Millathane® HT

A HIGH TEMPERATURE-RESISTANT POLYURETHANE

TSE INDUSTRIES, INC.

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The recommendations for the use of our products are based on tests believed to be reliable. However, we do not guarantee the results to be obtained by others under different conditions. Nothing in this brochure is intended as a recommendation to use our products so as to infringe on any patent.

TSE INDUSTRIES INC.
CLEARWATER, FLORIDA

For the past forty years, TSE Industries has been an industry leader in new, innovative solutions for the rubber industry. Our millable polyurethane gums, sold under the trade name **MILLATHANE®** have grown to be the sales leaders in the world today.

TSE Industries has recently completed its Phase Five Expansion encompassing 300,000 square feet spread over twenty acres in Clearwater, Florida. A large part of this is dedicated to significantly expanding our Research and Development efforts so that we will remain the Technology Leaders into the 22nd Century.

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MILLATHANE® HT

A High Temperature-Resistant Polyurethane

INTRODUCTION

MILLATHANE HT is a polyester millable polyurethane which has the ability to withstand elevated temperatures. Polyurethanes have been known for their excellent resistance to abrasion, impact, tear strength, oil and fuel resistance, and ozone resistance. The life expectancy of urethane is often 5 times longer than other elastomers, thus saving material costs and downtime expense. One shortcoming of polyurethanes is loss of physical properties at temperatures over 180°F (82°C). **MILLATHANE HT** has overcome this weakness.

MILLATHANE HT can withstand a continuous temperature of 250°F (121°C) and still retain the excellent physical properties of polyurethane.

MILLATHANE HT can be processed and cured by use of conventional rubber manufacturing equipment and techniques to yield finished urethane rubber parts. Compounds prepared from **MILLATHANE HT** can be vulcanized with either sulfur or organic peroxide based systems.

MILLATHANE HT has the following outstanding characteristics:

- Heat aging resistance
- Low temperature flexibility
- Abrasion resistance
- Tear strength
- Ozone and weathering resistance
- Oil and fuel resistance
- Processing ease
- Steam curable (with protection)

TYPICAL POLYMER PROPERTIES

Chemical type	Polyester polyurethane
Physical form	Solid bale or milled sheets*
Color	Dark to light amber
Odor	Faint, characteristic
Specific gravity	1.12
Mooney viscosity range (ML 1+4 @ 100° C)	35 to 65
Standard Mooney viscosity (ML 1+4 @ 100° C)	50 ± 10
Storage stability	Excellent
Health hazard	None

TYPICAL PHYSICAL PROPERTIES

Hardness range	30 – 90 A
Tensile strength	Up to 4000 psi, (28 MPa)
Elongation	Good
Low temperature properties	-75°F (-59°C) brittle point
Heat aging resistance	Excellent to: 250°F (121°C) continuous 300°F (149°C) intermittent
Ozone and weathering resistance	Excellent
Oil & fuel resistance	Excellent
Abrasion resistance	Excellent
Tear strength	Excellent
Resilience	20 to 40%

* milled sheets contain 1.5% carbodiimide stabilizer

VULCANIZATION OF MILLATHANE® HT

Compounds of **MILLATHANE® HT** respond well to vulcanization by sulfur or peroxide-cure systems. This versatility offers the compounder a broad range of cure times and temperatures in order to enable him to select a system exactly suited to his particular application, requirement and/or conditions.

SULFUR CURING SYSTEM

The sulfur-curing system consistently gives a desirable combination of optimum property values and processing safety. Selection of this system over peroxide, however, should be preceded by investigation into the possible effects of temperature. Sulfur-cured systems will give you better physical properties, but will not withstand a higher temperature of 300°F (149°C) as well as peroxide-cured systems.

One system which has produced desirable physical properties is a combination of sulfur, MBTS, MBT, THANECURE® ZM, and zinc stearate. The following combination gives a desirable balance of physical properties at a cure time which is practical in a molding operation.

Sulfur	1.5 phr	Curing agent
MBTS	4.0 phr	Primary Accelerator
MBT	2.0 phr	Secondary Accelerator
THANECURE ZM	1.0 phr	Zinc Activator
Zinc Stearate	0.5 phr	Activator/release agent

The effect of varying these ingredients from the combination shown above is on the following pages. A **MILLATHANE HT** masterbatch containing 40 phr N330 black was used in this evaluation.

EFFECT OF SULFUR

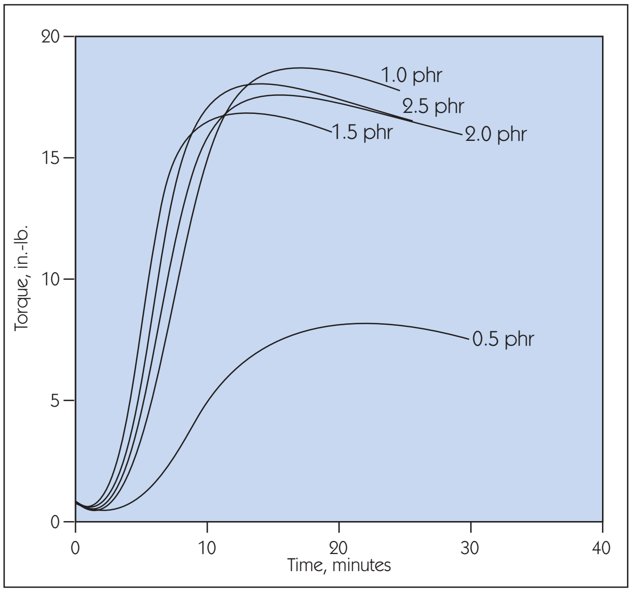
Increasing the concentration of sulfur produces:

- Faster cure rate
- Higher state of cure
- Better abrasion resistance
- Poorer aging properties

Decreasing the sulfur content below 1 phr results in a drastically reduced state of cure.

EFFECT OF SULFUR ON CURE RATE

MDR @ 160°C (320°F)



EFFECTS OF SULFUR CONCENTRATION ON PHYSICAL PROPERTIES

Parts per 100 Polymer	0.5	1.0	1.5	2.0	2.5
Press cured at 320°F (160°C), min.	16	12	12	12	11
Hardness, Durometer A	80	80	82	80	80
100% Modulus, psi	475	834	674	764	703
MPa	3.3	5.8	4.6	5.3	4.8
200% Modulus, psi	896	1680	1361	1538	1407
MPa	6.2	11.6	9.4	10.6	9.7
300% Modulus, psi	1317	2315	1963	2151	2022
MPa	9.1	16.0	13.5	14.8	13.9
Tensile Strength, psi	2184	2744	2707	2749	2738
MPa	15.1	18.9	18.7	19.0	18.9
Elongation, %	612	433	513	478	524
Tear Strength, Die C, lb/in	291	291	316	314	341
kN/m	51	51	55	55	60
DIN Abrasion, mm^3 loss	142	129	124	115	136
Compression Set, % 22h @ 70°C	55	58	57	69	69

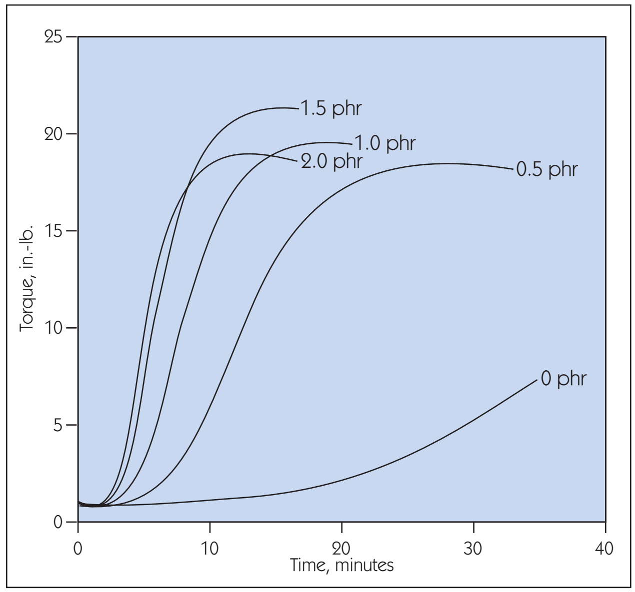
EFFECT OF THANECURE® ZM

THANECURE ZM activator is a partial complex of zinc chloride and MBTS which develops a fast rate of cure in **MILLATHANE® HT**. The improvement in the rate of cure in **MILLATHANE HT** imparted by the addition of THANECURE ZM is shown below. The addition of the THANECURE ZM improves the compression set resistance and does not detract from the outstanding abrasion and tear resistance of its vulcanizates.

For most practical applications, 1.0 part of THANECURE ZM provides a good balance between cure rate and processing safety. As the concentration of THANECURE ZM increases above 1.0 parts, cure rate improves only slightly with reduced processing safety. Some conditions may require a change in accelerator ratios rather than in the activator. If it becomes necessary to increase scorch time for greater processing safety, the MBT level can be reduced to 1.5 parts from 2. Under severe processing conditions, a change in the amount of activator and a change in accelerator ratio may be made simultaneously, but this practice is not usually recommended.

