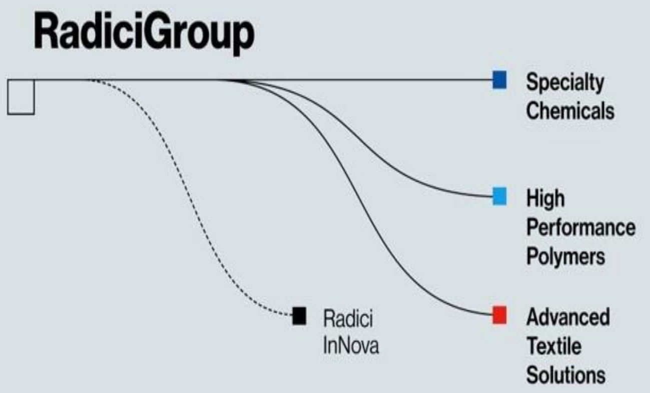
E-mobility Our solutions for today and challenges for the future

Erico Spini

Global Marketing Manager

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

RadiciGroup High Performance Polymers at a Glance



Upstream integration of PA6 Radilon® S, PA6.6 Radilon® A, PA6.10 Radilon® D, PA6.12 Radilon® DT and copolymers.

Worldwide industrial and sales network. Manufacturing footprint in Europe, Americas and Asia

Complete range of materials available in all countries including high performance products and special tailor-made grades

FACTS

VISION

Growth through **Innovation**, with a focus on speciality mainly based on polyamide grades. **Sustainability** commitment along the entire production chain.

Commitment to sustainability: we support Circular Economy. Our 15-year old commitment to Sustainability is embedded in the Mission RadiciGroup defined back in 2000.

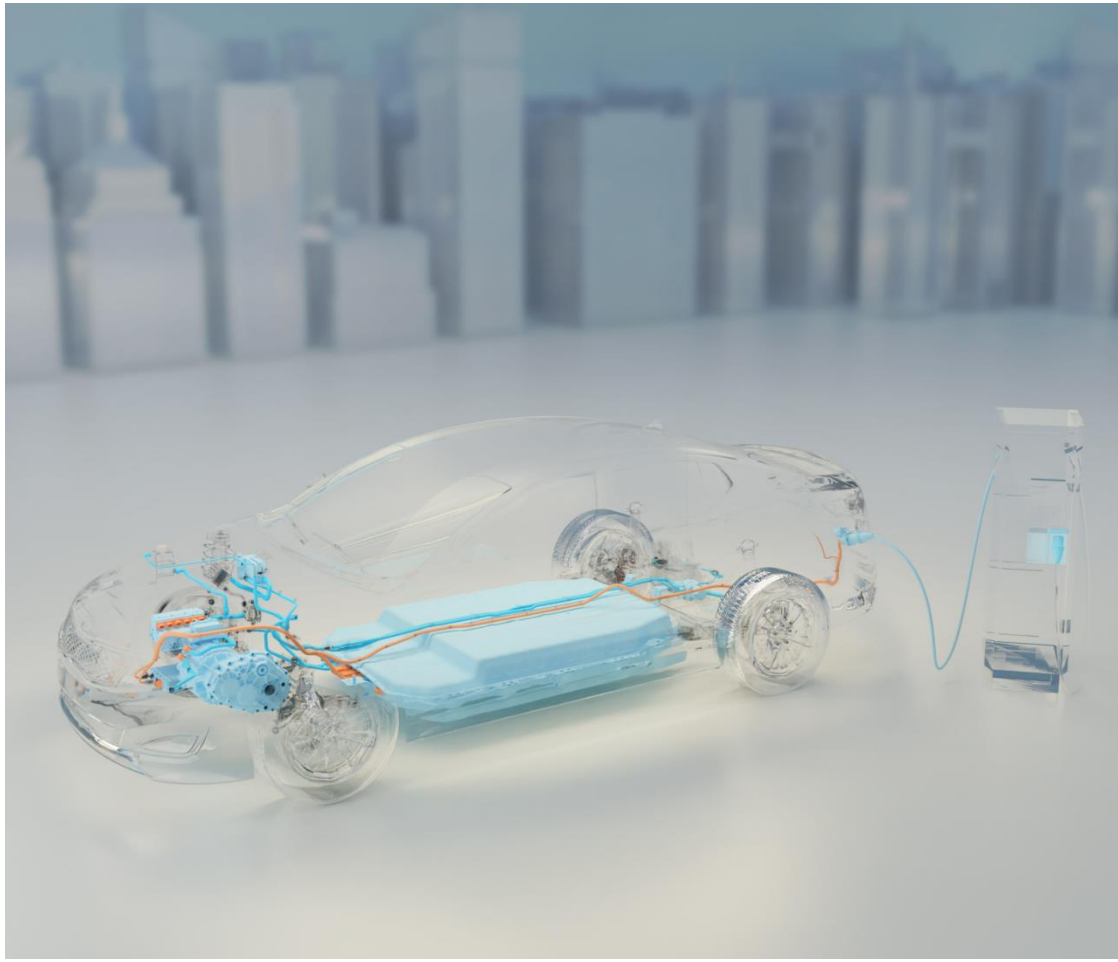
People's expertise and support for the development of new applications and solutions on a global level. We consider our approach to innovation as a competitive advantage, from CAE design to product development**.**

