Producers of wire and cable compounds are tackling strict global environmental concerns while being asked to satisfy increasingly demanding performance requirements. **Mark Holmes** reports

Cable industry rises to the environmental challenge

Technological and market innovation both continue to be key development drivers for the wire and cable compound sector, but perhaps an even greater impetus for new product development is environmental regulation. Such concerns have risen up the agenda to become a top priority in almost all geographical markets, according to Juan D Martinez, Global Market Manager Energy at **Buss**, a major supplier of compounding machinery to wire and cable producers.

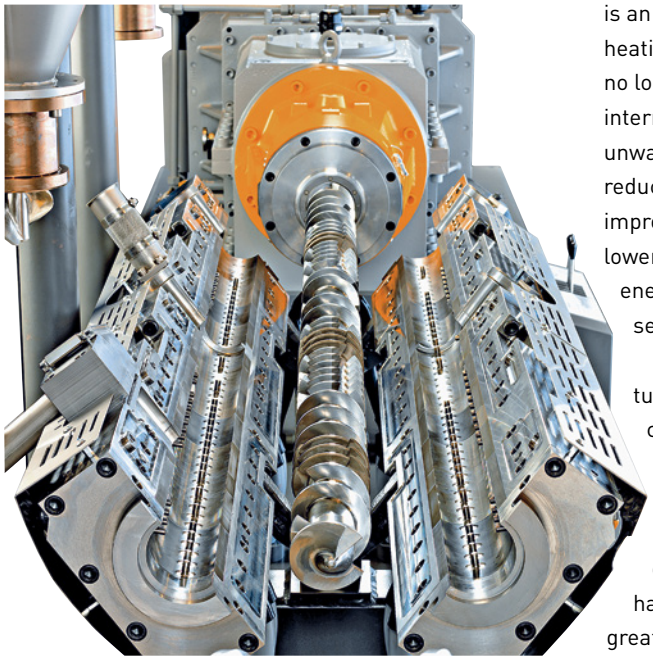
"For many years developed countries have been paying special attention to all issues related to the environmental impact of electrical cables, from the safety of electrical installations to implications for health of the materials used for cable manufacturing," Martinez says. "This view has driven the introduction of many new products, such as halogen-free flame retardant compounds, and encouraged the development of improved processes with lower energy consumption and more efficient use of raw materials. Now these concerns have spread to many other countries, particularly in Asia, and constitute some of the most significant growth areas."

Martinez says that Buss has been responding to these new developments, with one example evident in the introduction of its four-flight technology, which is said to require less energy than previous compounding technology standards. Of course, this focus on environmental aspects supplements, rather than replaces, traditional development drivers such as technical performance, market competition and regulation.

"New applications, for example in renewable energies, electric vehicles and smart grids, demand new or improved properties of the materials used for cable manufacturing. Additionally, the research and development work of all companies involved in the supply chain - suppliers of raw materials and additives, compounders, suppliers of machinery and cable manufacturers - continuously provide more competitive solutions for new and traditional applications," Martinez says.

Martinez adds that new or modified national international regulations can also play an important role in motivating the incorporation of novel developments. "For example, in Europe the new Construction Products Regulations originated with the intention of stimulating and clarifying competition, as well as highlighting the safety of electric installations. However, it will also undoubtedly encourage research and innovation in all aspects of fire performance of cables," he explains.

Main image: Down-hole applications in the oil & gas industries are just one example where high performance ETFE cable products from AGC can make a difference



Right: The process section of an MX105 co-kneader by Buss. The Swiss company is a major supplier to the wire and cable sector

"Finally, market competition provides the necessary stimulus for commercialising input emerging from all the other innovation drivers. This adds a strong incentive for developing new materials that fulfil the regulations starting with material manufacturing through to recycling or disposal, as well as achieving better performance and lower cost compounds," he adds.

According to Edgar von Gellhorn, Head of the Process Department at Buss, these new drivers are resulting in demand from compounders to be able to handle new additives and fillers with specific and demanding requirements, such as nanoclays, carbon nanotubes, and natural fillers with special aspect ratios. One specific example requiring a delicate balance to be struck between different process parameters is the compounding of silane cross-linkable HFFR materials.