EFFECT OF THANECURE ZM ON CURE RATE

MDR @ 160°C (320°F)



EFFECTS OF THANECURE ZM ON PHYSICAL PROPERTIES

Parts per 100 Polymer	0	0.5	1.0	1.5	2.0
Press cured at 320°F (160°C), min.	34	19	13	10	8
Hardness, Durometer A	81	80	82	81	81
100% Modulus, psi	580	747	797	842	811
MPa	4.0	5.2	5.5	5.8	5.6
200% Modulus, psi	1185	1565	1680	1736	1660
MPa	8.2	10.8	11.6	12.0	11.4
300% Modulus, psi	1767	2222	2346	2385	2301
MPa	12.2	15.3	16.2	16.4	15.9
Tensile Strength, psi	2400	2667	2683	2698	2595
MPa	16.6	18.4	18.5	18.6	17.9
Elongation, %	464	437	408	406	410
Tear Strength, Die C, lb/in	236	230	223	208	216
kN/m	41	40	39	36	38
DIN Abrasion, mm^3 loss	107	112	113	118	123
Compression Set, % 22h @ 70°C	68	64	59	62	60

EFFECT OF MBTS AND MBT

An increase in the level of MBTS results in more processing safety, plus it gives a higher state of cure. On the other hand, MBT acts as an accelerator which, when increased, will cause a decrease in processing safety and a higher state of cure.

The ratio of 4 parts MBTS and 2 parts MBT appear to be acceptable for producing balanced cured physical and scorch resistance. Varying either MBTS or MBT may tend to produce mostly minor trends in cured physical properties. For control of processing safety, a wide latitude can be obtained by varying either MBTS or MBT. This available wide variation in scorch resistance does not proportionately reflect itself in cured physicals, except for modulus and elongation.

EFFECTS OF MBTS ON PHYSICAL PROPERTIES

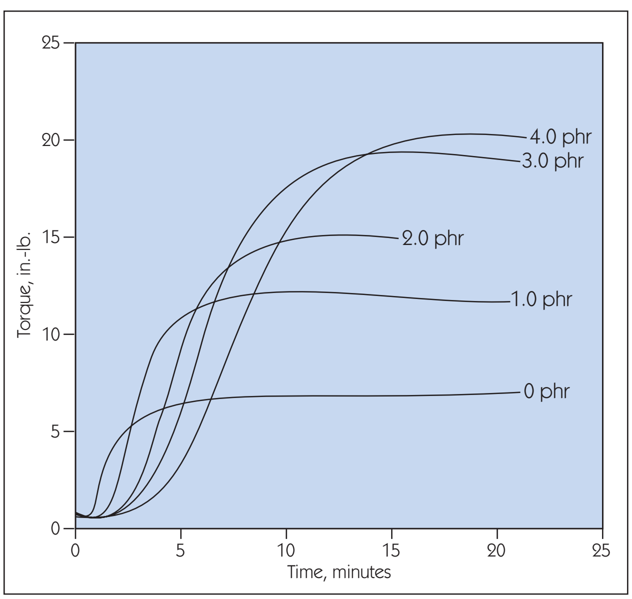
Parts per 100 Polymer	0	1	2	3	4
Press cured at 320°F (160°C), min.	6	5	7	10	12
Hardness, Durometer A	79	79	81	81	80
100% Modulus, psi	410	532	606	805	823
MPa	2.8	3.7	4.2	5.6	5.7
200% Modulus, psi	784	1062	1304	1628	1681
MPa	5.4	7.3	9.0	11.2	11.6
300% Modulus, psi	1185	1582	1990	2256	2313
MPa	8.2	10.9	13.7	15.6	16.0
Tensile Strength, psi	2304	2586	2719	2716	2654
MPa	15.9	17.8	18.8	18.7	18.3
Elongation, %	717	638	517	461	414
Tear Strength, Die C, lb/in	363	351	276	265	227
kN/m	64	61	48	46	40
DIN Abrasion, mm³ loss	140	136	124	120	115
Compression Set, % 22h @ 70°C	79	72	63	57	58

EFFECTS OF MBT ON PHYSICAL PROPERTIES

Parts per 100 Polymer	0	1	2	3	4
Press cured at 320°F (160°C), min.	17	15	12	11	10
Hardness, Durometer A	80	80	80	79	80
100% Modulus, psi	580	662	704	799	840
MPa	4.0	4.6	4.9	5.5	5.8
200% Modulus, psi	1188	1372	1512	1678	1728
MPa	8.2	9.5	10.4	11.6	11.9
300% Modulus, psi	1748	1980	2187	2340	2366
MPa	12.1	13.7	15.1	16.1	16.3
Tensile Strength, psi	2290	2441	2643	2704	2591
MPa	15.8	16.8	18.2	18.6	17.9
Elongation, %	462	437	423	408	383
Tear Strength, Die C, lb/in	221	250	202	220	212
kN/m	39	44	35	39	37
DIN Abrasion, mm³ loss	140	139	120	131	132
Compression Set, % 22h @ 70°C	82	76	58	61	63

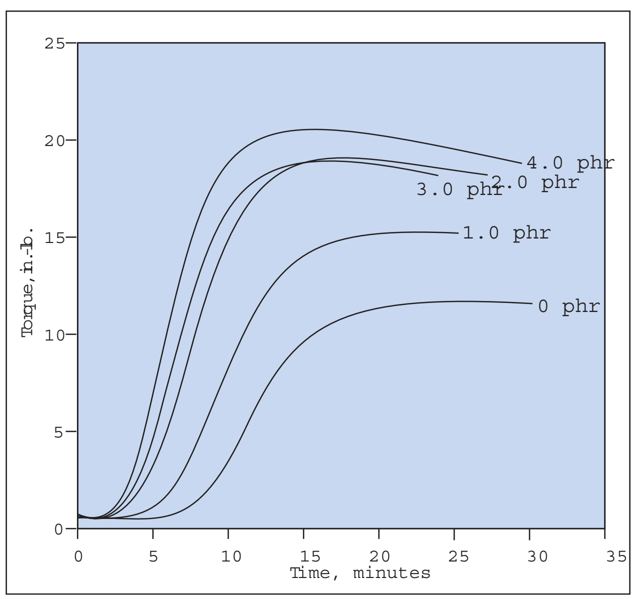
EFFECT OF MBTS ON CURE RATE

MDR @ 160°C (320°F)



EFFECT OF MBT ON CURE RATE

MDR @ 160°C (320°F)



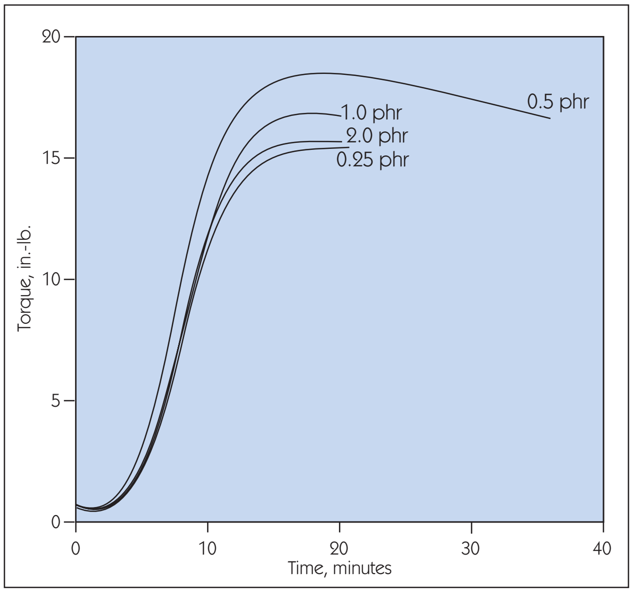
EFFECT OF ZINC STEARATE

Zinc stearate, when used as a co-activator with THANECURE® ZM, permits shorter cure times with improved compression set properties. Zinc stearate does contribute some lubricity to the batch and helps prevent sticking to mill rolls and surfaces of internal mixers, however its primary use is to help activate the cure and produce a tighter cure.

The recommended amount of zinc stearate is 0.5 parts per 100 parts of **MILLATHANE® HT** to obtain the best processing and physical properties. If THANECURE ZM is decreased, the amount of zinc stearate should also be decreased, as excessive amounts will act as a retarder.

EFFECT OF ZINC STEARATE ON CURE RATE

MDR @ 160°C (320°F)



EFFECTS OF ZINC STEARATE ON PHYSICAL PROPERTIES

Parts per 100 Polymer	0	0.25	0.5	1.0	2.0
Press cured at 320°F (160°C), min.	13	12	12	12	12
Hardness, Durometer A	82	83	80	84	85
100% Modulus, psi	871	833	911	830	738
MPa	6.0	5.7	6.3	5.7	5.1
200% Modulus, psi	1852	1706	1867	1697	1534
MPa	12.8	11.8	12.9	11.7	10.6
300% Modulus, psi	2510	2335	2469	2317	2177
MPa	17.3	16.1	17.0	16.0	15.0
Tensile Strength, psi	2650	2621	2762	2533	2558
MPa	18.3	18.1	19.0	17.5	17.6
Elongation, %	345	395	405	369	410
Tear Strength, Die C, lb/in	213	231	206	220	235
kN/m	37	40	36	39	41
DIN Abrasion, mm^3 loss	122	124	115	123	126
Compression Set, % 22h @ 70°C	61	59	57	61	60

PEROXIDE CURING SYSTEM

MILLATHANE® HT compounds need only three ingredients when curing with peroxide: **MILLATHANE HT**, stearic acid and peroxide. However, reinforcing fillers are necessary. Because without them, the tensile, elongation and tear properties of **MILLATHANE HT** compounds do not attain their maximum values.

In comparison with sulfur cures, peroxide-cured compounds have superior compression set, faster cure times and better heat resistance. However, sulfur-cured compounds exhibit higher tensile and elongation characteristics.

