-	-	-
Plasthall® 7050	-	20.0	-	-	-	-	-
Plasthall® DBEEA	-	-	20.0	-	-	-	-
Plasthall® DBEEEG	-	-	-	-	20.0	-	-
Plasthall® DOS	-	-	-	-	-	20.0	-
Paraplex® G-50	-	-	-	-	-	-	20.0
Plasthall® DBPPA	-	-	-	20.0	-	-	-
Sub Total	172.5	172.5	172.5	172.5	172.5	172.5	172.5

Mill Addition:

Calcium Carbonate	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Maglite® D	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Zisnet F-PT	0.8	0.8	0.8	0.8	0.8	0.8	0.8
DPG	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Santogard PVI	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Total	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>
Major Variable	7006	7050	DBEEA	DBPPA	DBEEEG	DOS	G-50

Viscosity and Curing Properties

Recipe KS11-137	1	2	3	4	5	6	7
Recipe Variable	7006	7050	DBEE A	DBPPA	DBEEEG	DOS	G-50

Mooney Viscosity at 125°C (257°F):

Minimum Viscosity	42.3	41.3	39.2	37.4	40.6	33.7	42.8
t5, min	8.3	7.3	7.7	8.8	7.7	12.0	8.5
t10, min	9.7	8.5	9.0	10.2	8.8	13.8	9.8
t35, min	12.5	10.8	11.5	13.2	11.2	17.8	12.8

Oscillating Disc Rheometer at 160°C (320°F):

ML lbf./in.	10.1	10.1	9.6	8.9	10.1	8.3	10.5
MH lbf./in.	39.1	45.0	44.5	42.9	51.1	33.3	47.7
ts2, min	2.8	2.8	2.8	2.8	2.8	3.0	2.7
t'c(90), min	19.5	21.8	22.8	24.2	24.3	18.7	23.5
1.25 x t'c(90), min	24.4	27.3	28.5	30.2	30.4	23.3	29.4
Cure Rate Index	6.0	5.3	5.0	4.7	4.7	6.4	4.8

Oscillating Disc Rheometer at 200°C (392°F):

ML lbf./in.	9.8	9.7	9.1	8.4	9.1	7.5	9.5
MH lbf./in.	49.0	44.5	44.4	41.6	46.4	30.0	37.4
ts2, min	1.2	1.0	1.0	1.2	1.0	1.2	1.0
t'c(90), min	7.2	4.3	4.3	4.3	4.0	3.7	3.7
1.25 x t'c(90), min	9.0	5.4	5.4	5.4	5.0	4.6	4.6
Cure Rate Index	16.7	30.0	30.0	31.7	33.3	40.0	37.5

*Compound showed exudation, testing discontinued.

Recipe KS11-137	1	2	3	4	5	7
Recipe Variable	7006	7050	DBEEA	DBPPA	DBEEEG	G-50

Original Physical Properties

Stress at 100% Elong, MPa	2.8	2.4	2.6	2.2	2.8	2.6
psi	400	350	375	325	400	375
Stress at 200% Elong., MPa	6.2	5.9	5.9	5.3	6.4	6.0
Stress at 300% Elong., MPa	9.1	8.6	8.8	7.9	9.1	8.8
Tensile, Ultimate, MPa	10.3	10.5	10.0	10.7	11.5	10.3
psi	1500	1525	1450	1550	1675	1500
Elongation at Break, %	365	405	375	465	395	405
Hardness, Duro A, pts.	64	61	63	62	64	63
Tear Resistance, ppi	236	250	237	239	249	250
Resilience, ave., pts.	32	33	32	31	34	28
Specific Gravity	1.378	1.389	1.379	1.374	1.391	1.400

