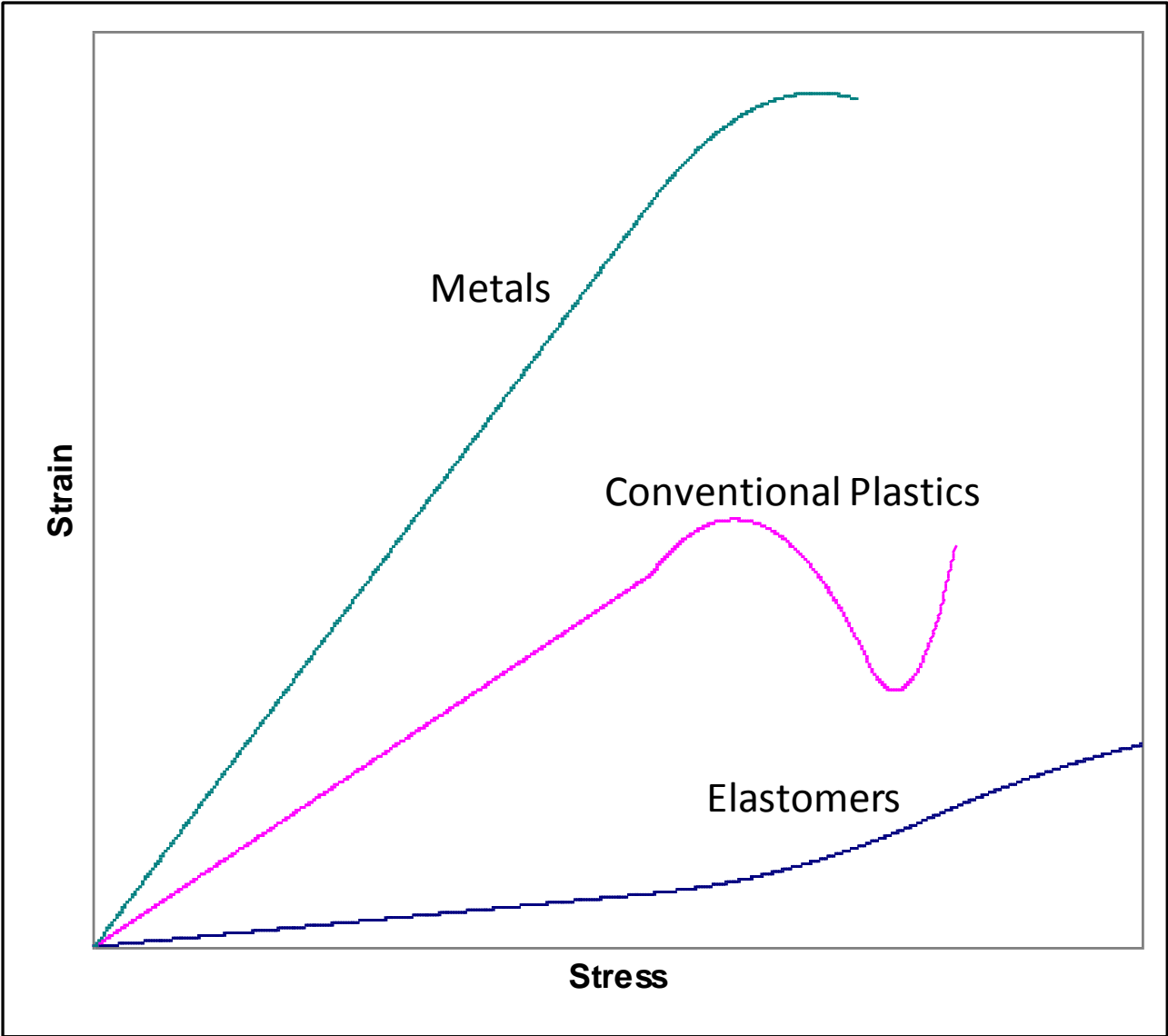


Materials for Automobiles

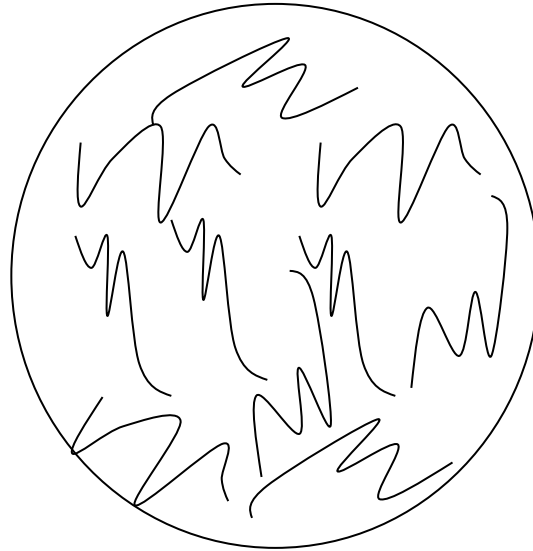
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Rubber