EFFECTS OF PEROXIDE CONCENTRATION ON PHYSICAL PROPERTIES

The peroxide concentration has a dramatic effect on physical properties and processing safety. As the peroxide level increases, modulus increases along with hardness and compression set also improves. However, tensile strength, elongation and tear strength decrease as shown in the following table. It appears that one part of Varox DBPH-50 gives excellent physical properties, plus giving the best balance of compression set and abrasion resistance.

Generally, when using black or non-black reinforcing fillers, the closer the filler level is to a pure gum, the less amount of peroxide is needed to produce useful compounds. In changing to different peroxides, it is wise to evaluate the new peroxide at a few different levels to determine its optimum concentration.

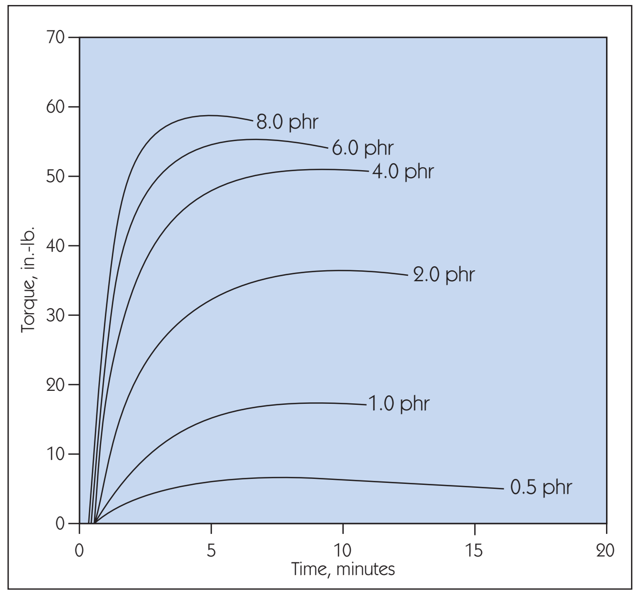
TEST FORMULATION

MILLATHANE® HT	100.0
Stearic Acid	0.5
N-550 Black	35.0
TP-95	5.0
Vanfre AP2	1.0
Poly AC617A	1
Varox DBPH-50*	As shown

*Varox DBPH-50 is 50% 2, 5-Dimethyl-2, 5-bis (t-butylperoxy) hexane

EFFECT OF DBPH-50 ON CURE RATE

MDR @ 350°F (176°C)



EFFECTS OF DBPH-50 PEROXIDE CONCENTRATION ON PHYSICAL PROPERTIES

DBPH-50 phr	0.5	1.0	2.0	4.0	6.0	8.0
Cure time at 350°F (176°C), minutes	4.9	5.0	4.9	4.1	2.9	2.4
Hardness, Durometer A	70	75	83	89	88	90
100% Modulus, psi	257	605	700	---	---	---
MPa	1.8	4.2				
200% Modulus, psi	587	1536	---	---	---	----
MPa	4.0	10.6				
300% Modulus, psi	987	1923	---	---	----	----
MPa	6.8	13.3				
Tensile Strength, psi	1626	2020	2180	2305	1726	2171
MPa	11.2	13.9	15.0	15.9	11.9	15.0
Elongation, %	523	300	125	85	59	40
Tear Strength, Die C, lb/in	190	152	78	55	54	48
kN/n	33.3	26.6	13.7	9.6	9.5	8.4
DIN Abrasion, mm³ Loss	139	148	174	227	245	268
Compression Set, %						
22 hours 100°C	39.7	20.7	10.6	9.9	8.9	6.0

COMPARISON OF SULFUR AND PEROXIDE CURES

	CARBON BLACK		NON-BLACK	
Cure System	**Sulfur**	**Peroxide**	**Sulfur**	**Peroxide**
MILLATHANE HT	100.0	100.0	100.0	100.0
N-330 Black	20.0	20.0	----	----
Hi Sil 243 LD	----	----	60.0	60.0
MBTS	4.0	----	4.0	----
MBT	2.0	----	2.0	----
Zinc Stearate	0.5	----	0.5	----
THANECURE® ZM	1.0	----	1.0	----
Sulfur	1.5	----	1.5	----
Di Cup 40C	----	1.0	----	1.0
Cure Time, minutes	20	10	30	10
Cure Temp. °F	300	340	310	320
Cure Temp. °C	149	171	154	160
Hardness, Durometer A	61	52	91	93
100% Modulus, psi	413	200	876	1057
MPa	2.9	1.4	6.0	7.3
200% Modulus, psi	1046	499	1618	1882
MPa	7.2	3.4	11.2	12.0
300% Modulus, psi	1914	1138	2329	2477
MPa	13.2	7.8	16.1	17.8
Tensile Strength, psi	3938	3088	3213	2861
MPa	27.1	21.3	22.1	19.7
Elongation, %	464	493	427	343
Tear Strength, Die C, lb/in	259	177	403	355
kN/m	45.3	31.0	70.5	62.1

MILLATHANE® HT ROLLER APPLICATION

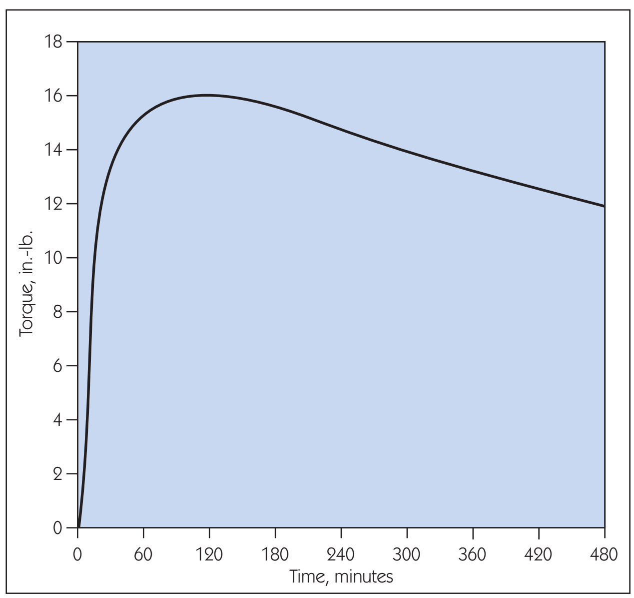
Due to the thermal stability of **MILLATHANE HT**, large rollers can be autoclave cured for several hours at 300°F (149°C). Below is a MDR curve showing only a slight amount of reversion when cured eight hours at 300°F. This stability at this temperature allows **MILLATHANE HT** roller compounds to be cured along side other rollers, thus saving time in curing large rollers.

MILLATHANE HT ROLLER FORMULATION

MILLATHANE HT	100.0
Stearic Acid	0.5
Vanfre AP-2	2.0
Poly AC 617A	2.0
Stabaxol P	1.5
N-220 Black	30.0
Cumar P10	5.0
Struktol 60NS	2.5
Saret SR350	1.0
Varox DBPH-50	6.0
Hardness, Durometer, A	78

MILLATHANE HT ROLLER COMPOUND

MDR @ 300°F (149°C)



PROCESSING OF MILLATHANE® MILLABLE URETHANES

MILLATHANE millable urethanes are processed on conventional rubber equipment, including mills, internal mixers, calenders and extruders. Because of their unique composition, the processing of millable urethanes is optimized when the following suggestions are followed.

PROCESS AIDS

Millable urethanes can tend to show sticking to mixer surfaces, especially when low Mooney viscosity polymers are used and mixing equipment is warm or hot. This can be alleviated by incorporating a small amount (0.5-2.0 parts) of a process aid into the compound. For sulfur cures, 0.5 part of zinc stearate is generally used and it acts both as a cure activator and a process/release agent. For peroxide cures, stearic acid is usually added at 0.25 – 0.5 parts. An additional process aid such as Struktol WB222, Aflux 54, Vanfre AP-2, or AC617A (low melt polyethylene) can also be added at 0.5-2 part levels.

MILL MIXING

For mill mixing of MILLATHANE millable urethane compounds, it's best to start with a cool mill and to keep the water (or other cooling medium) on to prevent sticking. Process aids should be added at the beginning of the mix, with the polymer, and blended well before adding fillers. Half the filler should then be added, with the most reinforcing filler added first. After blending, the remaining filler and any plasticizer or other ingredients should be added. If the batch temperature is below 100°C (212°F), curatives can be added; otherwise sheet off the stock and add after the stock cools.

INTERNAL MIXING

Full cooling is generally used, to prevent sticking, and a slow mixing speed (20-25 RPM) is usually used. A typical procedure is as follows:

0'	Add polymer and process aids
1'	Add 1/2 filler
3'-5'	Add remaining filler, plasticizer, and other ingredients
5'-7'	Dump 100°-125°C (212°-257°F)

When the amp meter or stock temperature has leveled off, the batch is ready to dump. Another indicator of time to dump is the characteristic "slurping" sound of a good mix. Add curatives to cooled stock on mill or in a second pass. If sticking occurs, try reducing the batch size, reducing the ram pressure and/or mixing speed, or adding a process aid. Zinc stearate should NOT be used for a slab dip; CRYSTAL® 2000, talc or clay solutions can be used. Stock should be cool and dry before stacking.

BRABENDER MIXING (SMALL INTERNAL MIXER)

Because of the toughness of urethane polymers, normal mixing procedures in Brabender mixers sometimes result in broken shear pins. It's best to undersize the batch by 10-20%, and to cut the rubber into small pieces and/or warm the rubber, in a conventional or microwave oven, before adding it to the mixer.