Main Brands

RADILON RADIFLAM HERAMID RADISTRONG RADITECK RADITER

Agenda

- E-Mobility: new opportunities and challenges with engineering polymers
- Parts/systems technical requirements
- Properties comparison: polyamides versus PC, PC-ABS and PP
- Application examples
- Advanced solutions with innovative composite prepregs



KEY WORDS:
increase of COMPONENTS LIFE, RELIABILITY, SAFETY

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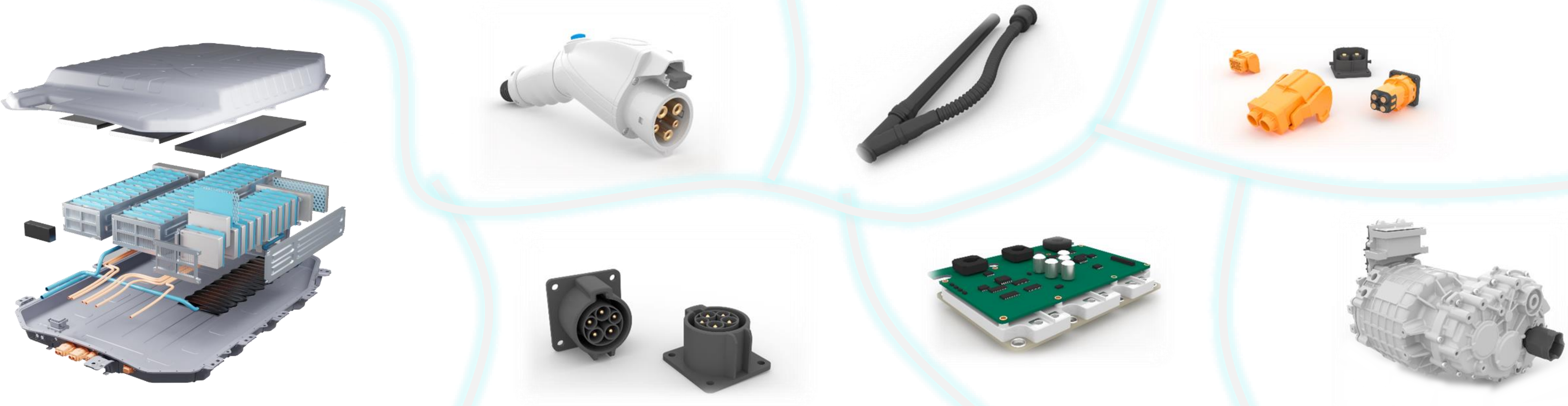
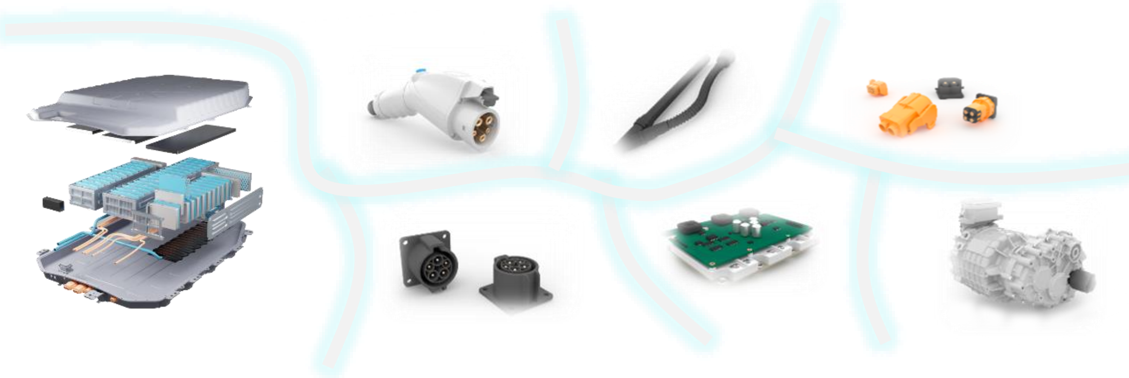


Target systems

- Traction Battery Pack
- Thermal Management
- Charging System
- Power Electronic
- E-motor
- Connectivity Systems

Main requirements

- Growing importance of lightweighting
- Components integrity through prolonged exposure in harsh environment
- Increasing fire safety requirements
- Electrical insulation also in the presence of high voltage
- EMI shielding
- Battery protection against intrusion and impact
- Electronic components duration with high voltage and high energy density
- Protection versus corrosion of contacts
- Chemical resistance (also versus battery acids)



