The combination of neoprene's excellent weathering performance and ozone resistance as well as its high tensile strength and low compression set makes it a very attractive synthetic rubber for these outdoor applications where exposure to adverse conditions imminent.

**Wire and Cable**

Neoprene rubber parts have been widely used for protective covering solutions in cable and wire systems. Offering many attributes similar to natural rubber in these jacketing applications, neoprene goes further to provide much better heat, chemical, flame, ozone and weathering resistance than its natural rubber counterpart. Additionally, neoprene's excellent physical toughness and resistance to cracking allows neoprene to be an optimal material for use in cables that are commonly bent and twisted repeatedly. Some specific wire and cable applications that benefit from neoprene rubber products include:

- Cable jackets
- Jacketing in lead press cured mining cables
- Jacketing in heavy-duty cables

**Compounding Neoprene**

Like all elastomers, the properties that are inherent to the base polymer are able to be enhanced or degraded through the addition and compounding of other ingredients. By effectively communicating with and engaging our prospects in the material selection process, Timco is able to develop neoprene compounds with optimum service life which will process both smoothly and economically. What follows below are brief accounts of some of the considerations and guidelines we follow in formulating custom neoprene compounds.

A balanced neoprene compound will normally contain some degree of the following:

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**Acid Acceptors**

**High-Activity Magnesium Oxide (Magnesia)**

This metal oxide is used in neoprene compounds primarily to neutralize trace hydrogen chloride that may be liberated by the polymer during processing, vulcanization, heat aging or service. The addition of magnesium oxide results in improved overall stability through the removal of hydrogen chloride which prevents auto catalytic decomposition. Magnesium oxide will also take part in the cross-linking process that takes place during vulcanization.

Typically, use of 4 parts magnesium oxide and 5 parts zinc oxide will result in a good overall balance of cure rate and processing safety. For applications that require high temperature molding, and especially injection molding, higher levels of magnesia may be used. Contrarily, lower levels of magnesia (2 pphr)
can be used in some cure systems that employ continuous vulcanization. The surface activity will indicate the oxides ability to absorb or react with hydrogen chloride and, therefore, the higher the value, the greater the vulcanizate properties and processing safety. The materials Mooney Scorch times will be directly related to the activity of the magnesium oxide that is incorporated.

**Red Lead**

By replacing magnesia/zinc oxide combinations with a lead oxide such as 20 parts read lead Pb3O4, improved water resistance can be achieved. As a safety and health precaution, red lead should always be added as dispersion, 90% in EPDM. Because the red lead has a more limited reactivity with hydrogen chloride than its magnesium counterpart, stabilization will be less efficient. Therefore, use of red lead in neoprene material compounds should be limited to safe curing systems.

**Calcium Stearate**

Although this substance has limited use as an acid acceptor, the replacement of 4 parts magnesium oxide with an equimolar quantity of 5.4 parts calcium stearate can result in the retarding of hardening on heat aging. This may be useful to applications that call for a material hardness increase of 5pt or less after 7 days at 100°C.

**Vulcanization Accelerators**

While some compounds of Neoprene do not require an organic accelerator to achieve a good state of cure, others will require such organic acceleration agents to increase cure rates. Typically, the best balance of vulcanizate modulus, compression set, resilience, and heat aging is provided by using ethylene thiourea (ETU) as a dispersion. Of course, the levels of increased state of cure rates and reduced scorch resistances are proportional to the amount of ETU added. The processing safety of the neoprene compound can be improved through the addition of CBS or TMTD in carbon black stocks, or MBTS with mineral fillers such as china clay.

In compounds where the presence of ETU is unacceptable even in dispersed form, alternative proprietary accelerators such as dimethyl ammonium hydrogen isophthalate, Vanax CPA may be used. The use of these accelerator agents may require higher amounts to achieve the equivalent cure rates.

Water resistant Neoprene compounds that contain red lead typically employ .5-1.0 part TMTM and sulphur each as a cure system.