Recipe KS11-137	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>7</u>
Recipe Variable	7006	7050	DBEEA	DBPPA	DBEEEG	G-50
<u>Compression Set, 70 h at 125°C</u>						
% Set	55	46	52	55	53	56
<u>Low Temperature Impact:</u>						
<u>Brittle Point:</u>						
<u>As Molded</u>						
All Pass, °C	-46	-45	-50	-48	-47	-40
<u>Air Oven Aging, 70 h at 150°C (302°F)</u>						
Stress at 100% Elong., MPa	4.8	4.1	4.5	4.5	4.1	4.1
psi	700	600	650	650	600	600
Stress Change, %	+75	+71	+73	+100	+50	+60
Tensile, Ultimate, MPa	10.0	8.8	9.7	9.1	8.6	9.7
psi	1450	1275	1400	1325	1250	1400
Tensile Change, %	-3.3	-16	-3.4	-15	-25	-6.7
Elongation at Break, %	205	200	200	200	200	195
Elongation Change, %	-44	-51	-47	-57	-49	-52
Hardness, Duro A, pts.	80	71	75	78	71	71
Hardness Change, pts.	+16	+10	+12	+16	7	+8
Weight Change, %	-10	-5.9	-9.2	-11	-4.4	-2.7
<u>ASTM 1 Oil, 70 h at 150°C (302°F)</u>						
Stress at 100% Elong., MPa	5.5	5.5	5.7	5.5	6.2	4.8
psi	800	800	825	800	900	700
Stress Change, %	+100	+129	+120	+146	+125	+87
Tensile, Ultimate, MPa	11.9	11.4	12.4	12.1	12.8	11.0
psi	1725	1650	1800	1750	1850	1600
Tensile Change, %	+15	+8.2	+24	+13	+10	+6.7
Elongation at Break, %	185	185	205	210	205	205
Elongation Change, %	-49	-54	-45	-55	-48	-49
Hardness, Duro A, pts.	75	75	76	78	75	71
Hardness Change, pts.	+11	+14	+13	+16	+11	+8
Volume Change, %	-13	-11	-12	-14	-12	-4.2
Weight Change, %	-9.6	-9.4	-9.9	-11	-9.6	-3.8

Recipe KS11-137	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>7</u>
Recipe Variable	7006	7050	DBEEA	DBPPA	DBEEEG	G-50
<u>ASTM Fuel C Immersion - 70 h at 23°C</u>						
Stress at 100% Elongation, MPa	3.7	3.9	3.7	3.0	3.9	3.9
psi	535	560	535	435	570	560
Stress Change, %	34	60	43	34	43	49
Tensile Ultimate, MPa	7.4	7.0	7.2	6.6	6.7	6.6
psi	1080	1015	1040	955	970	950
Tensile Change, %	-28	-33	-28	-38	-42	-37
Elongation at Break, %	215	185	200	250	175	175
Elongation Change, %	-41	-54	-47	-46	-56	-57
Hardness Duro A, pts	50	48	52	52	54	50
Hardness Change, pts.	-14	-13	-11	-10	-10	-13
Volume Change, %	15.3	24.5	23.2	20.6	23.1	33.3
Weight Change, %	12.4	12.7	12.5	11.2	12.1	19.1
<u>ASTM Fuel C Dry Out - 22 h at 70°C</u>						
Hardness Duro A, pts	75	72	75	76	76	71
Hardness Change, pts.	11	11	12	14	12	8
Volume Change, %	-17.3	-13.2	-13.9	-15.6	-13.9	-7.7
Weight Change, %	-12.6	-10.5	-10.4	-11.3	-10.6	-6.0
<u>IRM 903 Oil, 70 h at 150°C (302°F)</u>						
Stress at 100% Elong., MPa	4.8	4.5	4.5	4.5	5.2	4.0
psi	700	650	650	650	750	575
Stress Change, %	+75	+86	+73	+100	+88	+53
Tensile, Ultimate, MPa	10.0	9.8	10.2	10.5	9.3	9.7
psi	1450	1425	1475	1525	1350	1400
Tensile Change, %	-3.3	-6.6	+1.7	-1.6	-19	-6.7
Elongation at Break, %	215	205	220	240	185	220
Elongation Change, %	-41	-49	-41	-48	-53	-46
Hardness, Duro A, pts.	70	69	70	72	73	66
Hardness Change, pts.	+6	+8	+7	+10	+9	+3
Volume Change, %	-3.8	-3.3	-4.2	-5.5	-3.4	+4.1
Weight Change, %	-3.6	-4.1	-4.1	-4.9	-4.0	+1.4

Distilled Water, 70 h at 100°C (212°F)

Stress at 100% Elong., MPa	3.1	3.3	2.9	2.6	3.5	3.1
psi	450	475	425	375	500	450
Stress Change, %	+13	+36	+13	+15	+25	+20
Tensile, Ultimate, MPa	6.6	7.2	7.4	8.8	7.9	7.6
psi	950	1050	1075	1275	1150	1100
Tensile Change, %	-37	-31	-26	-18	-31	-27
Elongation @ Break, %	195	190	205	280	210	205
Elongation Change, %	-47	-53	-45	-40	-47	-49
Hardness, Duro A, pts.	51	48	53	53	49	53
Hardness Change, pts.	-13	-13	-10	-9	-15	-10
Volume Change, %	+33	+38	+32	+28	+40	+41
Weight Change, %	+25	+28	+24	+21	+30	+30