Parts/systems technical requirements

Requirement	Details	System/components affected
Flame retardant properties	Trend versus UL 94-V0	Connectors, cell spacers, battery holders, battery frames, cable brackets, battery end plates, plug & sockets for charging system
Insulation	High CTI (≥ 600V) Dielectric Strength ≥ 10 KV/mm at 140°C	Connectors, cell spacers, battery holders, battery frames, cable brackets, battery end plates, plug & sockets for charging system
Stress cracking & chemical resistance	Chemical resistance according to LV124	CMC, BMC, cell spacers, carrier, cable brackets, cooling lines
Long term mechanical properties	Creep, fatigue up to 110 °C for battery system components. Heat ageing up to 160 °C for HV connectors and E-motor components	Cell spacers, end plates, housing, carrier, frames Busbar holder, cooling lines
Easy processing	Filling of large parts, thin parts with lower injection molding machine clamping force	Battery holders, spacers, carriers, frames. Connectors, cooling lines. E-motor brush holder, end frames.
High temperature exposure	RTI up to 160 °C	E-engine components, connectors, power electronic components
Impact, crash resistance	Battery/components protection against crash	Battery holder, battery housing

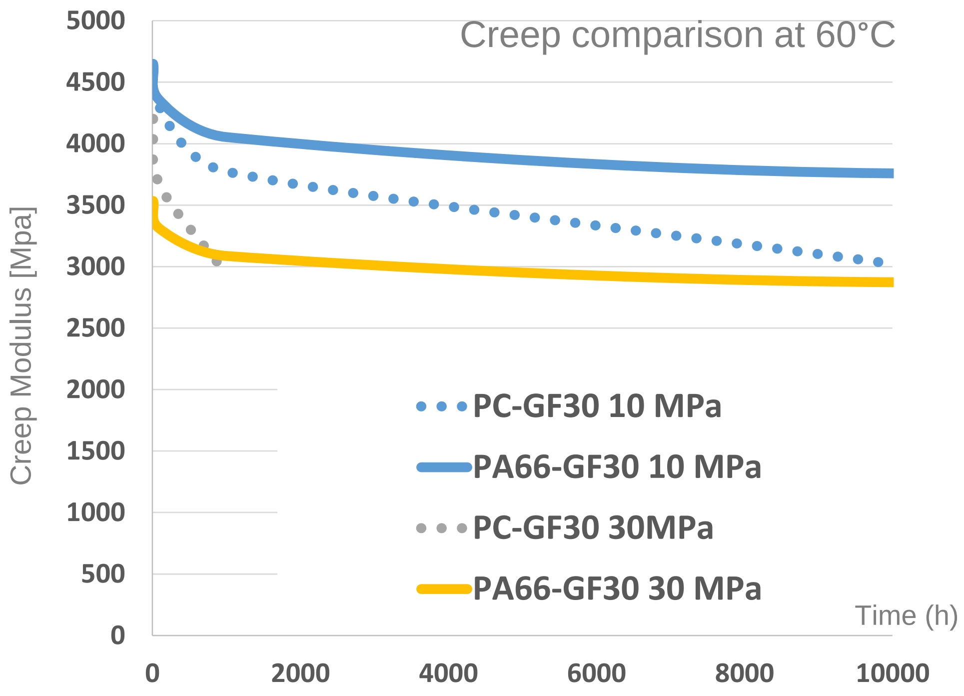
Property comparison:
polyamides versus PC, PC-ABS and PP