POLYMER BREAKDOWN

Generally, millable urethanes polymers can be reduced in viscosity by a breakdown step, either as a separate step or as an initial part of the mixing process. This may be desirable for improved transfer or injection molding of urethane compounds. Breakdown should be done with a process aid to avoid sticking, and is more efficient when done at moderate-to-high temperatures (70°-100°C; 158°-212°F). Cured properties are generally not affected by the breakdown step.

CALENDERING

For the best calendering of millable urethane compounds:

- Ply up thin sheets of 0.5-1.0 mm (0.020-0.040 in.) to make thicker sheets
- Cool stock before wrapping in liner
- Higher temperatures will give better sheet smoothness, as will differential roll speeds
- Use moderate temperatures:

Stock	60°-90°C (140°-194°F)
Top Roll	90°-105°C (194°-221°F)
Middle Roll	110°-120°C (230°-249°F)
Bottom Roll	60°-90°C (140°-194°F)

EXTRUSION

Millable urethanes can be extruded to make preforms for molding operations. Because urethanes have poor high temperature green strength, they are not suitable for continuous cure processes which operate at, or generate, high temperatures.

For the best extrusion characteristics,

- Use compounds with good scorch safety
- Avoid excessive heat to prevent softening and sticking
- Use fine particle blacks and silicas
- Generally, cold screw, cool barrel, and warm-hot heat and die work best.
- Typical temperatures used are:

Screw	20°-30°C (68°-86°F)
Barrel	60°-70°C (140°-158°F)
Head	75°-90°C (167°-194°F)
Die	85°-100°C (185°-212°F)

CRYSTAL® 2000 – SLAB DIP/ANTI-STICK AGENT

CRYSTAL 2000 is an effective anti-stick agent for mixed stock or mold preforms. A one-part CRYSTAL 2000 to three part water solution is recommended to prevent uncured rubber slabs or preforms from sticking to themselves. CRYSTAL 2000 is transparent and will not discolor white or colored stocks.

RELEASE AGENTS

CRYSTAL 1053 water based, semi-permanent mold release from TSE Industries has been found to be an effective mold release agent for **MILLATHANE® HT** and other millable polyurethane compounds.

BASIC COMPOUNDING

CARBON BLACK LOADING STUDIES

On the following pages, five different carbon blacks are evaluated in **MILLATHANE® HT**, at various loading levels. The blacks range from N-990 (MT) to the ultra fine furnace blacks N-330 (HAF) and N-220 (ISAF).

It is evident from the table that the modulus, hardness, and tear strength values, as well as abrasion properties, are directly related to the particle size of the carbon black. The finer the particle size, the stronger the reinforcement. For the finer particle size blacks, compression set, resilience and heat buildup (hysteresis) values are higher, with the cure rate lower. Tensile strength is similar for all carbon blacks because of the unusually high inherent tensile values of cured **MILLATHANE HT**.

TEST FORMULATION

MILLATHANE HT	100.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
THANECURE® ZM	1.0
Sulfur	1.5
Carbon Black	As Shown

Press-cured 20 minutes at 300°F (149°C).

CARBON BLACK N-990 (MT)

Parts per 100 polymer	20	30	40	50	60	70
Hardness, Durometer A	53	57	60	63	68	71
100% Modulus, psi	150	210	304	293	467	710
MPa	1.0	1.5	2.1	2.0	3.2	4.9
200% Modulus, psi	433	598	896	813	1300	1467
MPa	3.0	4.1	6.2	5.6	9.0	10.1
300% Modulus, psi	1050	1278	1457	1397	1683	1591
MPa	7.2	8.8	10.0	9.6	11.6	11.0
Tensile Strength, psi	2955	3043	2335	2114	1836	1730
MPa	20.4	30.0	16.1	14.7	12.7	11.9
Elongation, %	530	537	520	503	410	383
Tear Strength, Die C, lb/in	146	186	182	204	195	198
kN/m	25.6	32.6	31.9	35.7	34.1	34.7
Compression set 22 hrs at 158°F (70°C), %	55	57	56	55	57	53
Taber Abrasion Wheel H-18, mg loss/rev	0.10	0.14	0.19	0.25	0.43	0.47

CARBON BLACK N-774 (SRF)

Parts per 100 polymer	20	30	40	50	60	70
hardness, Durometer A	59	64	71	77	81	86
100% Modulus, psi	349	554	800	1107	1360	1776
MPa	2.4	3.8	5.5	7.6	9.3	12.2
200% Modulus, psi	941	1394	1867	2231	2362	2524
MPa	6.5	9.6	12.9	15.4	16.3	17.4
300% Modulus, psi	1731	2188	2567	2650	----	----
MPa	11.9	15.1	17.7	18.3	----	----
Tensile Strength, psi	2944	2903	2779	2703	2543	2518
MPa	20.3	20.0	19.1	18.6	17.3	17.3
Elongation, %	426	398	346	320	262	222
Tear Strength, Die C, lb/in	242	271	290	310	342	307
kN/m	42.4	47.4	50.8	54.3	59.9	53.7
Compression set 22 hrs at 158°F (70°C), %	62	63	56	57	62	60
Taber Abrasion Wheel H-18, mg loss/rev	0.08	0.09	0.08	0.11	0.09	0.21

CARBON BLACK N-550 (FEF)

Parts per 100 polymer	20	30	40	50	60	70
Hardness, Durometer A	61	69	77	81	85	90
100% Modulus, psi	434	703	935	1263	1828	2138
MPa	3.0	4.9	6.4	8.7	11.2	14.7
200% Modulus, psi	1146	1723	1996	2429	2717	2792
MPa	7.9	11.9	13.8	16.7	18.7	19.2
300% Modulus, psi	2005	2581	2689	2543	----	----
MPa	13.8	17.8	18.5	17.3	----	----
Tensile Strength, psi	3404	3298	3011	2891	2849	2830
MPa	23.4	22.7	20.7	19.9	19.6	19.5
Elongation, %	429	401	383	345	281	226
Tear Strength, Die C, lb/in	251	299	322	332	345	305
kN/m	43.9	52.3	56.4	58.1	60.4	53.4
Compression set 22 hrs at 158°F (70°C), %	62	61	65	61	59	62
Taber Abrasion Wheel H-18, mg loss/rev	0.03	0.06	0.09	0.11	0.17	0.26

CARBON BLACK N-330 (HAF)

Parts per 100 polymer	20	30	40	50	60	70
Hardness, Durometer A	61	71	80	87	89	90
100% Modulus, psi	413	619	1023	1272	1616	1736
MPa	2.9	4.3	7.1	8.8	11.1	12.0
200% Modulus, psi	1046	1433	2257	2484	2963	3109
MPa	7.2	9.9	15.6	17.1	20.4	21.4
300% Modulus, psi	1914	2625	3289	3245	3043	----
MPa	13.2	16.0	22.7	22.4	30.0	----
Tensile Strength, psi	3978	3571	3450	3258	3180	3115
MPa	27.1	24.6	27.8	22.5	21.9	21.5
Elongation, %	464	428	389	352	305	257
Tear Strength, Die C, lb/in	259	318	361	403	391	386
kN/m	45.3	55.7	63.2	70.5	68.4	67.6
Compression set 22 hrs at 158°F (70°C), %	61	64	56	61	54	56
Taber Abrasion Wheel H-18, mg loss/rev	0.07	0.08	0.10	0.16	0.18	0.17

CARBON BLACK N-220 (ISAF)

Parts per 100 polymer	20	30	40	50	60	70
Hardness, Durometer A	65	75	82	91	93	94
100% Modulus, psi	433	578	867	2013	1636	2169
MPa	3.0	4.0	6.0	13.9	11.3	15.0
200% Modulus, psi	976	1289	1790	3251	2883	3095
MPa	6.7.	8.9	12.3	22.4	19.9	21.3
300% Modulus, psi	1711	2119	2664	----	----	----
MPa	11.8	14.8	18.4	----	----	----
Tensile Strength, psi	4045	4044	3793	3385	3306	3247
MPa	27.9	27.9	26.1	23.3	22.8	22.4
Elongation, %	493	483	438	320	282	232
Tear Strength, Die C, lb/in	260	341	360	385	404	366
kN/m	45.5	59.7	63.0	67.4	70.7	64.1
Compression set 22 hrs at 158°F (70°C), %	61	56	64	58	57	56
Taber Abrasion Wheel H-18, mg loss/rev	0.05	0.09	0.11	0.20	0.20	0.24

NON-BLACK LOADING STUDIES

The non-black mineral fillers are mostly non-reinforcing in **MILLATHANE HT**, except for a fine silica and fine magnesium silicate. Fine silica is comparable to carbon black in its effect on tensile strength, but gives less improvement in abrasion resistance. The precipitated silica fillers retard the cure considerably and have an adverse effect on resistance to compression set. Compression set can be improved by using a peroxide cure system in place of a sulfur cure.

