

SULFUR-BASED CURE SYSTEMS

Vulcanization, the introduction of crosslinks into the elastomer's polymer matrix, is a fundamental determinant of rubber properties. In short, it converts a substance that is plastic and moldable into one that is flexible and elastic.

Sulfur is, by far, the most commonly used curing agent for elastomers with chemically unsaturated polymer backbones, particularly the more common diene rubbers: natural, SBR, polybutadiene, and polyisoprene. Other curing agents can be used with unsaturated elastomers, but sulfur dominates because it is low in cost and toxicity, broadly compatible with other compounding additives, and able to predictably provide the desired vulcanization properties. A typical sulfur vulcanization system is composed of sulfur, a metal oxide (usually zinc oxide), a fatty acid (to solubilize the oxide's metal) and one or more organic accelerators. Sulfur, nevertheless, will perform its crosslinking function even without promoters, as long as there is sufficient heat and time provided. Lacking the promoters, however, vulcanization could take many hours, or even days, while today's systems take only minutes.

Vulcanization by sulfur alone is believed to be primarily via a thermally induced free-radical reaction. The sulfur will slowly react allylic to the site of unsaturation to form polysulfide substituents. These then are subject to heat-induced cleavage to thiyl (R-S \cdot) and polysulfenyl (R-S $_x$ \cdot) free radicals, which in turn react with adjacent polymer chains to form monosulfide and (mostly) polysulfide links.

Activators

The rate at which sulfur reacts with unsaturated polymer can be accelerated by activators: a metal oxide plus fatty acid. The most common combination is zinc oxide and stearic acid, with the fatty acid solubilizing the zinc in the elastomer. It is believed that the sulfur reacts, in the presence of the metal, as a cation at the double bond. Metal activated vulcanization will proceed more rapidly than crosslinking by sulfur alone, but still too slow for most production purposes. The metal oxide/fatty acid is, in practice, used not to activate the sulfur itself, but to activate the organic compounds used as vulcanization accelerators.

Accelerators

Vulcanization accelerators, in simplest terms, hasten the cleavage of the sulfur ring and formation of thiyl and polysulfenyl radicals. The accelerators react in the form of their more active zinc salts, due to the nearly presence of zinc oxide in sulfur vulcanized compounds. The choice of accelerator will affect the scorch (premature vulcanization) safety, the cure rate, and the length and number of crosslinks which form. These properties, which are generally related to the speed with which the accelerator is converted to its very active salt form, are compared in Table 1.

Accelerator Type	Scorch Safety	Cure Rate	Crosslink Length
None		very slow	very long
Guanidines	moderate	moderate	medium-long
Mercaptobenzothiazoles	moderate	moderate	medium
Sulfenamides	long	fast	short-medium
Thiurams	short	very fast	short
Dithiocarbamates	least	very fast	short

Acceleration was discovered in 1906 with the observation that addition of aniline to a sulfur/zinc oxide system significantly decreased vulcanization times.

Retarders

The desired level of scorch safety can be obtained through use of scorch retarders in addition to the chosen accelerators. The traditional retarders are acids – benzoic acid, salicylic acid, phthalic anhydride – which interfere with the activity of the accelerators. These acids, however, do not only retard the scorch time, they also slow the cure rate and reduce the ultimate state of cure. With the widespread use of sulfenamide accelerators has come a new type of retarder which further improves upon these accelerators' superior scorch safety without significantly reducing cure rate or ultimate state of cure.

Crosslink Length

The length of the sulfide crosslinks formed during vulcanization affect rubber properties. Mono- and disulfide crosslinks are more stable (less prone to scission) than polysulfide links and so promote better thermal and aging characteristics. Polysulfide links, on the other hand, provide somewhat better molecular flexibility. This can result in better dynamic fatigue resistance. The more stable crosslinks are often preferred to provide reversion resistance. Reversion is the cleavage of sulfide crosslinks during vulcanization which results from extending the cure beyond the time required to obtain the desired optimized balance of vulcanizate properties. When overcured in this way, certain elastomers, particularly natural rubber, will revert to the soft, more plastic, less elastic condition characteristic of the uncured compound.