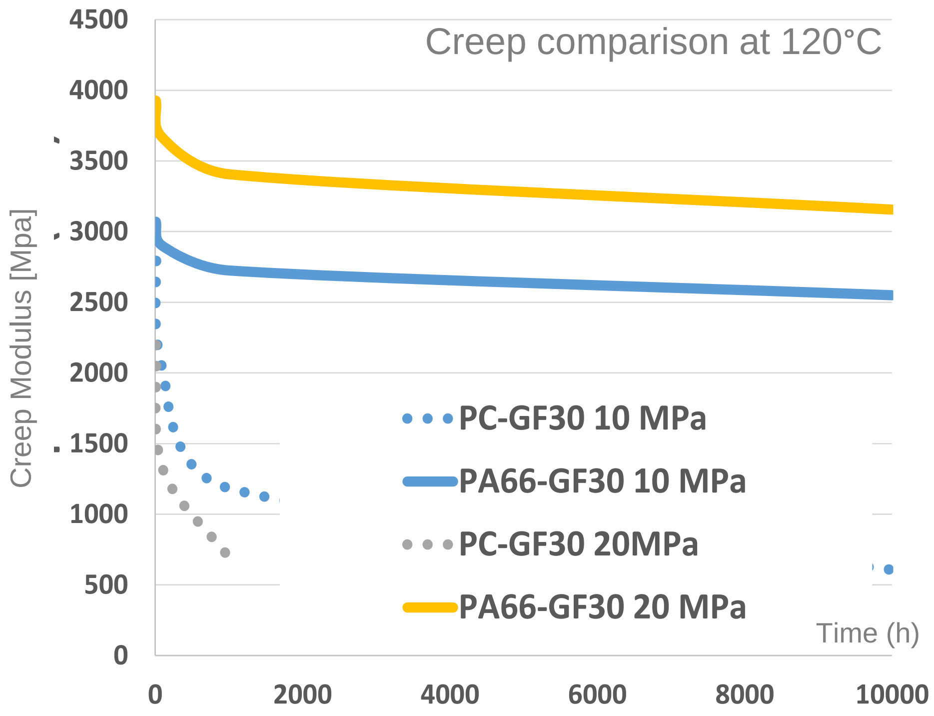
Property	PC, PC-ABS (amorphous)	Polyamide	Polypropylene	Comments
Stress cracking resistance Chemical resistance	-	=	+	Amorphous grades present a very low chemical and stress cracking resistance
Tensile strength and module	-	+	-	PP properties very low in the presence of welding line.
Creep resistance, fatigue resistance	-	+	-	Amorphous and PP low performance in presence of creep and fatigue
Impact resistance (basic polymer)	+	=	-	Strong point for amorphous on unfilled grade but not better than PA on flame retardant grades
Easy processing (flowability & cycle time)	-	+	+	Amorphous injection molding very difficult in the presence of limited thickness. Amorphous require high injection pressure and longer cycle time
Shrinkage & Warpage	+	=	-	Favourable for amorphous but limited advantages with flame retardant grades. PP affected by high warpage.
Flame retardant behaviour	=	+	=	PA easy to modify with flame retardant additives (UL 94-V0 also at 0,4 mm) High FR additives load requested for PP, Amorphous difficult to modify.
Prolonged exposure to high temperature	-	+	-	In case of long heat exposure both amorphous and PP are unsuitable. Associated with creep and fatigue the effect of high heat and long exposure is even more critical

Creep resistance

PA vs PC: long term mechanical properties

The graphs show the creep behavior at 60 and 120 °C. Polyamide loaded with 30% glass fiber shows a clearly superior performance compared to PC-GF30. This behavior is accentuated with increasing temperature and stress level. The poor creep resistance is also affecting other amorphous materials such as PC-ABS, ABS and M-PPO.

