Exceed™ Enable™

ExxonMobil

Performance polyethylene polymers for optimized halogen-free flame retardant (HFFR) wire & cable compounds

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ExxonMobil's broad portfolio of performance PE polymers can optimize the balance of filler loading, mechanical properties and processability for HFFR wire and cable compounds.

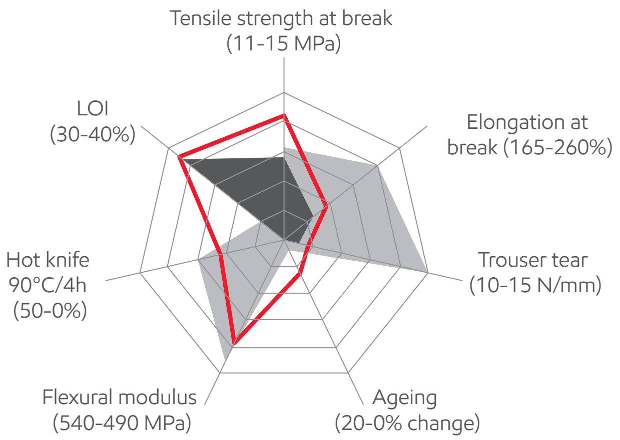
Market trends

Legislation and increasing safety and environmental awareness are significantly driving growth of halogen-free flame retardant (HFFR) compounds for wire & cable applications. As a result, the industry is looking to improve the flame retardancy of HFFR compounds, which often includes increasing flame retardant filler loadings. Aluminum (ATH) and magnesium hydroxide are the most frequently used fillers at concentrations of over 55% to deliver meaningful flame retardancy. However, filler loadings at this level have a detrimental effect on the mechanical and processing properties of these compounds.

Improving mechanical properties

Figure 1 demonstrates the negative impact on mechanical properties when the ATH level in HFFR compounds based on LLDPE (MI 2 g/10 min) is increased from 150 to 180 phr, while the limited oxygen index (LOI) — an indicator of the FR capability — is increased as desired (grey fields). The red line shows the properties of a 180 phr ATH containing compound, in which LLDPE has been replaced by **Exceed™ 3518 performance PE polymer.** Although the levels of a 150 phr ATH compound are not fully reached, Exceed 3518 provides significantly improved mechanical properties, including elongation and flexibility, in the 180 phr ATH compound. These improvements can be utilized to qualify HFFR compounds in applications in which regular LLDPE formulations cannot meet the specification, or to further increase the filler loading and FR properties.

Figure 1: Properties of HFFR compounds



	Reference 1 150 phr FR	Reference 2 180 phr FR	Exceed 3518 180 phr FR
Component	(phr)	(phr)	(phr)
LL1002 Exceed 3518	30 -	20 -	- 20
EVA UL00328	60	70	70
MAgr PE ATH (4 m²/g) Stabilizer	10 150 0.5	10 180 0.5	10 180 0.5

Each diagram axis names the property and its scale; the further away the data point from the center of the diagram, the stronger the property*.

During use, cables can be exposed to elevated temperatures because of internal and/or external heating, while also experiencing stress due to significant bending. As a result, "locked-in" polymer orientation can be released, causing the compound layer to shrink, which can result in cracks (typically initiating from small defect areas e.g. from installation). A thermal stress crack resistance test (similar to ASTM D1693, conducted at 70°C without aqueous solution) can simulate this behavior. Figure 2 demonstrates that Exceed™ performance PE polymers surpass the performance of LLDPE-based HFFR compound formulations to better ensure cable integrity.

Figure 2: Thermal stress crack resistance of 150 phr ATH containing compounds tested at 70°C*

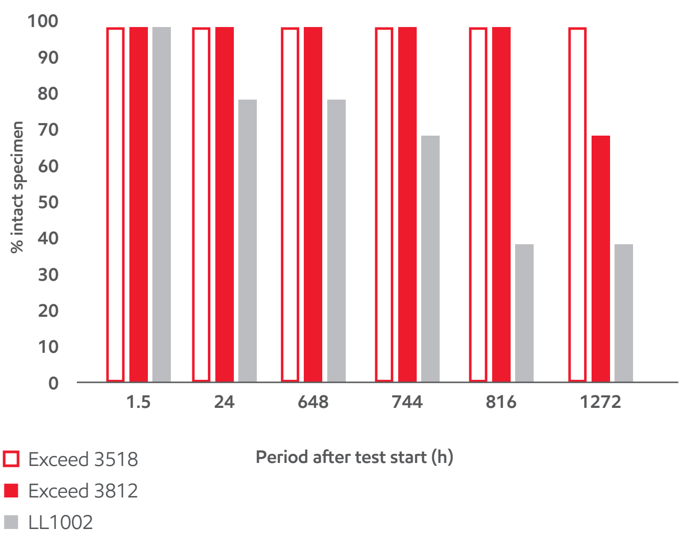
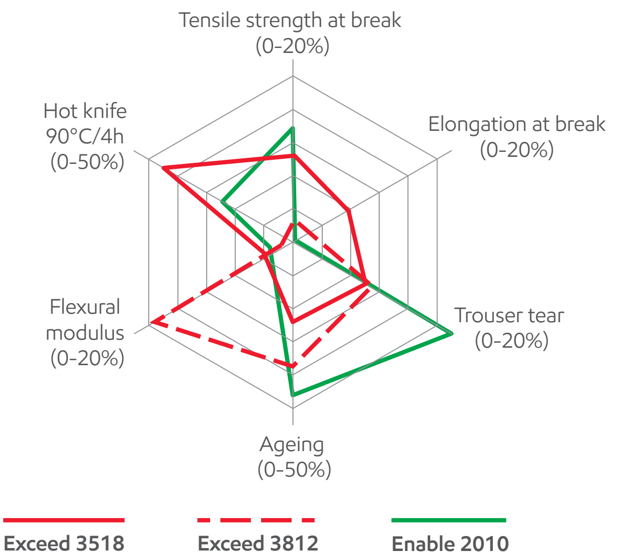


