



Millathane® E40

Millathane E40 is a sulfur or peroxide curable polyether millable polyurethane rubber used for production of parts for many applications including rollers, seals, footwear, belting and gaskets. Millathane E40 gives excellent strength and abrasion resistance properties, especially in sulfur cured compounds, and has very good processing characteristics. It also has very good low temperature properties, having good resistance to stiffening or hardening at low temperatures.

Product Description

Chemical Composition:	Synthetic rubber based on Ether/TDI polyurethane
Specific Gravity:	Approximately 1.07
Storage stability:	3 years from date of manufacture (stored under dry and cool conditions)

Part Number	Mooney Viscosity ML(1+4)/100° C	Appearance	Package size/carton
M-0040M-45 (Premilled)	35 - 55	Pale to dark amber solid sheets	50 pounds (22.7 kg)

Processing

Millathane E40 is processed by techniques which are common to the rubber industry: Compounds can be mixed on an open mill or in an internal mixer. The Premilled sheet physical form makes for easy mill mixing. Molded articles can be produced via compression, transfer or injection molding; calendered sheets can be press or roto-cured.

Properties

Vulcanizates based on Millathane E40 can be produced in hardnesses ranging from about 45 to 90 Shore A, and offer high strength properties, excellent abrasion resistance, water resistance and good oil resistance. Compounds have low brittle points, and are more resistant to low temperature hardening, due to crystallization, than Millathane E34 or Millathane CM.

Applications

A major application of Millathane E40 is in military and aeronautical applications, due to its very good, strength properties, abrasion resistance and low temperature properties. It is also used in rollers, belting, footwear and other applications.

Compounding

Reinforcing Fillers

Reinforcing fillers like N330 carbon black or precipitated silica increase the mechanical strength of Millathane E40 compounds. Fumed silicas such as Wacker HDK N20 or Cabosil M-5 will give somewhat higher reinforcement than precipitated silicas and will give translucent cured compounds (depending on other ingredients). Clay, talc and calcium carbonate can also be used as fillers to modify properties and processing, but are less reinforcing than silicas and blacks.



Coupling Agents

Silane coupling agents like Si 69 or Silquest A-189 for sulfur cures, or Silquest Y-15866, RC-1, or A172 for peroxide cures, will generally improve the tear strength and set properties of silica reinforced compounds and are typically used at about 2% of the mineral filler content.

Plasticizers

TP-95 is a plasticizer that is very compatible with Millathane E40 and other Millathane grades. Other plasticizers such as Medioplast NB-4 and Benzoflex 9-88SG can also be used to plasticize and soften compounds. The antistatic plasticizer Struktol AW-1 can be used to a limited extent, to lower surface resistivity, but may tend to bleed at levels over 10 parts.

Antidegradants

Polyurethanes are generally very resistant to ozone and oxygen attack because of their saturated polymer backbones (like EPDM). Small amounts (0.5-2 phr) of antioxidants like Naugard 445 and Irganox 1010 can provide some benefit to the heat aging characteristics of peroxide-cured Millathane E34 compounds.

Process Aids

Small amounts of process aids are normally used to prevent sticking to processing equipment and to improve flow during molding. For sulfur-cured compounds, the 0.5 phr of zinc stearate used as an activator is usually adequate. For more release, 0.5-2 phr of another process aid such as Struktol WB222 or Vanfre AP-2 can be used. For peroxide cures, 0.2-0.5 phr of stearic acid is use in place of the zinc stearate. A low molecular weight polyethylene like AC617A, added at 1-4 phr, gives good release for calendaring and molding.

Curing Agents

The best physical properties and abrasion resistance are achieved with sulfur cures, while the best compression set, heat aging and reversion resistance comes from peroxide cures. The sulfur cure system is a combination of MBTS (4 phr), MBT (2 phr), Thanecure® ZM (1 phr) and sulfur (1.5-2.0 phr), along with zinc stearate (0.5 phr), used as an activator. Peroxide cures can be used for better set and heat aging characteristics. Typical peroxides used are dicumyl peroxide and DBPH, typically used at about 0.6 – 1.2 phr active peroxide (1.5 – 3.0 phr of 40% active).

The use of low levels of coagents such as triallyl cyanurate (TAC) and trifunctional methacrylates like SR350 (TMTDMA) increase the crosslink density and improve compression set. Blends of the difunctional methacrylate SR231 (DEGDMA) with the trifunctional methacrylate SR350 are recommended for high hardness compounds, as the blend gives a good balance of strength properties, elongation and set. High crosslink densities, seen with high peroxide and/or coagent levels, will improve compression set but strength properties and elongation may be adversely affected.

Vulcanization Conditions

Sulfur-cured Millathane E40 compounds are typically molded at temperatures of 150° - 165°C; higher temperatures can give poor cures due to reversion. Peroxide-cured compounds can be cured from 145°-175°C, depending on the peroxide, dimensions of the part etc. Rubber covered rollers are often cured in steam or electric autoclaves, under pressure, at 140°-155°C for 1-6 hours (very large rolls for longer times at lower temperatures), depending on the compound and roll geometry.