The choice of accelerator will influence the length of crosslinks, but this can be further controlled by adjusting the accelerator:sulfur ratio. Increasing this ratio progressively favors shorter crosslinks. This can be alternatively accomplished by using sulfur donors in place of most or all of the elemental sulfur

for vulcanization. The thiuram accelerators, particularly the disulfides, and dithiodimorpholine are commonly used for this purpose. The use of a cure system designed to form predominately short crosslinks is referred to as efficient vulcanization (EV).

NON-SULFUR CURE SYSTEMS

Elastomers with chemically saturated backbones cannot be crosslinked with sulfur and so require alternate curing agents. The most widely used are the peroxides, which are also used with unsaturated elastomers. Metal oxides or difunctional compounds are used in special cases.

Peroxides

Peroxides cure by thermal decomposition into oxy radicals, which abstract a hydrogen from the elastomer to generate polymer radicals. These then react to form carbon-carbon crosslinks. With unsaturated elastomers, this occurs preferentially at the site of allylic hydrogens. The rate of crosslinking is directly proportional to the rate of decomposition of the peroxide. Cure rates and curing temperatures therefore depend on the stability of the peroxide.

Although carbon-carbon crosslinks are more thermally stable than sulfur crosslinks, they provide generally poorer tensile and tear strength. Peroxides are also incompatible with many of the antioxidants used in rubber, since the antioxidants are designed to scavenge and destroy oxy and peroxy free radicals. Peroxides cannot be used with butyl rubber because they cause chain scission and depolymerization.

Difunctional Compounds

Certain difunctional compounds are used to crosslink elastomers by reacting to bridge polymer chains. For example, diamines (e.g., hexamethylenediamine carbamate) are used as crosslinks for fluoroelastomers.

Metal Oxides

Metal oxides, usually zinc oxide but on occasion lead oxide for improved water resistance, are used as crosslinking agents for halogenated elastomers such as neoprene, halobutyl rubber, and chlorosulfonated polyethylene. The metal oxide abstracts the allylic halogen of adjacent polymer chains to form an oxygen crosslink plus the metal chloride salt.



FILLERS

A rubber compound contains, on average, less than 5 lbs. of chemical additives per 100 lbs. of elastomer. Filler loading is typically 10-15 times higher. Of the ingredients used to modify the properties of rubber products, the filler plays a dominant role. The term “filler” is misleading, implying, as it does, a material intended primarily to occupy space and act as a cheap diluent of the more costly elastomer. Most of the rubber fillers used today offer some functional benefit that contributes to the processability or utility of the rubber product