TEST FORMULATION FOR NON-BLACK FILLERS

MILLATHANE HT	100.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
THANECURE ZM	1.0
Sulfur	1.5
Non-Black Filler	As Shown

DIXIE CLAY

Parts per 100 polymer	20	40	60	80
Press cured at 310°F (155°C), min.	19	38	33	43
Hardness, Durometer A	54	61	66	70
100% Modulus, psi	365	685	1059	1571
MPa	2.5	4.7	7.3	10.8
200% Modulus, psi	847	1423	1953	2461
MPa	5.8	9.8	13.5	17.0
300% Modulus, psi	1342	1934	2433	2815
MPa	9.3	13.3	16.8	19.4
Tensile Strength, psi	2858	2796	3050	2911
MPa	19.7	19.3	21.0	15.7
Elongation, %	456	418	421	336
Tear Strength, Die C, lb/in	202	248	285	265
kN/m	35.4	43.4	49.9	46.4
Compression set 22 hours at 158°F (70°C), %	58	55	55	72

LAMINAR

Parts per 100 polymer	20	40	60	80
Press cured at 310°F (155°C), min.	20	22	26	23
Hardness, Durometer A	54	58	62	67
100% Modulus, psi	260	330	387	512
MPa	1.8	2.3	2.6	3.5
200% Modulus, psi	427	572	573	705
MPa	2.9	3.9	4.0	4.9
300% Modulus, psi	662	732	769	915
MPa	4.6	5.0	5.3	6.3
Tensile Strength, psi	1540	2077	2032	2081
MPa	10.6	14.3	14.0	14.3
Elongation, %	426	463	479	470
Tear Strength, Die C, lb/in	151	166	175	184
kN/m	26.4	29.1	30.6	32.2
Compression set 22 hours at 158°F (70°C), %	57	52	52	68

HI SIL 243 LD

Parts per 100 polymer	20	40	60	80
Press cured at 310°F (155°C), min.	24	27	28	30
Hardness, Durometer A	63	78	91	97
100% Modulus, psi	336	682	867	1520
MPa	2.3	4.7	6.0	10.5
200% Modulus, psi	716	1356	1618	2344
MPa	4.9	93	11.2	16.2
300% Modulus, psi	1307	2149	2329	---
MPa	9.0	14.8	16.1	---
Tensile Strength, psi	3757	3795	3213	2620
MPa	25.9	26.2	22.1	18.1
Elongation, %	478	447	427	283
Tear Strength, Die C, lb/in	238	380	403	408
kN/m	41.7	66.5	70.5	71.4
Compression set 22 hours at 158°F (70°C), %	59	62	64	78

MISTRON VAPOR

Parts per 100 polymer	20	40	60	80
Press cured at 310°F (155°C), min.	21	19	19	20
Hardness, Durometer A	57	66	70	78
100% Modulus, psi	375	690	981	1366
MPa	2.6	4.8	6.8	9.4
200% Modulus, psi	654	996	1212	1587
MPa	4.5	6.9	8.4	10.9
300% Modulus, psi	949	1242	1475	1812
MPa	6.5	8.6	10.2	12.5
Tensile Strength, psi	3770	3716	3201	3150
MPa	26.0	25.6	22.1	21.7
Elongation, %	496	519	476	473
Tear Strength, Die C, lb/in	150	212	264	321
kN/m	26.3	37.1	46.2	56.2
Compression set 22 hours at 158°F (70°C), %	60	62	62	62

PLASTICIZER STUDIES

A number of plasticizers have been evaluated for compatibility and softening effect in **MILLATHANE® HT**. These plasticizers improve the processibility and lower the modulus and hardness without seriously affecting other properties of the finished part.

On the following pages are eight plasticizers compared at equal loadings in **MILLATHANE HT**. All plasticizers reduced Mooney viscosity, enhanced tack and improved low-temperature properties. In general, 15 parts of recommended plasticizer can be expected to lower the hardness of vulcanizates approximately 8 points at optimum cure.

TEST FORMULATION FOR PLASTICIZERS

MILLATHANE HT	100.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
THANECURE ZM	1.0
Sulfur	1.5
N-330 Black	20.0
Plasticizer as shown	15.0

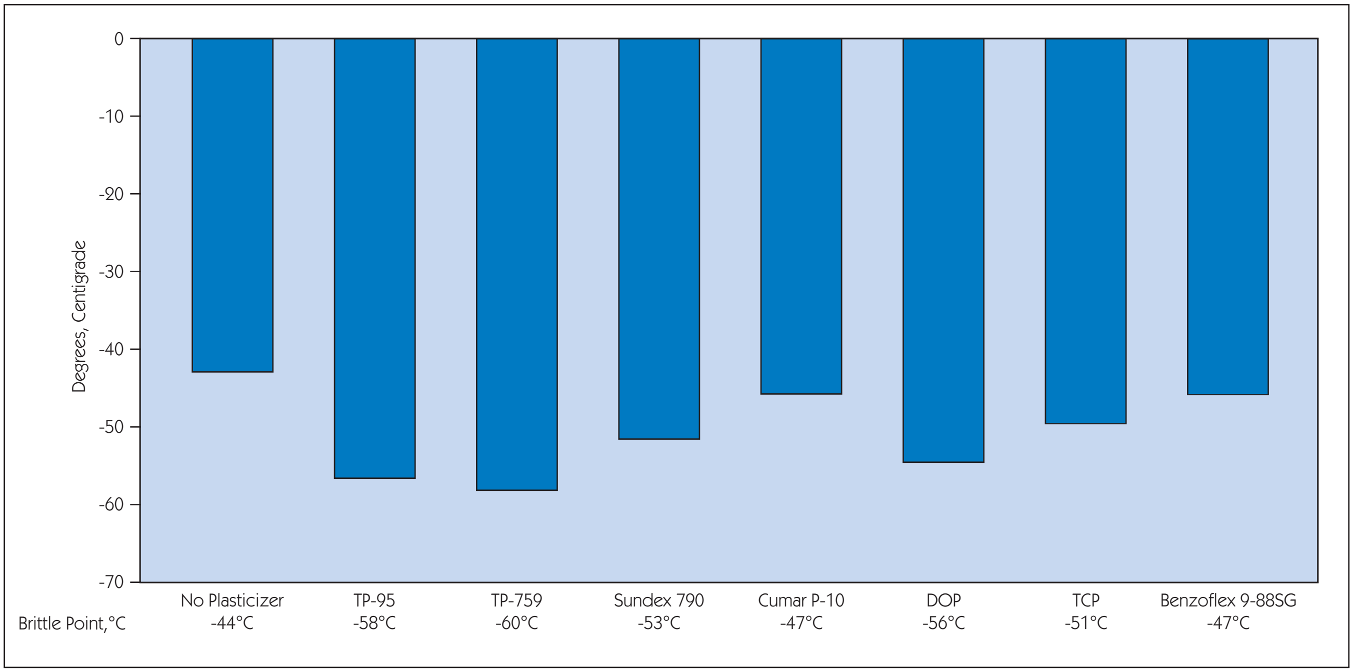
IDENTIFICATION OF PLASTICIZERS EVALUATED

Brand Name	Chemical Name	Manufacturer	Specific Gravity
Benzoflex 9-88 SG	Dipropylene glycol dibenzoate	Velsicol Chemical	1.13
Cumar P-10	Coumarone-indene resin	Neville Chemical	1.12
DOP	Dioctyl Phthalate	C.P. Hall	0.98
Lindol	Tricresyl Phosphate (TCP)	Harwick Standard	1.17
Sundex 790	Aromatic Hydrocarbon Oil	Sunoco, Inc.	1.00
TP-95 Plasticizer	Di (butoxy-ethoxy-ethyl) adipate	Rohm and Haas	1.01
TP-759 Plasticizer	Ether/ester type	Rohm and Haas	1.03

EFFECTS OF PLASTICIZERS ON PHYSICAL PROPERTIES

Plasticizers	Control	TP-95	TP-759	Sundex 790	Cumar P-10	DOP	TCP	Benzoflex 9-88SG
Cure Time, minutes @ 310°F (155°C)	20	35	25	20	23	27	25	22
Hardness, Durometer A	61	50	51	60	53	53	55	55
100% Modulus, psi	413	219	218	295	200	234	260	268
MPa	2.9	1.5	1.5	2.0	1.4	1.6	1.8	1.9
200% Modulus, psi	1046	538	554	727	416	569	589	673
MPa	7.2	3.7	3.8	5.0	2.9	3.9	4.1	4.6
300% Modulus, psi	1914	1145	1123	1424	850	1137	1160	1277
MPa	13.2	7.9	7.7	9.8	5.9	7.8	8.0	8.8
Tensile Strength, psi	3938	2404	3511	4404	3730	3738	2375	3513
MPa	27.1	16.6	24.2	30.3	25.7	25.8	23.9	24.2
Elongation, %	464	467	573	540	617	557	563	530
Tear Strength, Die C, lb/in	259	185	203	261	256	242	258	266
kN/m	45.3	32.4	35.5	45.7	44.8	42.4	45.2	46.6
Brittle Point °F	-47	-72	-76	-63	-53	-69	-60	-53
Brittle Point °C	-44	-58	-60	-53	-47	-56	-51	-47

EFFECT OF PLASTICIZER ON BRITTLE POINT ASTM D2137-94



EFFECTS OF CURING TEMPERATURE -- SULFUR CURED SYSTEM

TEST FORMULATION

MILLATHANE HT	100.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
N-330 Black	20.0
Sulfur	1.5
THANECURE® ZM	1.0

EFFECTS OF CURING TEMPERATURE / EFFECTS OF OVER-CURING

	Effects of Curing Temperature					Effects of Over-Curing
	285°F (140°C)	**300°F (149°C)**	**310°F (154°C)**	**330°F (166°C)**	**350°F (177°C)**	**330°F (166°C)**
Cure Time, Minutes	40	25	20	13	9	39
Hardness, Durometer A	62	62	62	60	57	57
100% Modulus, psi	455	452	450	408	375	346
MPa	3.1	3.1	3.1	2.8	2.6	2.4
200% Modulus, psi	1198	1228	1200	1077	922	962
MPa	8.3	8.5	8.3	7.4	6.4	6.6
300% Modulus, psi	2245	2286	2261	2036	1732	1892
MPa	15.5	15.8	15.6	14.0	11.9	13.0
Tensile Strength, psi	4589	3939	3904	3901	3810	3551
MPa	31.6	27.1	26.9	26.9	26.3	24.5
Elongation, %	447	403	412	437	487	446
Tear Strength, Die C, lb/in	240	296	270	255	205	219
kN/m	42.0	51.8	47.3	44.6	35.9	38.3

VULCANIZATE PROPERTIES

MILLATHANE HT was developed to meet the continuing demand for an abrasion resistant polyurethane that can maintain its excellent physical properties at elevated temperatures. Polyurethanes have been limited in applications because the highest temperature they could be used in was 180°F (82°C) for continuous use. **MILLATHANE HT** can withstand 250°F (121°C) for continuous use without a dramatic loss of physical properties.