**Formulation Examples****63 Shore A Black Molding Compound, Sulfur Cured**

Millathane® E40	100.0	Press Cured Properties, Cured 6 min/160°C		
Zinc Stearate	0.50	Hardness Shore A	63	
N330 Black	20.0	TSE-100, psi (MPa)	300	(2.1)
Cumar P-10	10.0	TSE-300, psi (MPa)	1088	(7.5)
AC617A Polyethylene	1.0	Tensile strength, psi (MPa)	4647	(32.0)
MBTS	4.0	Elongation, %	596	
MBT	2.0	Tear Die C, lb/in (kN/m)	230	(40.3)
Thanecure® ZM	1.5	Tear Die B, lb/in (kN/m)	280	(49.0)
Sulfur	1.5	Bashore Resilience, %	34	
		Compression set, 22hr/70°C, % set	44	
		DIN Abrasion, mm ³ loss	65	
		Brittle Point, ASTM D2137	-66°C	
		Torsional Stiffness, ASTM D1053		
		T ₂	-32°C	
		T ₁₀	-44°C	
		T ₁₀₀	-54°C	

64 Shore A Black Molding Compound, Peroxide Cured

Millathane® E40	100.0	Press Cured Properties, Cured 8 min/160°C		
Stearic acid	0.25	Hardness Shore A	64	
N330 Black	20.0	TSE-100, psi (MPa)	365	(2.5)
N550 Black	10.0	TSE-300, psi (MPa)	1830	(12.6)
TP-95	5.0	Tensile strength, psi (MPa)	2960	(20.4)
Struktol WB-222	1.0	Elongation, %	405	
Irganox 1010	0.5	Tear Die C, lb/in (kN/m)	137	(24.0)
SR-350	1.0	Bashore Resilience, %	49	
Di-Cup 20C	2.0	Compression set, 22hr/70°C, % set	14	
		DIN Abrasion, mm ³ loss	79	

88 Shore A Black Compound, Sulfur Cured

Millathane® E40	100.0	Press Cured Properties, Cured 8 min/160°C		
Zinc Stearate	0.50	Hardness Shore A	88	
N220 Black	60.0	TSE-100, psi (MPa)	930	(6.4)
TP-95	6.0	TSE-300, psi (MPa)	2920	(20.1)
Struktol WB-222	1.0	Tensile strength, psi (MPa)	3640	(25.1)
AC617A Polyethylene	2.0	Elongation, %	440	
MBTS	4.0	Tear Die C, lb/in (kN/m)	270	(47.3)
MBT	2.0	Tear Die B, lb/in (kN/m)	491	(85.9)
Thanecure® ZM	1.0	Bashore Resilience, %	31	
Sulfur	1.5	Compression set, 22hr/70°C, % set	49	
		DIN Abrasion, mm ³ loss	94	



Adhesion to Metal

Millable polyurethanes generally have very good adhesion to metal, and adhesives from several manufacturers give excellent bonding. Below are results of testing done by adhesive manufacturer on bonding a sulfur-cured, silica reinforced Millathane E34 compound to steel (Millathane E40 is very similar to Millathane E34). Note that the testing was done by the three different companies under different conditions with probably different steel grades and different test sample preparation and adhesion test protocols, so the test results should only be used as a guide to recommended adhesives and should not be used as a direct comparison between the adhesives.

Adhesive	Adhesion	Failure
Ty-Ply BN ¹	111 lb/in [19.4 N/mm]	Rubber Failure 100%
Chemlok 218 ¹	128 lb/in [22.4 N/mm]	Rubber Failure 100%
Cilbond 49SF+Cilcure B ²	115 lb/in [20.2 N/mm]	Rubber Failure 100%
Thixon 715-1/720:MEK 1:1 ³	106 lb/in [18.6 N/mm]	Rubber Failure 100%

Other adhesives that have been used successfully and/or recommended for use for bonding to metal are:

Megum 15637³ for bonding to metal.

Chemlok 213¹, Chemlok 218¹ and Chemlok 219¹ for bonding to Aluminum and steel.

Chemlok 250¹ and Thixon³ 405 for bonding during injection molding.

¹Lord Corporation

²Chemical Innovations Ltd. (CIL)

³Dow Chemical

Additional Information

Visit our web site (www.tse-industries.com or www.millathane.com) for information on Millathane E34 and other Millathane grades, as well as technical studies, TIPS and SDS documents, and other information. Inquiries can be sent to millathaneinfo@tseind.com.

Ingredients	Description	Supplier/Manufacturer
AC617A	Low molecular weight polyethylene	Honeywell
Benzoflex 9-88SG	Dipropylene glycol dibenzoate	Eastman Chemical
Cabosil M-5	Fumed silica, surface area 200 m ² /g	Cabot Corporation
Cumar P-10	Liquid coumarone indene resin	Neville Chemical Co.
Di-Cup 40C	Dicumyl Peroxide, 40%	Arkema Inc.
Irganox 1010	Antioxidant	Ciba Specialty Chemicals
Mediaplast NB-4	Adipine acid plasticizer	Kettlitz-Chemie
Naugard 445	Antioxidant	Chemtura
Si 69	Silane Coupling Agent	Evonik
Silquest RC-1, A172, A-189, Y-15866	Silane Coupling Agents	Momentive Performance Materials
SR231	Diethyleneglycol Dimethacrylate (DEGDMA)	Sartomer/Cray Valley
SR350	Trimethylol propane Trimethacrylate (TMPTMA)	Sartomer/Cray Valley
Struktol AW-1	Antistatic plasticizer	Struktol Corporation
Struktol WB-222	Process aid	Struktol Corporation
TP-95	Di (butoxy-ethoxy-ethyl) adipate (DBEEA)	Hallstar
Ultrasil VN3	Precipitated silica	Evonik
Vanfre AP-2	Process aid	R. T. Vanderbilt
Varox DBPH-50	2,5-Dimethyl-2,5-di(t-butylperoxy)hexane, 50%	R. T. Vanderbilt
Wacker HDK N20	Fumed silica, surface area 200 m ² /g	Wacker Silicones