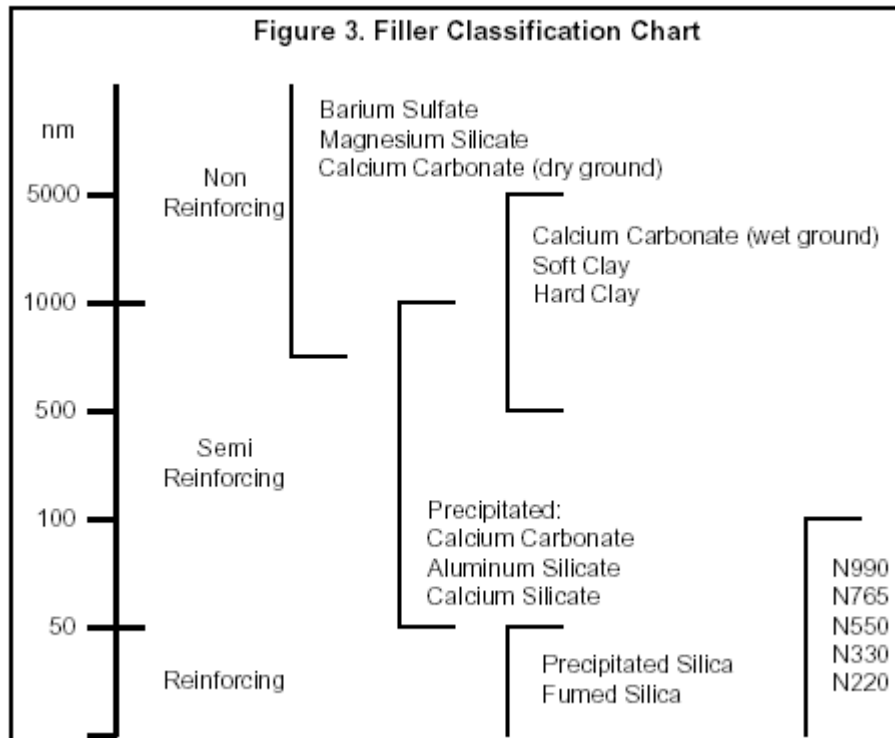
Filler Properties

The characteristics which determine the properties a filler will impart to a rubber compound are particle size, surface area, structure, and surface activity.

Particle Size – If the size of the filler particle greatly exceeds the polymer interchain distance, it introduces an area of localized stress. This can contribute to elastomer chain rupture on flexing or stretching. Fillers with particle size greater than 10,000 nm (10 μm) are therefore generally avoided because they can reduce performance rather than reinforce or extend. Fillers with particle sizes between 1,000 and 10,000 nm (1 to 10 μm) are used primarily as diluents and usually have no significant affect, positive or negative, on rubber properties. Semi-reinforcing fillers, which range from 100 to 1000 nm (0.1 to 1 μm) improve strength and modulus properties. The truly reinforcing fillers, which range from 10 nm to 100 nm (0.01 to 01 μm) significantly improve rubber properties.

Of the approximately 2.1 million tons of fillers used in rubber each year, 70% is carbon black, 15% is kaolin clay, 8% is calcium carbonate, 4% is the precipitated silicas and silicates. Figure 3 classifies the various fillers by particle size and consequent reinforcement potential.

Most talcs and dry-ground calcium carbonates are degrading fillers because of their large particles size, although the planar shape of the talc particles contributes some improvement in reinforcement potential. The soft clays would fall into a class of diluent fillers that do not contribute reinforcement.



The hard clays contribute some reinforcement to rubber compounds, primarily because of their smaller particle size, and are normally classified as semi-reinforcing fillers. Ultrafine precipitated calcium carbonates also fit into the semi-reinforcing class. The carbon blacks and precipitated silicates and silicas are available in various particle sizes that range from semireinforcing to highly reinforcing. They generally exist as structural agglomerates or aggregates rather than individual spherical particles.

Surface Area – Particle size is generally the inverse of surface area. A filler must make intimate contact with the elastomer chains if it is going to contribute to reinforcement. Fillers that have a high surface area have more contact area available, and therefore have a higher potential to reinforce the rubber chains.