Rubber Basics :Elastomeric Materials

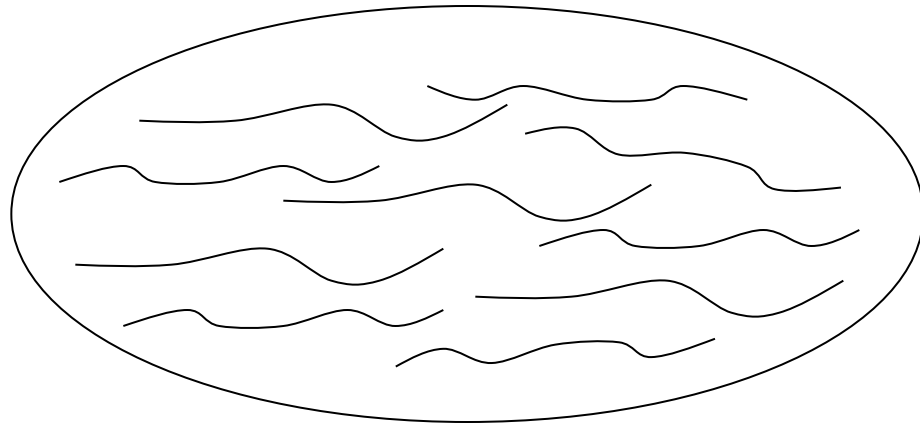


Rubber Basics :Elastomeric Materials

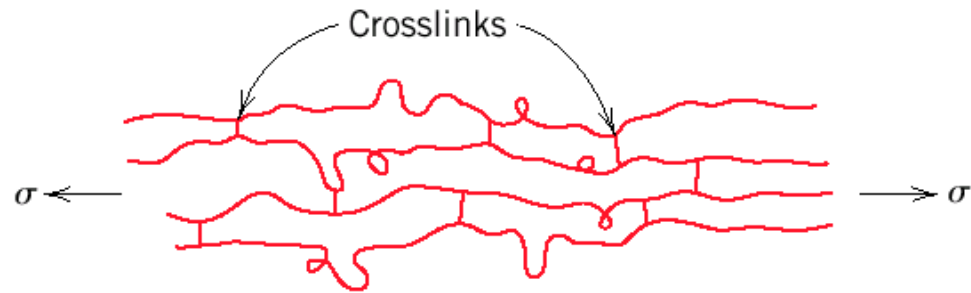


No Stress

Stressed
In tension

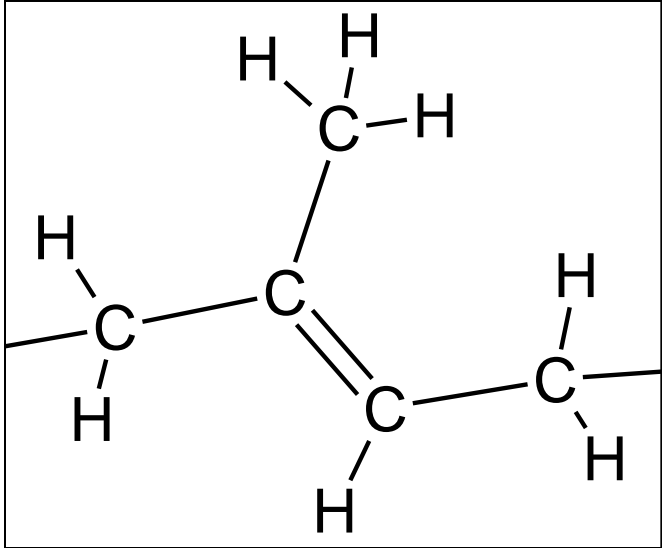


Rubber – Effect of Vulcanizing

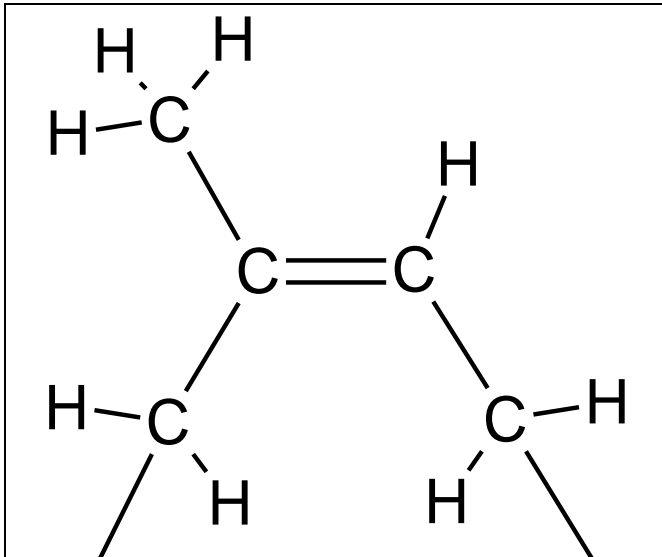
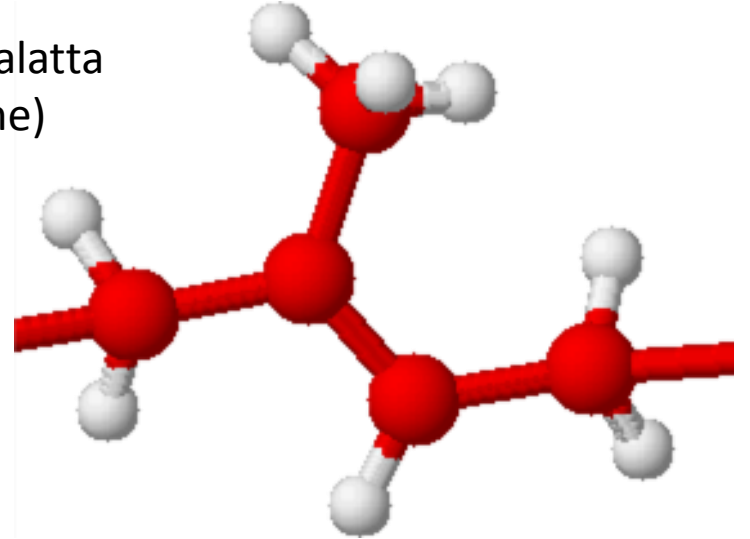


(b)

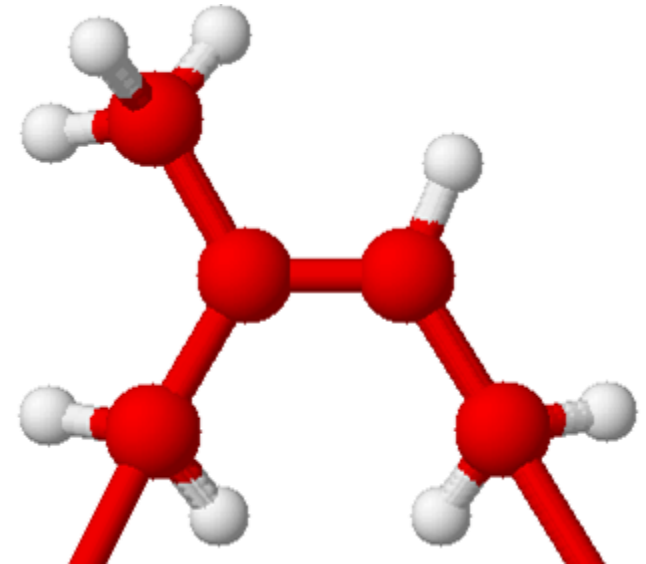
Rubber Basics : NR



Gutta percha or Balatta
(trans-polyisoprene)



Hevea Rubber
(cis-polyisoprenene)



Rubber Polymer Type : Natural Rubber

2.3.1 Natural rubber , NR

- Extracted from rubber trees with present suppliers being Malaysia, Indonesia, Sri Lanka, Nigeria and others.
- Polymer is polyisoprene,
- Vulcanized products made have high mechanical strength and very good dynamic mechanical properties
- Can be compounded to have excellent elasticity (ability to snap back to their original shape).
- NR has very good abrasion resistance ,
- low relative cost,

Rubber Polymer Type : Natural Rubber

Applications of NR :

- slurry pump liners and impellers as well as for tank linings.
- Tires, rubber springs and vibration mounts.
- excellent for fine particle impact applications. NR rubber has a very high elasticity, thus most of the kinetic energy of an impacting particle is converted into deformation which then releases the energy by returning to its original undeformed state.
- It also has very good low temperature resistance, down into the region of $-57\text{ }^{\circ}\text{C}$ at which its stiffness shows a considerable increase.
- Its high temperature heat aging resistance limit for 'continuous' use is in the region of $75\text{ }^{\circ}\text{C}$. Significant components of weather resistance, are UV light and ozone. Addition of carbon black to a compound gives resistance to UV. Antiozonants and waxes, and helps with ozone resistance. Ozone attack is of most concern for thin products and those that are subjected to stretching in service.
- Electrical insulation is very good and is dependant on compounding.
- Resistance to petroleum oils is poor while resistance to alcohols (such as ethanol and methanol) and ketones (such as methyl ethyl ketone (MEK) and acetone) is much better.
- Synthetic polyisoprene (IR) has basically similar properties to those of NR and has a more consistent rate of curing and processing characteristics, at a presently slightly higher relative price.

Rubber Polymer type : SBR

2.3.2 Styrene butadiene rubber

- SBR is derived from petroleum oil.
- SBR represents half of all synthetic rubber production, and is much consumed in tires, where it competes with and complements NR.
- In comparison with NR and CR, SBR has poor mechanical properties.
- The raw gum elastomer must have reinforcing fillers , such as carbon black, in order to attain good mechanical strength and the filler increases hardness at the same time.
- The properties of SBR are broadly similar to NR, for chemical, solvent, and weather resistance.
- The upper temperature heat aging resistance limit is a little higher.
- The cost of the raw gum elastomer is low on the relative scale for elastomers in general and is comparable with NR

Rubber Polymer type : Nitrile Rubber

2.3.4 Nitrile NBR

Acrylonitrile butadiene rubber, to others it is also called Buna-N or nitrile rubber.

