Sustainability: the RadiciGroup approach.

Automotive and consumer goods: materials & applications

Susanna Caprotti - *EPD Process Manager*

Michael Dreisbach - *Marketing & Technical Service*

Webinar: Innovative polymers solutions in a fast evolving market - Part two

Who we are

Vision

› To be **one of the leading chemical groups in the polyamide**, synthetic fibres and high performance polymers production chain.

Mission

› To promote the **development of our businesses** while pursuing our Group **values and culture**.

› To pursue our vision by **valorising and optimizing our resources**, establishing strategic alliances and searching for new markets, including niche markets.

› To embed **sustainability into new product and application development**.

Sustainability as a matter of fact… since 75 years

All oldest RadiciGroup companies:

- Were founded by the Radici family who still runs RadiciGroup.
- Operate in environmentally protected areas.
- Are located near densely populated villages/towns.
- Run their business in mountain/tourist areas.
- 80% of employees live within 20 km from the plants.

What we know:

Greenwashing is stronger than ever but **people** are increasingly **aware of it**

Incredible, huge **opportunities** are related to **sustainability** as for products and systems

New **issues and challenges** require new **skills**, mastery of appropriate **methodologies and market knowledge**

Regulations, **standards** certifications and **labeling** are showing the path

Choices to make

- For a “chemical” group, in a global and highly competitive market, the choice almost inevitably fell on **ISO standard methodologies** and Schemes with **third party assurance**.
- Evaluating their **consistency with strategic objectives** was essential for operational and marketing utility effective

Choices we made

› **Reliability and transparency**: RadiciGroup applied for the **Global Reporting Initiative** and got its first Sustainability Report assured in 2010.

› Over then these last 10 years all the RadiciGroup sites have been audited on raw material and natural resources consumption, energy sources and use, waste production and management, emissions, labor practices and business accountancy.

› The “letter of assurance” has always been published within the Report.

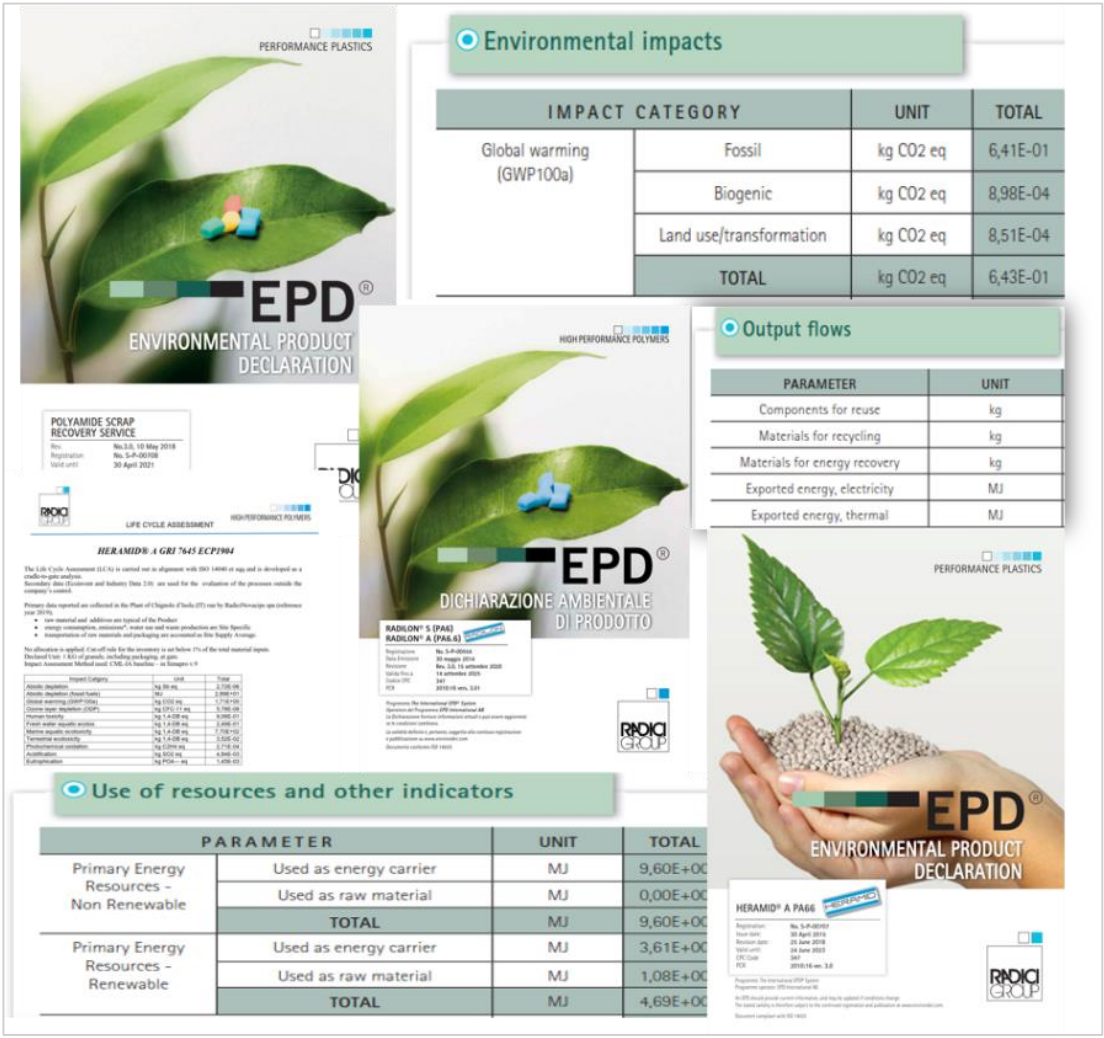
See our website: https://www.radicigroup.com/en/documentation/corporate/report

Choices we made

- **Reliability and transparency**: LCAs were developed and Environmental Product Declarations (EPD – ISO 14025 compliant) for six “families” of **Radilon®** (**more than 90 products**) were published, and at the same time the **EPD Process Certification** was obtained. PEF test was awarded with the “statement of compliance”

- EPDs for **Heramid®** and “**Polyamide scrap recovery**” were published.

- Procedures dedicated to the development (ISO 14040) of short **LCA studies of every product** were approved.