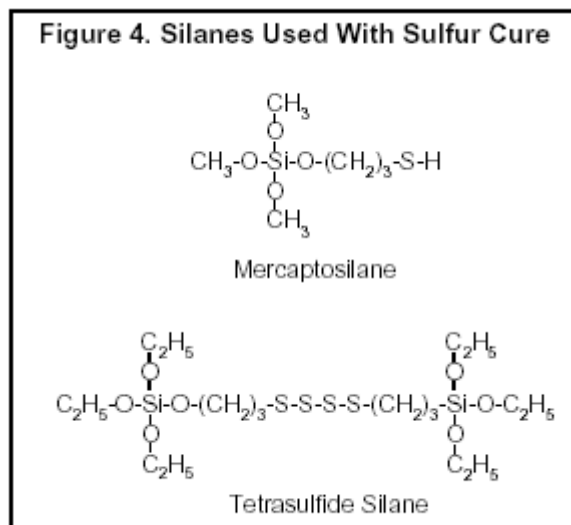
The shape of the particle is also important. Particles with a planar shape have more surface available for contacting the rubber than spherical particles with an equivalent average particle diameter. Clays have planar-shaped particles that align with the rubber chains during mixing and processing, and thus contribute more reinforcement than a spherical-shaped calcium carbonate particle of similar average particle size. Particles of carbon black or precipitated silica are generally spherical, but their aggregates are anisometric and are considerably smaller than the particles of clay. They thus have more surface area per unit weight available to make contact with the polymer. Rubber grade carbon blacks vary from 6 to 250 m²/g. Most reinforcing precipitated silicas range from 125 to 200 m²/g; a typical hard clay ranges from 20 to 25 m²/g.

Structure – The shape of an individual particle of reinforcing filler (e.g. carbon black or precipitated silica) is of less importance than the filler's effective shape once dispersed in elastomer. The blacks and precipitated inorganics used for reinforcement have generally round primary particles but function as anisometric aggregates. The round particles clump together into chains or bundles that can be very dense or open and latticelike. These aggregate properties – shape, density, size – define their structure.

For reinforcing fillers which exist as aggregates rather than discrete particles, carbon black and silica in particular. The high shear forces encountered in rubber milling will break down the weaker aggregates and agglomerates of aggregates. The structure that exists in the rubber compound, the persistent structure, is what affects processability and properties.

Surface Activity – A filler can offer high surface area and high structure, but still provide relatively poor reinforcement if it has low specific surface activity. The specific activity of the filler surface per cm² of filler-elastomer interface is determined by the physical and chemical nature of the filler surface in relation to

that of the elastomer. Nonpolar fillers are best suited to nonpolar elastomers; polar fillers work best in polar elastomers. Beyond this general chemical compatibility is the potential for reaction between the elastomer and active sites on the filler surfaces. Carbon black particles, for example, have carboxyl, lactone quinone, and other organic functional groups which promote a high affinity of rubber to filler. This, together with the high surface area of the black, means that there will be intimate elastomer-black contact. The black also has a limited number of chemically active sites (less than 5% of total surface) which arise from broken carbon-carbon bonds as a consequence of the methods used to manufacture the black. The close contact of elastomer and carbon black will allow these active sites to chemically react with elastomer chains. The carbon black particle effectively becomes a crosslink. The non-black fillers generally offer less affinity and less surface activity toward the common elastomers.

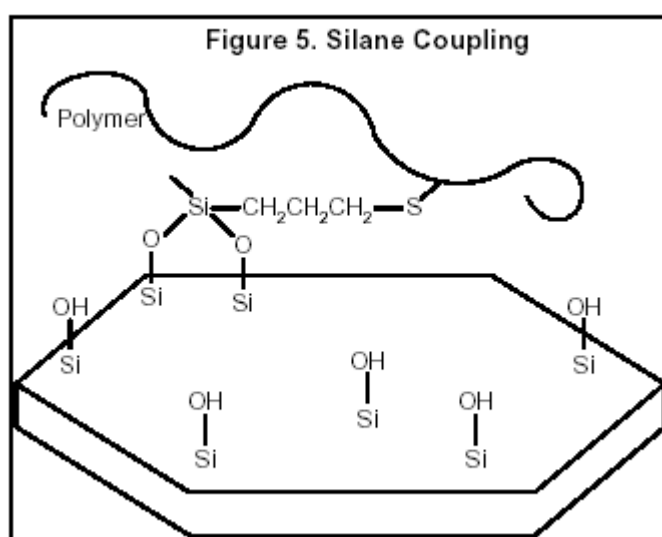


All of the non-black, non-carbonate reinforcing or semi-reinforcing fillers have one feature in common. The clays, silicas, and silicates all have surface silica (SiO₂) groups which have hydrolyzed to silanols (-SiOH). These silanol groups behave as acids (-SiO-H⁺) and are chemically active. The higher surface area fillers have more silanols available and are thus more reactive. One effective means to modify the surface chemistry of nonblack fillers is by the addition of