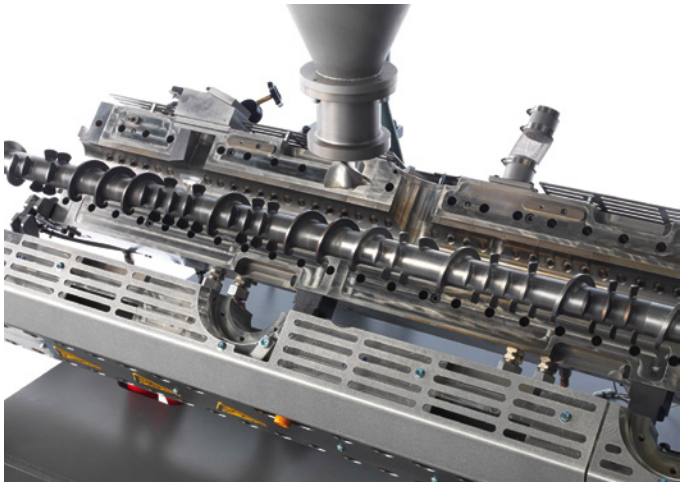
"Buss has developed a 'one-step' process that improves the standard process based on two production steps – grafting of silane to the polymer chain followed by the addition of fire retardant fillers and additives. This can now be achieved through silane grafting in the first section of the kneader, with the incorporation of fillers and additives in the remaining section," he says. "This process requires precise control of several conflicting parameters to avoid negative interactions and to create the right conditions for reactive extrusion without thermal degradation of sensitive components, as well as achieving uniform grafting and good dispersion of all the ingredients."

According to Buss, its streamlined process for production of silane crosslinked HFFR materials provides a number of advantages. Prime among these is an improvement in compound quality because heating the polymer several times is avoided. It is also no longer necessary to store grafted polymer in an intermediate storage phase, avoiding the risk of unwanted reaction in ambient humidity. Buss says reducing the process to one step from two also improves productivity, and offers better logistics and lower maintenance costs as well as providing better energy usage as intermediate cooling, pelletising and secondary melting of the polymer is avoided.

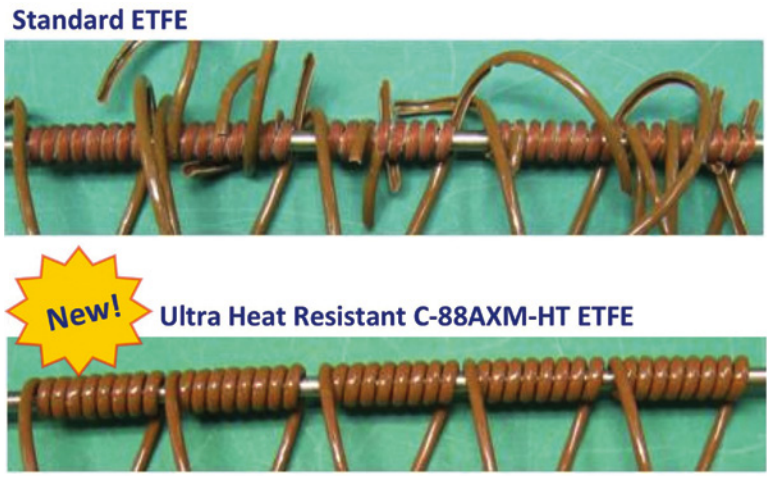
Martinez claims that cable compound manufactures can also benefit from access to more flexible compounding equipment, as this can help open up new business opportunities. "Flexibility in compounding means that cable manufacturers can introduce new products and address developing markets with a controlled risk. Buss has developed its kneader technology to give the greatest flexibility with the minimum possible configuration changes," he says.