See: https://www.environdec.com/ or our website: https://www.radicigroup.com/en/documentation/certification/plastics

Sustainability, in our view:

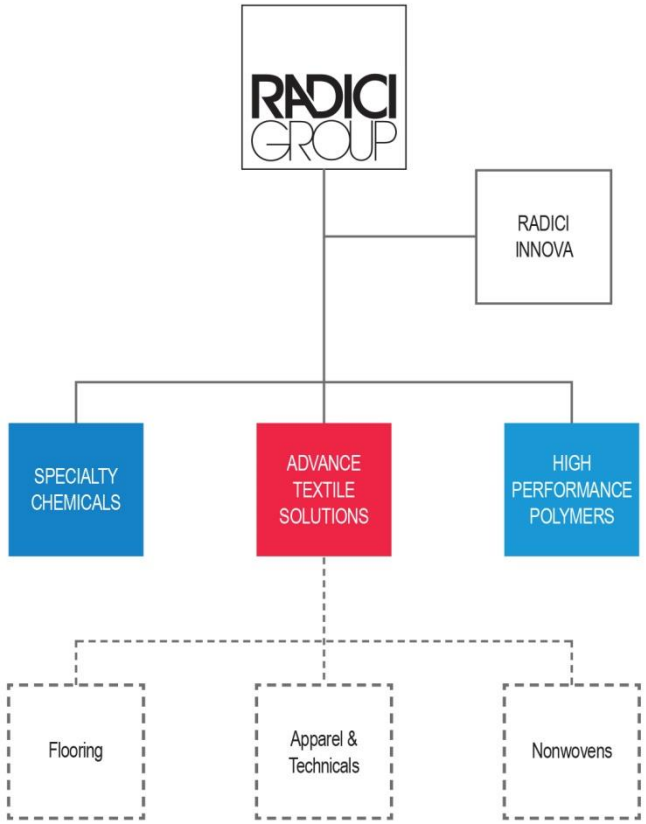
- Scientific and internationally recognized methodology
- Use of appropriate metrics and traceability
- Environmental assessing and labelling
- Fair representation of the content and product performance
- Work with authoritative partners

Encompassing the whole decision-making process, since the very beginning

RadiciGroup | World

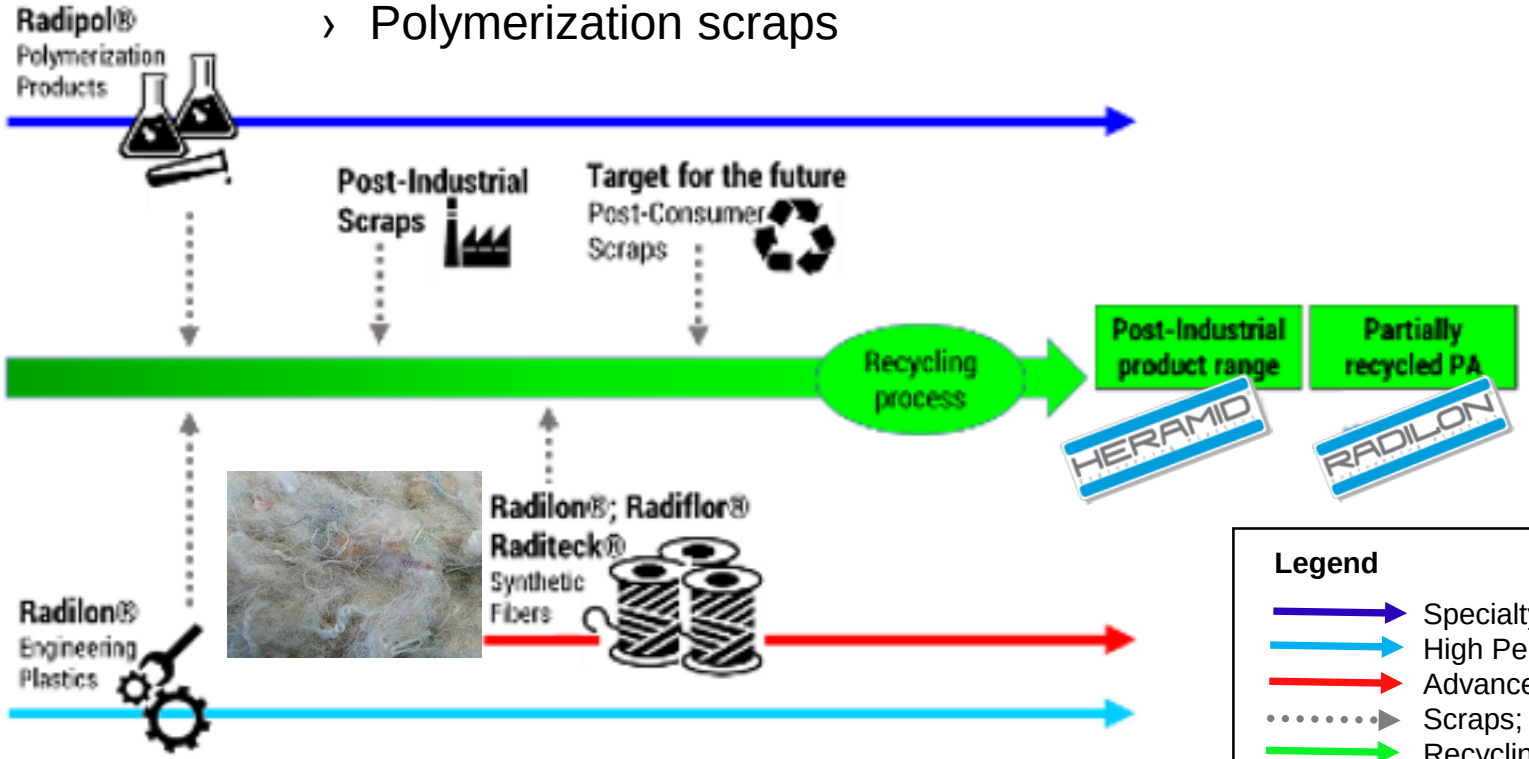
RadiciGroup is one of the most active chemical companies at an international level. Its diversified businesses operate worldwide and are focused on:

- **SPECIALTY CHEMICALS** (Polyamide 6, Polyamide 6.6, Co-Polyamide 6.6/6. Long chain polyamides (PA6.10, PA6.12) & Adipic Acid, HMDA, AGS, Nitric Acid production, KAOil, Esters
- **ADVANCED TEXTILE SOLUTIONS** (Synthetic fibres and nonwovens: from Polyamide, Polyester, Polyethylene, Polypropylene and Acrylic.)
- **HIGH PERFORMANCE POLYMERS** (Engineering polymers for injection moulding, blow moulding and extrusion)



Raw material sources for re-compounding activities:

- Off-spec polymers
- Fibers scraps
- Polymerization scraps



Legend

- Specialty Chemical Division
- High Performance Polymers Products
- Advanced Textile Solutions
- Scraps; non-compliants
- Recycling value-chain

Raw material sources & value for the customer:

Advantages for users:

› full control over the raw material,

› no pollution with unknown substances.

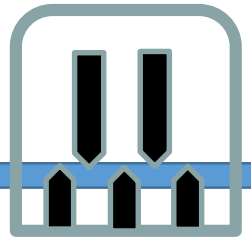
› Choice of the the best raw material depending on customers needs.

