



TSE Industries, Inc.
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Millathane® 5004 vs. HNBR

Millathane 5004 compounds were compared to a commercial HNBR compound used in an automotive belting application. Unaged physical properties were tested at room temperature and at temperatures up to 135°C (275°F). Properties were also tested after oven agings, at temperatures up to 135°C (275°F) and after motor oil immersion. Compression modulus was also tested at room temperature, 79°C (175° F), and 135°C (275°F).

All properties of the Millathane 5004 compounds were comparable to the commercial HNBR compound. Millathane 5004 should be considered for use in applications where HNBR is used at moderately high temperatures.

Ref: 39436
tlj
8/10/2004



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Millathane® 5004 vs. HNBR for High Temperature Properties

	39436C	39436D	Commercial HNBR Compound
Millathane® 5004	100.0	100.0	
Stearic Acid	0.3	0.3	
N330 Black	35.0	35.0	
TP-95	5.0	5.0	
Struktol WB-212	0.5	0.5	
Dicup 40C	4.5	6.0	
	145.30	146.80	

Mooney Viscosity

ML (1+4)/100°C	79	73
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MDR 2000, 30'/160°C (320°F)

ML, lb-in (dN-m)	1.7 (1.9)	1.7 (1.9)
MH, lb-in (dN-m)	38.8 (43.8)	50.2 (56.7)
ts1, min.	1.0	0.9
t50, min.	6.5	5.9
t90, min	14.9	13.9

Physical Properties

Unaged - Test at 23°C (RT)

	75	78	73
Hardness, Shore A	75	78	73
10% Modulus, psi (MPa)	160 (1.1)	175 (1.2)	170 (1.2)
25% Modulus, psi (MPa)	265 (1.8)	295 (2.0)	250 (1.7)
50% Modulus, psi (MPa)	395 (2.7)	460 (3.2)	330 (2.3)
100% Modulus, psi (MPa)	750 (5.2)	935 (6.4)	540 (3.7)
300% Modulus, psi (MPa)	3210 (22.1)	4010 (27.7)	1915 (13.2)
Tensile Strength, psi (MPa)	4380 (30.2)	4750 (32.8)	2730 (18.8)
Elongation, %	440	365	510

Observations:

The Millathane 5004 compounds had higher tensile strength and modulus, and lower elongation, than the 73H HNBR compound.



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TP-95	5.0	5.0	
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Dicup 40C	4.5	6.0	
	145.30	146.80	

Original Physical Properties

Unaged - Test at 175°F (79°C)

10% Modulus, psi (MPa)	140 (1.0)	160 (1.1)	100 (0.7)
25% Modulus, psi (MPa)	250 (1.7)	330 (2.3)	180 (1.2)
50% Modulus, psi (MPa)	360 (2.5)	470 (3.2)	240 (1.7)
100% Modulus, psi (MPa)	590 (4.1)	850 (5.9)	360 (2.5)
Tensile Strength, psi (MPa)	2890 (19.9)	2600 (17.9)	1530 (10.6)
% Change from RT	-34	-45	-44
Elongation, %	330	230	370
% Change from RT	-25	-37	-27

Unaged - Test at 225°F (107°C)

10% Modulus, psi (MPa)	140 (1.0)	150 (1.0)	110 (0.8)
25% Modulus, psi (MPa)	250 (1.7)	290 (2.0)	180 (1.2)
50% Modulus, psi (MPa)	350 (2.4)	440 (3.0)	240 (1.7)
100% Modulus, psi (MPa)	600 (4.1)	750 (5.2)	390 (2.7)
Tensile Strength, psi (MPa)	2000 (13.8)	1950 (13.4)	1130 (7.8)
% Change from RT	-54	-59	-59
Elongation, %	260	240	280
% Change from RT	-41	-34	-45

Unaged - Test at 275°F (135°C)

10% Modulus, psi (MPa)	160 (1.1)	150 (1.0)	110 (0.8)
25% Modulus, psi (MPa)	250 (1.7)	260 (1.8)	180 (1.2)
50% Modulus, psi (MPa)	370 (2.6)	460 (3.2)	230 (1.6)
100% Modulus, psi (MPa)	560 (3.9)	770 (5.3)	380 (2.6)
Tensile Strength, psi (MPa)	1150 (7.9)	1530 (10.6)	890 (6.1)
% Change from RT	-74	-68	-67
Elongation, %	180	170	240
% Change from RT	-59	-53	-53

Observations:

The urethane compounds have similar retentions of hot-tested properties compared to the HNBR compound .

Compound "D", Millathane 5004 with higher peroxide level than "C", has the best high temperature property retention.