Peroxide cures in neoprene promote poor heat aging, even though they provide very low compression set and good processing safety. This holds true even when high levels of efficient antioxidants are incorporated into the compound and, therefore, they are rarely used.

**Antiozonants and Antioxidants**

Neoprene rubber differs from unsaturated general purpose elastomers through its inherent resistance to attack by ozone, oxygen, heat and light. However, the addition of an effective antioxidant and antiozonant is required to achieve
optimum service performance in the long term.

2-4 parts octylated diphenylamine is the preferred antioxidant, among all others, as it imparts the best heat stability while being relatively non-staining and having no effect upon scorch or bin storage. Antioxidants that are ketone amine and quinoline based can seriously affect scorch and bin storage and, therefore, should be avoided.

When considering effective antiozonants, it is important to note that these additives tend to adversely affect processing safety and promote staining in the finished product. A mixed diaryl para-phenylene diamine will have only a limited effect on scorch and bin storage while also providing the best balance of long term oxidation protection, being non-extractable in water and of low volatility. Given the limited options available for effective non-staining antiozonants, a more thorough material selection consultation with Timco is suggested if the application appears to require such an agent.

**Reinforcing and Extending Fillers**

As with all elastomers, Neoprene compounds require additional reinforcing fillers to achieve a desirable balance of hardness, processability, and tensile or tear properties. Such fillers include carbon blacks, plasticizers, mineral filters and processing aids.

**Carbon Blacks**

Being the most widely used filler for all elastomers, a variety of carbon black grades can be used in neoprene compounding to achieve a number of desirable results. When mixing conditions are optimal, highly reinforcing blacks such as N110 (SAF) or N219, N220, N231, N242 (ISAF) can give the best tensile and tear strength values. However, in practice, dispersion difficulties have led to the general use of N330 (HAF) or N326 (HAF-LS). Most applications specifications can be met through the use of N550 (FEF), N660 (GPF), N683 (APF), N990 (MT), N772 or 774(SRF) blacks or blends.

For extrusion or calendering stocks, the use of N683, N550, or N660 either alone or blended with N774 or N772 are preferred.

If the applications requirements permit, highly economical compounds can be prepared using high loads of N660, N772 or N774 blacks in addition to significant levels of plasticizer.

Where compression set and physical property requirements are modest, blends of N774 or N772 with mineral fillers such as whiting or china clay can be considered.

**Plasticizers**

Softeners, plasticizers and extenders are commonly added to neoprene compounds to facilitate processing, enhance specific properties, or reduce cost. The levels of these additives can range from 5 to over 50 parts, and a significant amount of care should be taken both in the selection of type and quantity to ensure the neoprene material retains its inherently attractive property balance.
The use of highly aromatic oils is relatively low in cost and they are also compatible with all levels of neoprene material. At high dosage levels, these oils increase uncured tack and can cause slight staining in paint films of vulcanizates. Naphthenic oils will not have these effects and will also give better long-term heat resistance; however, depending on the source, their compatibility will be limited to approx. 15 parts maximum.

The use of polymeric plasticizers and hydrocarbon or coumarone-indene resins can retard crystallization; however these additives do not improve the neoprene materials low temperature flexibility. In applications where temperature flexibility is less critical than self-extinguishing characteristics in the material, phosphates tend to be used.

In neoprene vulcanizates at temperatures to -40°C, ester plasticizers are required in order to maintain and increase flexibility. The use of these esters, however, tends to increase the crystallization rate of susceptible grades. Depending on the specific customers needs for balance in low temperature flexibility, volatility, and cost, most commercial esters such as adipates, phosphates, sebacates, phthalates and oleates may be used.

Chlorinated hydrocarbons and waxes, available in both solid and liquid forms, can be added with chlorine content ranging between 40% and 70%. Liquid chlorinated hydrocarbons tend to cause mold sticking and, therefore, solid grades or blends are often preferred. However, their usage will be confined to Neoprene material compounds with optimum self-extinguishing characteristics or ignition resistance.