Production flow of Post-Industrial material

Milling

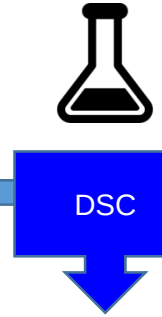
Metal Detector

Blades
(First cutting)



Metal Detector

DSC

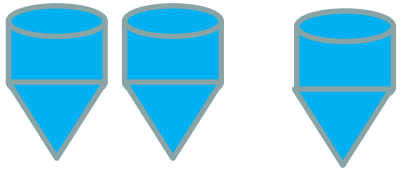


Visual Control

Fiberscraps

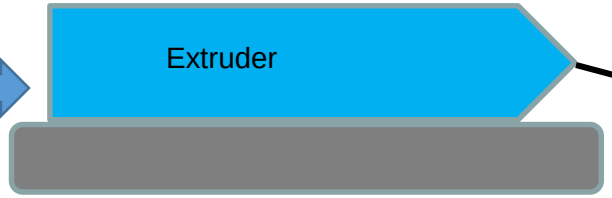
Silos
(Raw Material)

Feeders

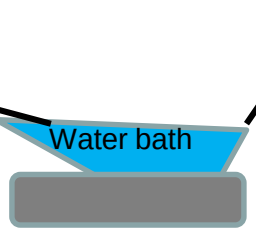


Metal Detector

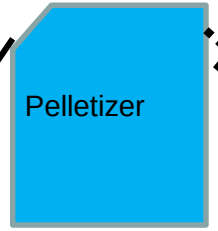
Extruder



Water bath



Pelletizer

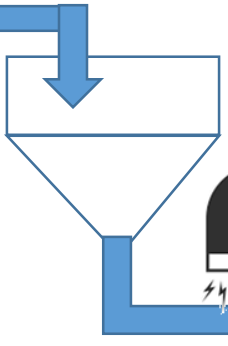


Dimension
check

Metal Detector

DSC

Finish product Silos

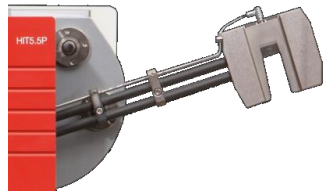


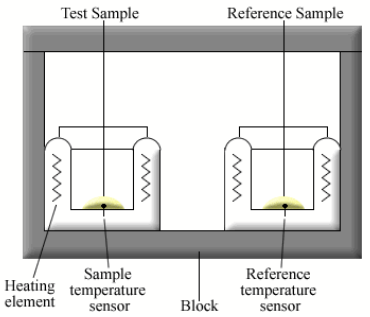
Metal Detector

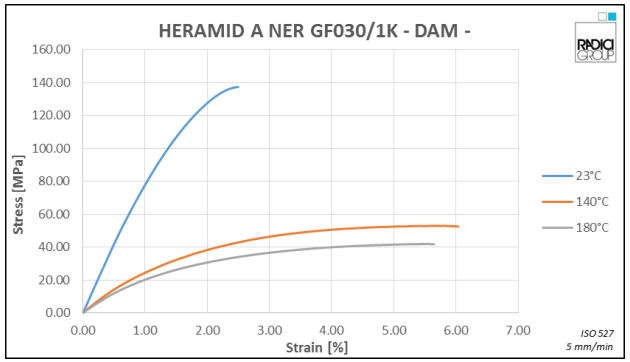
Packaging

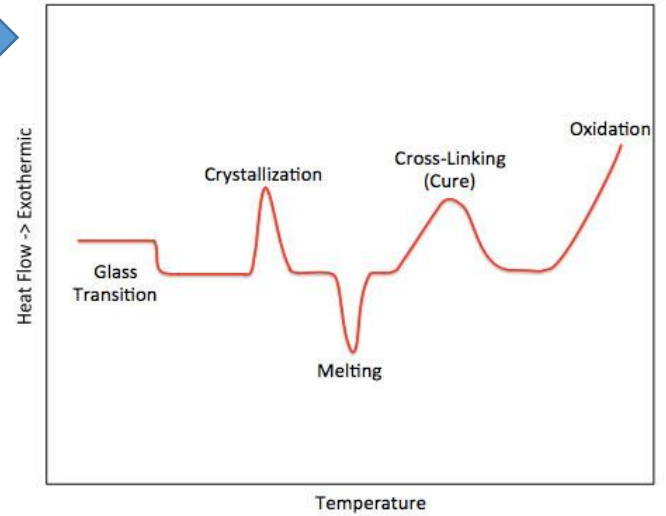
Material Testing for quality control

Severe quality controls are applied to detect impurities (metal, different polymers) and to guarantee constant quality (material properties) before selling the material on the market.









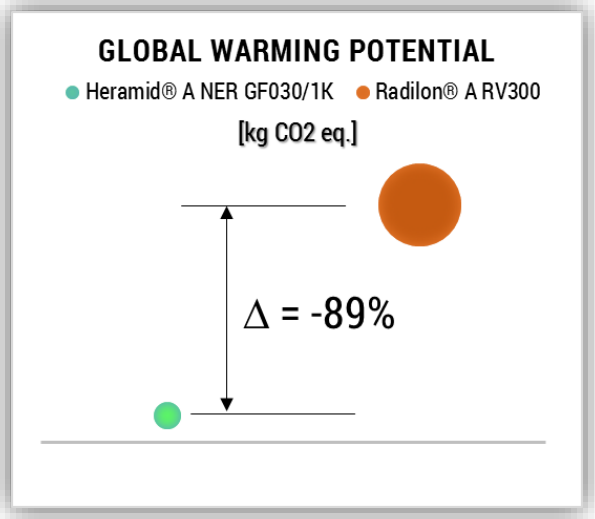
Post-Industrial material: different grades offered by RadiciGroup

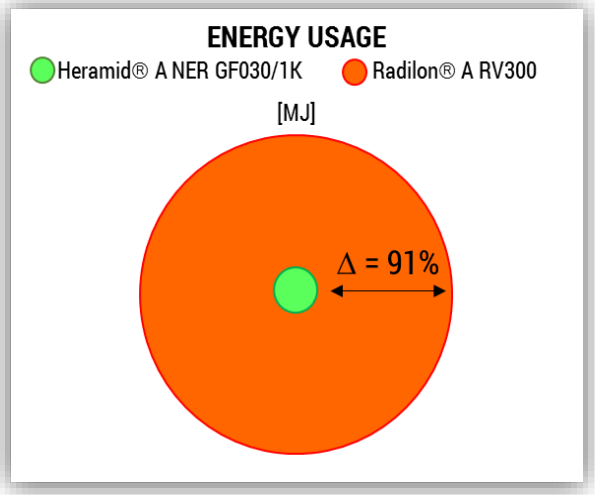
- Grades sold as **Heramid®** or **Torzen®** are 100% recycled materials (PA66 & PA6) and available in all industrial sectors
- Specific grades sold as **Radilon®** are a mix of recycled and first grade. They have been developed for special automotive applications.
- All grades have global availability and are sold as global grades.

Examples of Recycled grades:

Material	Description	Application
TORZEN® T2021HSL BK01	PA66-Impact Modified, heat stabilized, 100% recycled Polyamide, black color	Baffles
Heramid® A NER GF030/1K	PA66-GF30, heat stabilized,100% recycled Polyamide, black color	Shrouds
Radilon® A GF350W 333BK	PA66-GF35, heat stabilized, mix of recycled & prime grade, black color	Valve covers
Radilon® A NER GF250W	PA6-GF25, heat stabilized, mix of recycled & prime grade, black color	Fan/shrouds
Radilon® S NER GFP3010/1K	PA6-GF-M 30%, mix of recycled & prime grades, black color	Engine cover
Heramid® A NER MP/1K	PA66 -Impact Modified, heat stabilized, 100% recycled Polyamide, black color	Cable Channels
Heramid® S NER 233 MP/1K	PA6 -Impact Modified, heat stabilized, 100% recycled Polyamide, black color	Cable Channels