- It is the workhorse of the marketplace for its oil resistant properties.
- The grades offered differ in the percentage of acrylonitrile (ACN) in the polymer chain as well as the overall viscosity of the polymer.
- NBR also has superior fuel resistance. The terms oil and fuel used here refers loosely to those products derived from petroleum.
- The weather resistance of NBR is poor, similar to NR and SBR, although it can be enhanced by blending with the plastic, polyvinyl chloride (PVC), at some 'cost' to its low temperature properties.
- The alcohol causes NBR in contact with the gasoline alcohol blend to swell significantly. Blends above 5% should be treated with caution unless a resistant rubber type is used. However it has excellent resistance to non polar petroleum oils.
- This also means that NBR has poor resistance to polar liquids such as ketones, esters, chlorinated solvents, and highly aromatic solvents such as benzene and toluene.

Rubber Polymer type : Chloroprene Rubber

2.3.3 Polychloroprene CR

The CR (chloroprene rubber), more popularly known as Neoprene.

- it has a measure of both oil and weather resistance.
- The oil resistance would only be considered moderate.
- CR has similar dynamic mechanical characteristics to NR, including good mechanical strength .
- CR has some ability to retard flame, which means that when a source of flame is removed, the burning polymer will have a tendency to self extinguish, (this can be modified to improve or unintentionally diminish this property), while NR, EPDM, and SBR for example, will continue to burn.
- Upper continuous heat aging resistance temperature limits are of the order of 90 °C. SAE defines continuous upper temperature resistance as, the temperature at which the material retains a minimum of 50% of both original elongation and tensile strength at break after 1008 hours (**6 weeks**).
- Recommended upper range for CR in air is 99 °C for 1,000 cumulative hours and 85 °C for 10,000 cumulative hours. Other sources put it at 91 °C for 1,000 cumulative hours and 85 °C for 10,000 cumulative hours.
- CR shows some stiffening at around -18 °C , becoming brittle around -40 deg C, although this can be lowered using certain compounding ingredients.
- Resistance of CR to dilute acids and bases is better than that of NR or SBR,
- Cost is somewhat higher than NR/ SBR

Rubber Polymer type : EPDM Rubber

2.3.5 Ethylene propylene rubber EPM and EPDM

EPM is a copolymer consisting of ethylene and propylene units as part of the main polymer chain

- EPDM is largely unaffected by weather with very good resistance to ozone.
- Dupont literature quotes EPDM products which were exposed to 10,000 parts per hundred million of ozone for 1,000 hours in air, at room temperature, without cracking.
- Raw gum elastomer manufacturers' literature [12, 13, 14, 15] indicate upper 'continuous' heat aging temperature limits in air five cumulative years at 100 deg C.
- Low temperature flexibility is very good and compares well with NR, and
- like NR and SBR, EPDM (with a lower polarity than NR) has very poor oil resistance.
- The price conscious rubber compounder is aware of the low specific gravity of the raw gum
- The use of EPDM is dominant in roof membrane linings and extruded channels for windows because of the above properties.
- EPDM has also been used as a blend with NR in tire sidewalls to improve resistance to cracking by ozone attack.
- The excellent electrical resistance of EPDM promotes its use in medium and high voltage cable covers.
- Automotive applications of EPDM would include radiator and heater hoses and

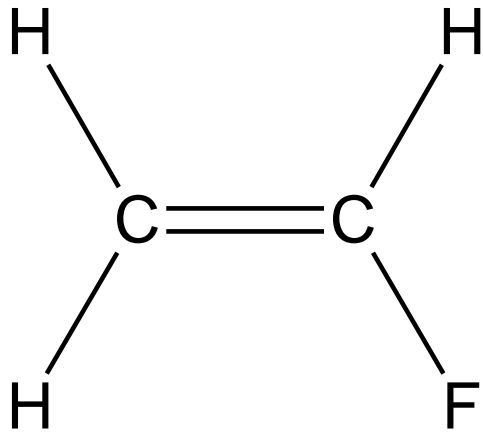
Rubber Polymer type : Butyl Rubber

2.3.6 Butyl rubber IIR and halobutyl rubber CIIR and BIIR

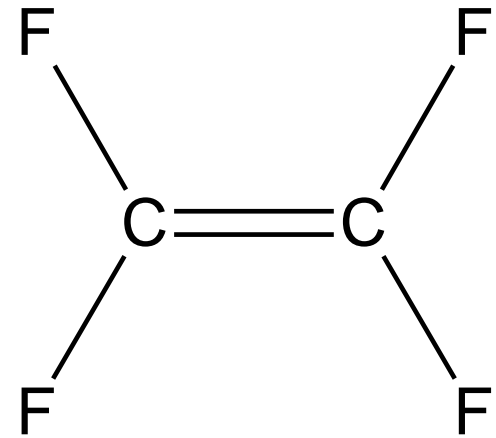
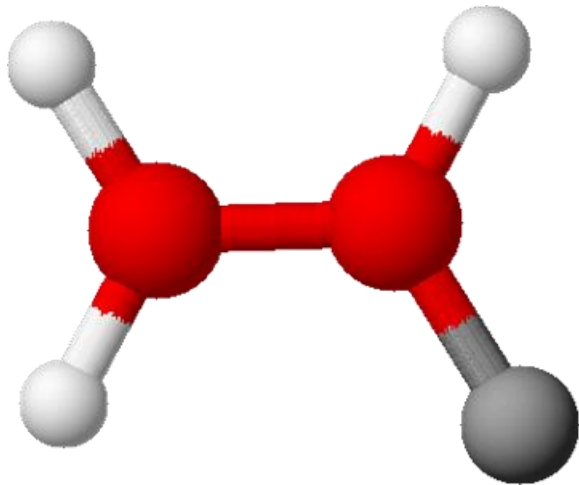
Butyl rubber is a copolymer of isobutylene and isoprene, hence IIR. If a halogen, such as chlorine or bromine, is introduced into the polymer architecture, it becomes CIIR or BIIR, respectively.

- IIR has some properties similar to those of EPDM, such as good mineral acid and base resistance (like EPDM some concentrated mineral acids are a problem), and weather resistance which is similar to that of EPDM.
- IIR has excellent resistance to permeability by gases. For example, Fusco [18] mentions its permeability to air being as low as 10% that of NR, at 65 deg C.
- Like EPDM, the polarity of IIR is low which means poor resistance to petroleum oils and conversely low swell in many polar solvents, such as ketones.
- Resilience is poor, which translates to good damping ability.
- The upper continuous heat aging temperature limit is around 121 deg C, which can be distinctly improved with IIR compounds containing resin (polymethylol-phenol) cure systems.
- For low temperature properties the vulcanizate becomes stiff and leathery at around -18 deg C, although it is not brittle until around -70 deg C.
- Applications naturally following from these properties include mounts and bumpers for vibration and shock prevention, roof and tank linings, curing bladders and inner tubes for tires.
- A significant use is inner liners for tubeless tires, where halobutyl is preferred due to improved interply adhesion with the rest of the inner tire.

