



TAKE THE HEAT

Starflam[®] FR polyamides enable safer,
higher-voltage EV power systems

July 2023



Fire safety



High levels of electric power

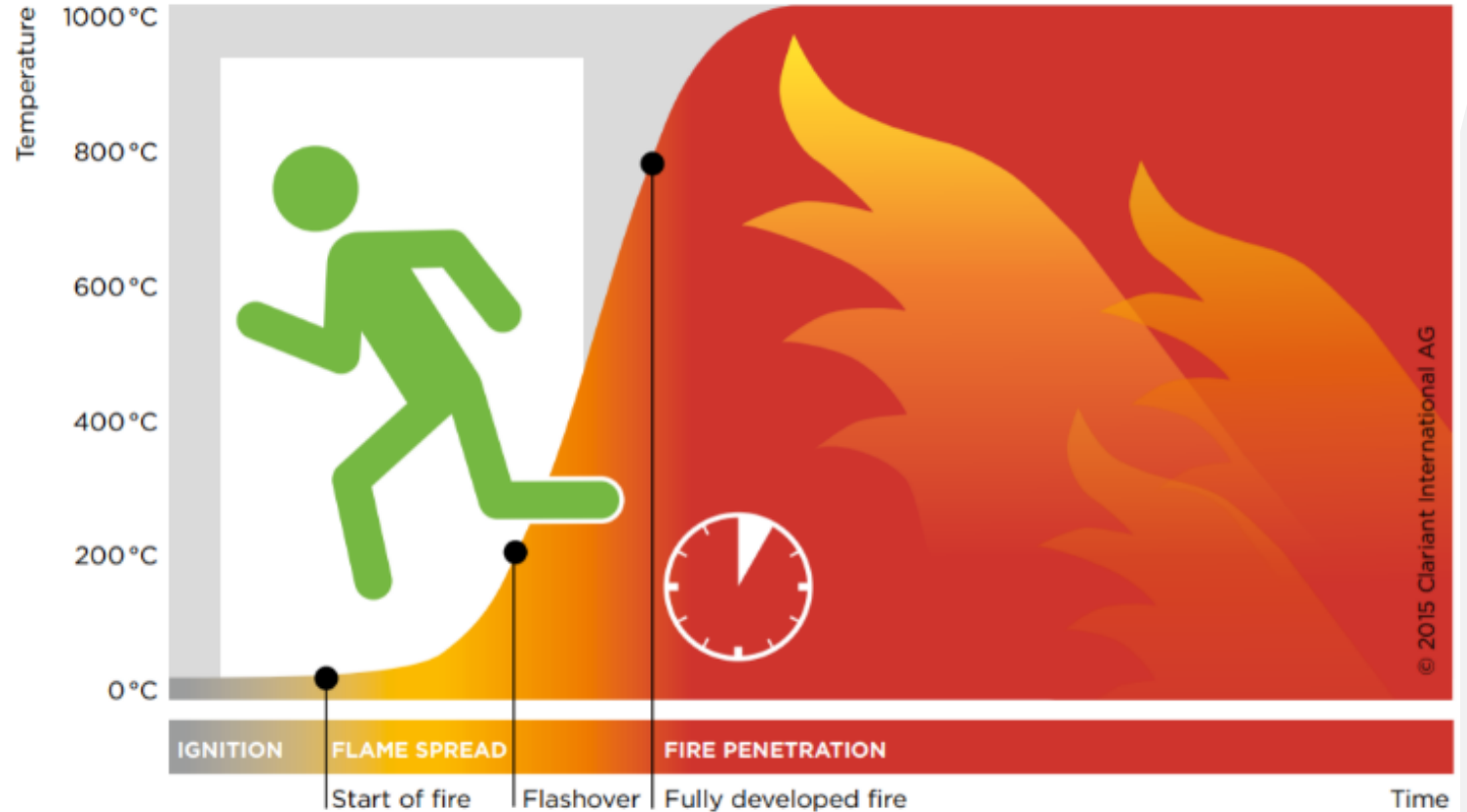


Presence of “fuel,” oxygen, heat



Thermal runaway

* Standard GBT38031, 2020.



Escape time → **5 min** FRs delay ignition, increase escape time

Safe electrical systems using Starflam

Challenges and needs

High Voltage Insulation



- Voltage Breakdown
- Insulation Resistance
- Temperature
- Voltage exceeding CTI

Corrosion



- Voltage
- Temperature
- Humidity
- Chemistry

Flame Retardant Orange



- Higher Current & Voltage
- RAL Orange
- FR V0
- Color Retention
- Processability

Thermal Runaway Resistance



- Extreme Temperatures
- Pressure Spikes
- Occupant Escape Time
- Safety

Starflam 500 Series portfolio

Non-Halogenated product with two heat stabilizer options



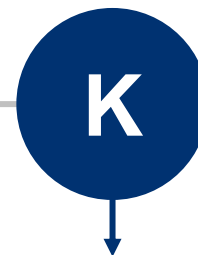
Number defines the product type:

- *5XX Series: Glass Filled, PA66*



Numbers indicate the filler level (%)

- 15%
- 25%
- 35%

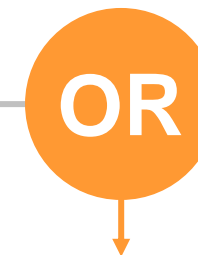


Stabilization technology

- *No letter – no stabilizer*
- *H – Heat stabilized (bound Copper)**
- *K – Heat stabilized (electrically neutral)*