Recipe KS11-161

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6*</u>	<u>7</u>
Hydrin C2000L	100.0	100.0	100.0	100.0	100.0	100.0	100.0
N-330	50.0	50.0	50.0	50.0	50.0	50.0	50.0
Stearic Acid	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Naugard 445	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Vanox MTI	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Plasthall® 4141	20.0	-	-	-	-	-	-
Plasthall® P-7068	-	20.0	-	-	-	-	-
Plasthall® P-670	-	-	20.0	-	-	-	-
Plasthall® P-7046	-	-	-	20.0	-	10.0	-
Plasthall® G-40	-	-	-	-	20.0	-	-
Plasthall® 100	-	-	-	-	-	10.0	-
Paraplex® G-50	-	-	-	-	-	-	20.0
Sub Total	<u>172.5</u>	<u>172.5</u>	<u>172.5</u>	<u>172.5</u>	<u>172.5</u>	<u>172.5</u>	<u>172.5</u>

Mill Addition:

Calcium Carbonate	5.0	5.0	5.0	5.0	5.0	5.0	5.0
Maglite® D	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Zisnet F-PT	0.8	0.8	0.8	0.8	0.8	0.8	0.8
DPG	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Santogard PVI	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Total	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>	<u>182.1</u>
Major Variable	4141	P-7068	P-670	P-7046	G-40	P-7046/ 100	G-50

*Compound showed exudation, testing was discontinued.

Viscosity and Curing Properties

Mooney Viscosity at 125°C (257°F):

Minimum Viscosity	37.6	41.3	42.5	43.3	44.9	-	44.2
t5, min	10.0	9.3	8.3	8.3	8.0	-	8.2
t10, min	11.8	10.7	9.8	9.7	9.3	-	9.5
t35, min	15.3	13.3	12.7	12.3	12.0	-	12.2

Oscillating Disc Rheometer at 160°C (320°F):

ML lbf./in.	8.6	9.8	10.3	10.2	10.5	-	10.5
MH lbf./in.	43.4	48.8	51.9	52.0	49.0	-	52.9
ts2, min	2.8	2.7	2.7	2.7	2.7	-	2.5
t'c(90), min	26.7	24.2	28.2	26.3	19.8	-	25.5
1.25 x t'c(90), min	33.3	30.2	35.2	32.9	24.8	-	31.9
Cure Rate Index	4.2	4.7	3.9	4.2	5.8	-	4.4

Recipe KS11-161

Recipe Variable

<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>7</u>
4141	P-7068	P-670	P-7046	G-40	G-50

Oscillating Disc Rheometer at 200°C (392°F):

ML lbf./in.	9.0	9.8	9.9	9.9	10.4	10.2
MH lbf./in.	52.6	54.1	57.5	54.6	60.8	59.2
ts2, min	1.0	1.0	1.0	1.0	1.0	1.0
t'c(90), min	11.5	9.7	19.8	13.2	7.8	22.3
1.25 x t'c(90), min	14.4	12.1	24.8	16.5	9.8	27.9
Cure Rate Index	9.5	11.5	5.3	8.2	14.6	4.7

Original Physical Properties

Stress at 100% Elong, MPa	2.6	2.6	2.6	2.6	2.6	2.6
psi	375	375	375	375	375	375
Stress at 200% Elong., MPa	6.0	6.0	6.2	6.2	6.2	6.0
Stress at 300% Elong., MPa	8.6	8.6	9.0	9.1	9.3	8.8
Tensile, Ultimate, MPa	10.2	9.7	11.0	12.1	11.7	11.2
psi	1475	1400	1600	1750	1700	1625
Elongation at Break, %	385	360	405	460	425	425
Hardness, Duro A, pts.	60	58	62	61	60	62
Tear Resistance, ppi	224	244	246	257	277	258
Resilience, ave., pts.	33	29	30	26	26	28
Specific Gravity	1.369	1.382	1.395	1.398	1.401	1.399

Compression Set, 70 h at 125°C

% Set	53	49	53	51	52	55
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Low-Temperature Impact:

Brittle Point:

As Molded

All Pass, °C	-47	-40	-42	-42	-39	-40
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Air Oven Aging, 70 h at 150°C (302°F)

