TSE INDUSTRIES

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Technical Information for Performance Solutions

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MILLATHANE® URETHANE ROLL VULCANIZATION

Millathane millable polyurethane rubber is a tough polymer that offers roll compounders a unique blend of desirable properties such as excellent abrasion resistance and excellent tensile and tear properties. Millable urethanes also have very good resistance to oils and solvents that are used in printing inks, and have very good compressive strength and compression set properties. Millable urethanes can also be processed on conventional rubber equipment, so rolls can be made of compounds mixed in internal mixers or mills, and built into rolls by the use of roll-building extruders or by the use of calendered stock.

Millable urethane can be tricky to cure, especially with other rolls, as it tends to revert upon overcuring, similar to natural rubber. Because of this, the curing conditions need to be chosen carefully to avoid over- as well as under-curing to obtain optimum properties. Urethanes are also sensitive to moisture, especially polyester types, so curing in steam autoclaves requires protection from the steam. The following shows several compounds that have been evaluated for curing in autoclaves.

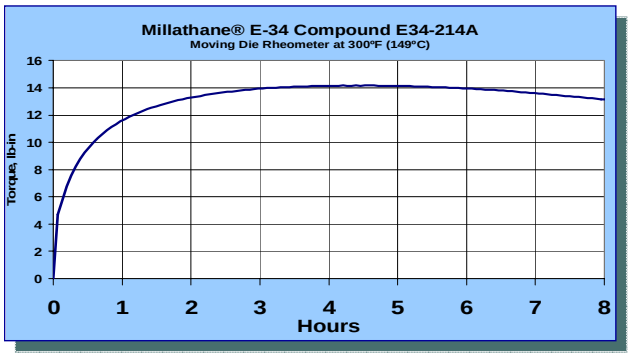
Non-Black Millathane® E34 Roll

A roll was made from a peroxide-cured Millathane E34 compound, formula E34-214A (shown below), fabricated from calendered stock and cured in a hot-air autoclave. This compound had excellent physical properties, as shown in the table. The curing characteristics were evaluated by running an MDR (moving die rheometer) test at 300ºF (149ºC) using a Tech Pro MDpt (Moving Die Processibility Tester). The cure curve, shown on the next page, shows good resistance to reversion even up to an 8-hour cure.

	E34-214A
Millathane E-34	100.0
Stearic Acid	0.5
HiSil 233	35.0
Tricresyl Phosphate	10.0
AC 617A Polyethylene	2.0
Blue Akrosperse 630MB	0.5
Varox 130XL	2.5
Di-Cup 40C	0.5
Total	151.0

Physical Properties, Press Cure 10 min./171ºC (340ºF)

Hardness, Shore A	60
100% Modulus, psi (MPa)	265 (1.8)
200% Modulus, psi (MPa)	510 (3.5)
Tensile Strength, psi (MPa)	2750 (19)
Elongation, %	500
Tear, Die C, lb/in (kN/m)	153 (26.8)



Roll Building Procedure

Calendered stock (1/8 in. [3 mm] thick) was wrapped around an 18 inch [46 cm] long solid core with a diameter of 1 1/8 inch [2.9 cm], to a rubber thickness of ¾ in. [1.9 cm]. The roll was previously shot-blasted and one coat of Chemlok 219 was applied. The roll was wrapped with 6 layers of high-shrink Mylar film.

Roll Curing Procedure

This small diameter roll was given a 2 hour cure in a hot-air autoclave with the following conditions:

* Air pressure: 60 psi [0.4 MPa]
* Temperature cycle: 40 minute rise to 300ºF [149ºC], 2 hr/300F.

Finished Roll Properties

The roll was ground with a taper to check hardness throughout the thickness of the rubber. The roll tested a consistent 58-59 Shore A throughout its thickness and length, and the rubber had a very good bond to the core.

Non-Black Millathane® 76 Roll

A second roll of similar size was made from a sulfur-cured Millathane 76 compound, formula shown below. It was also cured using the same cure cycle (40 minutes rise to 149ºC + 2 hours at 149ºC). The roll, shown below, had a good state of cure and the final hardness was consistent throughout the roll.

Formulation	
Millathane® 76	100
Zinc Stearate	0.5
HiSil 243LD	12
Mistron Vapor	30
Cumar P-10	5
TP-95	3
Struktol WB222	1
Carbowax 3350	1
Red Iron Oxide	2
MBTS-75%	5.3
MBT-75%	2.7
THANECURE® ZM	1
Sulfur-80%	2
	165.5

Physical Properties

Autoclave cure 40' to 149ºC + 120' at 149ºC

Hardness, Shore A	55
100% Modulus, psi (MPa)	325 (2.3)
200% Modulus, psi (MPa)	505 (3.5)
300% Modulus, psi (MPa)	775 (5.3)
Tensile Strength, psi (MPa)	2510 (17)
Elongation, %	580
Tear, Die C, lb/in (kN/m)	146 (26)

Black Millathane® HT Roll

A third roll was made with a peroxide-cured Millathane HT compound, shown below, using calendered stock. This roll also had solid core, but was much larger in diameter (4 inches [10 cm] and had a thicker shaft than the previous rolls, so a slower, longer cure cycle was used.