Recycled material vs. prime grades: Background, consequences and benefits



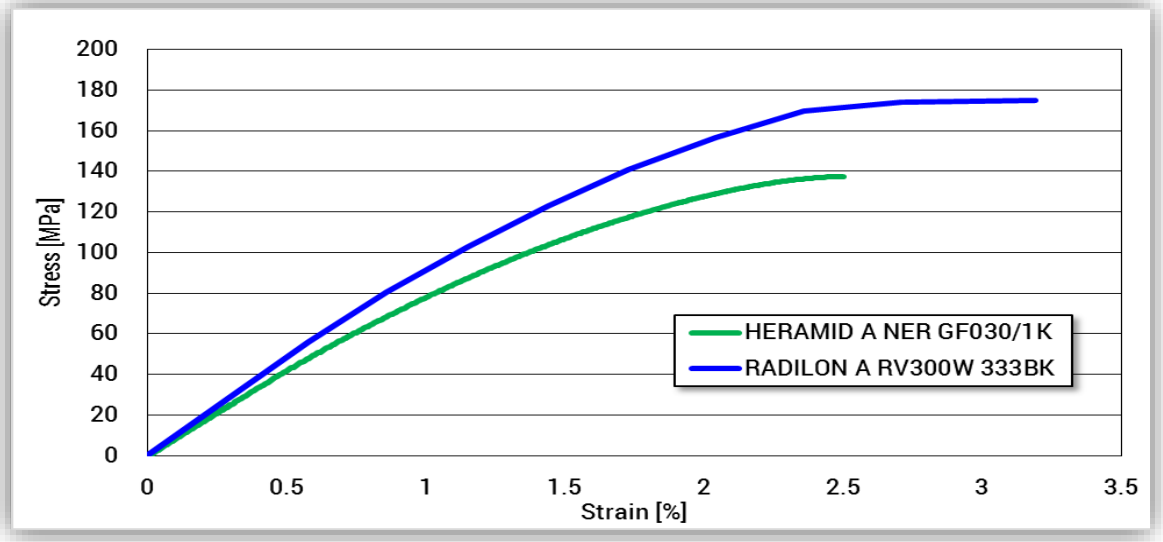


Advantage:

Reduced global warming potential

&

less consumption of energy

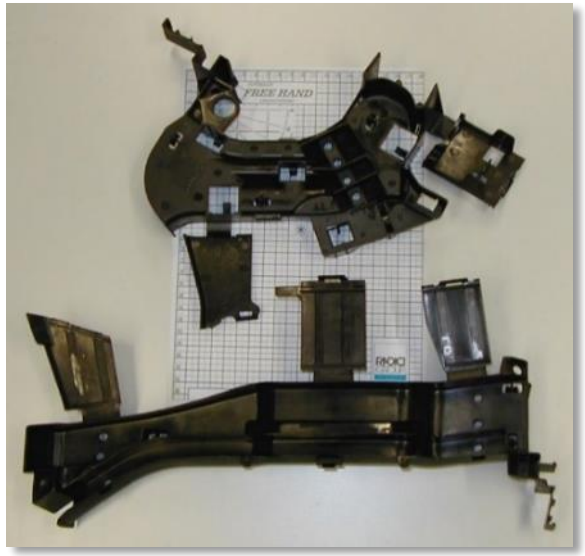


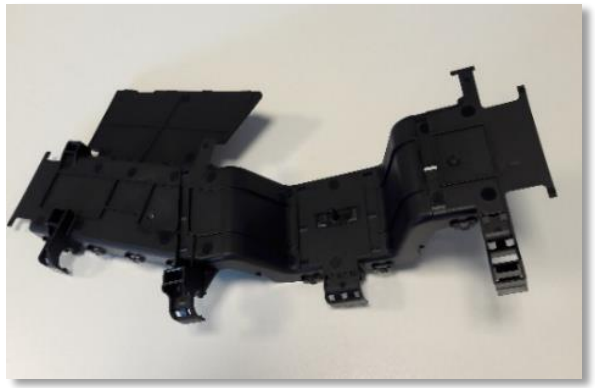
- It is not realistic to expect characteristics of a prime grade.
- Mechanical properties and intrinsic color depend on the raw material used.
- The quality needs to be defined in a certain product specification

Application example - Automotive: Cable channels

Heramid® A NER MP/1 K
Heramid® S NER 233 MP/1K

- impact modified and heat stabilized polyamide (66 and 6), 100% from selected re-compounded raw material
- Commercial material for cable channels





Application example - Automotive: Fan shroud

Heramid® A NER GF030/1 K

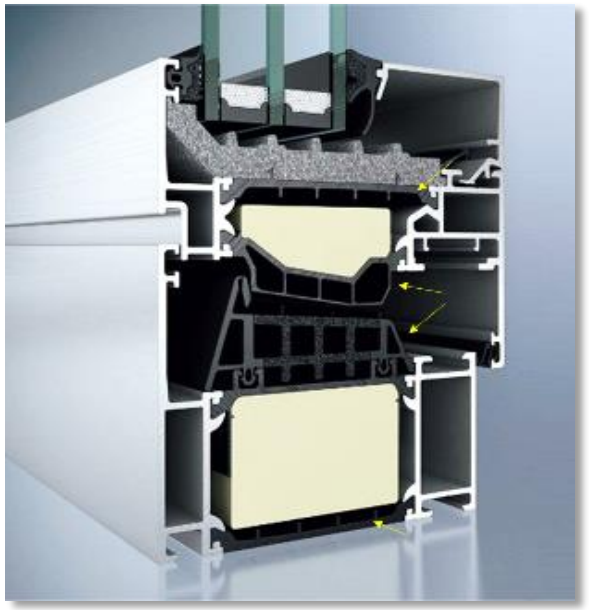
- PA66-GF30, heat stabilized 100% from selected re-compounded raw material
- Quality certification
- Commercial for fans, shrouds and gear shift housing

Application example - non Automotive: Thermal breakers

Heramid® A / black

› PA66 100% re-compounded, extrusion quality.

› Material spec & Quality certification, high volumes possible

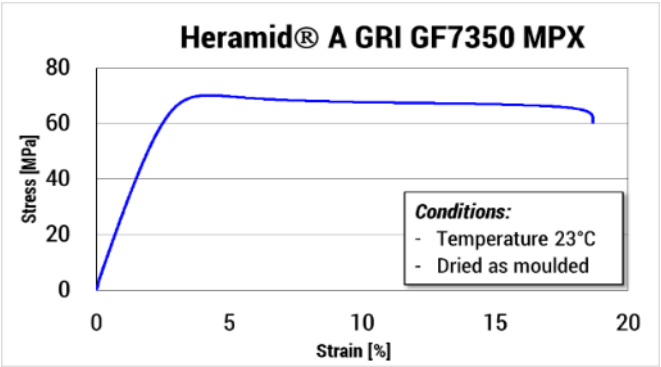


Thermal breakers or “heat barriers” for window and door frames.
In this application we combine the good thermal insulation function with reduced environmental impact (by using recycled material)

Application example - non Automotive: Dowels

Heramid® S GRI 7350 MPX

- PA6 impact modified in grey color.
- Product obtained from 100% recycled Polymer (from polymerization, spinning and compounding)
- Material Spec & Quality certification, constant color over high volumes possible.
- Stress-strain curve demonstrates the good flexibility of this material grade.
- Material spec & Quality certification, high volumes possible



