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Technical Information for Performance Solutions

Dynamic (Goodrich Flexometer) Properties of Millathane® Compounds

Introduction

Polyurethanes are commonly used for applications where flexing and heat build-up are factors, such as rubber-covered rollers and wheels. To understand better the best formulation and polymer selection variables, we ran a study evaluating several Millathane compounds for Goodrich Flexometer heat build-up.

This test method was initially developed by the B.F. Goodrich Co. in Akron in the mid-1930s and described by E.T. Lessig in a 1937 article[1]. The ASTM D623, Method A, test method subjects a cylindrical specimen to rapidly oscillating compressive stresses under controlled conditions. The heat build-up is measured, as well as the permanent (compression) set. The conditions used for these tests were:

Base temperature: 100°C (212°F)
Length of stroke: 4.45 mm (0.175 in)
Static load: 244.6 N (55 lbf)
Conditioning time: 20 min.
Running time: 25 and 60 minutes.

Samples

Formulations are as shown in the following tables. The Millathane compounds are based upon both polyether (Millathane grades: E34, 55, 97, 26) and polyester (Millathane 76 Premilled ("M76M")) polyurethanes. Most compounds were peroxide-cured and silica-reinforced, but there were two comparisons of these ingredient variables: precipitated silica/silane was compared to N330 black in Millathane E34, and sulfur and peroxide cures were compared in Millathane 76 Premilled. Millathane 76 Premilled contains 1.5 phr of Millstab™ P hydrolysis stabilizer. One phr of the antioxidant Irganox 1010 was also evaluated in the non-black, peroxide-cured Millathane E34 compound.

Two non-PU compounds were also tested for comparison purposes: a black-reinforced SBR sulfur -cured compound (the control compound recommended in ASTM D623) and a black-reinforced NBR sulfur-cured compound. The NBR compound had a semi-EV (semi-Efficient Vulcanization) system, with only 0.5 phr (active) sulfur.

The compounds are identified in the tables by the Polymer Name – Cure system (S=Sulfur, P=Peroxide) – Reinforcing fillers (B=Carbon Black, N=Non-black (precipitated silica) (and 'AO' for the Millathane E34 compound with antioxidant).

Cured Properties

For testing physical properties, compounds were cured to tc90 (90% maximum torque on an MDR test). The physical properties of the peroxide-cured Millathane compounds were modest, definitely not as good as sulfur-cured compounds, but they had very good compression set characteristics and good DIN abrasion resistance. The sulfur cured NBR and SBR compounds had lower tensile strengths than the sulfur-cured Millathane 76M compound but they had somewhat higher tear strengths and lower compression set values.

Abrasion resistance for all of the Millathane compounds was much better than the SBR and NBR compounds, with the Millathane E34 and Millathane 55 compounds having the best abrasion resistance (lowest DIN abrasion loss).

[1] *"The Goodrich Flexometer", Industrial and Engineering Chemistry, Analytical Edition, Vol. 9, p.582-588, December 15, 1937.*

Topics:

- Dynamic (Goodrich Flexometer) Properties of Millathane® Compounds
- Samples
- Curing Properties
- Goodrich Flexometer Data
- Recommendations
- Ask Dr. Millathane

	E34-P-N	E34-P-B	55-P-N	76M-P-N	97-P-N	E34-P-NAO	26-P-N
	8278-A	8278-B	8278-C	8278-D	8278-F	8278-G	8278-H
Millathane® E34	100	100	—	—	—	100	—
Millathane 55	—	—	100	—	—	—	—
Millathane 76 Premilled	—	—	—	101.5	—	—	—
Millathane 97	—	—	—	—	100	—	—
Millathane 26	—	—	—	—	—	—	100
Stearic acid	0.5	0.5	0.5	0.5	0.25	0.5	0.5
Ultrasil VN3	25	—	25	25	20	25	25
Silquest RC-1	0.5	—	0.5	0.5	—	0.5	0.5
Silane A172DLC	—	—	—	—	0.5	—	—
N330 Black	—	25	—	—	—	—	—
TP-95 (DBEEA)	4	4	4	4	2	4	4
Irganox 1010	—	—	—	—	0.5	1	—
SR231 (DEGDMA)	2	2	2	2	—	2	2
SR350 (TMPTMA)	2	2	2	2	2	2	2
DiCup 40C	2	2	2	2	2	2	4

	76M-S-N	SBR-S-B
	8278-E	8278-J
Millathane 76 Premilled	101.5	—
SBR 1500	—	100
N330 Black	—	45
Ultrasil VN3	25	—
Silquest A189	0.5	—
TP-95 (DBEEA)	4	—
Zinc stearate	0.5	—
Stearic acid	—	1
Zinc oxide	—	5
MBTS	4	—
MBT	2	—
Thanecure® ZM	1	—
Sulfur, 80%	2.5	—
TMTD	—	3

