



Flame-retardant polyamides are critical for safety and performance

Starflam® excels in demanding applications

Introduction

Our world is more connected today than ever before. We're watching innovative products begin to link many parts of our home, work and play with the technology that powers the planet. A smart device is a safe one, and the rapid electrification of these devices demands smaller, lighter and thinner components that perform reliably while meeting rigid safety standards.

For engineers and designers, selecting the right material is often the first critical decision. Electrical properties and flame-retardant (FR) performance are primary considerations when it comes to sensors, circuit breakers, terminal blocks and a multitude of other parts. Fortunately, modern polymer technology has yielded a wide range of complex, specialized and functional engineered plastics that are light weight, custom colorable, easily processed into complex shapes and durable at high temperatures and in the harshest environments.

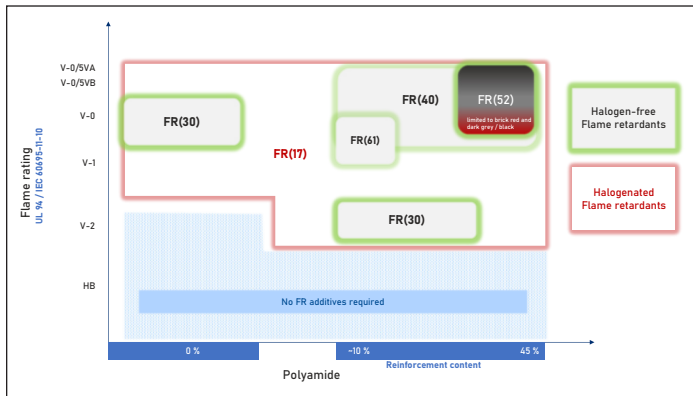
With decades of experience producing specialty polyamides, Ascend Performance Materials is a trusted advisor to manufacturers worldwide. With best-in-class electrical insulation and flame retardancy, our materials create products that move electricity safely and reliably. When it comes to safety and performance, we realize how much material decisions matter.

Starflam product portfolio

As a leading global polyamide supplier, we offer a full-range FR portfolio to meet or exceed the strictest international safety standards. These FR products are used in commercial applications by most major OEMs in the consumer, industrial, electrical and automotive markets and are registered under the Starflam trademark.

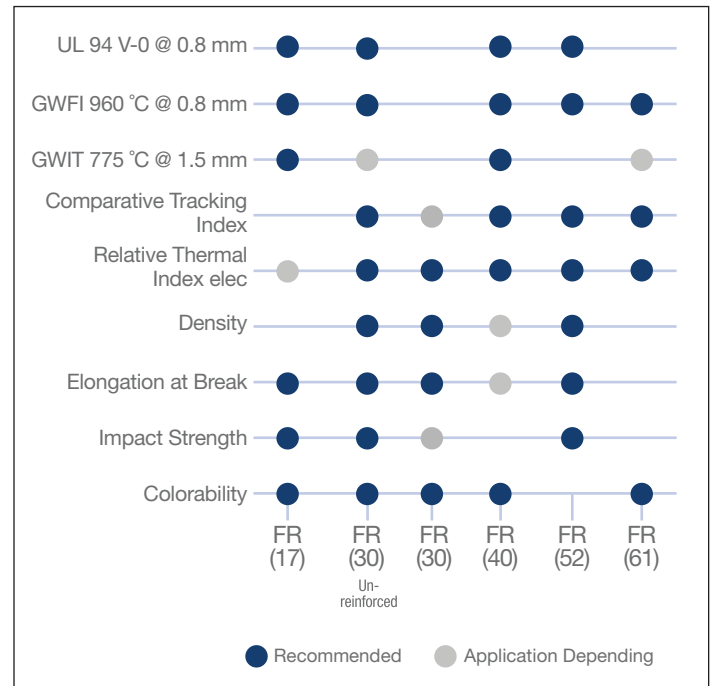
Starflam products have been formulated with all major technologies by taking advantage of the strengths of special chemistries (see Graph 1). (Please reference ISO 1043-4 for the full list of ID codes of all FR chemistries. FR (40), for example, identifies halogen-free phosphorous compounds FR chemistry).