New trends and developments

Material	Description	Comment
Rad A NER GF300RKC	PA66 heat stabilized, improved hydrolysis resistance, black color	New development for RET of engines for tractors
Her S in orange	PA6 from 100% re-compounded source, colored in orange (RAL 2003 – RAL 2008)	New development for special cable ducts in E- and hybrid cars
Her S NER GF050	PA6 from 100% re-compounded source with 50% GF, black color	Material with high strength and stiffness for gear application (Bowden cable adapter)
Her S NER GF035/1K	PA6 from 100% re-compounded source with 35% GF, heat stabilized, black color	Parts of the damping system (replacement of prime grade)

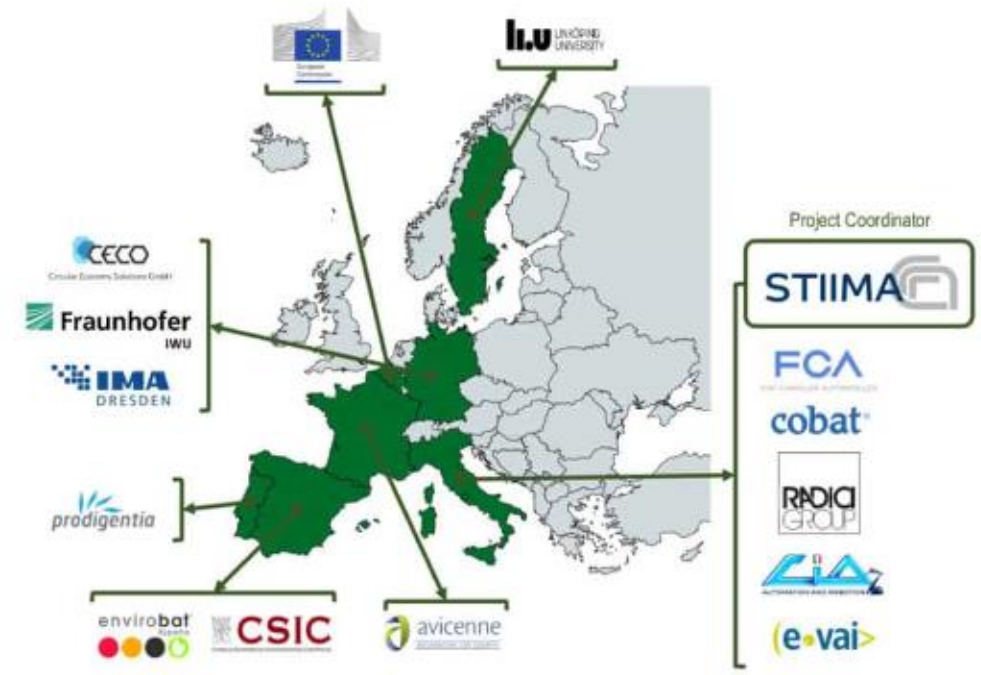
Activities for the future

The CarE-Service project aims at demonstrating Innovative Circular Economy Business Models based on advanced mobility services exploiting hybrid and electric vehicles. Such business models will entail re-use, remanufacturing and recycling of components and materials of hybrid and electric vehicles for applications in the automotive sector as well as in other sectors. http://www.careserviceproject.eu/

CarE-Service

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 776851

Part of this project is to check the possibility of re-using and recycling components and materials @ “End of Life”.
So making “post consumer sources” available.



Additional value for customer: FEA Support

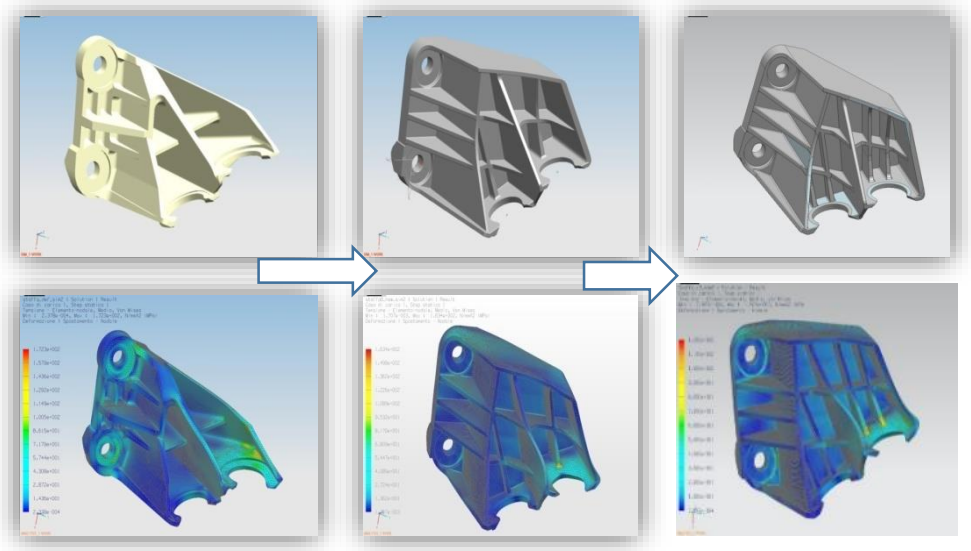
Standard FEA Support

› Concept design (from metal to plastics)

› Stress analysis (Nastran®, isotropic behavior assumption)

› Process simulation (Moldflow®)

› Impact analysis (High speed Stress-Strain data of Radilon S NER GF350K will be provided)



Advanced FEA Support

› Coupled Process simulation + structural analysis (fiber orientation considered)

Disclaimer note

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Future trends and challenges in EE Market:
Innovative solutions and application examples

Joachim Stricker - *EE Marketing Leader*

Antonio Nerone - *EE Market Expert*

RADICI GROUP
HIGH PERFORMANCE POLYMERS

Webinar: Innovative polymers solutions in a fast evolving market - Part two

Agenda

- Main Trends in Electric/Electronic Industry
- Overview of Radici Flame Retardant Products Offer
- Examples of Applications and Radici Product Offer
- Conclusions

E&E Drivers

› Product safety

Fire behaviour, electrical properties, low smoke density and toxicity. Materials must comply with restrictive tests in conformity with the latest IEC, VDE, UL and EN standards and others.

› Health & environment

Materials for the E&E market are required to comply with the WEEE Directive, the RoHS Directive and the REACH Regulation, in order to provide protection for human health and the environment.

› Performance

Excellent flame retardant behaviour and high mechanical, chemical and thermal properties.
A very important technical aspect is the ease of processing.
For increasingly thinner components, such as connectors, the challenge is to offer very fluid materials with high mechanical properties.

› Global offer

Worldwide material availability and global technical service support are key priorities at RadiciGroup High Performance Polymers. Computer-aided engineering simulations is also offered in order to speed up the component development phase.