silane coupling agents. These react with the silanols on the filler surface to give a strong bond, and also contain a functional group that will bond to the rubber during vulcanization. The result is filler-polymer bonding (crosslinking) that increases modulus and tensile strength and improves abrasion resistance. Modification of the filler surface also improves wetting and dispersion. The silane coupling agents are expensive, and as a result they are used mostly in higher priced rubber compounds, primarily to promote maximum abrasion resistance.

There are two silane coupling agents commonly used with non-black fillers in sulfur-cured compounds. These are mercaptosilane and tetrasulfide silane, shown in Figure 4.

The silane coupling bond is depicted in Figure 5. To make the most efficient use of these high-cost chemicals, it is important to mix the polymer, filler, and silane coupling agent for 1 to 2 minutes before adding any other ingredients that will interfere with the reaction between the filler and the silane. If the mixing temperature gets too high (above about 150 to 160°C) the tetrasulfide group can be broken prematurely, reducing its ability to bond to the polymer during vulcanization.



Filler Effects

The principal characteristics of rubber fillers – particle size, surface area, structure, and surface activity – are interdependent in improving rubber properties.

The general influence of each of these filler characteristics above on rubber properties can be summarized as follows:

1. Increasing surface area (decreasing particle size) gives lower resilience and higher Mooney viscosity, tensile strength, abrasion resistance, tear resistance, and hysteresis.
2. Increasing surface activity (including surface treatment) gives higher abrasion resistance, chemical adsorption or reaction, modulus (at elongation >300%), and hysteresis.
3. Increasing persistent structure/anisometry gives higher Mooney viscosity, modulus (at elongation <300%), and hysteresis, lower extrusion shrinkage, tear resistance, and resilience, and longer incorporation time.

TIRE COVER STRIP COMPOUND



	1	2
Naugawhite Antioxidant	1.0	2.0
Sunproof@ Improved Wax	45.0	1.0
Natural Rubber Chlorobutyl Rubber	25.0	45.0
Royalene 505	32.0	25.0
N-660 Black	33.0	30.0
Naphthenic Oil	10.0	35.0
Zinc Oxide	5.0	10.0
Stearic Acid	2.0	5.0
Vultac 5	0.5	2.0
Delac NS	0.7	0.5
<u>Insoluble Sulfur, 80% Oiled</u>	<u>2.0</u>	<u>0.7</u>
Mooney Viscosity	<u>37</u>	<u>2.0</u>
<u>ML (1+4) @ 100 °C</u>		<u>35</u>
Mooney Scorch, MS @ 132 °C	<u>13.2</u>	
<u>3 pt. Rise, minutes</u>		<u>13.7</u>
Physical Properties at Room Temperature		
Press Cured 10 minutes @ 160 °C		
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Tensile Strength, MPa	15.7	15.9
Elongation, %	540	560
300% Modulus, MPa	6.7	6.5
Hardness, Shore A	52	51
<u>Tear, Die C, kN/m</u>	<u>26.3</u>	<u>29.8</u>
Oven Aging, 2 Weeks @ 70 °C, % Retention		
Tensile Strength	88	96
Elongation	72	85
300% Modulus	140	130
Hardness, points change	+5	+5
Tear, Die C	89	92