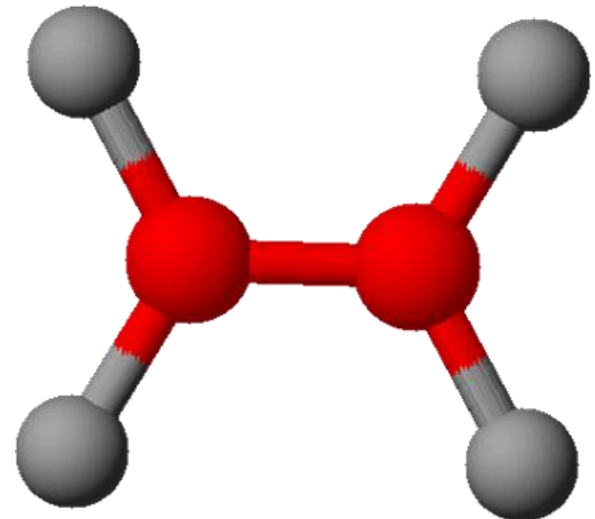
Rubber Basics : Fluoroelastomers



Vinylidene fluoride monomer



Tetrafluoroethylene monomer



Rubber Basics : Fluoroelastomers

- Many of the desirable properties of fluoropolymers
 - Low solvent effects
 - Excellent for chemical and petroleum handling applications
 - High thermal stability
 - Good for gaskets and seals

Rubber Polymer type : Fluorocarbon Rubber

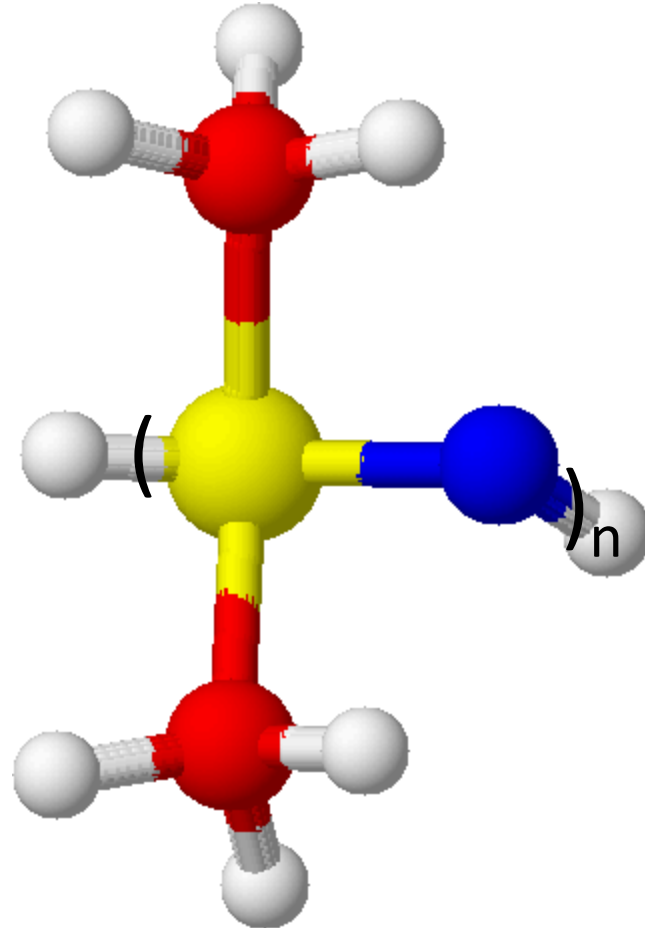
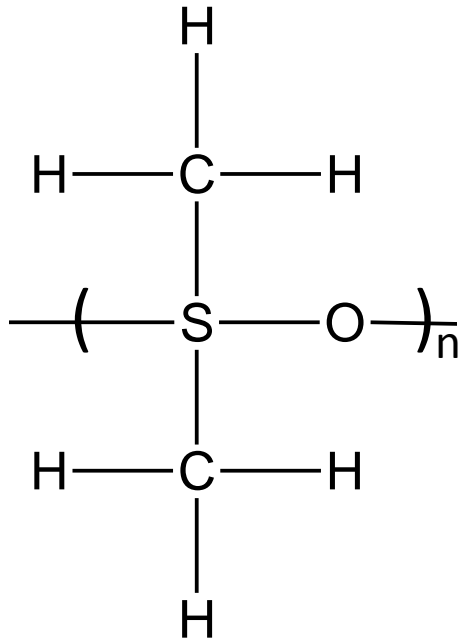
2.3.9 Fluorocarbon rubber FKM (FPM)

In the United States fluorocarbon rubber is well known by its trade name of **Viton**

Based on vinylidene fluoride and hexafluoro-propylene

- Like silicone rubber, FKM has excellent high temperature resistance with an upper continuous heat aging temperature limit of 205 deg C.
- FKM is usually serviceable at temperatures down to -20 deg C in dynamic applications, while for static use the temperature can be lower.
- A primary variable in FKM grades is the level of fluorine in the elastomer molecule, FKMs being fluorohydrocarbons . Terpolymers tend to have a higher fluorine content than copolymers excellent resistance to oxidation, ozone, fuels and petroleum oils and are resistant to most mineral acids at high concentrations.
- Although FKM has good resistance to many chemicals, excessive swelling occurs in some polar solvents such as low molecular weight ethers, esters and ketones.
- Chemicals such as alkalis and amines should be used with caution, with standard fluorocarbon grades,.
- FKM has a tendency to self extinguish when a flame is removed
- Applications for FKM include automotive fuel hose liners and seals and flue duct expansion joints, where high temperatures and acidic exhaust is present.
- The relative cost of FKM is high, more than any of the elastomers mentioned so far, also a high specific gravity (around 1.8) means less cured product (volume) per unit weight

Rubber Basics : Silicones



Rubber Polymer type : Silicone Rubber

2.3.7 Silicone rubber Q

- Most elastomers have a carbon main chain, while Q has a silicone oxygen backbone.
- Silicone has an upper continuous heat aging temperature in the region of 205 deg C.
- Estimated service life for Q as follows: 40 years at 90 deg C, 2-5 years at 200 deg C and two weeks at 315 deg C. Moisture, such as might be found in a poorly ventilated environment, can be a problem at high temperature [21].
- Silicone is among the best elastomers for both high and low temperature resistance.
- Silicone rubber has excellent ozone, weather resistance and electrical insulation.
- Like CR, Q has a measure of flame retardant ability.
- Mechanical properties such as tensile strength, are low, but change very little when measured at higher temperatures; at 150 deg C, it is catching up with other elastomers
- Oil resistance is about the same as that of CR;
- acid and alkali resistance are not good.
- Applications include aerospace, medical, food contact, and automotive ignition cable.
- The cost of the raw gum elastomer is higher than any of the rubbers.