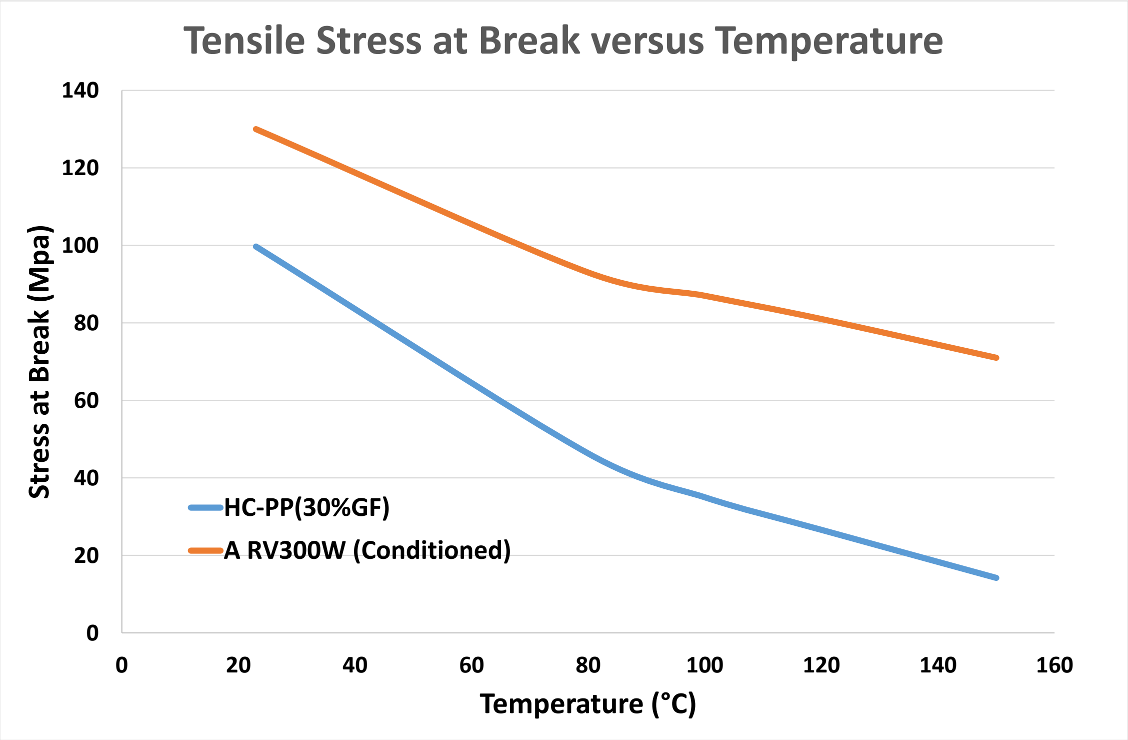


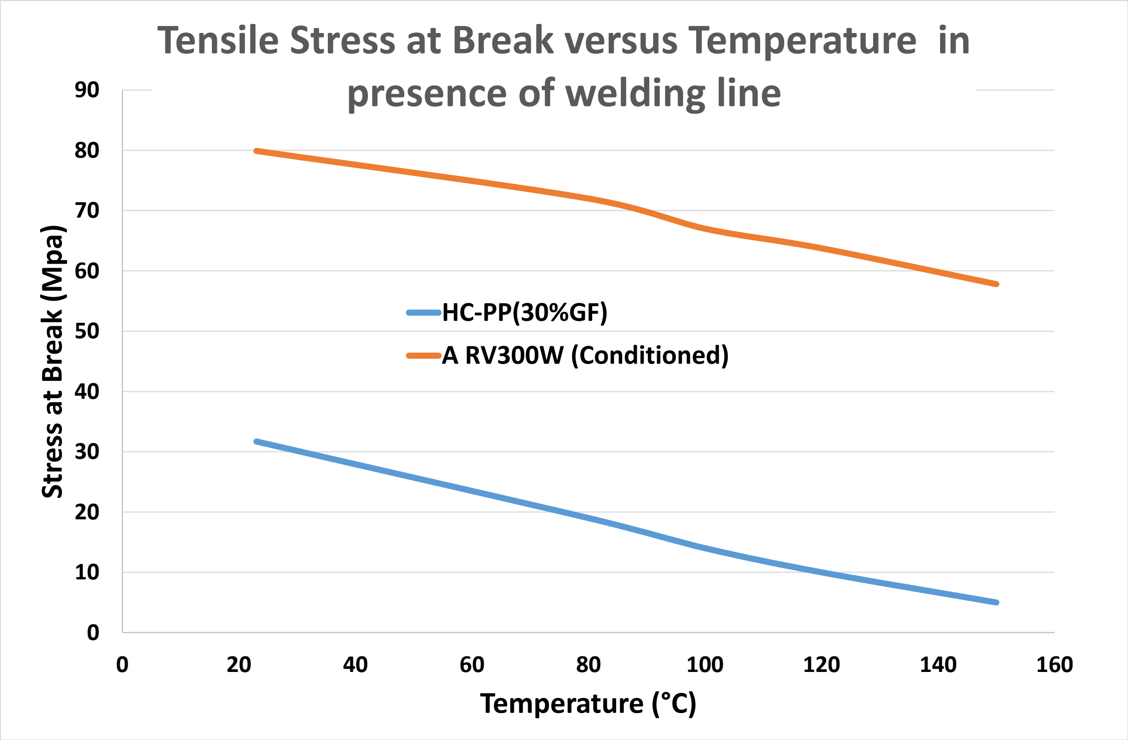


Property comparison

Radilon® A RV300W (PA66-GF30) and high cristallinity PP-GF30

The tensile strength at break of high crystallinity PP-GF30, compared with that of Radilon® A RV300W (PA66-GF30) decreases rapidly with increasing temperature (left graph).
This behavior is strongly accentuated in the presence of welding lines (right graph).