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N330 Black	35.0	35.0	
TP-95	5.0	5.0	
Struktol WB-212	0.5	0.5	
Dicup 40C	4.5	6.0	
	145.30	146.80	

Heat Aged Properties

Oven Aged - 168 hr/212°F (100°C)

	39436C	39436D	Commercial HNBR Compound
Hardness, Shore A	80	80	80
Change	5	2	7
10% Modulus, psi (MPa)	155 (1.1)	180 (1.2)	170 (1.2)
25% Modulus, psi (MPa)	255 (1.8)	300 (2.1)	255 (1.8)
50% Modulus, psi (MPa)	405 (2.8)	470 (3.2)	360 (2.5)
100% Modulus, psi (MPa)	800 (5.5)	1010 (7.0)	650 (4.5)
300% Modulus, psi (MPa)	3330 (23.0)	4150 (28.6)	2320 (16.0)
Tensile Strength, psi (MPa)	4190 (28.9)	4480 (30.9)	2740 (18.9)
% Change	-4	-6	0
Elongation, %	400	325	400
% Change	-9	-11	-22

Oven Aged - 168 hr/250°F (121°C)

	39436C	39436D	Commercial HNBR Compound
Hardness, Shore A	80	80	88
Change	5	2	15
10% Modulus, psi (MPa)	170 (1.2)	205 (1.4)	280 (1.9)
25% Modulus, psi (MPa)	300 (2.1)	345 (2.4)	420 (2.9)
50% Modulus, psi (MPa)	475 (3.3)	555 (3.8)	630 (4.3)
100% Modulus, psi (MPa)	970 (6.7)	1155 (8.0)	1205 (8.3)
300% Modulus, psi (MPa)	3750 (25.9)	()	3095 (21.3)
Tensile Strength, psi (MPa)	4350 (30.0)	4415 (30.4)	3105 (21.4)
% Change	-1	-7	14
Elongation, %	330	290	315
% Change	-25	-21	-38

Oven Aged - 70 hr/275°F (135°C)

	39436C	39436D	Commercial HNBR Compound
Hardness, Shore A	83	87	91
Change	8	9	18
10% Modulus, psi (MPa)	180 (1.2)	210 (1.4)	280 (1.9)
25% Modulus, psi (MPa)	290 (2.0)	340 (2.3)	400 (2.8)
50% Modulus, psi (MPa)	460 (3.2)	550 (3.8)	570 (3.9)
100% Modulus, psi (MPa)	955 (6.6)	1095 (7.6)	1025 (7.1)
300% Modulus, psi (MPa)	3740 (25.8)	()	2910 (20.1)
Tensile Strength, psi (MPa)	4365 (30.1)	4100 (28.3)	3000 (20.7)
% Change	0	-14	10
Elongation, %	365	295	330
% Change	-17	-19	-35

Observations:

The Millathane 5004 compounds have better heat aging properties at the temperatures tested than the HNBR compound.



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Stearic Acid	0.3	0.3	
N330 Black	35.0	35.0	
TP-95	5.0	5.0	
Struktol WB-212	0.5	0.5	
Dicup 40C	4.5	6.0	
	145.30	146.80	

Oil Aging, 10W30 Motor Oil, 22 hr/212°F (100°C)

	39436C	39436D	Commercial HNBR Compound
Hardness, Shore A	79	78	72
Change	4	0	-1
10% Modulus, psi (MPa)	125 (0.9)	150 (1.0)	135 (0.9)
25% Modulus, psi (MPa)	210 (1.4)	255 (1.8)	220 (1.5)
50% Modulus, psi (MPa)	320 (2.2)	390 (2.7)	315 (2.2)
100% Modulus, psi (MPa)	600 (4.1)	780 (5.4)	565 (3.9)
300% Modulus, psi (MPa)	2680 (18.5)	3360 (23.2)	2155 (14.9)
Tensile Strength, psi (MPa)	3675 (25.3)	4160 (28.7)	3640 (25.1)
% Change	-16	-12	33
Elongation, %	515	380	410
% Change	17	4	-20
Volume Change, %	-1.8	-2.2	0.5
Weight Change, %	-1.6	-2.1	-0.2

Observations:

The Millathane 5004 compounds have similar oil aging characteristics compared to the HNBR. They showed a slight weight loss after oil aging, suggesting some extraction of plasticizer.

Compression Modulus at RT, psi (MPa)

	39436C	39436D	Commercial HNBR Compound
10%	179 (1.2)	201 (1.4)	181 (1.2)
25%	457 (3.2)	544 (3.8)	404 (2.8)

Compression Modulus at 79°C (175°F), psi (MPa)

	39436C	39436D	Commercial HNBR Compound
10%	47 (0.3)	50 (0.3)	31 (0.2)
% Change	-74	-75	-83
25%	213 (1.5)	256 (1.8)	159 (1.1)
% Change	-53	-53	-61

Compression Modulus at 135°C (275°F), psi (MPa)

	39436C	39436D	Commercial HNBR Compound
10%	134 (0.9)	164 (1.1)	120 (0.8)
% Change	-25	-18	-34
25%	332 (2.3)	430 (3.0)	284 (2.0)
% Change	-27	-21	-30

Observations:

The Millathane 5004* compounds have better retention of compression modulus at high temperatures vs. the HNBR compounds.

Conclusions:

Urethane compounds based upon Millathane* 5004 had good properties, original and aged, compared to the 73H HNBR compound.

*Vibrathane 5004 was used.