Stress at 100% Elong., MPa	5.0	3.5	3.6	3.3	3.6	3.5
psi	725	500	525	475	525	500
Stress Change, %	+92	+35	+40	+27	+40	+33
Tensile, Ultimate, MPa	10.0	8.3	8.6	8.1	8.6	7.9
psi	1450	1200	1250	1175	1250	1150
Tensile Change, %	-1.6	-14	-22	-33	-26	-29
Elongation at Break, %	205	205	210	200	210	210
Elongation Change, %	-47	-43	-48	-56	-51	-51
Hardness, Duro A, pts.	77	66	65	63	64	66
Hardness Change, pts.	+17	+8	+3	+2	+4	+4
Weight Change, %	-11	-5.4	-2.5	-2.0	-1.9	-2.4

Recipe KS11-161	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>7</u>
Recipe Variable	4141	P-7068	P-670	P-7046	G-40	G-50
ASTM 1 Oil, 70 h at 150°C (302°F)						
Stress at 100% Elong., MPa	6.0	5.5	5.0	4.7	4.8	4.8
psi	875	800	725	675	700	700
Stress Change, %	+133	+113	+93	+80	+87	+87
Tensile, Ultimate, MPa	12.2	11.4	11.7	11.9	11.5	11.7
psi	1775	1650	1700	1725	1675	1700
Tensile Change, %	+20	+18	+6.3	-1.4	-1.5	+4.6
Elongation at Break, %	195	190	210	225	220	215
Elongation Change, %	-50	-47	-48	-51	-48	-49
Hardness, Duro A, pts.	77	74	69	68	67	69
Hardness Change, pts.	+17	+16	+7	+7	+7	+7
Volume Change, %	-13	-11	-4.9	-2.3	-1.4	-3.4
Weight Change, %	-10	-8.7	-4.4	-2.8	-1.9	-3.4
ASTM Fuel C Immersion - 70 h at 23°C						
Stress at 100% Elongation, MPa	3.7	3.7	3.9	3.8	3.8	3.9
psi	530	535	565	545	545	560
Stress Change, %	41	43	51	45	45	49
Tensile Ultimate, MPa	6.9	6.0	7.1	6.1	5.2	6.6
psi	1000	865	1035	880	755	950
Tensile Change, %	-32	-38	-35	-50	-56	-37
Elongation at Break, %	200	165	190	170	140	175
Elongation Change, %	-48	-54	-53	-63	-67	-57
Hardness Duro A, pts	50	49	45	48	50	50
Hardness Change, pts.	-24	-9	-17	-13	-10	-13
Volume Change, %	21.1	25.9	32.0	33.8	40.7	33.3
Weight Change, %	11.8	13.9	18.0	18.6	23.8	19.1
ASTM Fuel C Dry Out - 22 h at 70°C						
Hardness Duro A, pts	76	73	67	69	67	71
Hardness Change, pts.	2	15	5	8	7	8
Volume Change, %	-15.4	-12.7	-9.5	-8.4	-3.0	-7.7
Weight Change, %	-10.9	-9.6	-7.5	-7.0	-2.5	-6.0

Recipe KS11-161

Recipe Variable

<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>7</u>
4141	P-7068	P-670	P-7046	G-40	G-50

IRM 903 Oil, 70 h at 150°C (302°F)

Stress at 100% Elong., MPa	4.5	4.5	4.1	3.8	4.0	4.1
psi	650	650	600	550	575	600
Stress Change, %	+73	+73	+60	+47	+53	+60
Tensile, Ultimate, MPa	10.3	10.3	11.2	10.2	10.7	10.3
psi	1500	1500	1625	1475	1550	1500
Tensile Change, %	+2	+7	+2	-16	-9	-8
Elongation at Break, %	230	220	225	255	230	225
Elongation Change, %	-40	-39	-44	-45	-46	-47
Hardness, Duro A, pts.	71	69	66	64	64	64
Hardness Change, pts.	+11	+11	+4	+3	+4	+2
Volume Change, %	-4.3	-2.5	+2.4	+5.0	+7.6	+3.8
Weight Change, %	-3.9	-3.1	+0.2	+2.0	+4.3	+1.4

Distilled Water, 70 h at 100°C (212°F)