**DUROMETER 75
COMPOUND FOR
BUSHINGS**



IR 2200	100.0
Ciptane I	55.0
Tall Oil mo	3.0
Naphthenic Oil Titanium	3.5
Dioxide	2.5
ZMTI	1.0
ODPA	1.0
Zinc Oxide	3.0
Stearic Acid	2.0
PEG 3350	1.0
Sulfur	3.0
TBBS	3.0
<u>TMTM</u>	<u>0.3</u>
<u>Specific Gravity</u>	<u>1.14</u>
Cure rate, MDR 155C, T50 minutes	2.9
Mooney Scorch 121C, T5 minutes	21
Mooney Viscosity, ML 100	40

Durometer at 23C at	74
100C	71

<u>Stress/Strain</u>	<u>Original</u>	<u>Aged 700 hrs. 80C</u>
Durometer	74	84
M300, Ml)a	11	
Tensile	27	14
<u>Elongation, %</u>	<u>555</u>	<u>270</u>

SOLE FORMULATIONS



	High	Standard Oil Quality	Quality Resistant
Plioflex 1502	94.0	90.0	30.0
SBR 1805	12.0	21.0	15.0
Neoprene W			50.0
BUDENE 1208			10.0
Pliolite S-6F	55.0	30.0	20.0
Extending Resin	25.0	30.0	
Processing 01	10.0	13.0	15.0
Stearic Acid	3.0	3.0	2.0
Zinc Oxide	4.0	4.0	2.0
Magnesium Oxide			2.0
AGERITE RESIN D	1.5	1.5	
AGERITE STALITE S			2.0
Hi-Sil 143LD	55.0		50.0
DIXIE CLAY		250.0	
Diethylene Glycol	3.0	1.0	1.0
VANTARD PVI	0.3	0.3	
Sulfur	3.0	2.6	2.5
ALTAX	2.5	2.2	1.5
METHYL TUADS	0.5	0.6	
VANAX DOTG			1.0

Total	268.8	449.3	204.0
Properties			
Hardness, Shore A	90	92	70
Tensile, MPa (psi)	14(2030)	7(1020)	10(1450)
Elongation, %	600	550	350

CELLULAR SHOE SOLING



	1	2	3
SBR8107	70.00	70.00	70.00
SBR-S Resin MB	60.00	60.00	60.00
Silica	30.00	30.00	30.00
Hard Clay	100.00	100.00	100.00
Aromatic Resin	10.00	10.00	10.00
OctamineO	2.00	2.00	2.00
Naphthenic Oil Type 103	10.00	10.00	10.00
Stearic Acid	1.00	1.00	1.00
Zinc Oxide	5.00	5.00	5.00
Polyethylene Glycol	1.50	1.70	1.80
BIKO-OT MB (75% Active)	1.30	1.10	2.10
DelacO S	0.80	0.80	0.80
DPG MB (65% Active)	0.45	0.45	0.45
Sulfur	2.50	2.50	2.50
Celogen 765A	4.50		
Celogen 754A		4.50	

<u>DNPT (80%)</u>			<u>5.00</u>
<u>Total</u>	<u>299.05</u>	<u>299.05</u>	<u>300.75</u>
Press Cure Time, min.	13	13	13
Temp., °c	157	157	157
Temp., °F	315	315	315
Specific Gravity		0.42	0.39
Compression Set, %	13.4	11.4	15.5
Shrinkage, L-w, %		1.4-1.5	0.6-0.6
<u>Shore A Hardness</u>	<u>60</u>	<u>60</u>	<u>55</u>

EXTRUSION COMPOUNDS

<u>ASTM mooo</u>	<u>BC 515</u>	<u>BC 720</u>
Neoprene TW	100.0	100.0
Stearic Acid	1.0	1.0
Maglite D	4.0	4.0
VANFRE AP-2	2.5	2.0
VANPLAST R	4.5	5.0
AGERITE STALITE S	2.0	2.0
NEOPHAX A	35.0	15.0
Sundex 790	10.0	
FEE Black (N-550)	20.0	30.0
THERMAX (N-990)	40.0	55.0
Zinc Oxide	5.0	5.0
<u>THIATE U</u>	<u>1.5</u>	<u>1.5</u>
<u>Total</u>	<u>225.5</u>	<u>220.5</u>