Rubber Polymer type : Trade Names

Symbol	Generic name	Some trade names	Company
SBR	Styrene butadiene rubber Emulsion	Copo Cariflex Ameripol-Synpol	DSM Elastomers Shell Ameripol Synpol
CR	Chloroprene rubber	Neoprene Baypren Denka	DuPont Dow Elastomers Bayer Denki Kabushiki Kaisha Kagaku Kogyo
NBR	Nitrile	Nipol Krynac Paracril Chemigum Perbunan N Nysyn	Zeon Bayer Uniroyal Goodyear Bayer DSM Copolymer

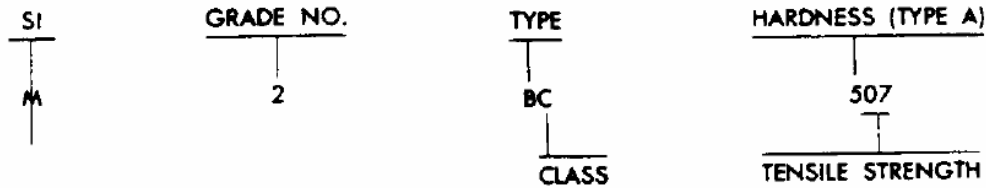
Rubber Polymer type : Trade Names

Symbol	Generic name	Some trade names	Company
EPDM	Ethylene propylene diene rubber	Buna EP Nordel Vistalon Royalene Keltan	Bayer DuPont Dow Elastomers Exxon Uniroyal DSM Copolymer
IIR CIIR BIIR	Butyl	Exxon Butyl Polysar Butyl	Exxon Bayer
MQ	Silicone elastomers	Elastosil Silopren	Wacker Chemie Bayer FKM (FPM)
HNBR	Highly saturated (<i>hydrogenated</i>) nitrile	Zetpol Therban	Zeon Bayer
FKM	Fluorocarbon	Fluorel Viton Tecnoflon	Dyneon DuPont Dow Elastomers Montedison
BR	Polybutadiene rubber	Taktene Budene Diene Solprene Intene Buna	Bayer Goodyear Firestone Negromex EniChem Hils GmbH
ACM	Polyacrylate	HyTemp Europrene AR	Zeon EniChem

SAE J200 Rubber Classification

SAE J200/ANSI/ASTM D 2000—M2BC507A14E034

BASIC REQUIREMENTS



SUFFIX REQUIREMENTS

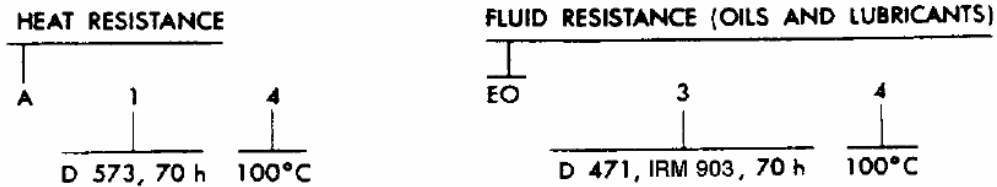


FIGURE 1 - LINE CALL-OUT

TABLE 1 - BASIC REQUIREMENTS FOR ESTABLISHING TYPE BY TEMPERATURE

Type	Test Temperature, °C
A	70
B	100
C	125
D	150
E	175
F	200
G	225
H	250
J	275
K	300

TABLE 2 - BASIC REQUIREMENTS FOR ESTABLISHING CLASS BY VOLUME SWELL

Class	Volume Swell, max, %
A	no requirement
B	140
C	120
D	100
E	80
F	60
G	40
H	30
J	20
K	10

SAE J200 Rubber Classification

TABLE 3 - MEANING OF SUFFIX LETTERS

Suffix Letter	Test Required
A	Heat Aging Resistance
B	Compression Set
C	Ozone or Weather Resistance
D	Compression-Deflection Resistance
EA	Fluid Resistance (Aqueous)
EF	Fluid Resistance (Fuels)
EO	Fluid Resistance (Oils and Lubricants)
F	Low-Temperature Resistance
G	Tear Resistance
H	Flex Resistance
J	Abrasion Resistance
K	Adhesion
M	Flammability Resistance
N	Impact Resistance
P	Staining Resistance
R	Resilience
Z	Any special requirement which shall be specified in detail

TABLE 5 - SUFFIX NUMBERS TO INDICATE TEMPERATURE OF TEST

Applicable Suffix Requirements	Second Suffix No.	Test Temperature °C ⁽¹⁾
	11	275
	10	250
	9	225
	8	200
	7	175
	6	150
A, B, C,	5	125
EA, EF, EO,	4	100
G, K,	3	70
	2	38
	1	23
	0	⁽²⁾
	1	23
	2	0
	3	-10
	4	-18
	5	-25
	6	-35
F	7	-40
	8	-50
	9	-55
	10	-65
	11	-75
	12	-80

1. These test temperatures are based on the ASTM Recommended Practice D 1240, Annual Book of ASTM Standards, Parts 27 and 28

SAEJ200M2BG617B14EO14F17Z1

Suffix Z1 – A14, hardness change, ±5 points max; tensile strength change, ±15% max; ultimate elongation change, -15% max.

SAE J200 Rubber Classification

TABLE 4 - ASTM METHODS OF TEST⁽¹⁾

Requirement or Suffix Letter	Basic	1	2	3	4	5	6	7	8
Durometer Hardness (Type A)	D 2240	—	—	—	—	—	—	—	—
Tensile Strength, Elongation	D 412 die C	—	—	—	—	—	—	—	—
Suffix A, Heat Aging Resistance	—	D 573, 70 h	D 865, 70 h	D 865, 168 h	D 573, 168 h	D 573, 1000 h	D 865, 1000 h	—	—
Suffix B, Compression Set	—	D 395, 22 h, Method B, solid	D 395, 70 h, Method B, solid	D 395, 22 h, Method B, plied	D 395, 70 h, Method B, plied	D 395, 1000 h, Method B, solid	D 395, 1000 h, Method B, plied	—	—
Suffix C, Ozone or Weather Resistance	—	D 1171, ⁽²⁾ ozone exposure, Method A	D 1171, ⁽³⁾ weather exposure	D 1171, ⁽⁴⁾ ozone exposure, Method B	—	—	—	—	—

SAE J200 Rubber Classification

TABLE 6.AA - BASIC AND SUPPLEMENTARY (SUFFIX) REQUIREMENTS FOR CLASSIFICATION OF RUBBER MATERIALS - AA MATERIALS

Durometer Hardness, ±5 points	Tensile Strength, min (MPa)	Tensile Strength, min (psi)	Ultimate Elongation, min, %	Heat Aged, ASTM D 573, 70 h at 70 °C	Oil Immersion, ASTM D 471, IRM 903 Oil ⁽¹⁾ , 70 h at 70 °C	Compression Set, ASTM D 395, Method B, Solid, max, %, 22 h at 70 °C	Available Suffix Grade Numbers
30	7	1015	400				2, 4
30	10	1450	400				2, 4
30	14	2031	400				2, 4
40	7	1015	400				2, 4
40	10	1450	400				2, 4
40	14	2031	400				2, 4
40	17	2466	500				2, 4
40	21	3046	600				2, 4

TABLE 6.AA - SUPPLEMENTARY (SUFFIX) REQUIREMENTS FOR CLASSIFICATION OF RUBBER MATERIALS - AA MATERIALS (CONTINUED)

Suffix Requirements		Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Grade 6	Grade 7	Grade 8
A13	Heat aging resistance, ASTM D 573, 70 h at 70°C:								
	Change in hardness, max, points	Basic Requirements Only	±15		+10	+10			
	Change in tensile strength, max, %	Basic Requirements Only	±30		-25	-25			
	Change in ultimate elongation, max, %	Basic Requirements Only	-50		-25	-25			
B13	Compression set, ASTM D 395, Method B, 22 h at 70 °C, max, %	Basic Requirements Only		25	25	25			
B33	Compression set, ASTM D 395, Method B, 22 h at 70 °C, max, %	Basic Requirements Only		35	35	35			

SAE J200 Rubber Classification

TABLE A1 - SAE J200 DESIGNATION

SAE J200 Material Designation (Type and Class)	Type of Polymer ⁽¹⁾ Frequently Used
AA	NR, SBR, IR, IIR, BIIR, CIIR, EPM, EPDM, BR, Reclaim RBR
AK	T
BA	SBR, IIR, BIIR, CIIR, EPM, EPDM
BC	CR, CM
BE	CR, CM
BF	NBR
BG	NBR, AU, EU
BK	NBR
CA	EPM, EPDM
CE	CSM, CM
CH	NBR, CO, ECO
DA	EPM, EPDM
DE	CM, CSM
DF	ACM
DH	ACM, HNBR
EE	AEM
EH	ACM
EK	FZ
FC	PVMQ
FE	MQ
FK	FVMQ
GE	VMQ
HK	FKM
KK	FFKM

1. Symbols and names are based on ASTM D 1418. Trade Names for the majority of rubber compounds utilizing above polymers may be located in the following and other publications of the rubber industry: "The Synthetic Rubber Manual," International Institute of Synthetic Rubber Producers, Inc."Rubber World Magazine Blue Book," Lippincott & Peto.