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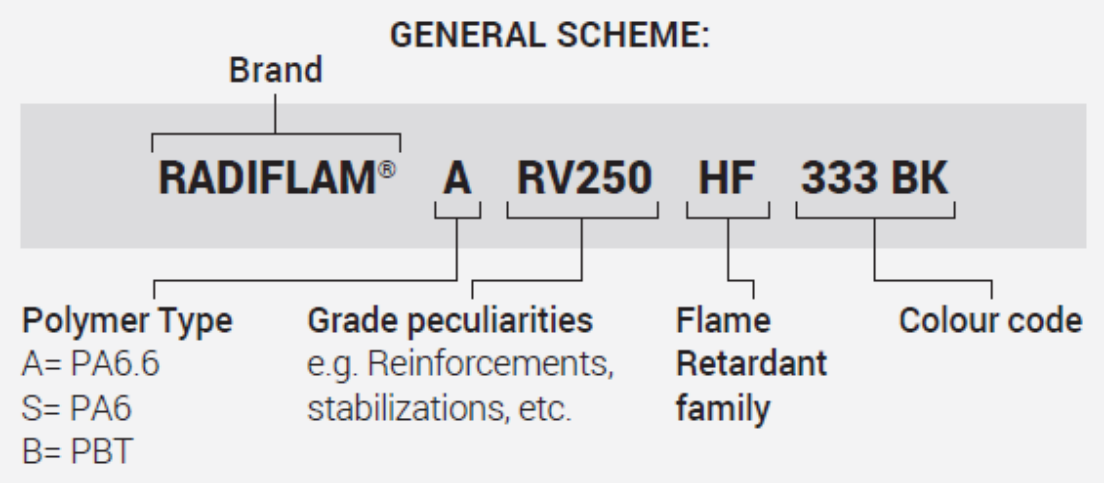
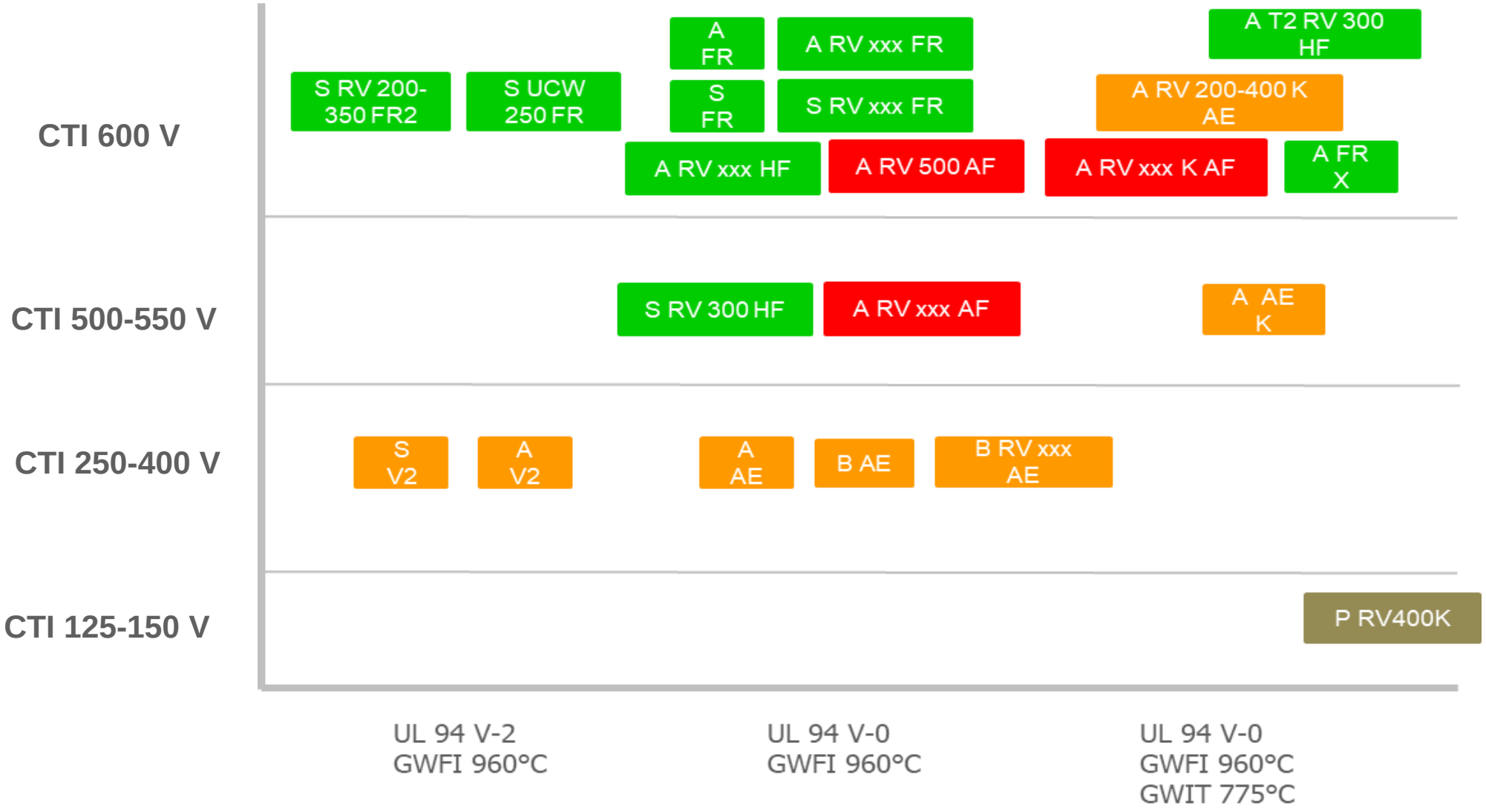
Product Range



RADICIGROUP HIGH PERFORMANCE GRADES	FLAME RETARDANT TECHNOLOGY	UL 94
RADIFLAM® FR (unfilled)	NITROGENATED	Self-extinguishing V-0
RADILON® FR2 (filled)	NITROGENATED	Self-extinguishing V-2
RADIFLAM® FR (filled)	INORGANIC HYDROXIDE	Self-extinguishing V-0
RADIFLAM® HF	ORGANIC PHOSPHINATES	Self-extinguishing V-0
RADIFLAM® AF	RED PHOSPHOROUS	Self-extinguishing V-0
RADIFLAM® AE	HALOGENATED	Self-extinguishing V-0
RADILON®	HALOGENATED, NITROGENATED, OTHERS	Self-extinguishing V-2, HB