	NBR-S-B
	8278-K
NBR-Medium ACN	100
Carbon black	55
Plasticizer	12
Process aids	2
Antioxidant	2
Zinc oxide	5
Stearic acid	1
Sulfasan R	1
TMTD	1.3
Sulfur, 80%	0.6

Goodrich Flexometer Data

Goodrich Flexometer testing, conducted by Smithers Rapra, was done per ASTM D623, Method A, with the heat build-up and compression set results shown in the table. Heat build-up data was also plotted vs. time of the test, as both 25 minute and 60 minute values were recorded. The data showed:

The SBR compound had the highest heat buildup (HBU), with the Millathane 26 compound being a close second. The Millathane 26 compound also had the highest increase in HBU from 25' to 60'. The compounds with the lowest HBU were the two Millathane 76M compounds (sulfur and peroxide cured) and the Millathane 97 compound, with the (non-black) Millathane E34 compounds to be only a little higher in HBU. The NBR, Millathane 55 and the black Millathane E34 compounds had intermediate HBU values. The addition of 1 phr antioxidant did not have any effect on the HBU, set or physical properties of the Millathane E34 compound.

The sulfur cured Millathane 76M compound had the highest compression set (17.6%) and the sulfur cured SBR, the peroxide cured Millathane 26 and the black peroxide cured Millathane E34 compound had moderately high sets (7.2-7.7%). The peroxide cured Millathane E34, with or without AO, Millathane 76M and Millathane 97 compounds had fairly low set (2.9-3.8%) while sulfur cured NBR had the lowest compression set (1.9%).

Recommendations

For applications such as pressure rollers, where low heat build-up and compression set are important, peroxide cured Millathane 76M, 97 or E34 would be recommended. If compression set is not an important factor, sulfur cured Millathane 76M would be a good choice. If abrasion resistance is also a factor, along with HBU and set, the best polymer choice would probably be Millathane E34.