Cured 30 Minutes at 153 °C(307 °F)

200% Modulus, MI)a (psi)	4.3(630)	13.30930)
Tensile Strength, MPa (psi)	11.7(1700)	16.5(2390)
Elongation, %	400	250
Hardness, Shore A	51	68
<u>Tear Die A, kN/m(pli)</u>	<u>10.6(60)</u>	<u>13.2(75)</u>

HIGH HARDNESS COMPOUND

Neoprene WM-I	80.0
Neoprene FB	20.0
Magnesium Oxide	4.0
Stearic Acid	0.5
AGERITE STALITE S	2.0
THERMAX (N-990) Carbon Black	80.0
SRF (N-774) Carbon Black	100.0
Circo RPO Naphthenic Oil	8.0
Zinc Oxide	5.0
VANAX DOTG	1.0
UNADS	1.0
<u>Sulfur</u>	<u>0.5</u>
<u>Total</u>	<u>302.0</u>
Properties, Cured minPC	30/153
Hardness, Shore A	92

Tensile, MPa (psi)	12(1700)
Elongation, %	120
<u>Density, Mg/m³</u>	<u>1.55</u>

**HIGH QUALITY HEAT
RESISTANT HOSE**



Keltan P558	60.0
Keitan 7506 Agerite	60.0
Resin D	1.0
N-650 Black	130.0
Sunpar 2280	45.0
Zinc Oxide	5.0
Stearic Acid	1.0
TMTD	0.7
DPTH	0.9
ZBDC	2.0
<u>DTDM</u>	<u>2.0</u>
<u>Total</u>	<u>307.6</u>
Physical Properties	

<u>Compound Viscosity, ML (1+4) 100 °C</u>	<u>86</u>
Mooney Scorch @ 132 °C	
Minutes to 5 Pt. Rise	21.2

Minimum Reading **36**

Press Cure @ 170 °C

Tensile, MPa 13.6 Elongation, % 332

Hardness, Shore A **62**

**COVER COMPOUND FOR
WIRE BRAID HOSE**



RoyaleneO 539	100
N-650 Black N-762	55
Black Hi-Sil 243LD	30
Whiting Sunpar 2280	20
Zinc Oxide	18
Stearic Acid	62
Vanox ZMTI	10
NaugardO 445	1
Bonding Agent R6	1.5
Sulfur Sulfads	1.5
TuexO	2
ButazateO	2
NaugexO SD-I	0.4
Vulk10rO 75	0.4
	2
	2
	1.3

Total	<u>309.1</u>
Mooney Viscosity	
ML (1+4) @ ° c	69

Mooney Scorch, MS @ 135 °C(270 °F)		
Minimum	25.8	t3, minutes 7.8
ML, dNm (lb-in)		7.8(6.9)
MH, kn. (lb-in)		44.7(39.6)
ts2, minutes		1.9
t90, minutes		13.3

EPDM HEAVY DUTY JACKET (ASTM D752)

Vistalon 3708	100.00	
Zinc Oxide	5.00	
BUCA Kaolin	110.00	
FEE Black	41.00	
Sunpar 2280	44.00	
Microcrystalline Wax (175 °F,m.p.)	5.00	
A-174 Silane	0.50	
Sulfur	1.00	
TMTDS	0.80	
TDEDC (80%)	0.80	
DPTTS	0.80	
MBTS	1.50	
Vocol S	3.00	
Specific Gravity	1.28	
Processability		
Mooney Scorch @ 121 °C, t3, minutes	9	
t5, minutes	11	
Mooney Plasticity @ 121 °C, (MS)		
Minimum Reading	25	
Physical Properties		
Steam Cured 60 Seconds @ 225 psi		
Hardness, Shore A	70	
200% Modulus, psi	570	
Tensile Strength, psi	2120	500
Elongation, %	625	1800
Maximum Set (IPCEA 4.13.3), m	35/64	300