The formula and cured lab-properties are shown below, along with an MDR chart showing the cure characteristics and the autoclave temperature/pressure plot.

Millathane® HT	100.0
Zinc stearate	0.5
N220 Black	30.0
TP-95	10.0
Cumar P10	5.0
Struktol 60NS	2.5
AC617A Polyethylene	2.0
Vanfre AP-2	2.0
SR-350	1.0
Stabaxol P	2.0
Varox DBPH-50	6.0
	161.0

Physical Properties

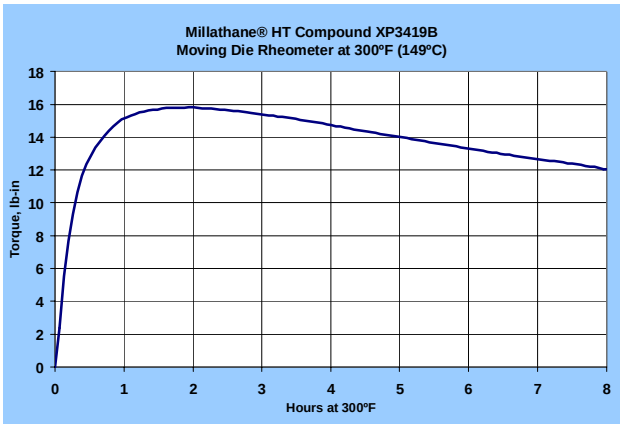
Press cure 10 min./340°F (171°C)

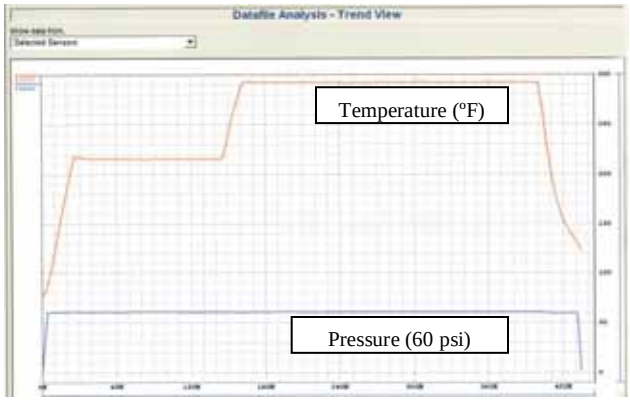
Hardness, Shore A	73
100% Modulus, psi (MPa)	676 (4.6)
Tensile Strength, psi (MPa)	2000 (13.8)
Elongation, %	188
Tear, Die C, lb/in (kN/m)	77 (13.5)

The roll was cured in a hot-air autoclave with the following conditions:

- Air pressure: 60 psi [0.4 MPa]
- Temperature cycle: 25 minute rise to 215ºF (102ºC), 2 hr/215ºF, 20 minutes to 292ºF [144ºC], then 4 hours at 292ºF.The autoclave temperature/pressure chart is shown below.

The ground roll had a smooth surface with consistent hardness across the face.





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SUMMARY

Rolls can be readily made out of various Millathane® millable urethane rubbers, giving excellent wear properties along with excellent oil and aging resistance. To make a good roll, several precautions need to be taken. Several general tips for making millable urethane rolls:

1. **Urethane rolls may need a different cure cycle than other rolls.**
   Cure the roll for the appropriate time based upon the compound's curing characteristics and the roll size. Generally, for autoclave curing small-to-moderate sized rolls, 1 to 4 hours at 290 to 300°F (143 to 149°C) should be appropriate, with a rise in temperature of 3 to 6ºF/minute (1.5 to 3ºC/min.) from room temperature to the curing temperature. A soak at a moderate temperature (about 212°F/100°C) may be desirable for heavy cores and/or stiff compounds (to help flow before the onset of curing).

2. **Urethane rolls need a good pressure wrap and, if steam cured, a moisture barrier.**
   Rolls for autoclave curing should be wrapped with a high shrink Mylar tape or similar material. This provides pressure during cure to eliminate any trapped air or volatiles. Urethanes are sensitive to moisture, so curing in steam autoclaves requires protection from direct contact with the steam, achieved by wrapping the rolls in aluminum foil or additional Mylar wrap. Peroxide cures tend to be more sensitive to contact with hot air than sulfur cures, so care should be taken in wrapping these rolls.

Please contact us if you have any questions about curing Millathane millable urethane rolls. We can assist with formula recommendations as well as curing suggestions and assistance in determining the proper time and temperature for curing your rolls.