Product Range

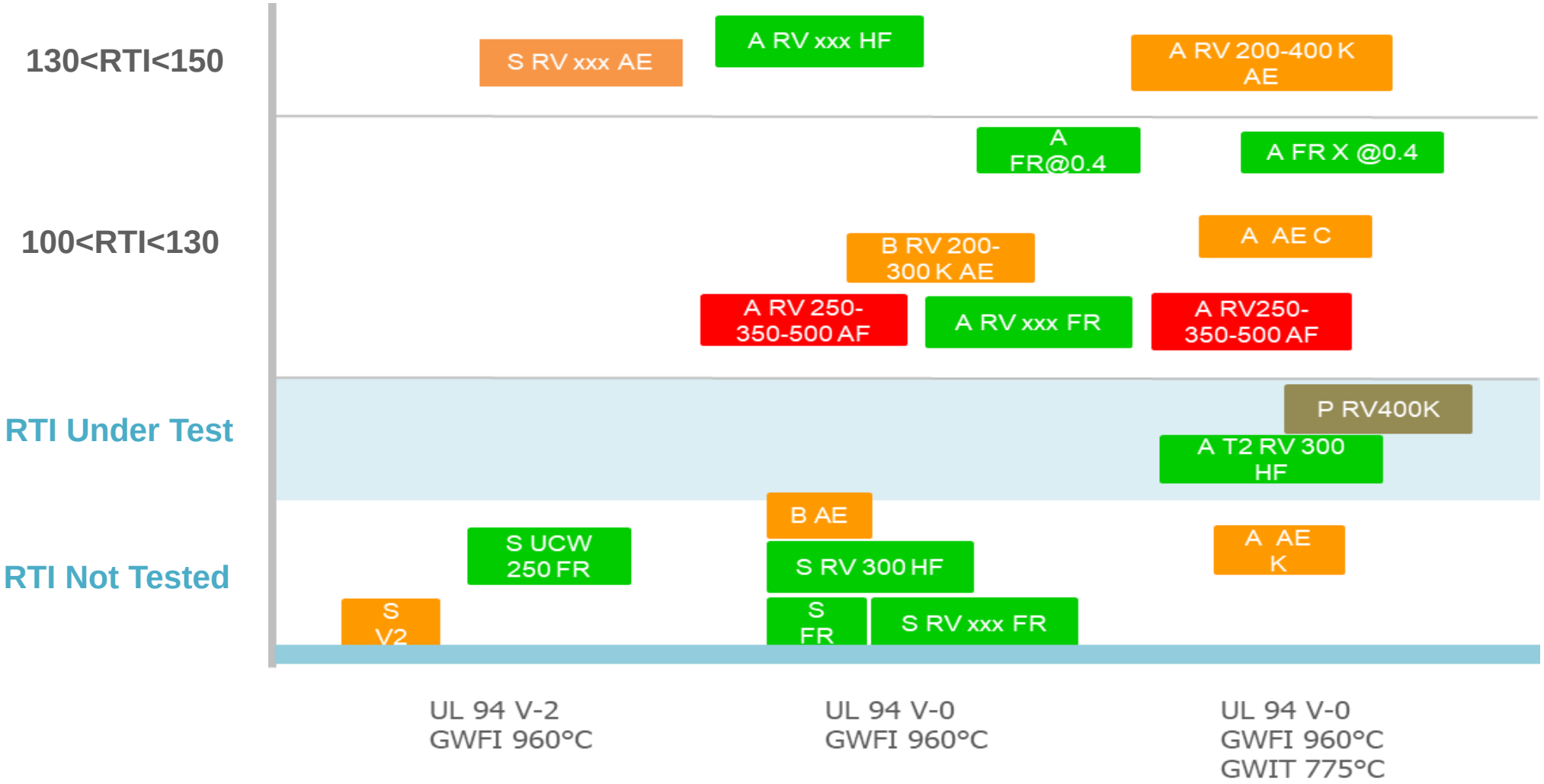


Nomenclature Slide 5
Reference thickness: 0.75-0.8 mm

- Inherent FR
- Halogen free, including (red) phosphorous free
- Red Phosphorous
- Halogenated

Product Range

RTI-E



Nomenclature Slide 5
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Applications Examples: Mini Circuit Breakers (MCB)

Basic Requirements

- Halogen FreeCTI≥ 400V
- GWFI 960ºC
- Strain @ Bk>4% (DAM)
- Tensile Modulus =4GPa (Cond)

Housing	Radilon® S RV200 FR2	PA66-GF20 UL-V2 @ 0.80 mm Halogen & Phosphorus free
	Radilon® S RV250 FR2	PA66-GF25 UL-V2 @ 0.80 mm Halogen & Phosphorus free
	Radilon® S RV300 FR2	PA6-GF30 UL-V2 @ 0.80 mm Halogen & Phosphorous free
	Radilon® S LCW250 FR2	PA6-MF25 UL-V2 @ 0.80 mm Halogen & Phosphorus free
	Radiflam® A RV250HF	PA66-GF25 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® A RV300HF	PA66-GF30 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® Aestus T2 RV300HF	PPA-GF30 UL-V0 @ 0.40 mm Halogen & Phosphorus free

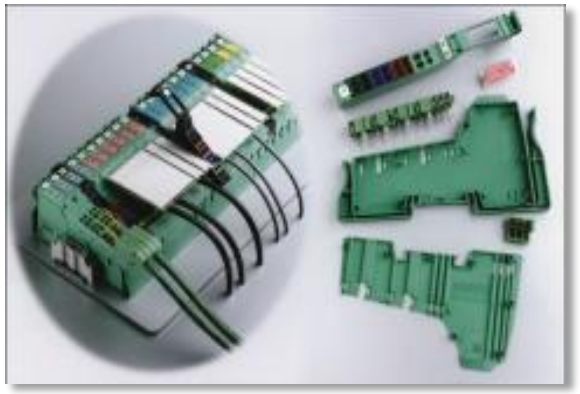
Applications Examples:
Molded Case Circuit Breakers (MCCB) & Contactors

Basic Requirements

- UL 94 V0
- CTI 400V
- GWFI 960ºC
- Strain @ Bk>3% (DAM)
- Tensile Modulus >5GPa (Cond)

Housing & Cover	Radiflam® A RV250HF	PA66-GF25 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® A RV300HF	PA66-GF30 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® A RV250AF	PA66-GF25 UL-V0 @ 0.75 mm Halogen free
	Radiflam® A RV300AF	PA66-GF30 UL-V0 @ 0.75 mm Halogen free
	Radiflam® S RV300HF	PA6-GF30 UL-V0 @ 0.80 mm Halogen & Phosphorus free
	Radiflam® Aestus T2 V300HF	PPA-GF30 UL-V0 @ 0.40 mm Halogen & Phosphorus free
Internal Components	Radiflam® B RV300AE	PBT-GF30 UL-V0 @ 0.80 mm Halogen FR system

Applications Examples: Terminal Blocks



Standard	Radiflam® AFRX	PA66- Not Filled UL-V0 @ 0.40 mm Halogen & Phosphorus free
LFS	Radiflam® Aestus T2 RV300HF	PPA-GF30 UL-V0 @ 0.40 mm Halogen & Phosphorus free

Basic Requirements Standard

- Halogen Free
- UL 94 V0 ≥0.4 mm
- CTI =600V
- High Flow
- High dimensional stability
- Dimensional stability
- Strain at break > 7% (DAM)
- Colors

Additional requirements for SMD

- Strain @ Bk>2.2% (DAM)
- Tensile Modulus>8GPa (Cond.)
- RTI>110ºC @ 0.4mm
- Pass Reflow @ 260ºC
- Dimensionally stable between -40°C and 80°C

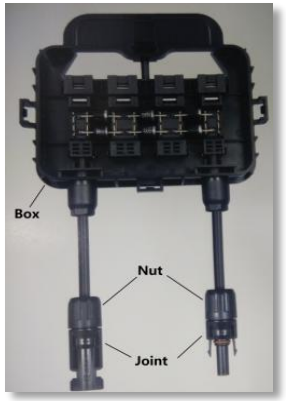
Applications Examples: Power Electronics (IGBTS)

Basic Requirements

- UL 94 V0
- Strain @ Bk>2% (DAM)
- Tensile Modulus >5GPa (Cond)
- RTI>140°C
- Dimensionally stable
- 85°C/85%RH 1,000 hr test
- CTI≥600V
- R22/23 HL2/3 rating according to EN 45545
- Low CTE (Coefficient of Thermal Expansion)