The following charts show the stability of peroxide-cured **MILLATHANE HT** at elevated temperatures compared with Neoprene W, Nitrile rubber (medium ACN) and **MILLATHANE 76**, a polyester-based millable polyurethane. It is evident from the test data that **MILLATHANE HT** is the first polyurethane that can withstand intermittent exposure to 300°F (149°C), and outperform chloroprene and nitrile elastomers at this elevated temperature.

TEST FORMULATIONS

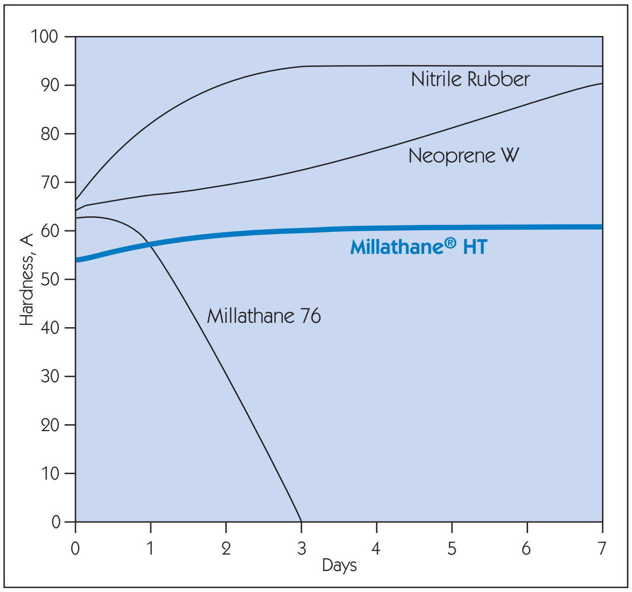
MILLATHANE HT	100.0	**MILLATHANE 76**	100.0	NEOPRENE W	100.0	NITRILE RUBBER	100.0
Stearic Acid	0.5	Stearic Acid	0.5	Octamine	4.0	Zinc Oxide	5.0
N-330 Black	20.0	N-330 Black	20.0	Magnesium Oxide	4.0	Stearic Acid	1.0
Trigonox 145-45B*	1.0	Di Cup 40C	3.0	Stearic Acid	0.5	AgeRite Resin D	5.0
				N-550 Black	20.0	Poly AC 617A	2.0
				Whiting	90.0	N-550 Black	25.0
				Rapeseed Oil	15.0	N-990 Black	125.0
				Zinc Oxide	10.0	DOP	15.0
				ETU	1.25	MBTS	1.5
						TMTD	0.5
						Sulfur	1.5
						Antozite No. 2	4.0

*2.5-Dimethyl-2.5-di-(tert-butylperoxy) hexyne-3

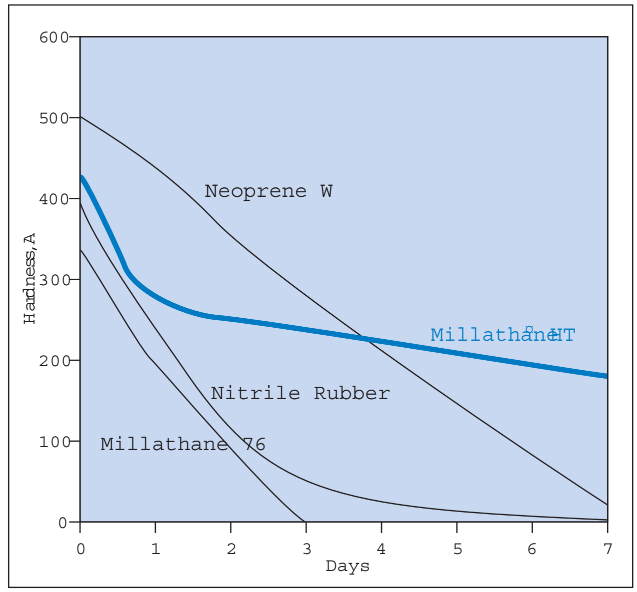
HEAT AGING COMPARISON OF DIFFERENT ELASTOMERS AT 300°F (149°C)

	MILLATHANE HT	**MILLATHANE 76**	NEOPRENE W	NITRILE RUBBER
Original				
Hardness, Durometer A	54	64	65	67
Tensile Strength, psi	3181	4645	1500	1550
MPa	21.9	32.0	10.3	10.7
Elongation, %	429	343	500	400
24 Hours Air Oven @ 300°F (149°C)				
Hardness, points change	+4	-7	+3	+16
Tensile Strength, % change	-20	-42	-8	-9
Elongation, % change	-36	-38	-12	-40
72 Hours Air Oven @ 300°F (149°C)				
Hardness, points change	+6	Failed	+8	+27
Tensile Strength, % change	-23		-23	-48
Elongation, % change	-44		-44	-88
168 Hours Air Oven @ 300°F (149°C)				
Hardness, points change	+7	Failed	+26	+27
Tensile Strength, % change	-39		-68	-59
Elongation, % change	-59		-96	-100

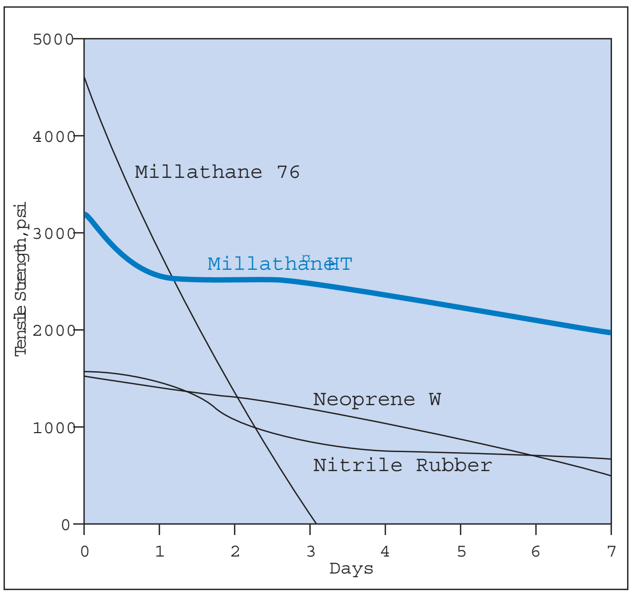
EFFECT ON HARDNESS, HEAT AGED 149°C (300°F)



EFFECT ON ELONGATION, HEAT AGED 149°C (300°F)



EFFECT ON TENSILE, HEAT AGED 149°C (300°F)



HEAT AGING COMPARISON AT VARIOUS TEMPERATURES – SULFUR-CURED SYSTEM

MILLATHANE® HT is resistant to heat aging, even when using a sulfur-cured system. It can be seen from the charts and graphs that **MILLATHANE HT**, with a sulfur cure, can withstand 275°F (135°C) hot air aging.

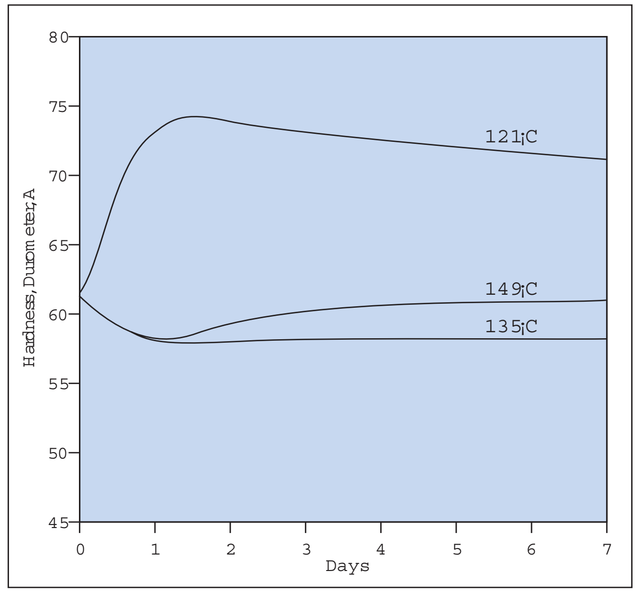
TEST FORMULATION

MILLATHANE HT	100.0
Zinc Stearate	0.5
MBTS	4.0
MBT	2.0
N-330 Black	20.0
THANECURE® ZM	1.0
Sulfur	1.5