*Bound Copper

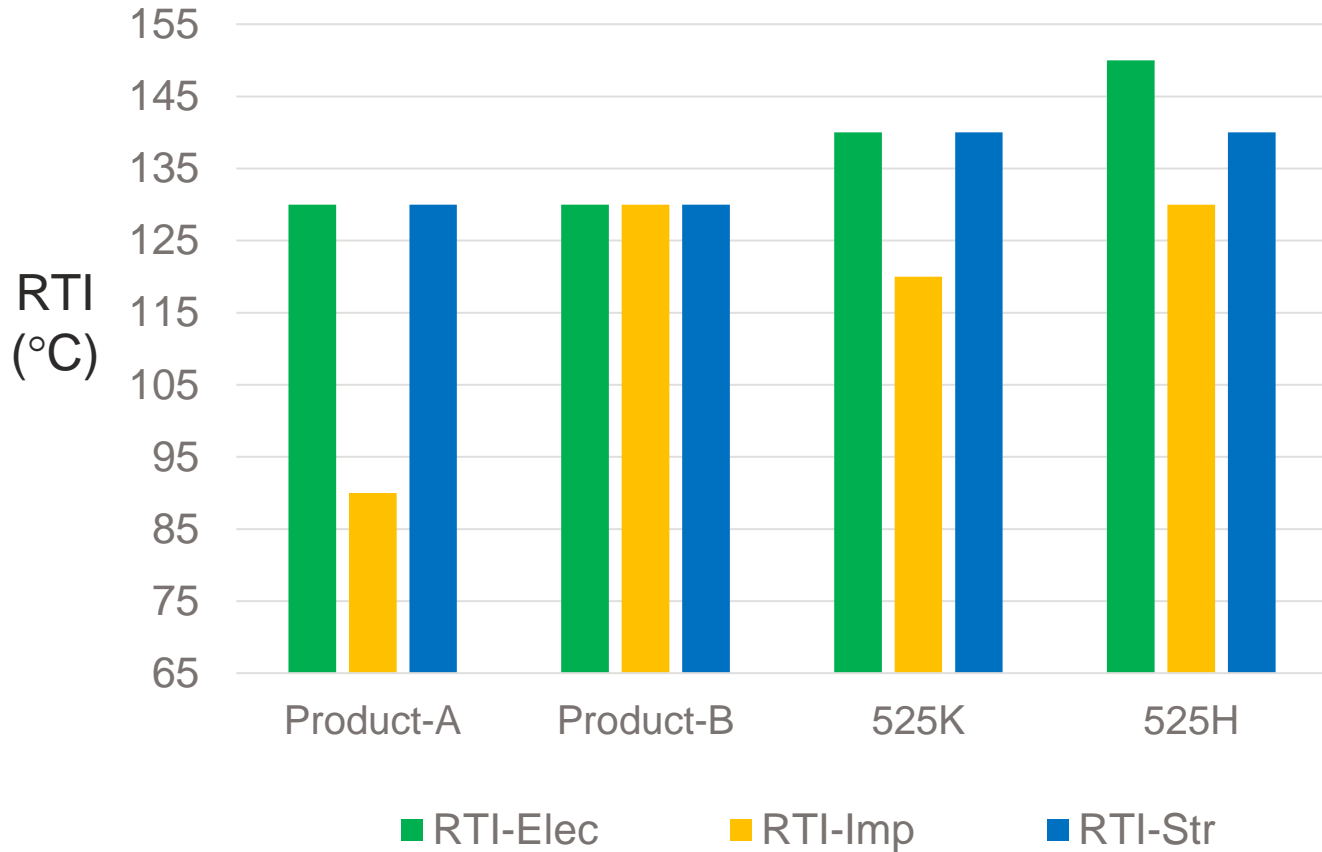
- *Complexed to P*
- *Not water soluble*
- *Melt blendable*



Color

- *NT – Natural*
- *BK - Black*
- *OR – Orange*

Starflam 525K & 525H thermal aging



Best in Class

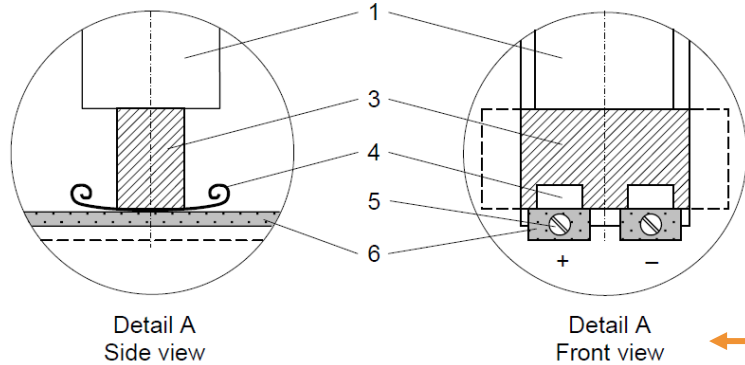
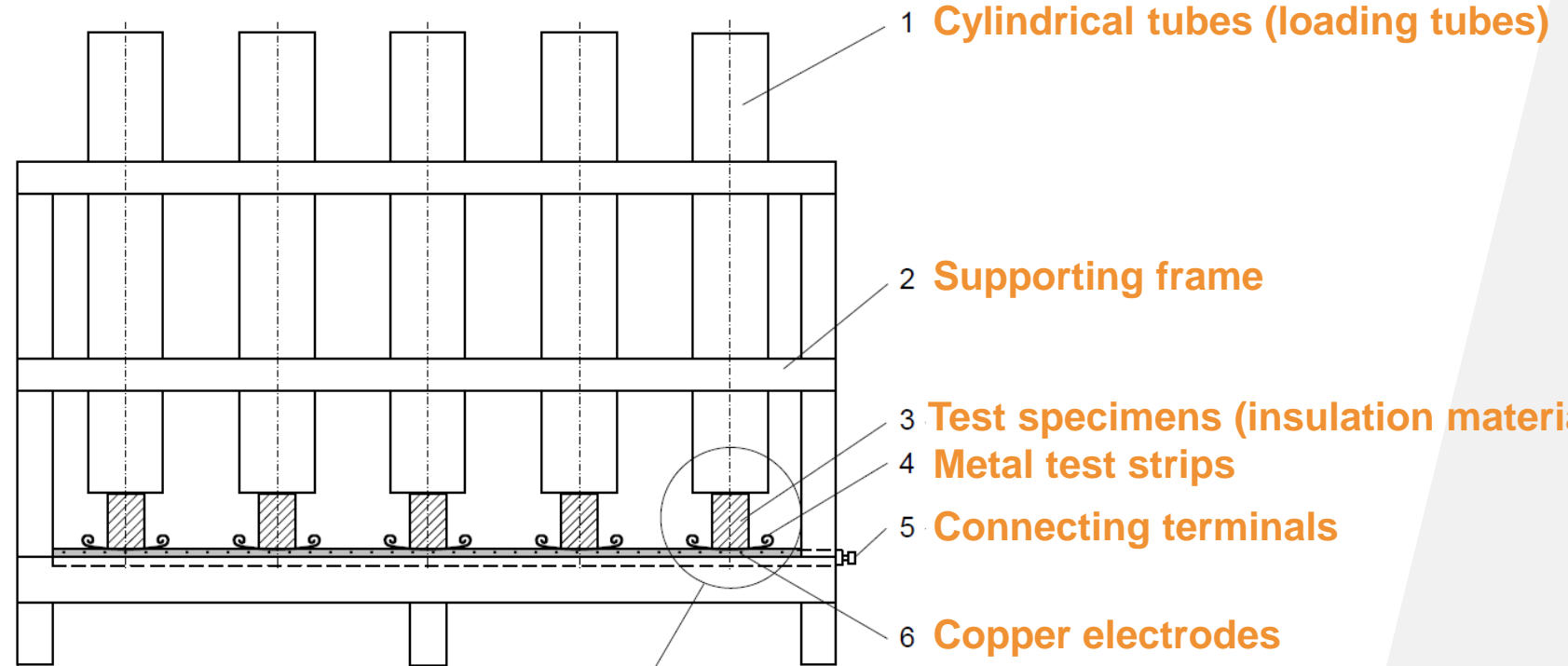
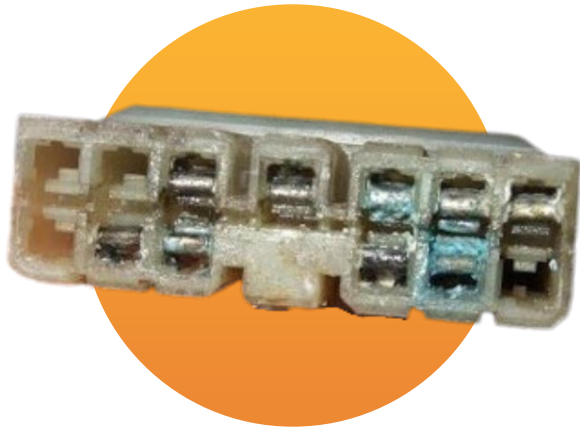
- RTI-Elec: 150°C
- RTI-Impact: 130°C
- RTI-Strength: 140°C