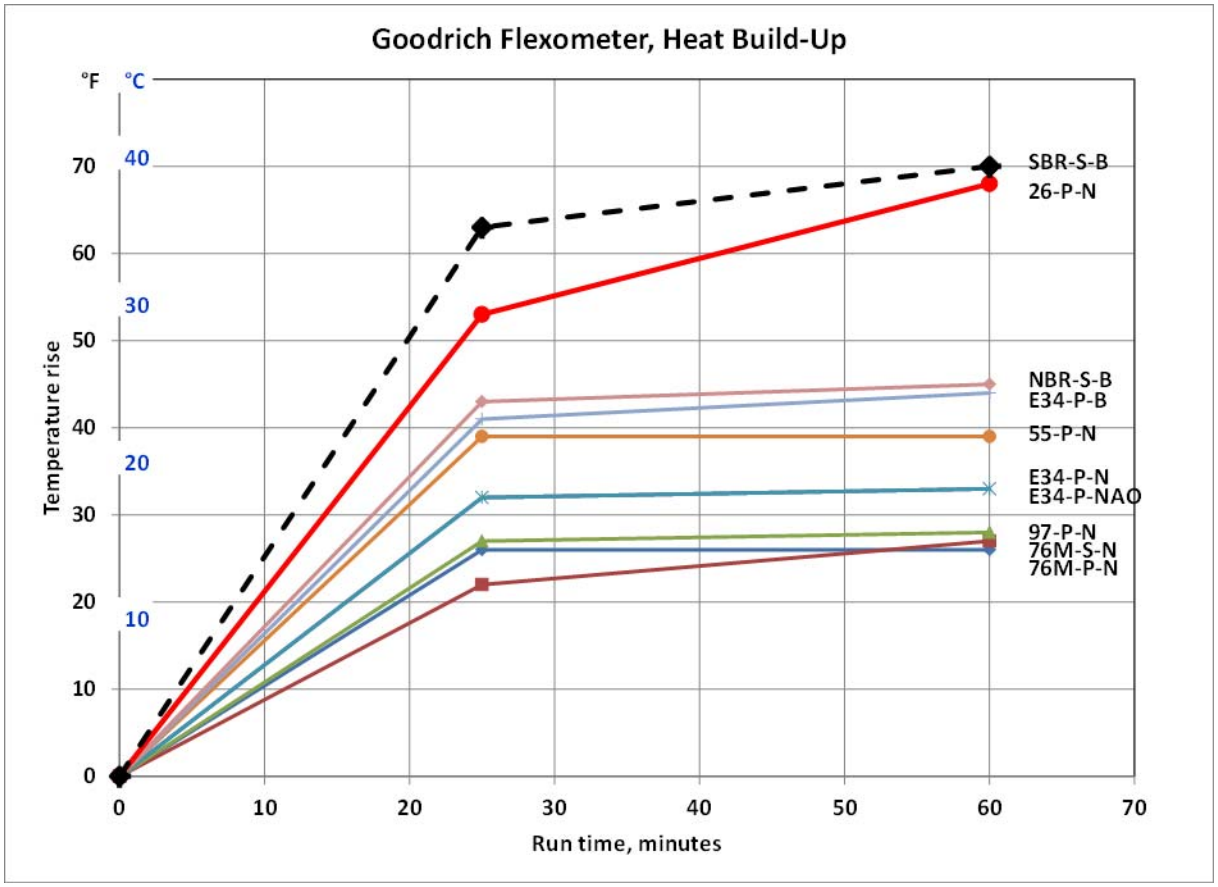
ID	E34-P-N	E34-P-B	55-P-N	76M-P-N	76M-S-N	97-P-N	E34-P-NAO	26-P-N	SBR-S-B	NBR-S-B
Ref:	8278-A	8278-B	8278-C	8278-D	8278-E	8278-F	8278-G	8278-H	8278-J	8278-K
Physical Properties, Press cured tc90 at 160°C										
Hardness, Shore A	70	63	71	72	60	62	70	63	60	65
TSE-100*, psi	440	325	430	580	255	235	445	220	185	325
MPa	3.0	2.2	3.0	4.0	1.8	1.6	3.1	1.5	1.3	2.2
TSE-300, psi	1750	1800	1640	—	1000	635	1890	690	675	1320
MPa	12.1	12.4	11.3	—	6.9	4.4	13.0	4.8	4.7	9.1
Tensile Strength, psi	2050	2250	1900	2460	4090	2230	1980	2960	2615	2190
MPa	14.1	15.5	13.1	17.0	28.2	15.4	13.7	20.4	18.0	15.1
Elongation, %	330	350	320	285	700	505	310	620	755	510
Tear, Die C, lb/in	175	141	177	162	252	155	163	183	312	281
kN/m	30.6	24.7	31.0	28.4	44.1	27.1	28.5	32.0	54.6	49.2
Tear, Die B, lb/in	191	183	206	223	420	231	201	305	559	470
kN/m	33.4	32.0	36.1	39.0	73.5	40.4	35.2	53.4	97.8	82.3

*TSE-xxx=Tensile Stress at xxx% Elongation

Bashore Resilience, %	51	54	50	25	20	59	50	54	49	22
Compression Set, 22 hr/70°C, %	13	15	13	11	53	21	13	21	23	13
DIN Abrasion, mm³ loss**	61	58	57	88	66	78	60	65	117	114

**ASTM D5963 Test Method B (rotating test piece)

Goodrich Flexometer Testing										
Temperature Rise, °F										
25' Run Time	32	41	39	26	22	27	32	53	63	43
60' Run Time	33	44	39	26	27	28	33	68	70	45
Compression Set, %										
60' Run Time	3.0	7.2	2.9	2.5	17.6	3.8	3.5	7.3	7.7	1.9



MILLATHANE® FACTOID: *Difunctional methacrylates like DEGDMA (SR231) generally give better tear strength than trifunctional methacrylates like TMPTMA (SR350), though set properties aren't as good.*

MILLATHANE® FACTOID: *Safipol TPU7840, can greatly improve bonding during cure of Millathane to SBR, NR, NBR or EVA substrates.*

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ASK Doctor Millathane®

Dear Dr. Millathane,

Can extrusions of Millathane Millable polyurethanes be produced?
Xiomara Trude Jacobs

Dear X. Trude,

Yes!

For the first time, Millable polyurethanes can be extruded and continuously cured! Our new product line, Millathane UV compounds, are fully formulated Millable polyurethane compounds that can be extruded or calendered, and continuously cured in UV curing conveyor systems. Because UV curing is a low temperature process, the problems of porosity (due to compound moisture volatilization) and shape retention (due to sagging at high temperatures), which are complications in curing extrusions of conventional Millathane compounds, are no longer present.

As with extrusions of other rubber types, it's highly desirable to use a vacuum extruder to eliminate air from the extruded compound.

Contact us for more info on this exciting new material!

Dr. Millathane

If you have any Millathane millable urethane questions you'd like answered, please send an email to millathaneinfo@tse-industries.com.