Housing	Radiflam® A RV250HF	PA66-GF25 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® A RV300HF	PA66-GF30 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® A RV350HF	PA66-GF35 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® A RV250AF	PA66-GF25 UL-V0 @ 0.75 mm Halogen free
	Radiflam® A RV300AF	PA66-GF30 UL-V0 @ 0.75 mm Halogen free
	Radiflam® A RV350AF	PA66-GF30 UL-V0 @ 0.75 mm Halogen free
	Radiflam® Aestus T2 RV300HF	PPA-GF30 UL-V0 @ 0.40 mm Halogen & Phosphorus free

Applications Examples: Solar Inverters Components



Basic Requirements

- UL 94 V0 /5VA
- Strain @ Bk>2% (DAM)
- Tensile Modulus >3GPa (Cond)
- RTI>140°C
- Impact at - 40°C
- Dimensionally stable
- 85ºC/85%RH 1,000 hr test
- UV and Chemical Resistant
- IPT≥1kV

Housing	Radiflam® A RV 250HF	PA66-GF25 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® A RV300HF	PA66-GF30 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® A RV250-300AF	PA66-GF25-30 UL-V0 @ 0.75 mm Halogen free
Junction Box	Radiflam® AFRX HF	PA66- Not Filled UL-V0 @ 0.40 mm Halogen & Phosphorus free
	Radiflam® A RV 250HF	PA66-GF25 UL-V0 @ 0.75 mm Halogen & Phosphorus free
	Radiflam® A RV300HF	PA66-GF30 UL-V0 @ 0.75 mm Halogen & Phosphorus free

Applications Examples:
Electronic Housings for Applances

Radiflam® A RV250HF	PA66-GF25 UL-V0 @ 0.75 mm Halogen & Phosphorus free
Radiflam® A RV300HF	PA66-GF30 UL-V0 @ 0.75 mm Halogen & Phosphorus free

Basic Requirements

- UL 94 V0/5VA
- Strain @ Bk>2%
- Tensile Modulus >5GPa
- RTI>120°C
- Dimensionally stable
- CTI≥300V
- GWFI≥960ºC
- GWEPT≥750ºC

Applications Examples:
EV/PHEV Charging Components

Recharge Plug	Radiflam® S RV300HF	PA6-GF30 UL-V0 @ 0.80 mm Halogen & Phosphorus free
	Radiflam® A RV300HF	PA66-GF30 UL-V0 @ 0.75 mm Halogen & Phosphorus free

Basic Requirements

- UL 94 V0/5VA
- Strain @ Bk>2.5% (DAM)
- Tensile Modulus >5GPa (Cond)
- RTI>120°C
- Dimensionally stable
- CTI≥250V
- GWFI≥960ºC
- Stone Impact Resistance up to -40°C
- UV Resistance

Applications Examples: Electronic connectors

Basic Requirements

- UL 94 V0 <0.4 mm
- High Flow
- Dimensional stability
- JEDEC MSL 1
- Low Df and Dk
- Low CTE

Additional requirements for SMT

- No blistering after reflow up to 260°C

Through Hole	Radiflam® B N100AE	PBT-Not Filled UL-V0 @ 0.80 mm Halogen FR system
	Radiflam® B RV150AE	PBT-GF15 UL-V0 @ 0.80 mm Halogen FR system
	Radiflam® B RV200AE	PBT-GF20 UL-V0 @ 0.80 mm Halogen FR system
	Radiflam® B RV300AE	PBT-GF30 UL-V0 @ 0.80 mm Halogen FR system
	Radiflam® Aestus T2 RV300HF	PPA-GF30 UL-V0 @ 0.40 mm Halogen & Phosphorus free
SMT	Radiflam® Aestus T2 RV300HF	PPA-GF30 UL-V0 @ 0.40 mm Halogen & Phosphorus free

Method		ISO 1183	UL94	IEC 60695-2-13	IEC 60695-2-12	IEC 60112	UL-746B
Units		gr/cm3		°C	°C	V	°C
		Properties					

Product	FR System	Polymer Family	Density	Flammability Classification (mm)	Glow Wire Ignition Temperature °(GWIT) (mm)	Glow Wire Flammability Index (GWFI) (mm)	CTI (Comparative Tracking Index) (≥3 mm)	RTI Elec. (mm)	Typical Applications: Automotive Connector	EV/HEV Connectors	Appliance Connector	Electronic Connector	Terminal Blocks	MCBs	Circuit Breakers & Contactors	Motors , Bobbins & Transformers	Relays	Switches
Radilon® SFR2	Nitrogen	PA6-Unfilled	1.14	V0 (3.2)	NA	NA	NA	NA	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radilon® SHXFR2	Nitrogen	PA6-I-Unfilled	1.13	HB (0.8)	NA	750 (1)	NA	NA	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radilon® SERV100FR2	Nitrogen	PA6-I-GF10	1.22	V2 (0.8)	NA	NA	NA	NA	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radilon® SRV200-300FR2	Nitrogen	PA6-GF20-30	1.32-1.42	V2 (0.8)	NA	960 (1)	600	NA	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radilon® SLCW260FR2	Nitrogen	PA6-MR25	1.38	V2 (0.8)	NA	960 (1)	600	NA	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radilon® SV2181CNT	Halogen	PA6-Unfilled	1.28	V2 (0.8)	775 (1-2)	850 (1-2)	600	NA	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radiflam® SAE 100-121	Halogen	PA6-Unfilled	1.33	V0 (0.8)	775 (1-2)	960 (1-2)	NA	NA	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radiflam® SRV150-400KAEC	Halogen	PA6-GF15-40	1.53-1.69	V0 (0.8)	725 -825 (1.0)	960 (1.0)	550 (40%GF)	140 (0.75)	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radiflam® SCV300KAE	Halogen	PA6-GB30	1.62	V0 (0.8)	NA	NA	NA	NA	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radiflam® AAE121-131	Halogen	PA66-Unfilled	1.35	V0 (0.4)	775 (1-2)	960 (1-2)	NA	125 (0.75)	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radiflam® ARV100-400 KAEC	Halogen	PA66-GF10-40	1.47-1.70	V0 (0.4)	775 (1)	960 (1-2)	600 (40% GF)	140 (0.75)	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radiflam® BN100AE	Halogen	PBT -Unfilled	1.47	V0 (0.8)	NA	NA	NA	NA	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radiflam® BRV200AE	Halogen	PBT-GF20	1.64	V0 (0.8)	NA	960 (1)	NA	120 (0.75)	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
Radiflam® BRV300AE	Halogen	PBT-GF30	1.78	V0 (0.8)	NA	960 (1.0)	NA	120 (0.75)	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆

Agenda

- Main Trends in Electric/Electronic Industry
- Overview of Radici Flame Retardant Products Offer
- Examples of Applications and Radici Product Offer
- Conclusions

Conclusions

RadiciGroup is committed to long term growth in EE industry because:

› Has a broad product portfolio which includes PA 6 and 66 , PBT, PPA and PPS able to cover main challenging requirements for EE Industry.

› Can develop special customised products (if business case justifies it) to fulfill the most severe market requirements

› Can grant same product quality across the globe thanks to manufacturing plants in EU, AMS and AP

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