Relative Temperature Index (RTI)




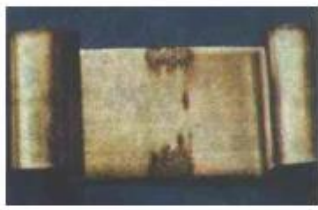
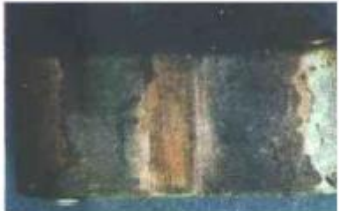



- Maximum temperature where a property will not be unacceptably compromised
- Relative to reference material having a confirmed, corresponding RTI

IEC 60426 corrosion test set-up

240 hours @ 120-960V, 55°C and 93% relative humidity



IEC 60426 corrosion classification criteria

Negative pole strip			Positive pole strip			Tensile strength corrosion liability factor K %	General evaluation
Description of visual appearance	Illustration	Visual corrosion index	Description of visual appearance	Illustration	Visual corrosion index		
No change or appearance of slight ground colour on the contact surface with specimen		K 1	No change or appearance of slight ground colour on the contact surface with specimen		A 1	$K \leq 3$	Not corrosive
Dark-brown or black spots cover up to 50 % of contact surface; on the remaining no change or slight discolouration		K 2	Brown tarnish or single rose-coloured etching spots cover to 50 % of contact surface		A 2	$3 < K < 15$	Slightly corrosive
Black spots cover the whole or a prevailing part of the contact surface, as well on the other side of the strip		K 3	50 % to 100 % of contact surface covered by brown (brick-red) deposit or rosy etching spots; possible appearance of green spots		A 3	$15 < K \leq 30$	Corrosive
Intense black spots spread wide over the contact surface and on the other side of the strip; the black or brown spots may not appear on the contact surface		K 4	Total contact surface covered by thick brown deposit or deep etched (rose-coloured) or great amount of green corrosion products; possibility of cross-etching of the strip		A 4	$K > 30$	Strongly corrosive

A2, K2
3 < K < 15

Starflam 525K vs. H selection

IEC 60426 metal contact corrosion test

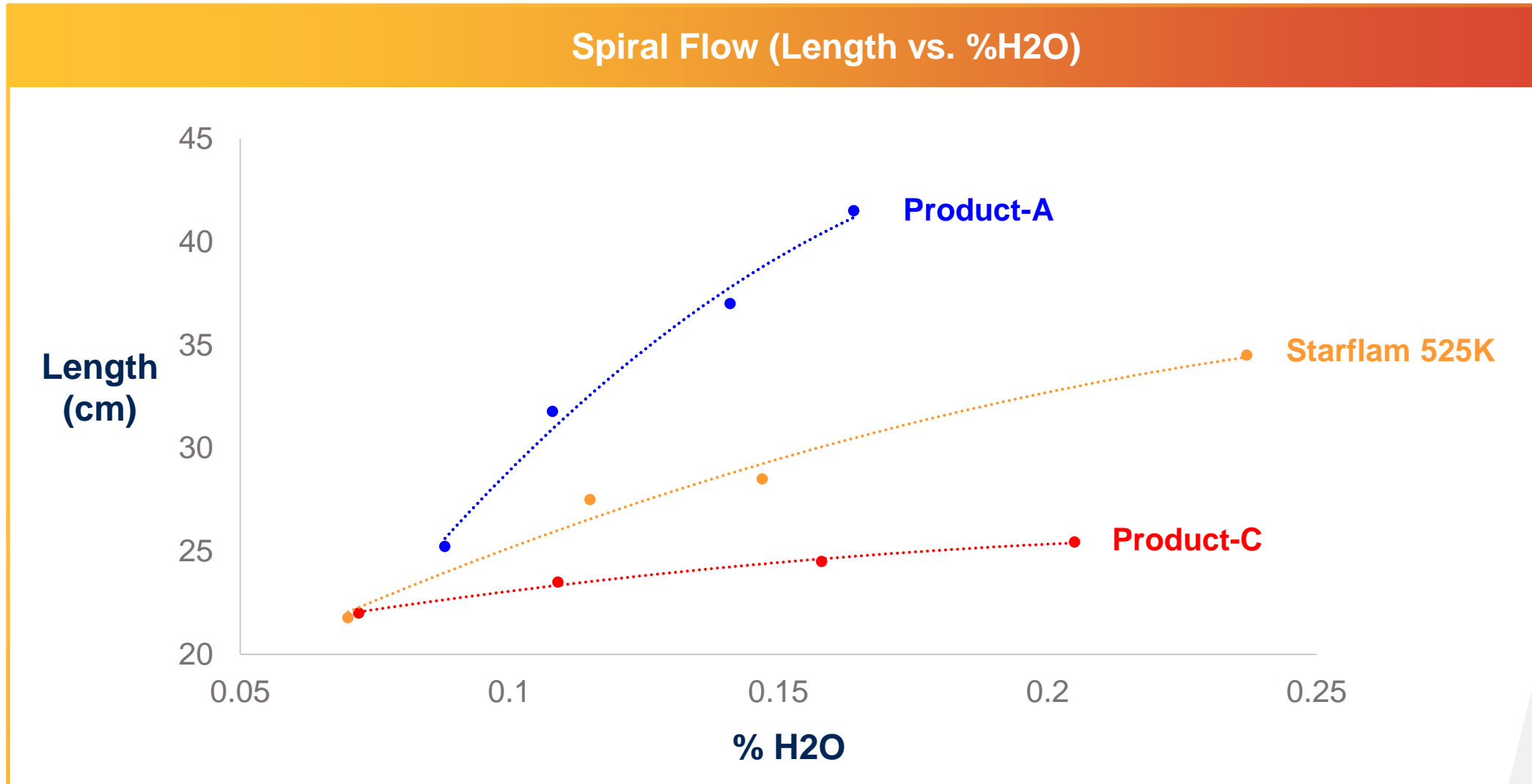
Voltage	525K (A2, K2)	525H (A2, K2)
120* – 240^ V	K = 8%	K = 7%
480^ – 960^ V	K = 1-6%	K = 8-13%

*UL testing; ^Ascend testing



Key Attributes	525K	525H
Contact Corrosion Applications		
120 – 240 V	✓	✓
240 – 480 V	✓	✓ (potentially)
480 – 960 V	✓ (for EV, HV)	
EU Rail EN45545		
		✓