Power infrastructure

From a materials perspective, compounding remains robust due to ongoing global demand for wire and cables for new and rehabilitated power infrastructure, as well to meet continued growth in data transmission and wireless communications, according to Robert Tarimo, Associate Marketing Director, **Dow Electrical & Telecommunications**. "On the power side, compounds that go into cable constructions that deliver long, reliable service life for power transmission and distribution networks will continue to see growth," he says. "Connecting renewable energy resources to the grid will also be a growth area. For telecommunications, compounds that help protect wires and cables - particularly for fibre optic applications - will continue to see demand. In addition, compounds that cater to high performance data centre cables will continue to grow."



Right: Flexibility is a key requirement for a modern cable compounding line, claims Buss



Above: Coiling tests show the stress crack improvement offered by AGC's Fluon C-88AXMP-HT

Reliability and long-service life will continue to be among the top demands for power utilities and service providers, Tarimo says. "Compound suppliers, like Dow, are always working on a number of solutions to meet those needs, discover unmet needs and anticipate the needs of the future. Trends in telecom surface in quick succession and compounds are developed with those trends in mind. Manufacturing efficiency for cable makers is essential along with the attributes of the finished wires and cables that must demonstrate signal efficiency, longevity, and ease of installation," he says.

Sustainability and safety continue to be big issues for formulators of new compounding solutions for wire and cable applications. "This is particularly the case for low-voltage and industrial cables that come from the street, through the walls and into homes, businesses, factories, medical and recreational facilities and mass transit terminals," he adds. "Fire performance with low toxicity is essential. Solutions that are tin-, halogen- and PVC-free are also in high demand. In addition, lower signal loss with increased speed of data transfer is an ongoing need for radio frequency (RF) cables that will see continued use and growth in cellular networks."

Among recent developments at Dow are a new line of tin-free, moisture-curable compounds for high-quality low-voltage and industrial cables. The company also offers a range of premium flame-retardant materials for wire and cable applications. And in telecom, its recent developments in cellular insulation compounds have been specifically targeted to meet the needs for improvements in RF cables.

Si-Link AC, a moisture-curable, cross-linkable

insulation system, is an environmentally safe (tin-free) solution enabling production of high-quality LV cables and insulated overhead conductors at high output rates. The fire performance portfolio includes Unigard flame-retardant compounds in a choice of halogenated or non-halogen formulations. Dow says that these compounds demonstrate flame retardance exceeding industry standards, low smoke, good physical properties and ease of cable manufacturing. The non-halogen formulations demonstrate lower smoke, no corrosivity or toxicity and are more environmentally friendly.

Dow Axeleron CX 1258 NT compound (CPD) is claimed to offer improved electrical performance with a lower dissipation factor. In addition, it provides ease of mixing with rheology compatible with high-density polyethylene (HDPE) for manufacturing consistency, as well as physical properties that enable construction of higher-quality cables with lower signal loss.

Future developments

Tarimo also highlights some of the company's future cable sector developments. "Dow has recently passed all European requirements for its new, advanced TR-XLPE medium-voltage cable insulation compound," he says. "We are working toward widespread adoption of this compound for MV cables in Europe. Since 2013, the compound has been made into over 1 billion feet of cable in North America. Field-testing of the previous generation TR-XLPE along with Accelerated Life-Cycle Testing (ACLT) of the advanced compound, suggest that expected service life of cables made with this compound could far exceed 40 years."

Katie Sprick, Product and Development Engineer at **AGC Chemicals Americas**, agrees that wire and cable applications are becoming more demanding and require higher performance materials**.** "These include growth areas such oil and gas downhole cable, automotive/HDD under the hood, aerospace, telecommunications and industrial applications," she says. "These wires and cables have to withstand exposure to increased temperatures and harsh chemicals, as well as abrasion. Other influences include conductivity requirements and shrinkage prevention, as well as the need for lighter weight materials, the ability to create thin-walled constructions, and increased service life. This means cable materials require enhanced mechanical strength, chemical and temperature resistance, flame retardancy, as well as prevention of spark-outs and breakage, and improved processability."

The latest product from AGC pitched to meet these needs is Fluon EFTA C88AXMP-HT, which the company says has the highest MFR and temperature rating available. "The new compound is an ultra-heat-resistant grade that maintains performance characteristics at temperatures up to 200 °C without the need for cross-linking," says Sprick. "It is ideal for industrial and automotive wire and cable insulation, as well as under-floor heating cables, because it provides improved crack and abrasion resistance and enhanced mechanical strength."