Graph 1. FR chemistries formulated in Ascend's portfolio.

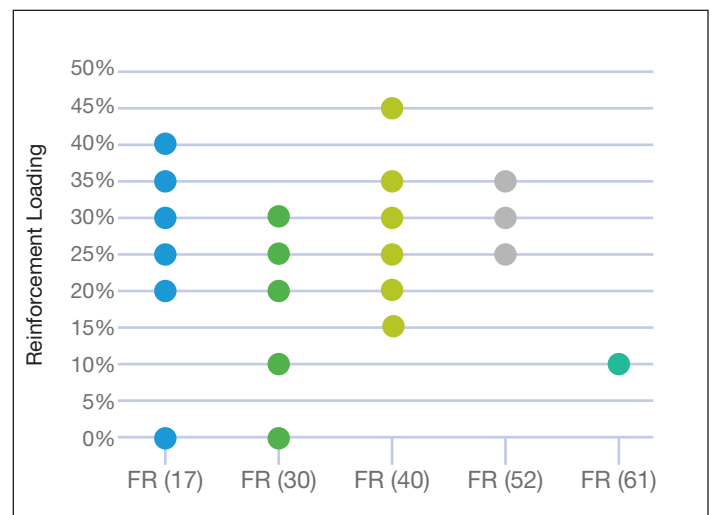


Each of the major FR categories achieve flame retardancy through a unique mechanism. The ability to select an optimum FR chemistry to achieve the best UL 94 flame rating balanced with electrical and physical properties is where Starflam excels. The Ascend portfolio offers customers design freedom and flexibility and, in addition to FR chemistry, incorporates the critical technologies of heat stabilization, reinforcement and processing aids. These performance additives are formulated together with the FR package to meet the unique application requirements. Graph 2 provides a comparison of important properties of the same 25% glass fiber reinforced products with various FR and heat stabilization. The latest FR (40) chemistry, as shown, offers the best overall balance of properties.

Graph 2. Comparison of typical important properties of different FR and heat stabilization of reinforced products.



Graph 3. Reinforcement combination with various FR chemistries.



This graph shows all the combinations of FR chemistries, filler and reinforcement technologies in our Starflam portfolio. These include glass fibers, glass beads and/or various minerals. These fillers give the final products better strength, higher modulus and/or better creep resistance.

Flame-retardant related test and standards

Many standards have been established and adopted to improve global communication in various industries. These documents are published by the International Organization for Standardization (ISO), UL and International Electrotechnical Commission (IEC), among others. The major certification institutes are UL, VDE and TÜV.

In terms of test method and ranking of flammability of plastics, the most common standard is UL 94. This standard has six flame classifications (listed below) for plastics compounds based on the results of a direct flame test. UL 94 also has VTM classification for very thin materials and HBF classifications for additional horizontal burns.

- UL 94-5VA Surface Burn; burning stops within 60 seconds, test specimens **MAY NOT** have a burn-through (no hole). This is the highest (most flame-retardant) UL94 rating.
- UL 94-5VB Surface Burn; burning stop within 60 seconds, test specimens **MAY HAVE** a burn-through (A hole may be present)
- UL 94 V-0 Vertical Burn; burning stops within 10 seconds, **NO** flaming drips are allowed
- UL 94 V-1 Vertical Burn; burning stops within 30 seconds, **NO** flaming drips are allowed
- UL 94 V-2 Vertical Burn; burning stops within 30 seconds, flaming drips **ARE** allowed.
- UL 94 HB Horizontal Burn; slow horizontal burn test (H-B) is considered “self-extinguishing.” The lowest (least flame-retardant) UL94 rating.

