



TSE Industries, Inc.
Millathane® Millable Polyurethane Division
4370 112th Terrace North
Clearwater, FL 33762 (USA)
727-573-7676 or 800-237-7634 www.tse-industries.com



Carbodiimide in Millathane® 5004

A study was done to evaluate an aromatic polycarbodiimide* in Millathane 5004 to evaluate its effect on improving the hydrolysis resistance of Millathane 5004 compounds. From 1 to 5 parts of the carbodiimide were added to a Millathane 5004 compound. The results showed:

1. Two parts of carbodiimide gave excellent properties after agings in 70C and 100C water, and in 95% Relative Humidity for one month. Five parts gave slight improvements in retained properties after the water and water vapor immersions vs. 2 parts.
2. The oven aging characteristics were improved slightly with the addition of carbodiimide, with benefits to property changes after aging and compression set. Beneficial effects were seen with as little as one part.
3. The addition of carbodiimide did not seem to affect other properties.

Recommendations:

For applications where Millathane 5004 is needed for its excellent aging and physical properties, and elevated temperature water exposure is a factor, carbodiimides should be added to the compound at the two part level.

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* Stabaxol P, from Rhein Chemie, was used. Stabilizer 7000 from Raschig Chemical is a similar material.

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Carbodiimide in Millathane® 5004

	1C	2E	3F	4G
Millathane 5004	100.0	100.0	100.0	100.0
N550	25.0	25.0	25.0	25.0
Carbodiimide	—	1.0	2.0	5.0
Stearic Acid	0.3	0.3	0.3	0.3
TP-95	2.0	2.0	2.0	2.0
Struktol WB-212	0.5	0.5	0.5	0.5
Dicup 40C	6.0	6.0	6.0	6.0
	133.8	134.8	135.8	138.8

Mooney Viscosity

ML(1+4)/100C	65	65	64	59
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MDR, 30°/160C

ML, lb-in	0.7	0.6	0.5	0.8
dN-m	0.8	0.7	0.6	0.9
MH, lb-in	45.4	44.7	41.1	40.4
dN-m	51.3	50.5	46.4	45.6
ts1, min.	0.8	0.9	0.9	0.9
t50, min.	4.0	4.8	4.8	5.0
t90, min.	8.1	10.3	11.5	11.1

Press Cure 15/160C

Hardness, Shore A	72	72	73	73
10% Modulus, psi	145	160	170	190
MPa	1.0	1.1	1.2	1.3
25% Modulus, psi	265	290	305	325
MPa	1.8	2.0	2.1	2.2
50% Modulus, psi	435	475	495	505
MPa	3.0	3.3	3.4	3.5
100% Modulus, psi	890	975	1020	955
MPa	6.1	6.7	7.0	6.6
Tensile Strength, psi	3980	3630	3760	3630
MPa	27.4	25.0	25.9	25.0
Elongation	365	345	370	380
Tear C, lb/in	260	250	270	----
kN/mm	45.5	43.8	47.3	----

Oven Aging, 4 Wks/70C

Hardness, Shore A	73	74	76	76
Change	1	2	3	3
100% Modulus, psi	1060	1190	1190	1160
MPa	7.3	8.2	8.2	8.0
% Change	19	22	17	21
Tensile Strength, psi	3880	4000	3940	3920
MPa	26.8	27.6	27.2	27.0
% Change	-3	10	5	8
Elongation	330	350	340	380
% Change	-10	1	-8	0



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Carbodiimide	—	1.0	2.0	5.0

Oven Aging, 7 days/125C

Hardness, Shore A	73	77	77	78
Change	1	5	4	5
100% Modulus, psi	1010	1020	1130	1060
MPa	7.0	7.0	7.8	7.3
% Change	13	5	11	11
Tensile Strength, psi	3310	3230	3690	3710
MPa	22.8	22.3	25.4	25.6
% Change	-17	-11	-2	2
Elongation	285	295	340	360
% Change	-22	-14	-8	-5

Oven Aging, 21 days/125C

Hardness, Shore A	72	74	76	75
Change	0	2	3	2
100% Modulus, psi	1150	1240	1290	1260
MPa	7.9	8.6	8.9	8.7
% Change	29	27	26	32
Tensile Strength, psi	3410	3770	3800	3780
MPa	23.5	26.0	26.2	26.1
% Change	-14	4	1	4
Elongation	260	300	310	310
% Change	-29	-13	-16	-18

Oven Aging, 168 hr/135C

Hardness, Shore A	72	73	74	74
Change	0	1	1	1
100% Modulus, psi	1020	1050	1110	1100
MPa	7.0	7.2	7.7	7.6
% Change	15	8	9	15
Tensile Strength, psi	3690	3490	3880	3800
MPa	25.4	24.1	26.8	26.2
% Change	-7	-4	3	5
Elongation	335	305	355	385
% Change	-8	-12	-4	1