Starflam 525 grades: stable, high flow



Starflam 525K: low plate-out

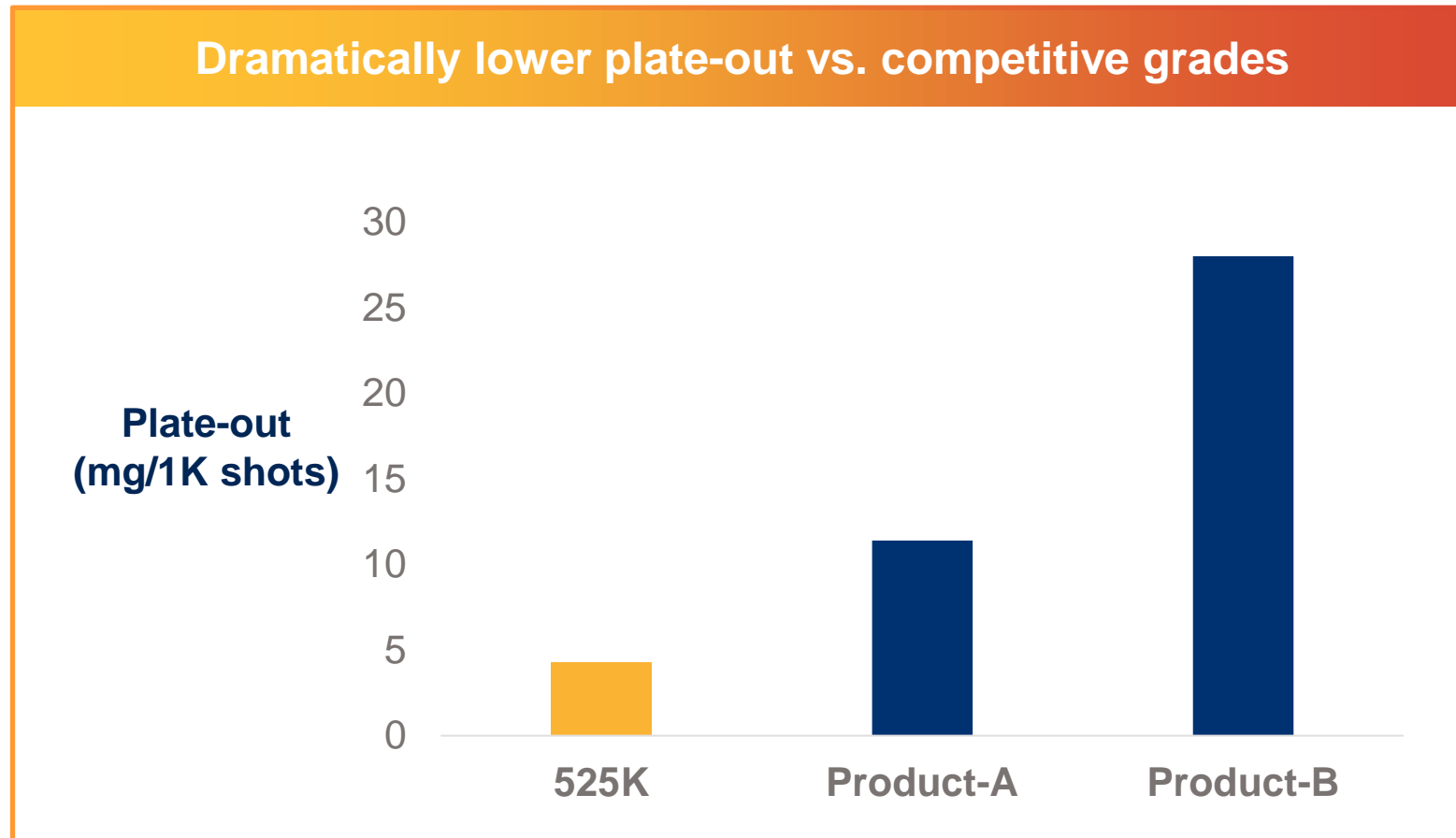
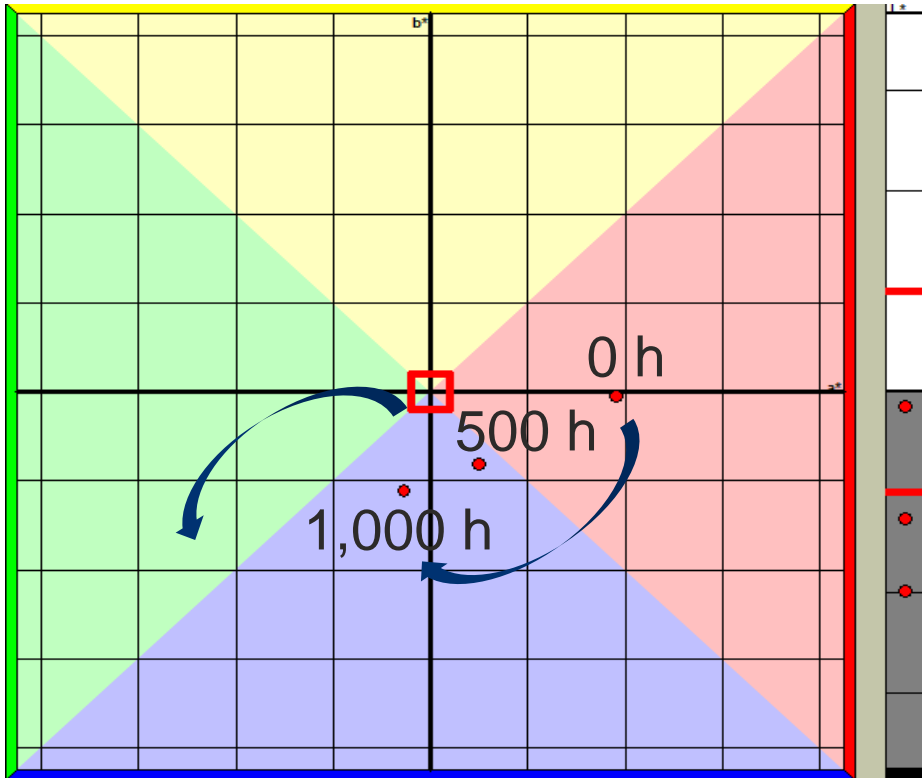


Plate-out measured by weighing and analyzing the residue that accumulates in the vents after 1,000 shots