UL 94 ratings define the testing and classification of flammability of materials. There are also numerous standards and guidelines for finished parts and structures such as UL 790 “Standard Test Methods for Fire Tests of Roof Coverings” and UL 723 “Test for Surface Burning Characteristics of Building Materials.” These standards must be considered in combination with UL 94 to determine the suitability of plastic material use in specific applications. Please visit the website of Underwriters Laboratories for more details on test methods and standards.

General purpose unreinforced Starflam products

Unreinforced FR materials are widely used in connectors, terminal blocks, clips, cable ties, etc. In addition to FR properties, these materials typically have good electrical insulation properties, ductility and have a stable base color for custom colors.

Table 1. Key properties of several Starflam grades.

	Test Method	Units	AFR200Y	315J	366
Density	ISO 1183	g/cm ³	1.17	1.16	1.17
Flame Rating @ 0.4 mm	UL 94		V-0	V-0	V-0
Tensile Strength	ISO 527-2	MPa	78	75	83
Tensile Elongation @ Break	ISO 527-2	%	9	22	5
Notched Izod	ISO 180/1A	kJ/m ²	4	5	6
RTI elec @ 0.4 mm	UL 746B	°C	130 @ 0.8 mm	130	120
CTI	IEC 60112	V	600	600	600

Specialty unreinforced Starflam products

Many electrical applications require specific performance criteria. Connectors used for residential unattended appliances must pass the IEC 60335-1 750 °C glow wire on molded parts with no flame (≤ 2 seconds) test. The FR350J is the industrial standard product for this application. In certain high installation density situations, the connectors and/or terminal blocks need to withstand relatively high operation temperatures. The class-leading 150 °C RTI of 366H fits well into this type of application.

Table 2. Key properties of these two grades.

	Test Method	Units	FR350J	366H
Density	ISO 1183	g/cm ³	1.32	1.17
Flame Rating @ 0.2 mm	UL 94		V-0	V-0
Tensile Strength	ISO 527-2	MPa	75	86
Tensile Elongation @ Break	ISO 527-2	%	22	7
Notched Izod	ISO 180/1A	kJ/m ²	3.8	3
RTI elec @ 0.4 mm	UL 746B	°C	130	150
GWIT @ 1.5 mm	IEC 60695-2-13	°C	960	800
CTI	IEC 60112	V		600
CTI	UL 746A		PLC 2	PLC 0

Reinforced Starflam products

Reinforced FR materials are often used in housings and isolation components for electrical switches, contactors, circuit breakers, junction boxes, etc. Other than FR, these applications also need good electrical insulation properties and high physical strength. The trend of miniaturization means that materials need to offer UL 94 V-0 at 0.4 mm or thinner and CTI of 600V.

Table 3. Several representative grades and their key properties.

	Test Method	Units	AFR450X2	RF0057E	RF0068E	RF0077E
Reinforcement		%	25	25	30	35
Density	ISO 1183	g/cm ³	1.38	1.37	1.43	1.49
Flame Rating	UL 94		V-0 @ 1.6 mm	V-0 @ 0.4 mm	V-0 @ 0.4 mm	V-0 @ 0.8 mm
Tensile Strength	ISO 527-2	MPa	139	126	133	160
Tensile Elongation @ Break	ISO 527-2	%	2.6	2.3	2.2	2.3
Notched Izod	ISO 180/1A	kJ/m ²	9.7	8.1	7.8	9.4
RTI elec @ 0.8 mm	UL 746B	°C	110	140	140	140
CTI	IEC 60112	V	600	600	600	600

X-Protect technology

A special offering in the Starflam portfolio is the X-Protect line. These FR materials can be molded using the same molding equipment under similar process conditions as any other polyamide materials. In tests, X-Protect parts offer extra performance not matched by standard polyamide. The parts have a slower moisture absorption rate, better wear resistance and can maintain part integrity beyond the melting temperature of polyamide. In extreme cases, X-Protect can remain a flame barrier for 15 minutes at 1100 °C. These materials have been used for re-flow solderable connectors and other housings for industrial power management components.