TABLE A2 - POLYMER MOST OFTEN USED FOR MATERIAL REQUIREMENTS

Polymer Symbol	Common Name (Chemical Name)	Polymer Symbol	Common Name (Chemical Name) ⁽¹⁾
NR	Natural Rubber	NBR	Nitrile Rubber
Reclaim RBR	Reclaimed Rubbers		(Acrylonitrile Butadiene Copolymer)
IR	Isoprene (Synthetic Rubber)		
SBR	Styrene Butadiene Rubber	HNBR	Hydrogenated Nitrile Rubber
BR	Butadiene Rubber		(Hydrogenated Acrylonitrile Butadiene Copolymer)
IIR	Butyl Rubber (Isobutene-Isoprene)		
CIIR	Chlorobutyl Rubber (Chloro Isobutene-Isoprene)	CM	Chlorinated Polyethylene
BIIR	Bromobutyl Rubber (Bromo Isobutene-Isoprene)	CSM	Chlorosulfonated Polyethylene
T	Polysulfide Rubbers	ACM	Polyacrylate Rubber
EPM	Ethylene Propylene Copolymer		(Acrylic Esters Copolymer)
EPDM	Ethylene Propylene Diene Terpolymer	AU	Polyurethane - Ester Type
CR	Polychloroprene		
CO	Epichlorohydrin Homopolymer (Polychloromethyl Oxirane)	EU	Polyurethane - Ether Type
AEM	Acrylic Ester/Ethylene Copolymer	MQ (MQ, VMQ, PVMQ)	Silicone Rubbers
		FVMQ	Fluorosilicone Rubber
FZ	Fluoroalkoxyphosphazene Rubber	FKM	Fluorocarbon Rubber
ECO	Epichlorohydrin/Ethylene Oxide (Oxirane) Copolymer	FFKM	Perfluoroelastomer

1. Symbols and names are based on ASTM D 1418. Trade names for the majority of rubber compounds utilizing above polymers may be located in the following and other publications of the rubber industry: "The Synthetic Rubber Manual," International Institute of Synthetic Rubber Producers, Inc."Rubber World Magazine Blue Book," Lippincott & Peto.

Typical Rubber Compound Ingredients

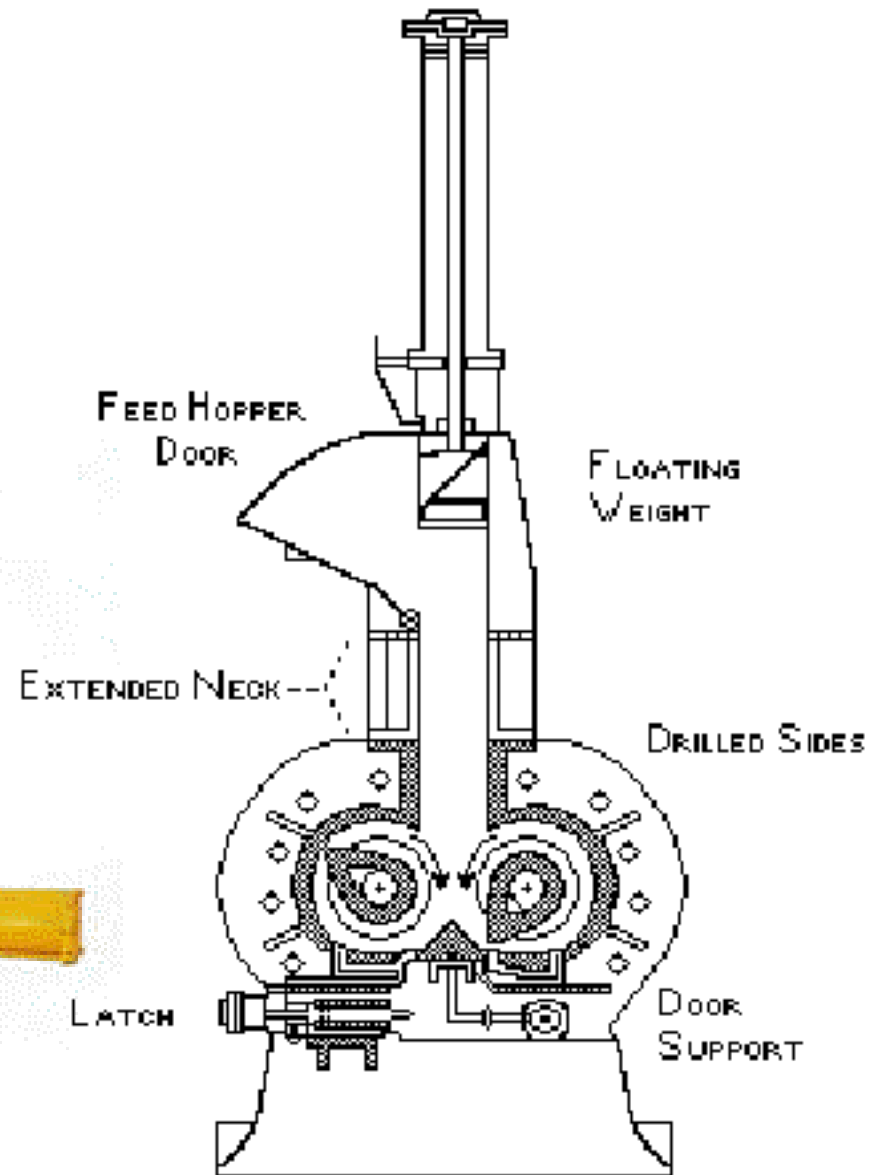
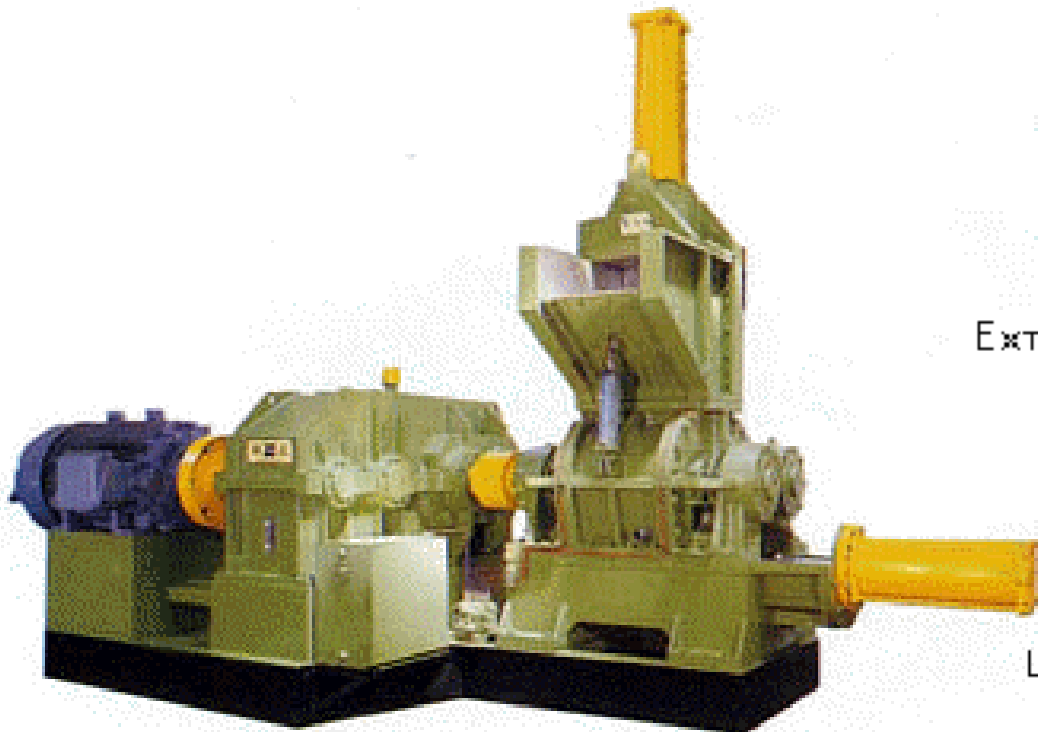
Table 3.1