Starflam 525K Orange

Anticipating color shift to stay close to RAL 2003

Making on target vs. Anticipating color shift over time



DAM 500 h 1k h



Laser Markable



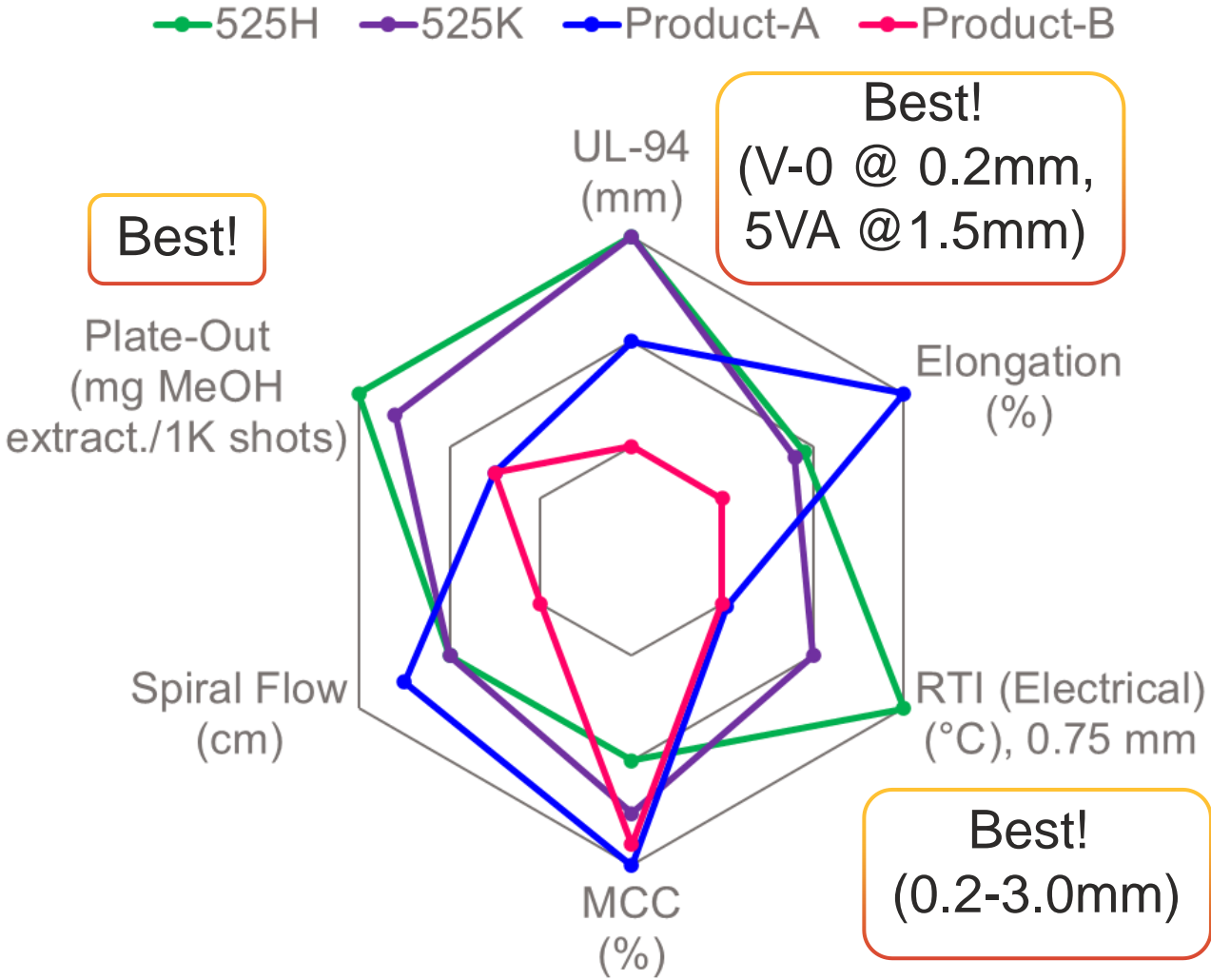
Starflam 515K, 525K, 535K

Property (DAM)	Method	Unit	Starflam 515K	Starflam 525K	Starflam 535K
Base Material	-	-	PA66-GF15	PA66-GF25	PA66-GF35
Density	ISO 1183	g/cm ³	1.3	1.4	1.5
Tensile Strength	ISO 527-2	MPa	102	132	146
Tensile Elongation	ISO 527-2	%	3.4	3.1	2.5
Tensile Modulus	ISO 527-2	MPa	6,700	8,700	12,100
Notched Charpy Impact Strength	ISO 180	kJ/m ²	7	10	11
Flammability	UL 94	-	V-0 @ 0.2 mm 5VA @ 1.5 mm		
Comparative Tracking Index (CTI)	IEC 60112	V	> 600		

- E-mobility and connectors
- HV circuit breakers
- Industrial power management devices (25%, 35% GF)
- Relays, HV switches and sensors
- EV MSD, PBD i.e., battery disconnect (35% GF)
- Industrial connectors (15% GF, H grade)
- European rail EN45545 (H grade)