Table 4. Key properties of several UL listed X-Protect grades. (Data shown are as molded.)

	Test Method	Units	RX12414	RF0023K	RF0067K
Reinforcement		%	0	10	30
Density	ISO 1183	g/cm ³	1.2	1.74	1.45
Flame Rating	UL 94		V-0 @ 3.0 mm	V-0 @ 1.6 mm	V-0 @ 0.8 mm
Tensile Strength	ISO 527-2	MPa	50	90	110
Tensile Elongation @ Break	ISO 527-2	%	11	1.5	1.8
Notched Izod	ISO 180/1A	kJ/m ²		3	7
RTI elec @ 0.8 mm	UL 746B	°C	130		140
CTI	UL 746A		PLC 0		
CTI	IEC 60112	V		600	575

New developments

Continued drive for miniaturization requires materials to withstand higher operating temperature and harsh chemical environments. Ascend is a leader in developing new products for these requirements. On the compound side, 377J is a non-halogen PA 66 product targeting high RTI and high elongation for applications including terminal blocks, connectors and cable glands. A glass reinforced non-halogen pair of materials, 525K and 525H, offer the UL 94 all-color at 0.2 mm, clean processing and an overall well-balanced performance. These products are being specified in e-mobility and industrial power management applications.

Table 5. Some of the key properties (some data are generated by Ascend’s lab, to be certified).

	Test Method	Units	377J	515K	525K	535K
Reinforcement		%	0	15	25	35
Density	ISO 1183	g/cm ³	1.17	1.32	1.4	1.5
Flame Rating	UL 94		V-0 @ 0.4 mm	V-0 @ 0.2 mm	V-0 @ 0.2 mm	V-0 @ 0.2 mm
Tensile Strength	ISO 527-2	MPa	85	101	132	146
Tensile Elongation @ Break	ISO 527-2	%	11	3.3	3.1	2.5
Notched Izod	ISO 180/1A	kJ/m ²	3	8	9.6	10
RTI elec @ 0.4 mm	UL 746B	°C	130	140	140	140
CTI	IEC 60112	V	600	600	600	600

As a fully vertically integrated company, Ascend is very active in bringing new polymers into the market. Our HiDura™ long chain polyamides, such as PA 610 and PA 612, offer exceptional chemical resistance and flexibility. The PPA polymers and blends will provide better properties and retention of properties at an even higher temperature.

Other advantages and summary

UL flame rating, physical and electrical properties are typically the first set of data an engineer will consider when selecting a material. The Starflam portfolio offers a broad range of choices with these properties but also includes products with many additional desirable attributes:

- Fast and easy processing
- Low off gas and low plate out for extended production time
- Low corrosion to the injection molding machine and tool
- Low contact corrosion of current carrying metal parts
- Outdoor applications with UL 746C f1 certification
- Consistent and heat stable custom colors
- Laser marking, both for 1064 nm and 355 nm laser
- RoHS and REACH compliance grades
- EN 45545-2 R22 & R23 HL3 and NF F 16-101, -102 certified grades

In summary, Ascend's Starflam FR portfolio has been widely specified in electrical, electronic, automotive, industrial and consumer appliance applications globally. These products provide mechanical, physical, electrical and flame-retardant performance that meet the most demanding conditions.

As a full-service engineered material solutions provider, Ascend is committed to being an industry leader in product performance and technical support. We offer global manufacturing and distribution, a vertically integrated material and supply chain, CAE services, analytical labs and field technical services designed to bring value to our customers. From the beginning of material selection and part design through molding of finished parts, we are ready to help you drive innovation, advance technology and ensure safety across every product you design.

Product finder

The Ascend materials database makes it easy to find exactly the right material for your specific application. All products are searchable by polymer, feature, industry or brand: <https://products.ascendmaterials.com/>



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