		Specific Formulation	
Material	phr	For Example	phr
Raw gum elastomer	100	SMR 20	100
Sulfur	from 0 to 4	Sulfur	0.35
Zinc oxide	5	Zinc oxide	5
Stearic acid	2	Stearic acid	2
Accelerators	from 0.5 to 3	MBS	1.4
		TMTD	0.4
Antioxidant	from 1 to 3	HPPD	2
Filler	from 0 to 150	N330 Black	45
Plasticizer	from 0 to 150	Aromatic petroleum oil	4
Miscellaneous		None	
		TOTAL	160.15

*phr is defined as parts by weight of ingredient per 100 parts of raw gum elastomer.
The limits given are typical examples and are not intended to be absolute values.*

Rubber Compound Mixing

- Compounding
 - Banbury mixer



Rubber Compounding Ingredients : Cross linking Agents

3.3.2 Sulfur

It is interesting to note that sulfur is still by far the most used cross-linking agent in the rubber industry since its use by Goodyear and Hancock.

It reacts chemically with the raw gum elastomer forming cross-links between the polymer chains, resulting in a more dimensionally stable and less heat-sensitive product.

Its cost is relatively low but its function is essential.

It is available in different particle sizes (fineness) as rubbermakers sulfur, and can also have a small quantity of oil added to reduce its dust in the air during handling.

Rubbermakers sulfur is sulfur suitable for vulcanizing rubber; it has a low ash content, low acidity and sufficient fineness for adequate dispersion and reaction.

3.3.3 Zinc oxide and stearic acid

These two materials, together with sulfur and accelerator, constitute the 'cure system' for the formulation. Zinc oxide reacts with stearic acid to form zinc stearate (in some cases zinc stearate is used in place of zinc oxide and stearic acid) and together with the accelerator they speed up the rate at which sulfur vulcanization occurs. With sulfur alone, the curing process might take hours. With this curing system, it can be reduced to minutes.

Rubber Compounding Ingredients : Cross linking Agents

3.3.5 Other cross-linking systems

Peroxides

Peroxides are suitable for curing rubber but are not recommended for some elastomers such as IIR or CIIR.

Peroxides can be used to cure many elastomers, since, unlike sulfur, they do not need unsaturated bonds (see section **6.1**) in the polymer. Thus they may be used to cure ether-type polyurethanes, certain fluoroelastomers, silicones and all of the previously mentioned saturated elastomers. Peroxides can also be used to cross-link CR.

Although not nearly as popular as sulfur, peroxides have a distinct place in rubber compounding, and are a major curative for silicone rubber.

In the basic rubber compound formulation, the zinc oxide, stearic acid, sulfur and accelerator can all be replaced by a single material, the peroxide.

Peroxides as curing agents can confer some advantages.:

- First an improvement in the heat aging resistance of the vulcanizate, thus upper temperature limits can be pushed up a little or the lifetime extended.
- Compression set (see section 5.4.5) is also improved. On the other hand, tensile strength, tear strength, and fatigue (dynamic deformation such as constant flexing) life are reduced. A post cure (continued cure outside of the mold) is sometimes undertaken with peroxide cured vulcanizates, to complete the cure and remove unwanted byproducts.
- The cross-link density of a peroxide cured compound can be increased by addition of chemicals called coagents, of which methacrylates are a good example. This results in a higher state of cure with improvements in properties such as

Rubber Compounding Ingredients : Accelerators

3.3.4 Accelerators

The accelerator (not to be confused with a catalyst, which remains fully available at the end of a chemical reaction), is usually understood to mean an organic chemical, and as the name implies, it speeds up the rate of vulcanization.

There are many accelerators available to the rubber chemist, grouped into several chemical classes.

Some have a built in delay time, so that when heat is applied to the compound at the beginning of the curing process, no vulcanization (cross-linking) takes place for a specified initial period of time. They are appropriately called delayed action accelerators, An example would be the sulfenamides. This delay is highly beneficial if a compound takes a long time to completely fill a cavity in a heated mold.

The following is a summary of some typical chemical classes of accelerators available to the rubber chemist.

- Zinc dibutyl dithiocarbamate (ZDBC).
- Thiurams Example: Tetramethylthiuram disulfide (TMTD).
- **Thiazoles**
- **Guanidines**
- **Sulfenamides**

Rubber Compounding Ingredients : Antioxidants

3.3.6 Antioxidants, age resistors and antidegradants

antioxidants are also necessary to protect other organic materials, such as most elastomers' from aging.

Aging can be caused by the ravages of oxygen, accelerated by heat. Antioxidants are designed to slow down this process and can act as free radical scavengers.

Antiozonants, such as the p-phenylene diamines, which provide sacrificial protection against ozone, are also important, and are often added to a compound.

Classification of antidegradants is found in ASTM D 4676 [12].

An antidegradant is a compounding material used to retard the deterioration caused by oxidation, ozone, light or combinations of these

Rubber Compounding Ingredients : Fillers

3.3.7 Fillers

- While the cured raw gum elastomers of NR and CR are mechanically strong, most gums are weak when vulcanized and they need reinforcing fillers.
- Reinforcement effect increases mechanical strength (for example tensile strength and resistance to tearing) and stiffness.
- Addition of filler increases hardness of the cured product. All fillers are not created equal, so that there is a range of reinforcement from very high to very low, corresponding to the primary size of the filler particle, from around 10 nm for very fine particle carbon blacks giving high reinforcement, to greater than 300 nm for some calcium carbonates which give low reinforcement. Use of the latter reduces compound cost.

The shape and surface chemistry of the filler particle also play an important part in reinforcement. Some popular fillers are, in order of decreasing reinforcement :

- carbon blacks and silicas,
- clays and then
- whittings (calcium carbonate, otherwise known as chalk).