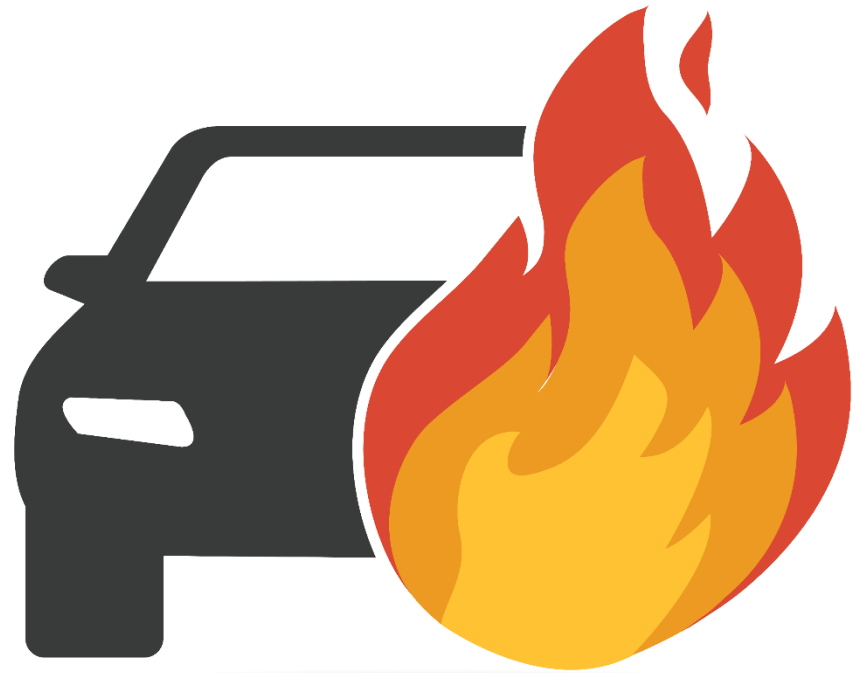
Summary of performance characteristics



Product Performance

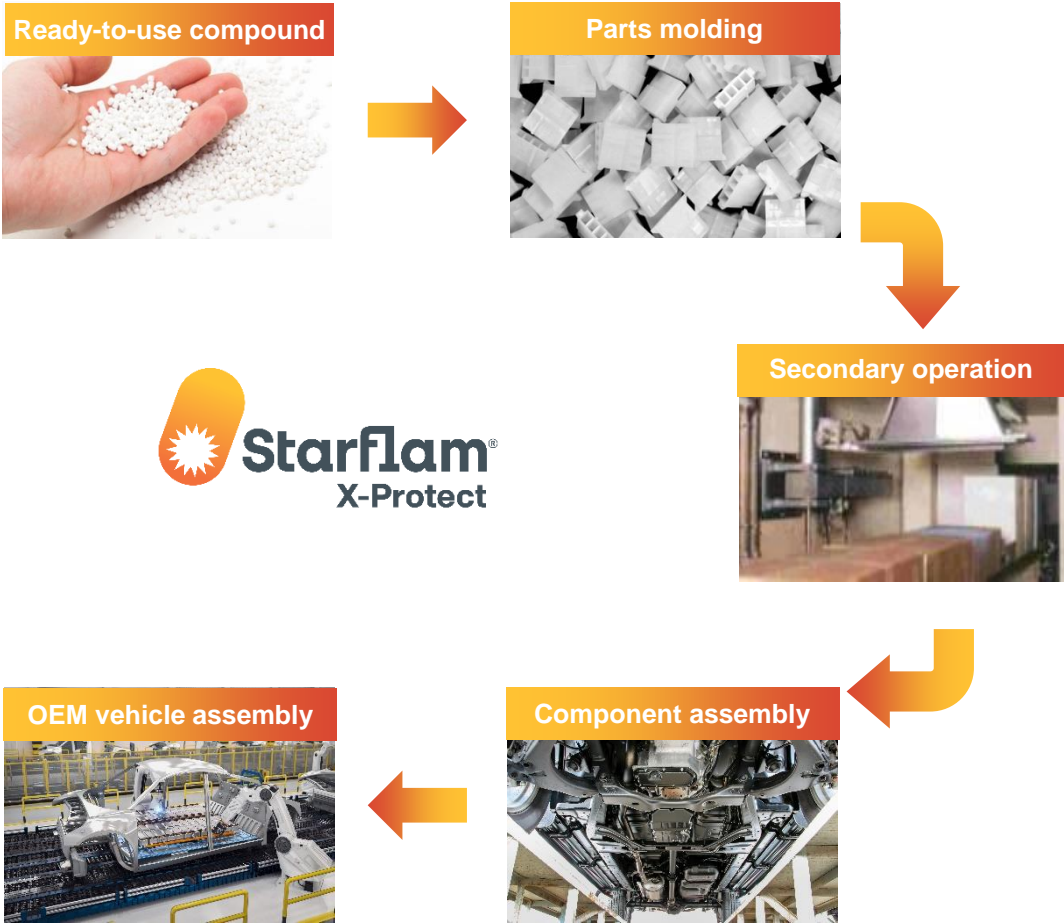
- Thin part ratings for flammability & RTIs for design flexibility
- Efficient molding (plate-out & flow)
- Improved ductility, especially 15% GF
- Low metal contact corrosion
- Recyclable (50% regrind)

Thermal runaway – a major challenge with Li-ion technology

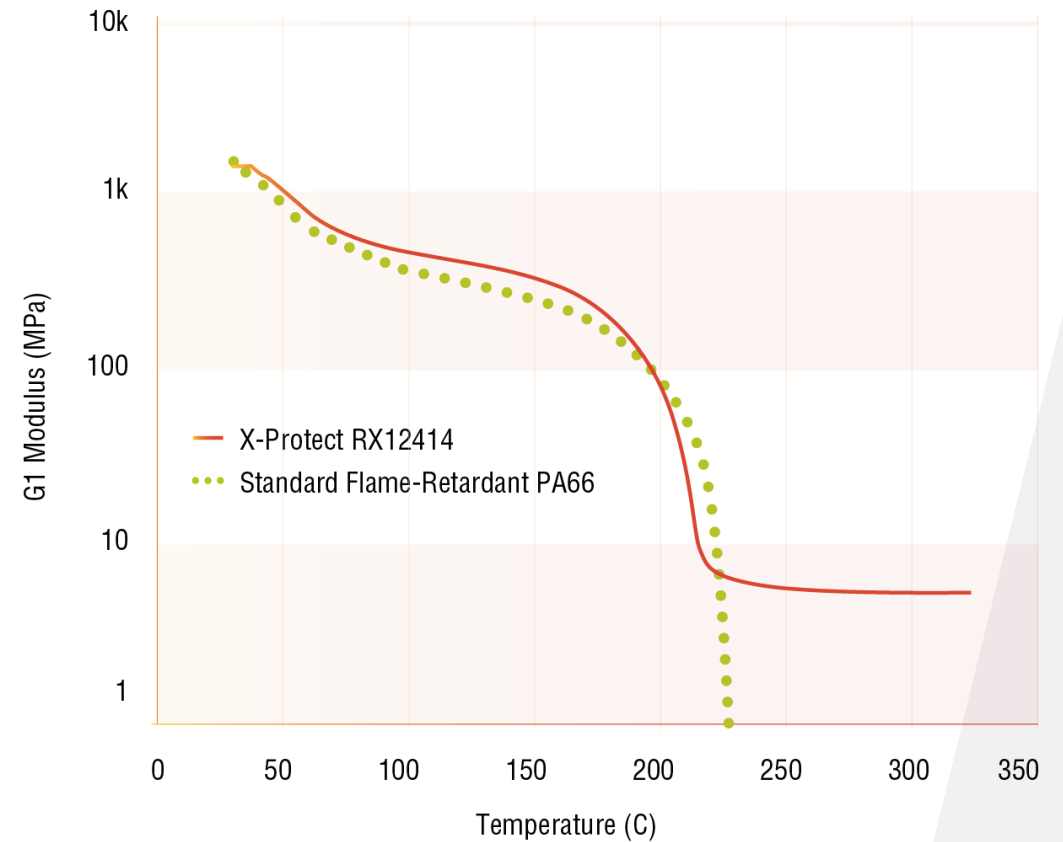


- Sophisticated BMS monitoring battery health status allows for early reactions and warnings
- Advanced disconnect units allow safe continued operation
- Pack design now has thermal management, barriers and vents to manage regular operation and runaway events
- Various performance tests established
- Material solutions providing integrated protection