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N550	25.0	25.0	25.0	25.0
Carbodiimide	—	1.0	2.0	5.0

Oven Aging, 21 days/140C

Hardness, Shore A	70	70	73	73
Change	-2	-2	0	0
100% Modulus, psi	920	1050	1190	1180
MPa	6.3	7.2	8.2	8.1
% Change	3	8	17	24
Tensile Strength, psi	3270	3640	3460	3740
MPa	22.6	25.1	23.9	25.8
% Change	-18	0	-8	3
Elongation	290	210	270	290
% Change	-21	-39	-27	-24

Oven Aging, 70 hr/150C

Hardness, Shore A	70	72	72	73
Change	-2	0	-1	0
100% Modulus, psi	945	975	1005	985
MPa	6.5	6.7	6.9	6.8
% Change	6	0	-1	3
Tensile Strength, psi	3255	3770	3930	3960
MPa	22.4	26.0	27.1	27.3
% Change	-18	4	5	9
Elongation	285	340	365	390
% Change	-22	-1	-1	3

Oil Aging, 22 hr/100C 15W40 Oil

Hardness, Shore A	72	73	74	74
Change	0	1	1	1
100% Modulus, psi	810	850	860	810
MPa	5.6	5.9	5.9	5.6
% Change	-9	-13	-16	-15
Tensile Strength, psi	3680	3400	3300	3620
MPa	25.4	23.4	22.8	25.0
% Change	-8	-6	-12	0
Elongation	395	345	375	410
% Change	8	0	1	8

Weight Change, %	-0.4	-0.6	0	0.3
Volume Change, %	-0.7	-0.2	0.7	0.1



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N550	25.0	25.0	25.0	25.0
Carbodiimide	—	1.0	2.0	5.0

Oil Aging, 70 hr/100C ASTM 903 Oil

Hardness, Shore A	73	74	74	72
Change	1	2	1	-1
100% Modulus, psi	830	900	815	795
MPa	5.7	6.2	5.6	5.5
% Change	-7	-8	-20	-17
Tensile Strength, psi	3680	3540	3450	3610
MPa	25.4	24.4	23.8	24.9
% Change	-8	-2	-8	-1
Elongation	380	350	370	400
% Change	4	1	0	5
Weight Change, %	0.5	0.8	0.9	2.7
Volume Change, %	1.3	2	2.1	4.1

Fuel C, 70 hr/RT (23C)

Hardness, Shore A	69	70	70	68
Change	-3	-2	-3	-5
100% Modulus, psi	840	830	890	730
MPa	5.8	5.7	6.1	5.0
% Change	-6	-15	-13	-24
Tensile Strength, psi	2740	2740	2550	2590
MPa	18.9	18.9	17.6	17.9
% Change	-31	-25	-32	-29
Elongation	210	220	220	200
% Change	-42	-36	-41	-47
Volume Change, %	20.7	21.5	21.8	25.6
Weight Change, %	13.1	13.7	13.9	16.1

Compression Set, 1/2" buttons cured 25'/160C

22 hr/70C	6	5	5	6
22 hr/100C	28	19	19	21
22 hr/125C	72	61	60	62
22 hr/150C	110	86	85	87



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N550	25.0	25.0	25.0	25.0
Carbodiimide	—	1.0	2.0	5.0

Water Immersions

70 hr/100C

Hardness, Shore A	35	69	70	72
Change	-37	-3	-3	-1
100% Modulus, psi	110	600	730	680
MPa	0.8	4.1	5.0	4.7
% Change	-88	-38	-28	-29
Tensile Strength, psi	950	2800	2890	3150
MPa	6.6	19.3	19.9	21.7
% Change	-76	-23	-23	-13
Elongation	600	380	370	400
% Change	64	10	0	5
Weight Change, %	2.9	2.3	1.8	0.6
Volume Change, %	3.8	2.8	2	2.4

1 Week/100C

Hardness, Shore A	Too Soft To Test	40	67	68
Change		-32	-6	-5
100% Modulus, psi		160	560	530
MPa		1.1	3.9	3.7
% Change		-84	-45	-45
Tensile Strength, psi		770	2740	2950
MPa		5.3	18.9	20.3
% Change		-79	-27	-19
Elongation		420	410	460
% Change		22	11	21
Weight Change, %		20	4.3	3.6
Volume Change, %		28	5.2	5.2

4 Weeks/70C

Weight Change, %	9.8	5.1	3.6	4
Volume Change, %	13.5	6.3	4.2	4.4

Humidity Aging: 30 days, 71C (160F), 95% RH

Hardness, Shore A	23	70	76	75
Change	-49	-2	3	2
100% Modulus, psi	57	670	905	840
MPa	0.4	4.6	6.2	5.8
% Change	-94	-31	-11	-12
Tensile Strength, psi	155	2825	3220	3370
MPa	1.1	19.5	22.2	23.2
% Change	-96	-22	-14	-7
Elongation	425	420	350	390
% Change	16	22	-5	3