# Dynamic Properties (Goodrich Flexometer) of Millathane® Compounds

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

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 minutes |
| Running Time | 25 and 60 minutes |

## SAMPLES

The Millathane® compounds are based upon both polyether (Grades E34, 55, 97, 26) and polyester (76 Premilled or “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, which 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.

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


TSE INDUSTRIES
5180 113th Avenue North, Clearwater, FL 33760 USA
www.tseind.com
(800) 237-7634 | (727) 573-7676

## Dynamic Properties of Millathane® Compounds (cont.)

Compounds are identified in the following tables by:

| Polymer Name | Cure System | Reinforcing Fillers |
|---|---|---|
| | S = Sulfur<br>P = Peroxide | B = Carbon Black<br>N = Non-black (precipitated silica)<br>AO = E34 compound with antioxidant |

| ID | E34 (P, N) | E34 (P, B) | 55 (P, N) | 76M (P, N) | 97 (P, N) | E34 (P, N, AO) | 26 (P, N) |
|---|---|---|---|---|---|---|---|
| Ref | 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 |

| ID | 76M (S, N) | SBR (S, B) |
|---|---|---|
| Ref | 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 |

| ID | NBR (S, B) |
|---|---|
| Ref | 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 |


TSE INDUSTRIES
5180 113th Avenue North, Clearwater, FL 33760 USA
www.tseind.com
(800) 237-7634 | (727) 573-7676

## Dynamic Properties of Millathane® Compounds (cont.)

### 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%).

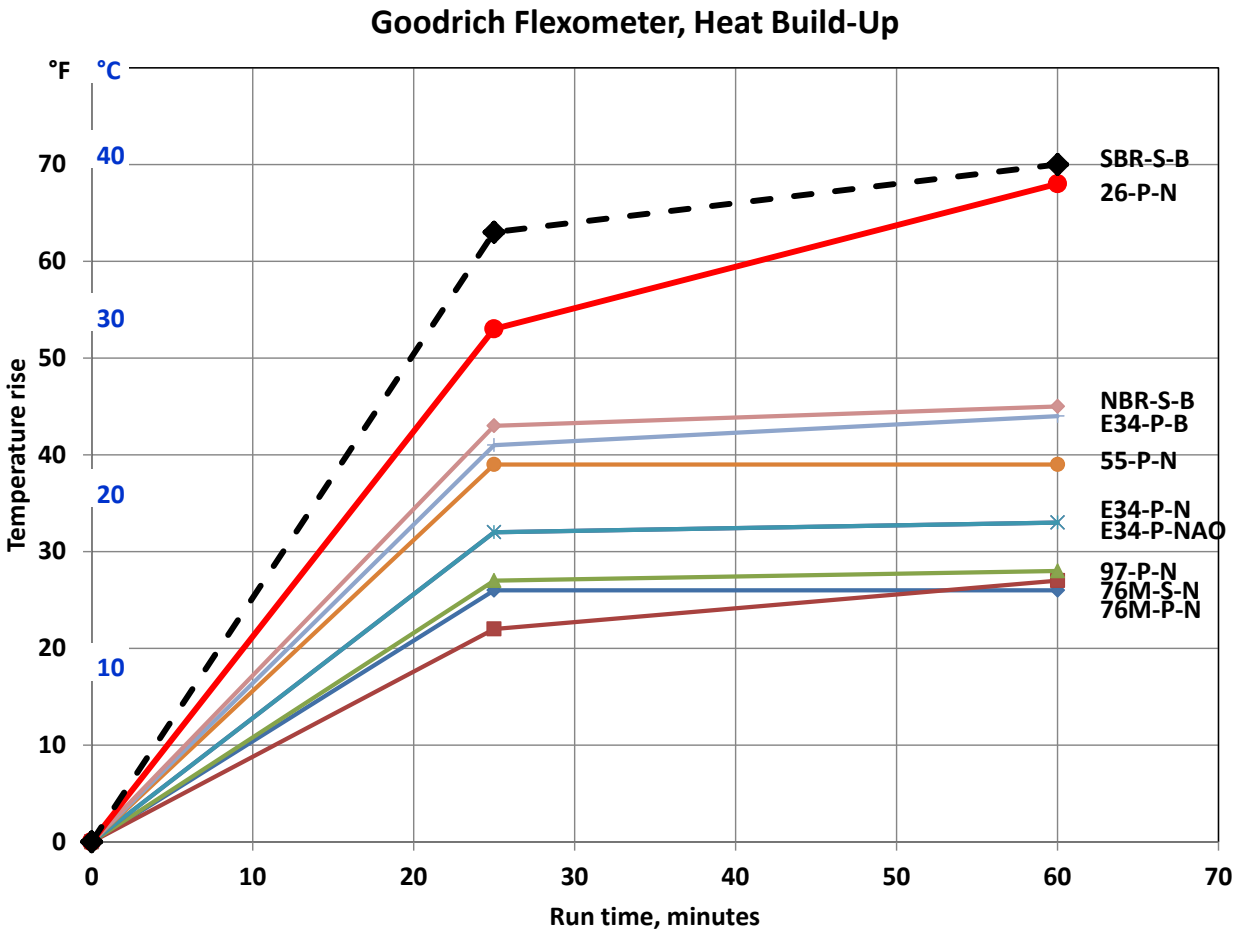
| ID | E34 (P, N) | E34 (P, B) | 55 (P, N) | 76M (P, N) | 76M (S, N) | 97 (P, N) | E34 (P, NAO) | 26 (P, N) | SBR (S, B) | NBR (S, B) |
|---|---|---|---|---|---|---|---|---|---|---|
| Ref | 8278-A | 8278-B | 8278-C | 8278-D | 8278-E | 8278-F | 8278-G | 8278-H | 8278-J | 8278-K |
| **Physical Properties,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

*TSE-xxx=Tensile Stress at xxx% Elongation
**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 |


TSE INDUSTRIES
5180 113th Avenue North, Clearwater, FL 33760 USA
www.tseind.com
(800) 237-7634 | (727) 573-7676

## Dynamic Properties of Millathane® Compounds (cont.)




### 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.




TSE INDUSTRIES
5180 113th Avenue North, Clearwater, FL 33760 USA
www.tseind.com
(800) 237-7634 | (727) 573-7676