Starflam X-Protect technology



Starflam X-Protect eliminates the melting point of PA66



Powerplant fire penetration test – rated fireproof

3 MINUTES



Standard Flame-Retardant PA66
(3mm) Breached in less than **3 minutes**

4 MINUTES

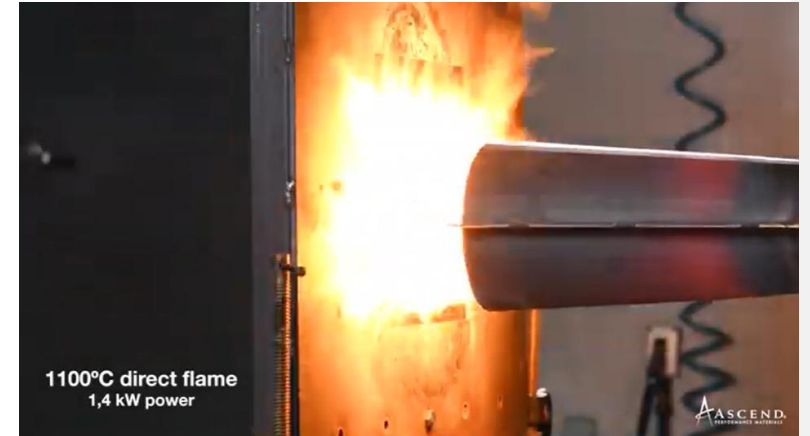


6061 T651 Aluminum (3mm)
Breached in less than **4 minutes**

15 MINUTES



X-Protect RF0067K PA66 (3mm)
Sustains direct flame for **15 minutes**

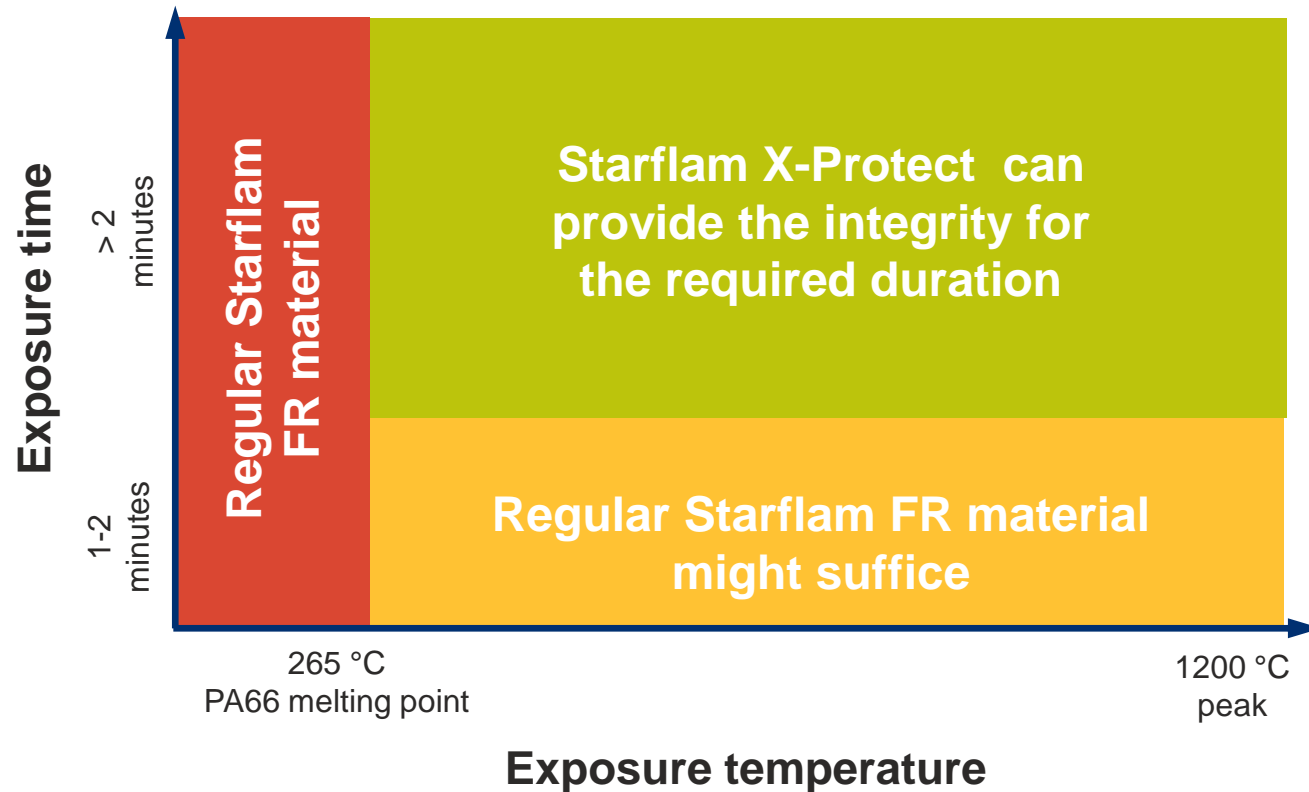


[Starflam X-Protect fire penetration test](https://youtu.be/Rv04TXBWAFa)

<https://youtu.be/Rv04TXBWAFa>

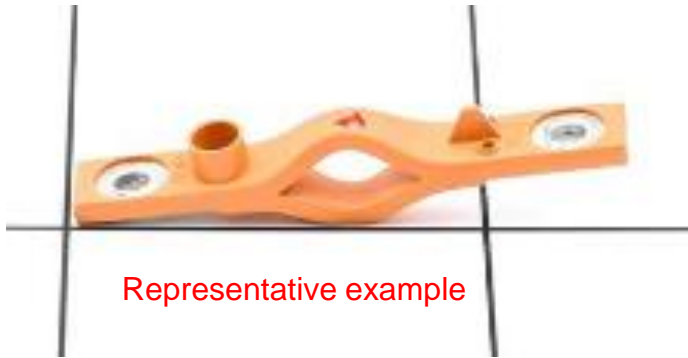
Suitable for applications prone to thermal runaway exposure, i.e., battery components

What to ask when selecting an FR



1. **Melting point:** Does the part need to perform above the polymer's melting point?
2. **Time:** How long does the part need to perform above the melting point?
3. **Cost:** What is the cost of using separate components over a one-shot solution?

Insulation functions



Representative example

Image courtesy of Caresoft

Overmolded busbars
e.g., for module to module connection

Ask: maintain electrical insulation
throughout a thermal event.



2 mins
300 °C

Status Quo

Insulation layer
burns and
melts away



25 mins
800 °C

Starflam X-Protect

Insulation layer stays
in place and passes
test for leakage
current and resistivity

Barrier functions

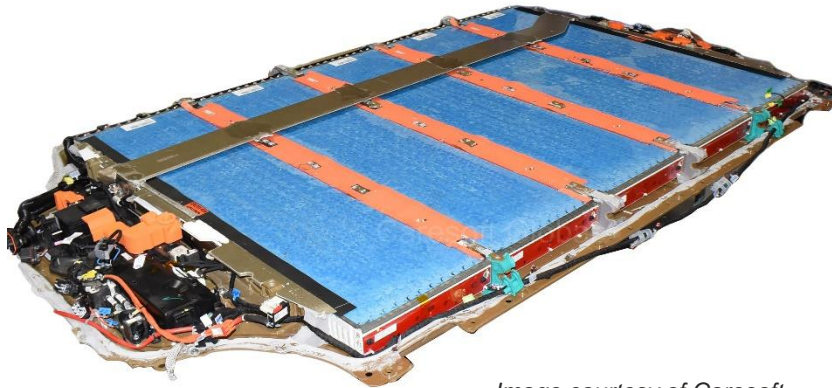
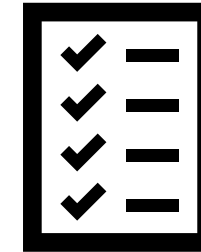


Image courtesy of Caresoft

Barrier components like battery module enclosures or module bay separators

Ask: prevent a thermal propagation from one module to the next for as long as possible.



Tests at component level successful.