Press-cured at 360°F (182°C) for 20 minutes

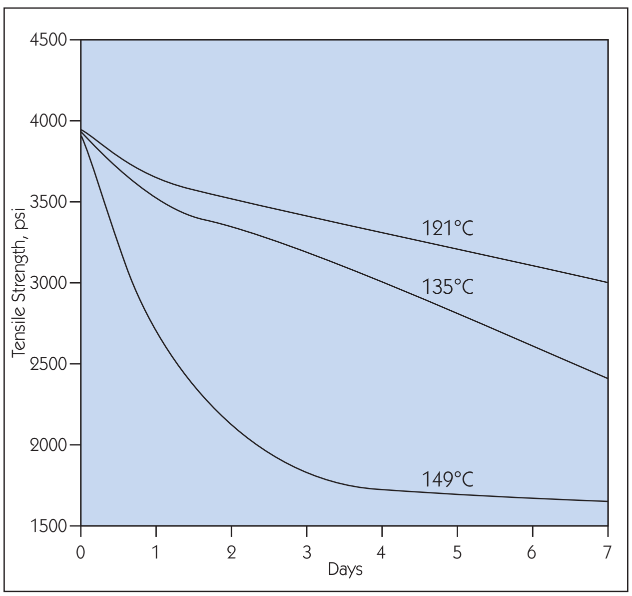
EFFECT OF HEAT AGING ON HARDNESS

MILLATHANE HT – SULFUR CURE



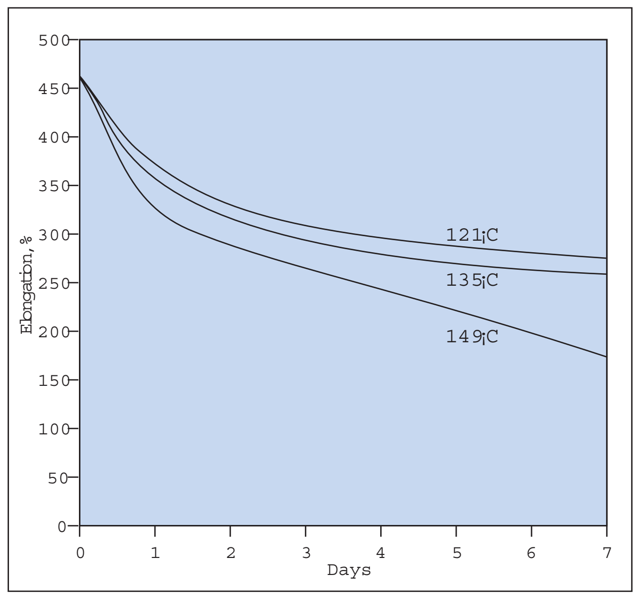
EFFECT OF HEAT AGING ON TENSILE STRENGTH

MILLATHANE HT – SULFUR CURE



EFFECT OF HEAT AGING ON ELONGATION

MILLATHANE HT – SULFUR CURE



HEAT RESISTANCE WITH A SULFUR-CURED SYSTEM

		Oven Age 250°F (121°C)			Oven Age 275°F (135°C)			Oven Age 300°F (149°C)		
	Original	**24 hr**	**72 hr**	**168 hr**	**24 hr**	**72 hr**	**168 hr**	**24 hr**	**72 hr**	**168 hr**
Hardness, Durometer A	61	73	73	71	71	67	65	58	58	58
100% Modulus, psi	413	951	994	932	745	641	708	392	439	440
MPa	2.9	6.6	6.9	6.4	5.1	4.4	4.9	2.7	3.0	3.0
200% Modulus, psi	1046	2612	2701	2536	2214	1867	1793	1213	1206	----
MPa	7.2	18.0	18.6	17.5	15.3	12.9	12.4	8.4	8.3	----
300% Modulus, psi	1914	3250	3300	----	3285	----	----	2408	----	----
MPa	13.2	22.4	22.8	----	22.6	----	----	16.6	----	----
Tensile Strength, psi	3938	3637	3401	3000	3500	3172	2405	2702	1809	1643
MPa	27.1	25.1	23.4	20.7	24.1	21.9	16.6	18.6	12.5	11.3
Elongation, %	464	375	310	275	360	294	258	331	267	177
Tear Strength, Die C, lb/in	259	235	225	209	226	210	173	195	149	118
kN/m	45.3	41.1	39.4	36.6	39.6	36.8	30.3	34.1	26.1	20.7

HEAT AGING COMPARISON AT VARIOUS TEMPERATURES – PEROXIDE-CURED SYSTEM

The following charts and graphs show the heat resistance of **MILLATHANE® HT** at temperatures ranging from 250°F (121°C) to 350°F (177°C).

TEST FORMULATION

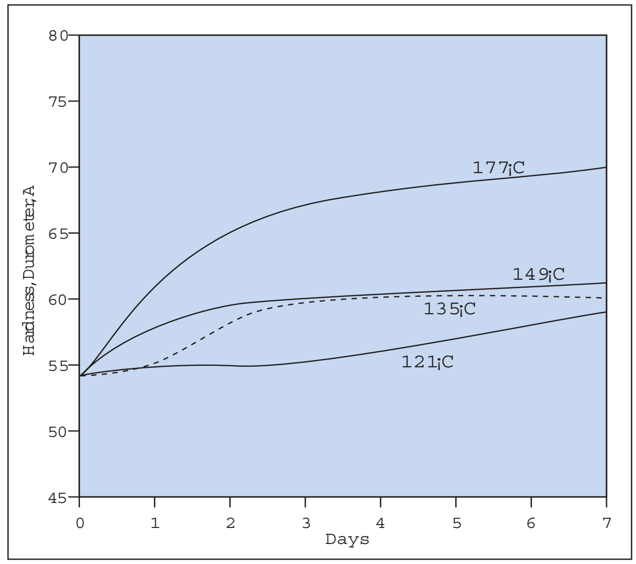
MILLATHANE HT	100.0
Stearic Acid	0.5
N-330 Black	20.0
Trigonox 145-45B*	1.0

Press-cured at 360°F (182°C) for 20 minutes.

*2.5-Dimethyl-2.5-di-(tert-butylperoxy) hexyne-3, 45%

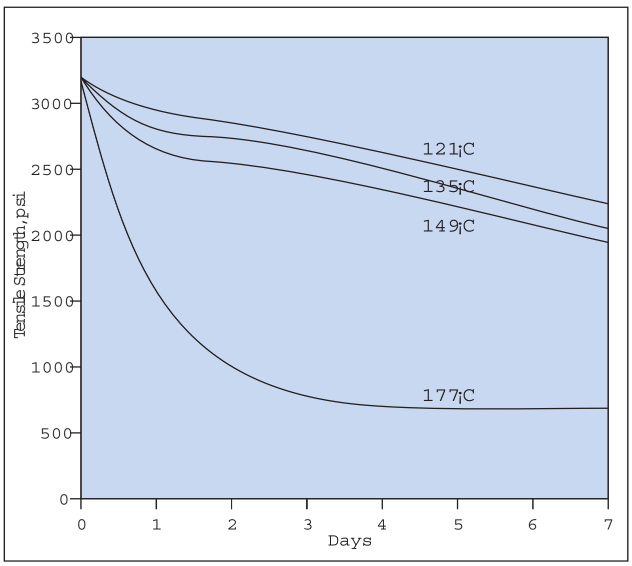
EFFECT OF HEAT AGING ON HARDNESS

MILLATHANE HT – PEROXIDE CURE



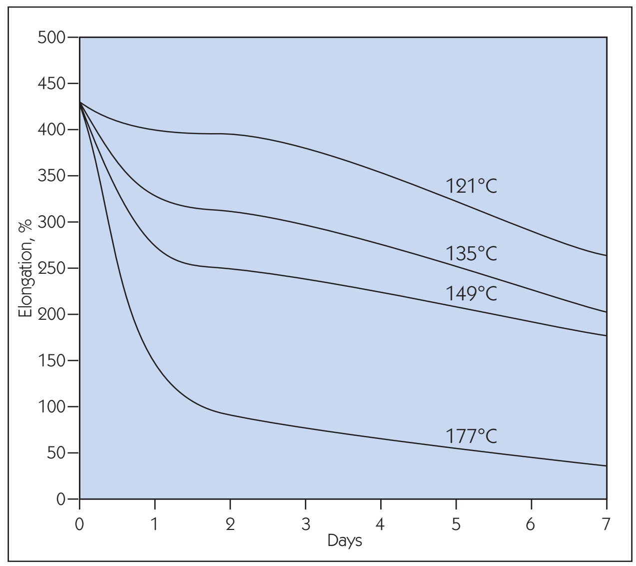
EFFECT OF HEAT AGING ON TENSILE STRENGTH

MILLATHANE HT – PEROXIDE CURE



EFFECT OF HEAT AGING ON ELONGATION

MILLATHANE HT – PEROXIDE CURE



HEAT RESISTANCE WITH A PEROXIDE-CURED SYSTEM

		250°F (121°C) Oven Age			275°F (135°C) Oven Age			300°F (149°C) Oven Age			350°F (177°C) Oven Age		
	Original	**24 hr**	**72 hr**	**168 hr**	**24 hr**	**72 hr**	**168 hr**	**24 hr**	**72 hr**	**168 hr**	**24 hr**	**72 hr**	**168 hr**
Durometer A	54	55	55	59	55	60	60	58	60	61	61	67	70
100% Modulus, psi	240	248	225	275	246	317	447	332	424	602	649	----	----
MPa	1.7	1.7	1.6	1.9	1.7	2.2	3.1	2.3	3.0	4.2	5.6	----	----
200% Modulus, psi	697	768	696	905	840	1120	----	1222	1649	----	----	----	----
MPa	4.8	5.3	4.8	6.2	5.8	7.7	----	8.4	11.4	---	----	----	----
300% Modulus, psi	1628	1936	1960	----	2119	----	----	----	----	----	----	----	----
MPa	11.2	13.3	13.5	----	14.6	----	----	----	----	----	----	----	----
Tensile Strength, psi	3181	2940	2740	2230	2800	2659	2050	2650	2457	1941	1562	780	671
MPa	21.9	20.3	18.9	15.4	19.3	18.5	14.1	18.3	16.9	13.4	10.8	5.4	4.6
Elongation, %	429	400	379	265	330	297	204	274	240	177	145	75	35

CHEMICAL RESISTANCE OF MILLATHANE® HT

The resistance of **MILLATHANE HT** to oils, fuels, solvents and other chemical compounds is very good. The information given in the subsequent tables illustrates the effects on physical properties of a variety of fluids on peroxide-cured **MILLATHANE HT**.