Electrical properties

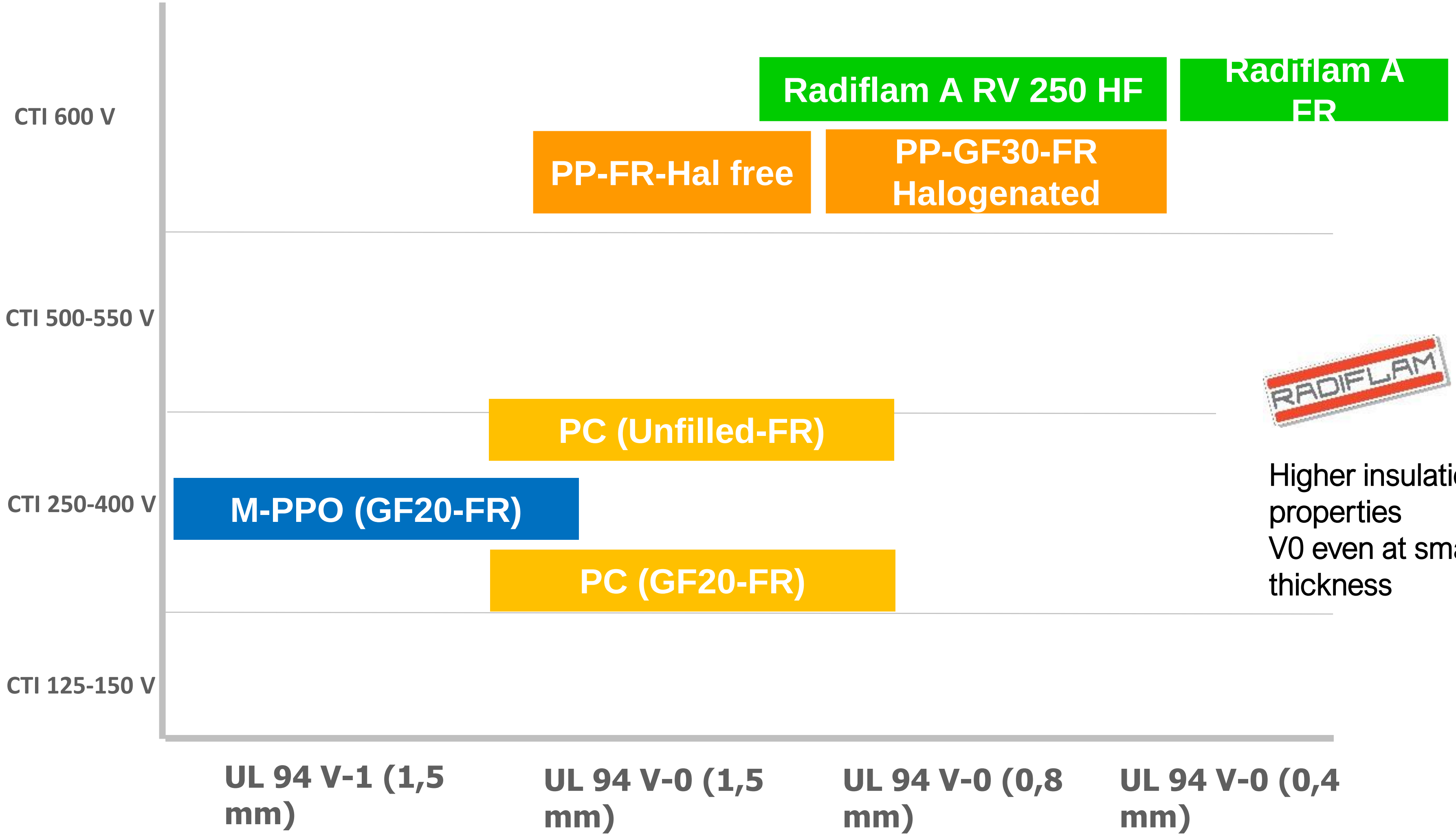
Flame retardancy and CTI
PA vs PP and amorphous materials

› Polyamide based materials, both filled and unfilled, are easily modified to obtain flame retardant products.

› PP-based products need a greater quantity of flame retardant additives with particularly negative consequences on mechanical properties.

› The highly viscous amorphous materials (PC, PC-ABS, M-PPO) are not easy to modify with FR additives and are critical especially in the presence of limited thicknesses.

Flame retardancy and CTI



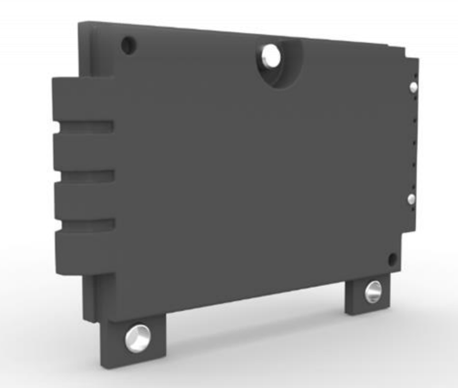
Higher insulation properties
V0 even at small thickness

Application examples
Traction Battery System

Cell management controller housing

Main requirements :
Good insulation and flame retardant properties
Part planarity
Easy molding
Chemical resistance (battery electrolytes, LV124)

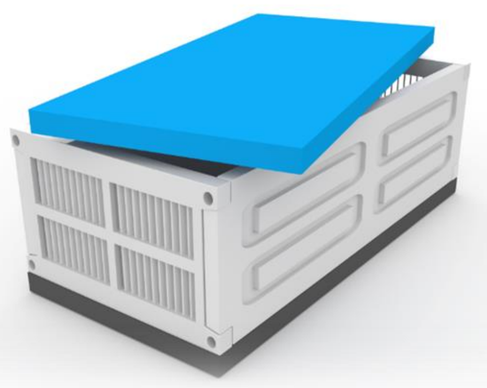
Material:
Radiflam® A RV250AF, PA66-GF25, FR (52+72) UL-V0 at 0.8 mm, CTI=400



Battery module cover

Main requirements :
Flame retardant
Part planarity
Easy molding
Chemical resistance (battery electrolytes, LV124)