Rubber Product : Tires

- Tire production can be summarized in three steps:
 1. Preforming of components
 2. Building the carcass and adding rubber strips to form the sidewalls and treads
 3. Molding and curing the components into one integral piece
- The following descriptions of these steps are typical; there are variations in processing depending on construction, tire size, and type of vehicle on which the tire will be used
- The carcass consists of a number of components, most of which are rubber or reinforced rubber
- These, as well as the sidewall and tread rubber, are produced by continuous processes and then pre-cut to size and shape for subsequent assembly
- The components include: bead coil, plies, inner lining, belts, tread, and sidewall

Rubber Product : Tires

Building the Carcass

- The carcass is traditionally assembled using a machine known as a *building drum*, whose main element is a cylindrical arbor that rotates

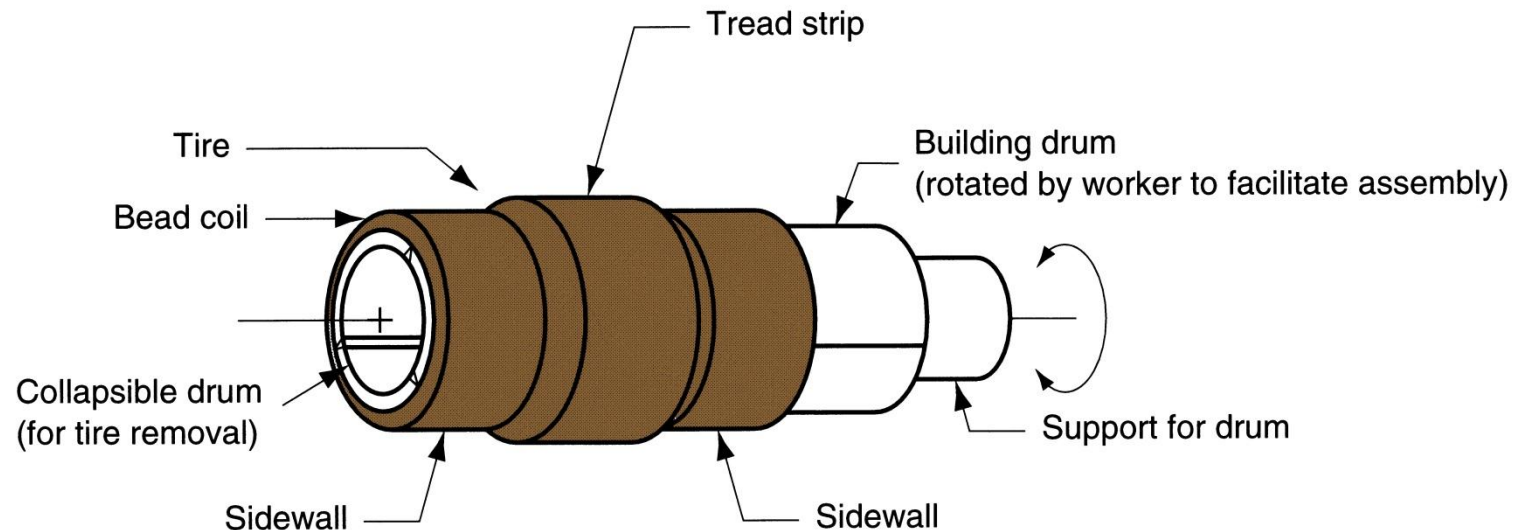


Figure 14.6 - Tire just before removal from building drum, but prior to molding and curing

Rubber Product : Tires

Molding and Curing

- Tire molds are usually split molds and contain the tread pattern to be impressed on the tire

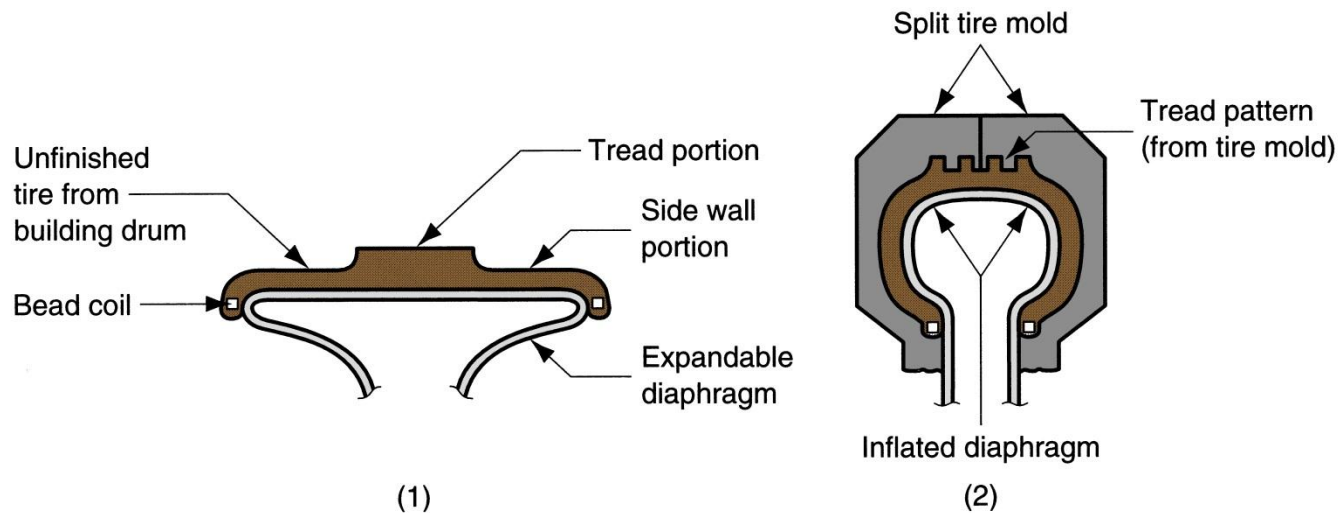


Figure 14.7 - Tire molding: (1) uncured tire is placed over expandable diaphragm; (2) mold is closed and diaphragm is expanded to force uncured rubber against mold cavity, impressing tread pattern into rubber; mold & diaphragm are heated to cure rubber

Rubber Belts for Conveyors and Pulleys

- Widely used in conveyors and mechanical power transmission systems
- As in tires, rubber is an ideal material for these products but the belt must have little or no extensibility in order to function
 - Accordingly, it is reinforced with fibers, commonly polyester or nylon
- Fabrics of these polymers are usually coated by calendering, assembled together to obtain required number of plies and thickness, and subsequently vulcanized by continuous or batch heating processes

Other Rubber Products – Hose

- Two basic types:
 1. Plain hose (no reinforcement) is extruded tubing
 2. Reinforced tube consists of:
 - Inner tube - extruded of a rubber compounded for particular liquid that will flow through it
 - Reinforcement layer - applied to the inner tube as a fabric, or by spiraling, knitting, braiding
 - Outer layer – compounded for environmental conditions and applied by extrusion

Rubber Product : Compression Moulding

- Rubber parts produced by compression molding (the traditional process) can often be produced in quantities of 1000 or less
 - The mold cost is relatively low compared to other molding methods
- Injection molding, as with plastic parts, requires higher production quantities to justify the more expensive mold
- Draft is usually unnecessary for molded parts of rubber, because its flexibility allows it to deform for removal from the mold
- Shallow undercuts, although undesirable, are possible with rubber molded parts for the same reason
- The low stiffness and high elasticity of the material permits removal from the mold