TEST FORMULATION

MILLATHANE HT	100.0
Stearic Acid	0.25
N-774 Black	40.0
Perkadox 14*	0.5

Cured 10' at 340°F (170°C)

*Di-(tertbutylperoxyisopropyl) benzene

ORIGINAL PROPERTIES

Hardness, Durometer A	75
100% Modulus, psi	969
MPa	6.7
200% Modulus, psi	2458
MPa	16.9
Tensile Strength, psi	2490
MPa	17.1
Elongation, %	204
Tear Strength, Die C, lb/in	165
kN/m	28.9
Compression Set, %	
22 hrs @ 100°C	13.0

OIL AND FUEL RESISTANCE

	Heat Aging: 72 Hrs @ 150°C	Fuel B: 72 Hrs @ RT	Oil Aging ASTM Oil #1: 70 Hrs @ 100°C	Oil Aging ASTM Oil #3: 70 Hrs @ 100°C
Change in Durometer, points	+4	-6	0	-1
Change in Tensile, %	+12.6	-48.5	+6.7	-0.2
Change in Elongation, %	-20.0	-24.5	+2.9	+17.6
Volume Swell, %	--	+16.1	-0.2	+3.4

MILLATHANE HT HYDROLYTIC STABILITY

As indicated by the small change in physical properties, **MILLATHANE HT** has excellent hydrolytic stability, when combined with the carbodiimide stabilizer, Stabaxol P. Molded parts have excellent storage stability in hot humid conditions.

TEST FORMULATION

MILLATHANE HT	100.0
Stearic Acid	0.25
Stabaxol P	3.0
N-774 Black	40.0
Perkadox 14	0.5

Cured 10' at 340°F (170°C)

ORIGINAL PROPERTIES

Hardness, Durometer A	76
100% Modulus, psi	1424
MPa	9.8
Tensile Strength, psi	2788
MPa	19.2
Elongation, %	204
Tear Strength, Die C, lb/in	165
kN/m	28.9
Compression Set, %	
22 hrs @ 100°C	13.0

HYDROLYTIC STABILITY

	100% Humidity 70 Hrs @ 70°C	Water 70 Hrs 100°C
Change in Durometer, points	0	-1
Change in Tensile, %	-7.7	-9.1
Change in Elongation, %	2.5	7.5
Volume Swell, %	1.8	2.7

ADHESION TO METALS

MILLATHANE® HT rubber compounds can be effectively bonded to metal. To insure consistent bonding results, metal surfaces must be thoroughly clean prior to application of the adhesive. Protective oils, cutting oils, greases, etc., are removed by solvent degreasing or alkaline cleaning. Rust, scale or tightly adherent oxide coatings are removed by suitable mechanical or chemical cleaning methods.

Grit blasting is the most widely used method of mechanical cleaning. However, machining, grinding or wire brushing may be used. Steel grit is used for fast cleaning of steel, cast iron or other ferrous metals. Aluminum oxide, sand or other non-ferrous grit is used for blast cleaning of stainless steel and aluminum, brass, zinc or other non-ferrous metals.

Chemical cleaning or pre-treatment of the metal will also remove rust, scale or tightly-adherent oxide coatings. Chemical treatments are readily adapted to automated metal treatment and adhesive application lines. Chemical treatments are also used on metal parts that would be distorted by blast cleaning or in cases where tight size tolerances must be maintained. Phophatizing is a commonly used treatment for steel while chromate conversion coating is commonly used for aluminum.

As in any bonding operation, testing should be done to see which adhesive works best in your application. If the one-coat system does not produce the results you want, then try the two-coat system. All adhesives are not the same and one may work better in a compression mold and another work better in a transfer mold.

Below is a list of commercially available adhesives that have been used to bond Millathane HT to metal:

LORD CORPORATION

Chemlok Ty Ply BN
Chemlok 219
Chemlok 218
Chemlok 250
Chemlok 233
Chemlok 205*

ROHM AND HAAS

Thixon 408
Thixon P-5*

*Chemlok 205 or Thixon P-5 are primers and should be used if a primer coat is needed.

GLOSSARY

TRADENAME	DESCRIPTION	SUPPLIER
Aflux® 54	Process Aid	Rhein Chemie
Agerite® Resin D	Antioxidant	R.T. Vanderbilt Corp.
Antozite® No. 2	Antioxidant	R.T. Vanderbilt Corp.
Crystal® 1053	Mold Release Agent	TSE Industries, Inc.
Crystal® 2000	Mold Release Agent	TSE Industries, Inc.
Cumar® P-10	Plasticizer	Neville Chemical Co.
Di Cup® 40C	Dicumyl Peroxide	GEO Specialty Chemicals
Dixie® Clay	Hard Clay	R.T. Vanderbilt Corp.
ETU	Vulcanizer	Rhein Chemie
Hi Sil® 243LD	Silica	PPG
Laminar	Calcium Carbonates	H.M. Royal Company
MILLATHANE® 76	Polyurethane Rubber	TSE Industries, Inc.
MILLATHANE® HT	Polyurethane Rubber	TSE Industries, Inc.
Mistron Vapor®	Magnesium Silicate	Cyprus Industrial Minerals
Neoprene W	Polychloroprene	DuPont Performance Elastomers
Nipol® DN3380	Nitrile Rubber	Zeon Chemicals
Octamine®	Antioxidant	Chemtura
Perkadox® 14	Peroxide Vulcanizer	Akzo Nobel
Poly AC 617A	Polyethylene Wax	Honeywell
SR 350	Co-Agent	Sartomer Corporation
Stabaxol® P	Hydrolytic Stabilizer	Rhein-Chemie
Struktol® WB222	Process Aid	Struktol Corporation
Struktol® 60NS	Process Aid/Homogenizer	Struktol Corporation
THANECURE® ZM	Activator	TSE Industries, Inc.
Triganox® 145-45B	Peroxide Vulcanizer	Akzo Nobel
Vanfre® AP-2	Process Aid	R.T. Vanderbilt
Varox® DBPH-50	Peroxide Vulcanizer	R.T. Vanderbilt

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The information in this bulletin is derived from laboratory testing and is believed to be accurate. However, no guarantee, express or implied, is made regarding the accuracy of these data or the use of these compounds, nor are statements in this bulletin intended to infringe on any patent.

TSE INDUSTRIES, INC., MILLATHANE® DIVISION PRODUCTS LIST:

MILLATHANE® 66 — A polyester-based millable polyurethane which is peroxide curable.

MILLATHANE® 76 — A polyester-based millable polyurethane which is sulfur or peroxide curable.

MILLATHANE® 97 — A transparent polyether-based millable polyurethane which is peroxide curable.

MILLATHANE® 5004 — A polyester polyurethane with excellent processing characteristics and can be easily injection molded and must be vulcanized with peroxide (formerly known as Vibrathane® 5004)

MILLATHANE® CM — A polyether polyurethane rubber exhibiting outstanding low temperature properties and excellent hydrolytic stability (formerly known as Adiprene® CM).

MILLATHANE® E34 — A polyether-based millable polyurethane which is sulfur or peroxide curable.

MILLATHANE® HT — A polyester-based millable polyurethane which is sulfur or peroxide curable and able to withstand elevated temperatures.

THANECURE® ZM — MBTS/zinc chloride activator for millable polyurethanes.

THANECURE® T9 — Dimeric 2,4-toluene diisocyanate can be used as vulcanization agent for polyurethane rubber; adhesion promoter for rubber to textile and PVC to textile bonding; as a cross linking component in heat activated one compound PUR elastomer systems, one component adhesive systems and one component coatings which include automotive undercoats.

CRYSTAL® 1053 — A semi-permanent mold release agent recommended for applications in rubber, composite, and thermoplastic molding. Excellent mold sealer and inhibits mold build-up.

CRYSTAL® 2000 — A semi-permanent mold release agent used as a mold lubricant and recommended for slab dip, lubricating extruded goods and prevents water spotting in open steam cure.

CRYSTAL® 4100 — A semi-permanent mold release agent used for applications in thermoplastic, epoxy, and urethane molding. Provides a high level of slip to the mold.

CRYSTAL® 7000 — A semi-permanent mold release agent which allows a greater number of releases for urethane integral skin foam.

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