The company says the compound is 20% less dense than fluorinated ethylene propylene (FEP), which reduces the amount of product required for applications. In addition, its high melt flow rate provides fast, highly efficient processing line speeds, and one product grade is suitable for all wire size cross sections (0.3-10 mm^2). C88AXMP-HT is also said to offer enhanced mechanical strength, and supported with a full range of compatible colour masterbatches. The grade is tested to German automotive LV112 class F and meets automotive FLUR specifications.

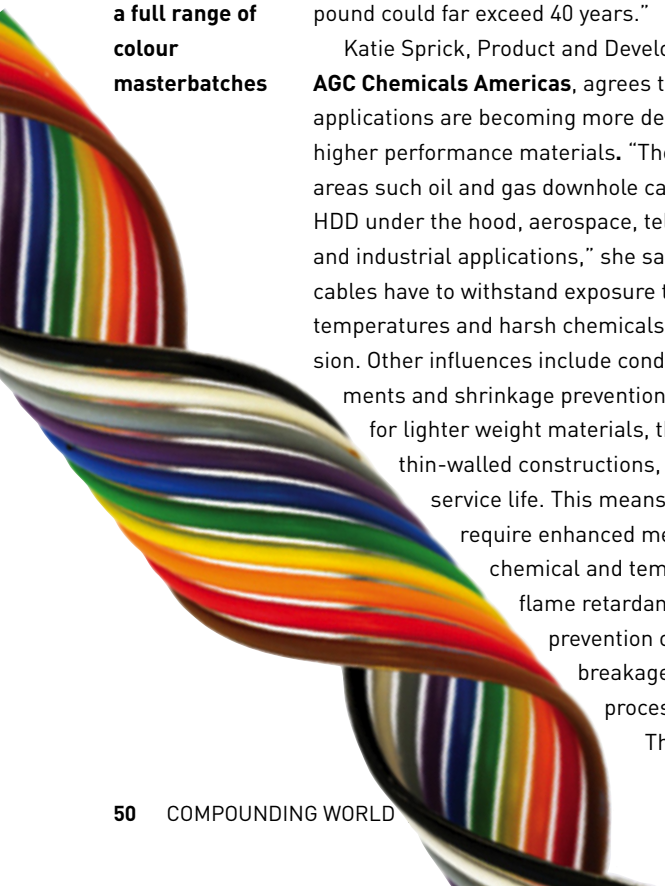
The new material is part of the Fluon fluoropolymer resins and reinforced compound range from AGC. These products are designed to protect and optimise high performance wire and cabling such as wire insulation, cable sheathing, tubing and moulded parts for automotive, industrial, aerospace, transit and appliance applications.

Specific applications for Fluon fluoropolymer resins have also included controlling shrinkage of perfluoroalkoxy (PFA) in cable applications. PFA cable jackets can be difficult to work with when adding connectors because the PFA tends to shrink, while the other layers of the construction do not. AGC says that it customises sets of speciality fillers and pigments to control shrinkage in its PFA-based Fluon compounds for cable constructions.

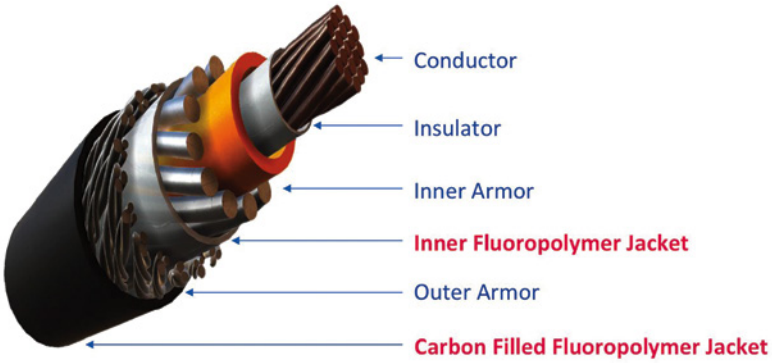
Oil & gas demands

Cables used in oil and gas recovery are a further example of where Fluon compounds are meeting demands for high performance. AGC says Fluon ETFE compounds that contain conductive, strengthening and reinforcing fillers are helping downhole cables better tolerate extreme temperatures, pressures, harsh chemicals and volatile weather conditions. These cable components can withstand depths of 25,000 feet (7,620 m), 15,000 psi, can resist abrasion and bending fatigue, have an ultra-smooth outer surface, and endure torsion, tension and extreme temperature cycling.