Material:
Radiflam® A RV250HF, PA66-GF25, FR (40) UL-V0 at 0.8 mm, CTI=600

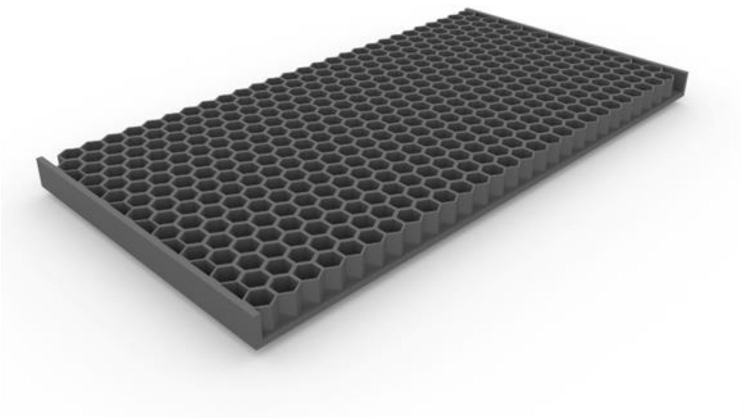


Application examples
Traction Battery System

Battery carrier

Main requirements :
Good insulation and flame retardant properties
Part planarity
Creep resistance
Easy molding
Chemical resistance (battery electrolytes, LV124)

Materials:
Radiflam® A FR, PA66, FR (30), UL-V0 at 0.8 mm, CTI=600
Radiflam® A RV250HF, PA66-GF25, FR (40), UL-V0 at 0.8 mm, CTI=600



Pouch cell frame

Main requirements :
Flame retardant
Dimensional tolerances
High stress
Chemical resistance (battery electrolytes, LV124)

Material:
Radiflam® A RV350HF, PA66-GF35, FR (40), UL-V0 at 0.8 mm, CTI=600

Application examples
Charging System

RADICI GROUP

E-charger plug - EV recharge socket

Main requirements :

FR grades , GWIT 775°C, Halogen&Red phosphorous free

Excellent Insulation properties (CTI up to 600V and more for fast charging)

UL746C f1 Ultraviolet Light Exposure, Water Exposure and Immersion in accordance with UL 746C)

Resistant to cooling fluids (high power (fast) charging (HPC) only)

Materials:

Radilon® S ERV70T, GF filled PA6, UL-V2, UV resistant, many colours

Radiflam® A RV250HF, 25% GF PA66, FR (40)

Application examples
Connectivity System

Connectors

Main requirements :

Stability of the orange colour

Excellent insulation properties (CTI 600V)

Excellent dielectric strength vs temperature (> 10 kV at 150 °C)

Flame retardancy UL-94 at 0,4 mm

Excellent fluidity for thin parts

Laser marking

Halide free to prevent circuit corrosion

Application examples
Connectivity System

Connectors

Materials:

Radiflam® A FR, PA66, FR (30)
Radiflam® S FR, PA6, FR(30)

Radiflam® Aestus T2 RV300HF, PPA-GF30, FR (40)

Raditer® B ERV300TKB, special products PBT's based. Improved hydrolysis resistance

Radilon® A RV350KN, PA66-GF35, electrically "neutral"
Radilon® S RV300KN, PA6-GF30, electrically "neutral"
Radilon® S RV400KN, PA6-GF40, electrically "neutral"

Radiflam® A RV300HF, PA66-GF30, FR (40), orange colour RAL 2003
Radiflam® A FR, PA66, FR (30), orange colour RAL 2003

Application examples
Power electronic

Power electronic components

Main requirements :

Excellent electrical insulation properties (CTI 600V) retention
Excellent dielectric strength vs temperature (> 10 kV at 150 °C)
Flame retardancy UL-94 at 0,4 mm
Thermal Conductivity to safeguard the integrity of the electrical and electronic components in case of excessive temperature rise
EMI shielding
Good mechanical properties
Low/zero halide content

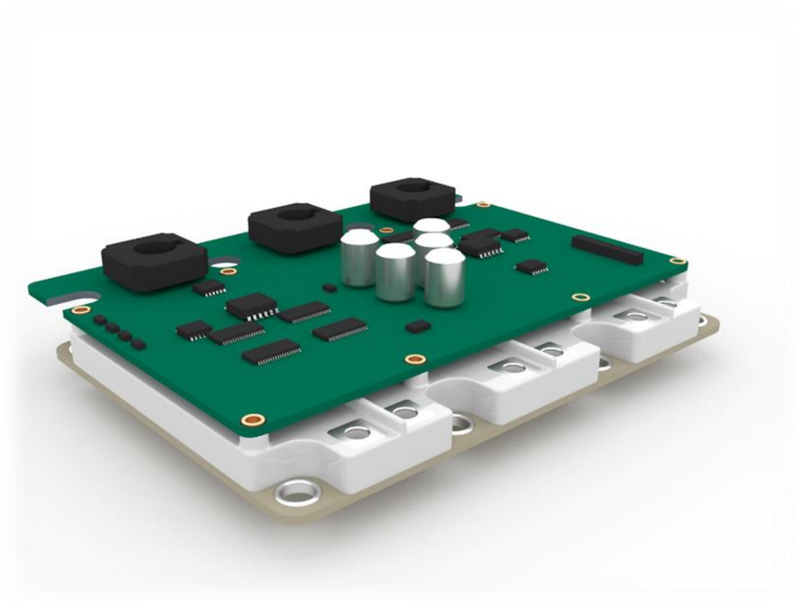
Materials:

