Trends toward 100% Peroxide Cured Construction

- In the early 1980’s, Dupont conducted a comprehensive evaluation of peroxide and sulfur cured molded EPR/EPDM rubber materials for cable and cable accessory applications. Results showed that conductive particles contained in sulfur cured shields would migrate into insulating layers causing premature failures. The Dupont study began a movement to 100% peroxide cured construction.

- In response to water/chemical treeing problems encountered by the utility industry, EPR cable manufacturers converted from sulfur to 100% peroxide cured construction.

- Industry standards IEEE 404 and 386 for splices and elbows were upgraded in 1986 to address utility concerns related to premature failures. In order to obtain the desired long term performance levels, products were converted from sulfur to 100% peroxide cured construction.

- Similar changes occurred in other industries utilizing EPR/EPDM molded rubber such as automotive components, membrane roofing and weather stripping. Quality, performance and reliability improvements were obtained by changing from sulfur to peroxide cured construction.
Introduction
Not all molded rubber cable accessory products are molded alike. By upgrading to 100% peroxide cured construction for conductive shields and insulating layers, the mechanical and electrical performance of molded rubber accessories is significantly improved.

Molded rubber cable accessories used on underground power distribution systems are typically rated 5 thru 35kV, 200 and 600 Amp. These components include:

- Elbows and Inserts
- Splices
- Terminations
- Other Components such as Junctions, Dead-end Caps, Feed Thrus, Stand Off Insulators, Fuses, Surge Arresters, Switches, Grounding Devices, Extenders, Adapters, Reducers.

Construction

Just like the cable they are intended to mate with, molded rubber accessories are constructed with layers of conductive and insulating materials. Each layer provides a specific function in the overall design.
Evolution of Sulfur and Peroxide Cured Materials

Years ago the process of vulcanizing rubber was discovered. This consisted of the addition of a curing agent to the base rubber to change its physical qualities. Strength and resilience were improved; stickiness and odor were reduced. It was determined that the changes resulted from the formation of cross linking bonds created by the curing agent and that the process could be applied to both natural and synthetic rubbers (EPR and EPDM).

Early curing agents were sulfur based and cross linking occurred through sulfur bonds. Later, peroxide curing agents were utilized which allowed direct cross linking to occur. Bond strengths were significantly improved resulting in stronger materials with superior resilience, compression set, elastic memory and electrical performance. These characteristics were important in the construction of cable and cable accessories which relied on tight interference fits for dielectric strength and water sealing.

Performance

Peroxide vs Sulfur Cured Material Performance

In the early 1980’s Dupont conducted an extensive evaluation of peroxide and sulfur cured molded rubber materials. Results were published in Dupont’s Report #EE-340.1, which provided valuable information verifying the importance of 100% peroxide cured construction for conductive shields and insulating layers in cable and cable accessory applications.

Conclusions were as follows:
1. Sulfur cured conductive shields should be avoided because they affect the performance of the insulating layer that they are in contact with. Dupont found that sulfur cured materials contain conductive contaminants which migrate into the insulating layer resulting in instability and failure. This migration is accelerated by common conditions found in actual service including high voltage stresses, elevated temperatures, presence of moisture and high voltage DC proof testing.

Accelerated tests on molded constructions with sulfur cured conductive shields produced failures of the insulating layer in 5 months.

The same tests on 100% peroxide cured construction withstood the entire 3 year test program without any loss of stability of the insulating layer.

2. Sulfur cured insulating layers should be avoided. Conductive contaminants accelerated by voltage, temperature and moisture caused the insulating layer to become unstable and fail after 5 months of laboratory testing. Peroxide cured insulating layers remained stable and passed the duration of the 3 year test program.
**Problem**

**Cable Problems with S-P-S**  
(Sulfur-Peroxide-Sulfur Construction)

Manufacturers of EPR cable discovered that the use of sulfur cured shields over peroxide cured insulation resulted in failures. It was found that the migration of free sulfur into the insulation reduced the dielectric withstand of the insulation.

**Solution**

**Solution using P-P-P**  
(Peroxide-Peroxide-Peroxide Construction)

Cable accessory manufacturers solved the problem by utilizing 100% peroxide cured construction which eliminated the potential for sulfur migration.

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**Problem**

**Problems with Molded Rubber Cable Accessories using S-P-S**  
(Sulfur-Peroxide-Sulfur Construction)

Cable accessory manufacturers observed that the combination of sulfur cured shields with peroxide cured insulation resulted in premature failure in moist, hot environments. This combination recreated the combination already observed to be a problem in early cable designs.

**Solution**

**Solution using P-P-P**  
(Peroxide-Peroxide-Peroxide Construction)

Cable accessory manufacturers solved the problem by utilizing 100% peroxide cured construction (P-P-P). Although this involved significant tooling expenses to accommodate the change in molding characteristics, the benefits of long term reliability and performance were important.
The Facts are Clear

Simply stated, the use of sulfur cured materials in cable and cable accessories should be avoided.

- Peroxide cured insulating layers provide superior electrical performance.
- Products that sandwich the peroxide cured insulating layer with the sulfur cured conductive shields are susceptible to premature failure.
- Sulfur cured shields contain conductive contaminants that migrate into the peroxide insulating layer making it conductive and electrically unstable resulting in eventual failure.
- The process is accelerated by common conditions found in actual application – high voltage, temperature, moisture and DC proof testing.

Today’s Technology – System Matched Performance

Utilities have invested in high performance cable systems to improve service reliability. Today’s elbows, splices and other cable accessory components are formulated to provide system matched performance levels.

These products incorporate 100% Peroxide Cured Materials and Construction for superior electrical performance, greater resistance to mechanical abuse, better water sealing, less compression set and improved aging characteristics.

Benefits of 100% Peroxide Construction

- Service life and performance is improved.
- Failures and repairs are reduced.
- Customer outages and lost revenues are reduced.
- Operating costs are reduced.

The cost of locating and repairing a failed elbow or splice can be several hundred dollars. In addition, consider lost revenues and customer outages. It has been shown that products using sulfur cured construction can fail prematurely while comparable peroxide-cured products extend service life. Estimated savings would include the costs of repairs plus replacement products plus lost revenues. Significant savings are apparent even if failure rates are low.

Avoid SPS

Non P-P-P Alternative Proposals

Proposals suggesting that S-P-S sandwich designs are equivalent to P-P-P construction may be encountered. Since this approach does not utilize generally accepted construction, any supporting data should be carefully evaluated. For example, the Dupont study suggests that heating sulfur cured components to 150°C for 14 days eliminates conductive contaminants. This approach is not only impractical but fails to provide the additional benefits of 100% peroxide construction including improved resilience, compression set, elastic memory and water sealing.

Specify PPP

Specification to Assure Maximum Reliability

Utility specifying engineers should add the following information to specifications for molded rubber cable accessories:

- Molded Rubber Cable Accessory Products shall be manufactured using 100% peroxide cured construction for conductive shields and insulating layers.
- 100% peroxide cured construction defines a rubber molding process which utilizes peroxide as a primary curing agent (not sulfur) for conductive shields and insulating layers.
Additional information concerning Peroxide vs. Sulfur Cured Molded Rubber Cable Accessories can be obtained by contacting your Elastimold Sales Representative and requesting the following:

- Publication #EE-340.1
  “The Migration of Sulfur and Sulfur-Containing Accelerators and Coagents into EPDM Electrical Insulation”
  Morton Brown, DuPont Company

- Bulletin #B-0797A
  “What the Utility Engineer should Know About Molded Electrical Connectors – Process, Materials and Reliability”
  Elastimold Engineering