According to AGC, Fluon ETFE can be compounded with fillers that dissipate the electrical charges that



Below: AGC's Fluon ETFE C88AXMP HT grade is supported with a full range of colour masterbatches

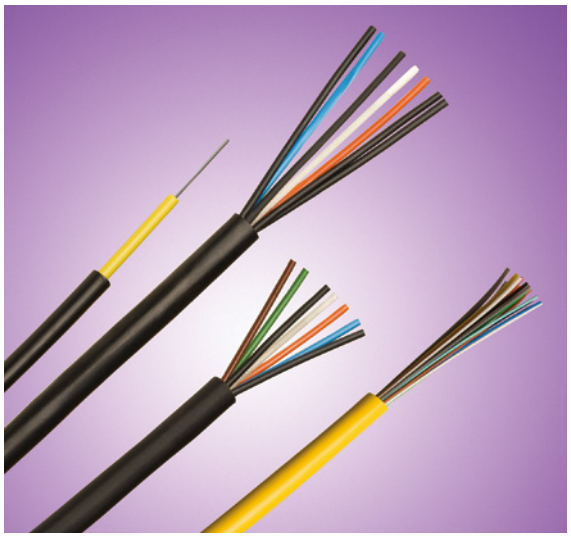


Above: This oil and gas recovery cable construction shows where AGC's fluoropolymers can be used in down-hole applications

accumulate within the cable construction during operation, reducing spark outs and heat build-up and keeping the cable operable. The use of reinforced Fluon ETFE compounds for the inner and outer layers of the cable jacket also protects against stress cracking and breakage from spooling and other motions of the cable. In addition, the compounds are claimed to improve cable manufacturing because they exhibit good adhesion and flow behaviour. Fluon melt processable compounds can be applied efficiently in intricate cable constructions, especially when it is critical to minimise gas migration.

Sprick says that future developments at AGC will include the introduction of Aflas fluoroelastomers as a lighter weight material with better performance over FKM, EPDM, XL-PE, particularly for EV/HEV automotive applications. In addition, AGC is looking at blending elastomers with ETFE to provide more flexibility for intricate constructions while maintaining high mechanical strength and performance.

Recent developments at **Borealis** and **Borouge** – its joint venture with the Abu Dhabi National Oil Company – have included new cable compounds to support sustainable grid development. These include Visico flame retardant (FR) systems for building and photovoltaic cables. Based on the Visico scorch retardant technology, the new low fire hazard (LFH) compounds Visico FR4450 and Visico FR4451 are halogen-free, silane cross-linkable insulation and jacketing systems for building wires and photovoltaic cables, respectively. Used together with the specially designed catalysts LE4439 (natural) and LE4433 (black), Borealis says that these compounds exhibit excellent processability and scorch resistance, combined with good mechanical properties and flexibility.



Right: Teknor Apex developed its Halguard 58625 TPE for fibre optic cable applications

Visico FR4450 is an LFH solution for building and industrial wire, and unlike conventional applications based on brominated flame-retardant additives, is halogen-free. Visico FR4451 is designed to meet demanding requirements for photovoltaic cables. When used in combination with LE4439 in insulation and jacketing, it is claimed to enable easier processing and a longer shelf life than most currently available solutions.