MEDIUM VOLTAGE (15 KV) INSULATION

<u>Ingredients</u>	<u>% By Weight</u>	<u>phr</u>
Epcar 545 EPDM	37.63	100.00
Zinc Oxide	1.88	5.00
Agerite MA	0.55	1.47
Translink 37	45.41	120.69
Red Lead Dispersion	1.8	5.00
Vinyl Silane A- 172	0.47	1.03
Paraffin wax	1.88	5.00
Sunpar 2280 Oil	7.53	20.00
<u>Di-Cup 40 KE Peroxide</u>	<u>2.85</u>	<u>7.59</u>
<u>Total</u>	<u>100.00</u>	<u>265.78</u>
Specific Gravity, calculated	1.33	
Polymer by Volume	58.97%	

Physical Properties

	Completed Cable	Required AEIC
Insulation		
Original Properties		
Tensile Strength, MPa(psi)	8.80277)	4.8(700) min. <u>250</u>
<u>Elongation, %</u>	<u>337</u>	<u>min.</u>
Air Oven Aged, 7 days @ 121 °c		
Tensile Retention 101 75 min. <u>Elongation, %</u>	<u>92 75 min.</u>	

NON-BLACK AUTOMOTIVE BUMPER STRIP



Keltan 7506	100.0
Hard Clay	100.0
Zeolex 23	25.0
Titanox	30.0
Sunpar 150	35.0
A-C Polyethylene 617	5.0
Zinc Oxide	5.0
Stearic Acid Diethylene	1.0
Glycol	1.5
MOTS	3.0
ZBDC	3.0
DTDM	1.0
TEDC	0.5
<u>Sulfur</u>	<u>0.8</u>
<u>Total</u>	<u>310.8</u>
Physical Properties	

<u>Specific Gravity</u>	<u>1.37</u>	<u>Compound Viscosity, ML (1+4) 100 °C</u>	<u>73</u>
Mooney Scorch @ 121 °c			
<u>Min. to 5 Pt. Rise</u>			<u>12.6</u>
Press Cure @ 168 °C, 10 min. cure			
Tensile, MPa			11.2
Elongation, %			630
300% Modulus, MPa			4.0
<u>Hardness, Shore A</u>			<u>68</u>

EXPANDED PROFILES (UHF OR "SHEAR HEAD" CURING)

DUTRAL TER 9049	100	
Zinc oxide	10	
Stearic acid	1	
FEF N550	48	
MT N990	42	
Socal UI SI	20	
Armide O	4	
Paraffinic oil	65	
Caloxol W-3	4	
Celogen AZ	3	
Celogen OT	2	
CBS	1.5	
TDEDC	1.5	
ZDBDC	2	
DPTTS	1	
Sulphur	1.3	
<hr/>		
Uncured properties		
ML (1+4) @ 100 °c Monsanto	30	
ODR @ 180°C	54"	
t90	4' 18"	
<hr/>		
Cured properties		Kron line*
Density, g/cm	0.47	0.5
Water absorption, % Load at 50% of deflection, Kg/5 cm	0.6	
C. set 70h/70°C (5 min.), %	1	1.1
C. set min.), %	19	24
70h/70°C(30	16	21

48 SHORE A COMPOUND

Royalene 6371)	175.0
HiSi1 532EP	15.0
N650 Black	50.0
N774 Black Sunpar 150	100.0
Zinc Oxide	90.0
Stearic Acid	8.3
Poly AC 617A	1.5
Struktol TR131	5.3
Paraffin Wax	2.7
Cumar P25 DLC	3.0
Sulfads	5.0
TuexO	0.7
ButazateO	0.7
MBTS	1.5
<u>Sulfur</u>	2.0
<u>Total</u>	<u>1.5</u>
	<u>462.2</u>
ML (1+4) @ 100 ° c	