Stress at 100% Elong., MPa	2.8	2.9	2.9	2.9	3.1	3.1
psi	400	425	425	425	450	450
Stress Change, %	+6.6	+13	+13	+13	+20	+20
Tensile, Ultimate, MPa	7.9	8.3	9.3	8.6	7.6	8.3
psi	1150	1200	1350	1250	1100	1200
Tensile Change, %	-22	-14	-16	-29	-35	-26
Elongation at Break, %	230	250	260	240	210	220
Elongation Change, %	-40	-31	-36	-48	-51	-48
Hardness, Duro A, pts.	53	55	53	53	51	52
Hardness Change, pts.	-7	-3	-9	-8	-9	-10
Volume Change, %	+30	+27	+32	+33	+46	+42
Weight Change, %	+22	+20	+24	+24	+33	+31

Plasticizer Physical Properties for KS11-137

Plasticizer	<u>7006</u>	<u>7050</u>	<u>DBEEA</u>	<u>DBPPA</u>	<u>DBEEEG</u>	<u>DOS</u>	<u>G-50</u>
Lot or Batch Number	040242	039954	032810	LLR378	040182	041515	040573
Appearance	Clear	Clear	Clear	Clear	Clear	Clear	Clear
Acid Value	1.18	0.48	0.76	0.35	0.22	0.08	0.93
Color, Gardner, APHA	1	1	(40)	(40)	3	(39)	1
Saponification Value	327	228	232	211	-	259	--
Refractive Index	1.4435	1.4463	1.4456	1.4393	1.449	1.4484	1.464
Specific Gravity at 25°C	0.9823	1.0634	1.0107	0.9725	1.038	0.9128	1.104
Moisture, %	0.08	0.09	0.12	0.05	0.12	0.03	0.03
Hydroxyl	-	-	-	-	13	-	-
Viscosity, TBR (cps)	-	-	-	-	-	-	21 (2700)

Plasticizer Physical Properties For KS11-161

Plasticizer	<u>4141</u>	<u>P-7068</u>	<u>P-670</u>	<u>P-7046</u>	<u>G-40</u>	<u>100</u>	<u>G-50</u>
Lot or Batch Number	042695	031088	021508	036256	039910	031911	040573
Appearance	Clear	Clear	Clear	Sl. Op.	Clear	Clear	Clear
Acid Value	0.3	1.4	0.34	0.47	1.8	0.86	0.93
Color, Gardner, APHA	1	1	(50)	2	(20)	3-4	1
Saponification Value	261	-	503	-	-	141	-
Refractive Index	1.4469	1.5014	1.4641	1.4659	1.469	1.4594	1.464
Specific Gravity at 25°C	0.964	1.0364	1.0753	1.1075	-	0.8725	1.104
Moisture, %	0.03	0.02	0.02	.01	0.05	0.04	0.03
Viscosity, TBR (cps)	-	(880)	(1260)	(11700)	{I}	-	21 (2700)
{Gardner Holt}							

Materials List

Material	Description	Supplier
Hydrin C2000L	Epichlorohydrin/Ethylene Oxide Copolymer	Zeon
Naugard 445	4,4'-Di(dimethylbenzyl) diphenylamine	R. T. Vanderbilt
Stearic Acid	Stearic acid	Hallstar
N-330	Carbon black	J. M. Huber
Vanox MTI	2-Mercaptotoluimidazole	R. T. Vanderbilt
Plasthall® 100	Isooctyl tallate	Hallstar
Plasthall® 7006	Alkyl alklyether diester	Hallstar
Plasthall® 7050	Dialkyl diether glutarate	Hallstar
Plasthall® DBEEA	Dibutoxyethoxyethyl adipate	Hallstar
Plasthall® DBEEEG	Dibutoxyethoxyethoxyethyl glutarate	Hallstar
Plasthall® DOS	Dioctyl sebacate	Hallstar
Plasthall® DBPPA	Dibutoxypropoxypropyl adipate	Hallstar
Paraplex® G-50	Polyester adipate	Hallstar
Paraplex® G-40	Polyester adipate	Hallstar
Plasthall® P-7068	Polyester phthalate	Hallstar
Plasthall® P-7046	Polyester glutarate	Hallstar
Plasthall® P-670	Polyester adipate	Hallstar
Plasthall® 4141	Triethylene glycol caprate caprylate	Hallstar
Calcium Carbonate	Calcium carbonate	Hallstar
Maglite® D	Magnesium Oxide	Hallstar
Zisnet F-PT	Triazine	Zeon
DPG	Diphenylguanidine	Hallstar (Swan)
Santogard PVI	N-(cyclohexylthio) phthalimide	Flexsys