According to Bart Verheule, head of Marketing, Energy at Borealis, there is a growing demand for cross-linkable flame retardant wire and cable compounds for US building wire and solar cable applications. "Visico FR is a new family of compounds based on a combination of Visico cross-linking technology and the Casico flame retardant technology platform," he says. "Visico FR4450 is designed to pass Underwriters Laboratories UL 44 and UL 854 building wire standards and Visico FR 4451 passes solar cable standards TÜV 2PfG1169 and EN50618. These compounds offer good extrusion performance, smooth cable finish, superior wet electrical properties and increased flexibility versus alternative materials. Visico FR therefore offers a cost competitive and a more environmentally sustainable solution against halogenated systems, which are still commonly used in the US."

The introduction of the new Visico FR compounds follows on from the introduction in 2014 of the polyolefin maker's Borlink LS4258DCE extruded cable technology for significantly higher voltage and transmission levels, as well as its Borlink LS4201EHV for demanding EHV

Right: Ultra-Carb flame retardant fillers from LKAB Minerals are widely used in wire and cable applications

power cable applications. "Direct Current (DC) cable technology is commonly preferred over Alternating Current (AC) to deliver large amounts of electricity over longer distances because of its lower losses, making it of particular interest to connect offshore windfarms to land, undergrounding of transmission networks and interconnectors between different countries," says Verheule.

"Borealis introduced the first generation of High Voltage Direct Current (HVDC) cable compounds in 1998 and over the years the transmission voltage has increased from 80kV to 320kV, which is the level currently in service. The latest generation of Borlink cable insulation compounds for HVDC applications have passed type tests at 525kV, which set a new record for extruded HVDC cables. Since the launch, cable system qualifications have been obtained by different cable makers, making it more widely available to fulfil the growing demand for these type of high capacity cables," he says.

To meet increased demand for these high performance cable compounds, a new high pressure LDPE plant and XLPE compounding facility has been constructed at the Borouge 3 expansion project now nearing completion in Abu Dhabi. Starting this year, wire and cable grades – including Borlink medium voltage and Visico low voltage grades - will be produced at the plant, which is part of the world's largest integrated polyolefins complex. Once all plants have been fully ramped up, Borouge will have an annual production capacity of 4.5m tonnes.

Borealis has also announced a €3.5 million investment in its Electrical Testing Laboratory at its Innovation Centre in Stenungsund, Sweden. The company says the investment will enhance existing electrical competence and expertise in project execution, and encourage cooperation with customers and external partners. The investment will increase the capability of electrical testing of cables produced at its own cable extrusion facility, opened in 2009. It will enable Borealis to simulate AC and DC performance of model medium voltage cables and expand development capabilities.

Teknor Apex has introduced a new halogen-free flame retardant (HFFR) compound for fibre optic cable that is claimed to provide good flame retardance while exhibiting significantly lower post-extrusion shrinkage than similar compounds with comparable flame properties. The company says that Halguard 58625 has a UL-94 flammability rating of V-0 and an oxygen index of 50%, while exhibiting post-extrusion linear shrinkage of only 2%. The new product is an addition to the Halguard family of compounds providing an economical alternative to premium grades because of their flame retardant formulation. Applications for Halguard 58625 include cables used in mass transit, data centres, cell towers and other infrastructure projects. For outdoor uses, the new product exhibits good sunlight resistance when tested per UL-1581.

According to the company, low shrinkage is particularly desirable in fibre optic applications because it reduces the degree of stress imposed on the sensitive optical fibres during post-extrusion temperature cycling and during end use. A low-shrinkage grade introduced in 2015, Halguard 58620, exhibits a Shore D hardness of 54 and shrinkage of 1.3%, with a UL-94 flammability rating of V-1 and oxygen index of 40.0%. "Halguard 58625 compound costs less than comparable premium materials while exhibiting little compromise in performance properties," says David Braun, Wire and Cable Industry Manager for the Vinyl Division at Teknor Apex. "It is the newest member of a series of HFFR compounds developed to meet a range of customer needs while providing lower-cost alternatives to other Halguard and competing HFFR products in general-purpose applications."

Meanwhile, **Melos** has developed a new bedding compound - FM 0474/5 - with improved fire behaviour properties. The company says that cone calorimeter tests at 50 kW/m² showed a total heat release of 35.2 MJ/m² and a time to ignition of 378 seconds. Further burning tests showed a limiting oxygen index of 63% and a temperature index of greater than 330°C.