Figure 3 demonstrates different performance PE polymer options and their relative property improvements, compared to HFFR compounds based on LLDPE (MI 2 g/10 min). Formulations with 150 and 180 phr ATH have been tested for various properties and the average improvements have been used in Figure 2. **Exceed 3812** delivers better compound bending flexibility, while **Enable™ 2010** delivers better tensile properties, tear resistance and compound melt strength given its lower MI (1 g/10 min).

Figure 3: Performance polymer portfolio to strengthen HFFR compound mechanical properties



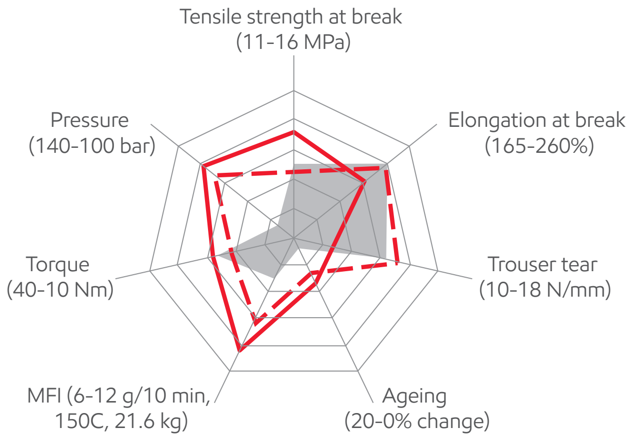
Potential relative improvements compared to LLDPE based formulations (tested on 150 and 180 phr ATH compounds) are shown*.

Enhancing extrudablity

High filler loadings make HFFR compounds quite viscous which can result in extrudability issues. Limitations on the maximum pressure and torque allowance can require compound modifications to ease extrudability. While various process aids are often used, they may negatively affect mechanical performance and flame retardation, or lead to other issues like die drool. To decrease the compound viscosity, the first modification frequently chosen is to change the polymer(s). Typically, base polymers are replaced with a higher MI polymer, or a higher MI polymer is added as a blend partner.

Figure 4 provides an example for either employing a 7 g/10 min MI EVA copolymer together with Exceed 3518, or to additionally blend a low amount of a 19 g/10 min MI grade (Exceed 0019). Compared to a standard LLDPE formulation without any compound viscosity modification, these alternatives demonstrate how pressure and torque (as tested on a laboratory extrusion line) can be decreased. When good elongation properties are key for the cable application, the use of **Exceed 0019** provides the best balance between the compound mechanical and processing properties.

Figure 4: Facilitating compound processability with appropriate polymer blend partners*



	LL1002	Exceed 3518 with 7 MI EVA	Exceed 3518 with 19 MI Exceed
Component	(phr)	(phr)	(phr)
LL1002	30	-	-
Exceed 3518	-	30	20
Exceed 0019	-	-	10
EVA UL00328	60	-	60
EVA UL00728	-	60	-
MAgr PE	10	10	10
ATH (4 m^2/g)	150	150	150
Stabilizer	0.5	0.5	0.5

With ExxonMobil's broad portfolio of performance PE polymers, HFFR compounders have the opportunity to optimize the balance between filler loading, mechanical properties, and processability.

ExxonMobil polymers portfolio for wire & cable

Key grades	MI (g/10 min)	Density (g/ccm)	VA%
Exceed 3518	3.5	0.918	-
Exceed 3812	3.8	0.912	-
Exceed 0019	19	0.918	-
Exceed 0015	15	0.918	-
Enable 2010	1.0	0.920	-
Escorene Ultra UL 00114	0.85		14
Escorene Ultra UL 00119	0.65		19
Escorene Ultra UL 00328	3.0		27
Escorene Ultra UL 00728	7		27.5
Exxelor PE 1040	1	0.960	
Exxelor VA 1202	17 (230°C, 5kg)	0.900	

Escorene™ Ultra resins are EVA copolymers; Exxelor™ polymer resins are maleic anhydride functionalized polymers.

Test item	Test method
Tensile strength	ExxonMobil test method (TS-03-05) based on IEC 60811-501
Elongation	ExxonMobil test method (TS-03-05) based on IEC 60811-501
Trouser tear resistance	ExxonMobil test method based on ISO 34-1(A), ISO 6133(E)
Flexural E-modulus (0.05-0.25%)	ExxonMobil test method (Z.1445.03) based on ASTM D790 A II
Thermal pressure resistance	ExxonMobil test method (MEZ 110) based on IEC 60811-508
Thermal stress crack resistance	ExxonMobil test method (set-up of MEZ 068) based on ASTM D1693
Limited oxygen index	ExxonMobil test method (MEZ 122) based on ASTM D2863 A
MFI	ExxonMobil test method (MEZ 0362-2) based on ISO 1133

*Data from tests performed by or on behalf of ExxonMobil.

Creating differentiated solutions. Together.

To find out more about our performance polymers portfolio, visit:
exxonmobilchemical.com/pe

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