Suitable for applications prone to thermal runaway exposure, i.e., battery components

Performance testing

Various test are available today for Starflam X-Protect

Testing mechanical properties at thermal runaway conditions



AZL Aachen GmbH
Excellence in Lightweight Production

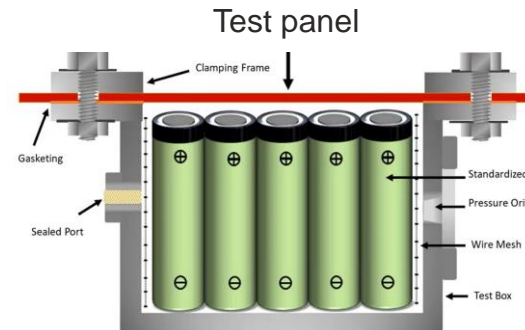
Testing continued fire exposure

Performed fireproof per SAE AS 5127/2




AEROBLAZE

Testing enclosure load case



Test according to UL2596 pending

 **Solutions**

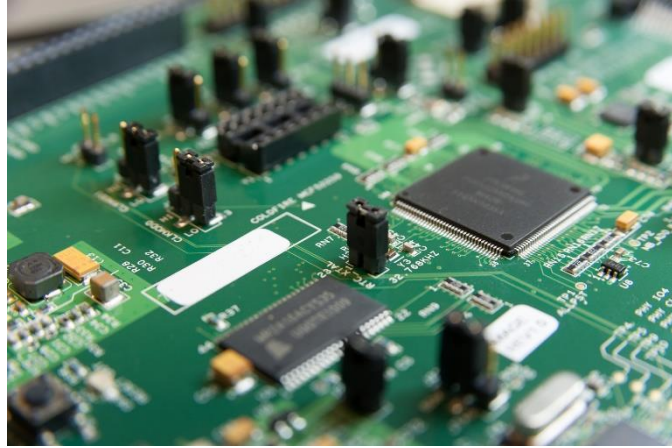
Testing particle blast resistance



Torch and particle blast test

- 30 s flame dwell
- 20 s grit blast
- SF X-Protect RF0067K passed 2 cycles

Reflow solder capable connectors with flexible parts



X-Protect RX12414 withstands up to 270°C reflow solder process without blistering while retaining the excellent flexibility for design with hingers or clips



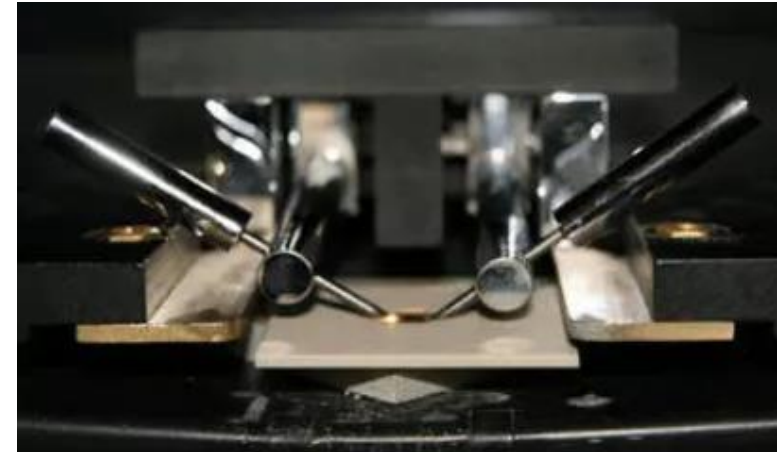
JEDEC J-STD-020 MSL 1 results coming soon
Moisture/Reflow
Sensitivity Classification for Nonhermetic Surface
Mount Devices

PPA level of reflow capability with standard PA66 processing and flexibility

Thermoset replacement



X-Protect RF0067K retains the physical shape at above PA66 melting temperature would enable device to be certified by UL 489



ASTM D-495 high voltage, low current arc resistance testing in progress

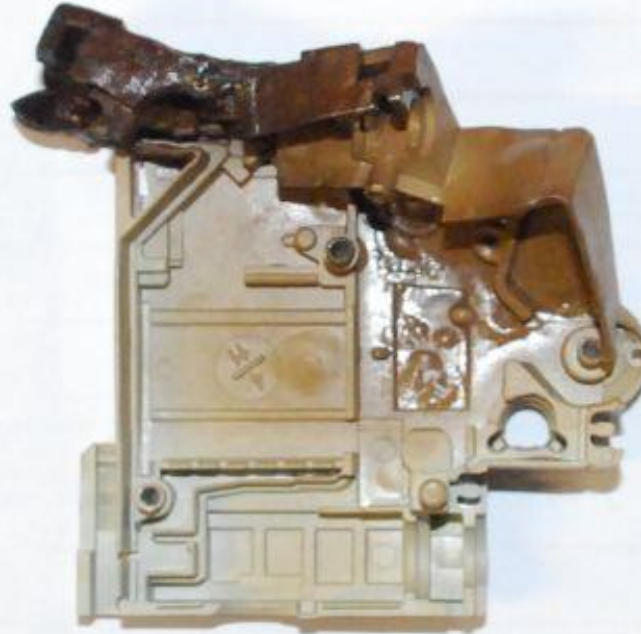
Reduce the weight and improve the sustainability over thermoset

Retains structure when exposed to 550°C

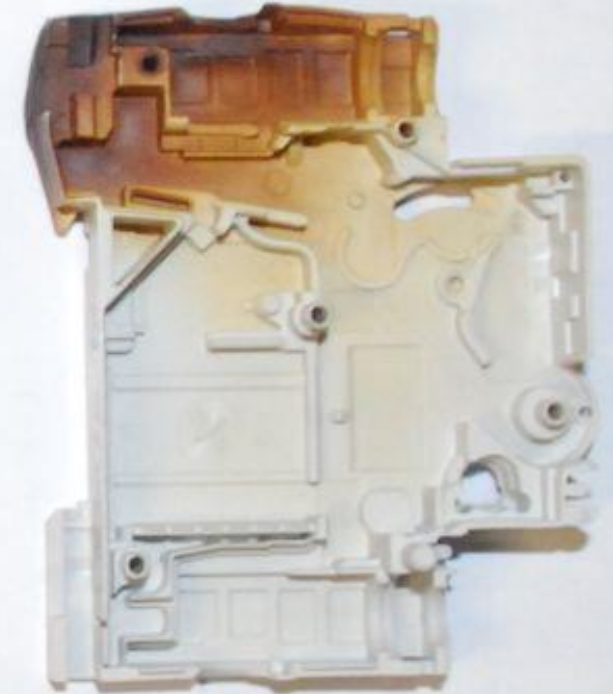
Standard FR PA66 25GF



PPA 30GF



Starflam X-Protect 30GF





Higher voltages create **new technical challenges** for safety and performance



Starflam 525 and X-Protect help you **design for safety without sacrificing performance**



And our industry and materials experts are here to help you **get to market faster** with the best solution



North America

Houston, TX, USA

+1 713 315 5700

Europe

Mont-St-Guibert, Belgium

+32 10 60 8600

Asia

Shanghai, China

+86 21 2315 0888

CONFIDENTIAL – NOT FOR DISTRIBUTION

© 2023 Ascend Performance Materials Operations. The Ascend Performance Materials, Vydyne, HiDura, Redefyne, Acteev, Acteev Protect, Acteev Biodefend, Endur by Ascend, FlexaTrac, FlexaTram, FlexaTril, Hexatran and Trinohex marks and logos are trademarks or registered trademarks of Ascend Performance Materials Operations.

Although the information and recommendations set forth herein (hereinafter "Information") are presented in good faith and believed to be correct as of the date hereof, Ascend Performance Materials Operations LLC makes no representations or warranties as to the completeness or accuracy thereof. The full disclaimer of warranty and liability can be found at ascendmaterials.com/disclaimer.