Mineral matters

Wire and cable applications continue to present growth opportunities in the minerals sector, according to Ian Yates, Business Development Manager, UltraCarb for **LKAB Minerals**. This is particularly the case in the area of flame retardant compounds. "This market is defined by the standards that need to be fulfilled in each geographical region," he says. "Whether the focus is more towards the initial reaction to fire, flame spread or smoke generation, one common theme amongst customers is lowering the cost of these compounds. In addition, UltraCarb responds to the need for environ-

mental friendly flame retardant solutions."

LKAB Minerals says natural mineral-based flame retardants are an attractive and viable solution to this challenge and the company has supplied its range of UltraCarb flame retardant fillers based on Huntite and Hydromagnesite to the wire and cable industry for many years. The company adds that it has developed new products and added further capacity in response to this growing demand. Most recently, during the second half of 2015, additional capacity came on stream and new efficiency improvements implemented.

"In volume terms, halogen-free cable compounds represent both the largest sector as well as the greater technical challenge for flame retardant fillers," explains Yates. "Customers demand a high level of product quality and consistency. LKAB Minerals' response has been to introduce new finer products with narrow particle size distributions previously not seen in natural flame retardant products. For example, the UltraCarb LH3 product line was successfully introduced during 2015 and has been extended to include special surface treated grades to improve performance further in both mechanical properties and fire retardance in a cable compound."

Huber Engineered Materials has significantly increased its global presence in flame retardants and smoke suppressants for wire and cable applications. In February, Huber acquired the Martinswerk halogen-free flame retardants and speciality chemical businesses of Albemarle Corporation - the fourth and largest acquisition to the fire retardant additive business over the past five years. In 2015, Huber purchased the Safire nitrogen and phosphorus flame retardant technology from Floridienne Group and Catena Additives. Key Martinswerk brands used in wire and cable applications are Martinal aluminium hydroxides and Magnifin magnesium hydroxide. Safire products are specialised char forming additives which have a broad temperature range and impart good fire retardance and smoke suppression in engineering plastics, electrical and coating applications. Huber says that it intends to integrate the technology within its existing halogen-free portfolio.

In addition to the acquisitions, Huber has introduced several new products to expand its line of fire retardants and smoke suppressants in wire and cable. These include Vertex 100 magnesium hydroxide and Zerogen 100 SP magnesium hydroxide. The company says Vertex 100 has a median particle size of 1.5 microns and a surface area of 14 m^2/g, and is a product well-suited for halogen-free cable jackets. It is also available in surface-treated versions, which offers the compounder flexibility with good physical properties. Zerogen 100 SP is an ultrafine particle size, low surface area, high purity grade designed to provide good dry and wet electrical properties in halogen-free wire and cable compounds. Median particle size is 0.8 microns with a surface area of 5 m^2/g.

Another new Huber fire retardant additive is Hydral 9280 FD precipitated alumina trihydrate. It is a fully deagglomerated powder with a median particle size of 2.0 microns and offers optimised particle size distribution, low soluble soda and low conductivity. The primary applications include copper clad laminates and wire and cable compounds. Huber also offers alumina trihydrate and magnesium hydroxide flame retardant products in a range of particle sizes and surface treatments for wire and cable.

According to the company, a noticeable trend in the wire and cable industry is the increasing use of treated ground calcium carbonates in wire insulation compounds that have historically used non-surface treated calcium carbonates. The company says addition of treated ground calcium carbonate results in a dramatic increase in linear line output and smoother surface finishes, due to the increased lubricity spread over the high surface area of the particles. In addition, physical properties in cold weather are improved and plasticizer levels can be optimised for greater cost savings. Huber offers a variety of Hubercarb calcium carbonates in 2- and 3-micron grades and high purity Optifil calcium carbonate 1-micron grades for wire jacketing and insulation applications.

Below: UltraCarb flame retardant fillers from LKAB Minerals are based on Huntite and Hydromagnesite minerals

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- **www.dow.com/electrical**
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