Radiflam® A RV300HF, PA66-GF30, FR (40)

Radiflam® S RV300HF, PA6-GF30, FR (40)

Radiflam® S RV100FR, PA6-GF10, FR (61+72), thermally conductive, low smoke density and toxicity

Radiflam® Aestus T2 RV300HF, PPA-GF30, FR (40)



IGBT base (Radiflam® A RV300HF)

Application examples
Thermal management

Cooling pipes quick connectors - cooling pipes

Main requirements :
Hydrolysis resistance
Excellent chemical resistance
Resistance to road salts
Good mechanical strength (pressure resistance)

Materials (extrusion):
Radilon® DT LX19067, PA612, flexible, improved hydrolysis resistance. T max = 125°C
Radilon® DT 40E50USR, PA612, flexible

Materials (injection molding)
Radilon® A RV300RG, PA66-GF30, hydrolysis resistant

Radilon® D RV300RG, PA610-GF30, excellent hydrolysis resistant, good dimensional stability

Radilon® Aestus T1 RV330RG, PPA-GF30,superior hydrolysis resistant, good dimensional stability

Raditeck® P RV400K, PPS-GF40, superior hydrolysis resistance, exceptional chemical resistance, inherently flame retardant, superior dimensional stability

Cooling pipes quick connectors (Radilon® A RV300RG)

Cooling pipes (Radilon® DT 40E50USR)

Advanced solutions with innovative composites

Battery housing & cover

Main requirements :
Superior impact resistance
High stiffness
High strength at break
EMI shielding
Chemical resistance versus battery electrolytes, oil, cooling liquids, etc

Innovative solution under evaluation with special composite prepregs

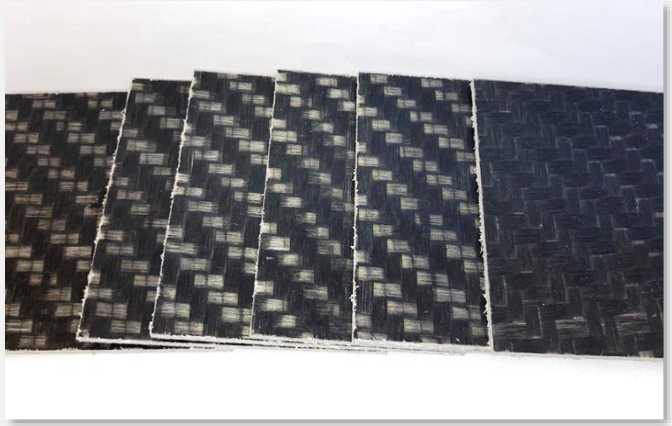
Thermoplastic Composites
RadiciGroup Innovation & Research | Scouting project

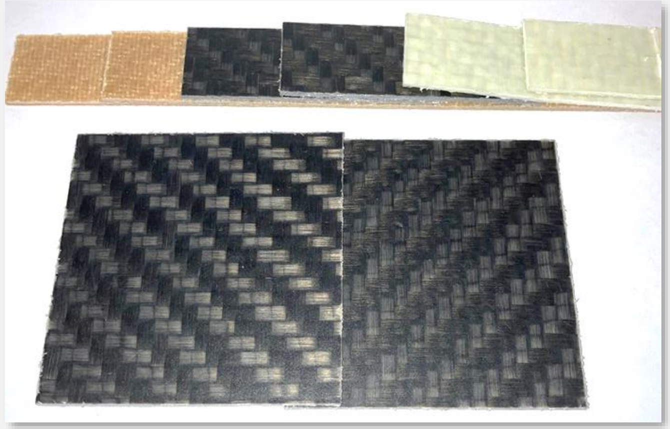
Innovative composite prepregs

Consolidated semi-finished laminates based on polyamide matrix and woven fabrics, suitable for thermoforming and back-injection processes.

Fibers for the woven fabrics are chosen between:

- **Glass** for high stiffness and strength
- **Specialty fibers** for improved impact resistance and weight saving
- **Hybrid** fibers combining the advantages of both GF and specialty fibers





Samples from preliminary impregnation/consolidation production process

Advanced Lightweight solutions

High Performance Thermoplastics + Continuous Fiber Reinforcements (UD and woven solutions)

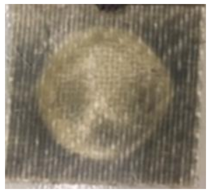
Drop weight impact

Sandwich structure with cross ply using GF UD tapes
Core: Radistrong® A RV500W

Sandwich structure with specialty fibers reinforced laminates
Core: Radistrong® A RV500W

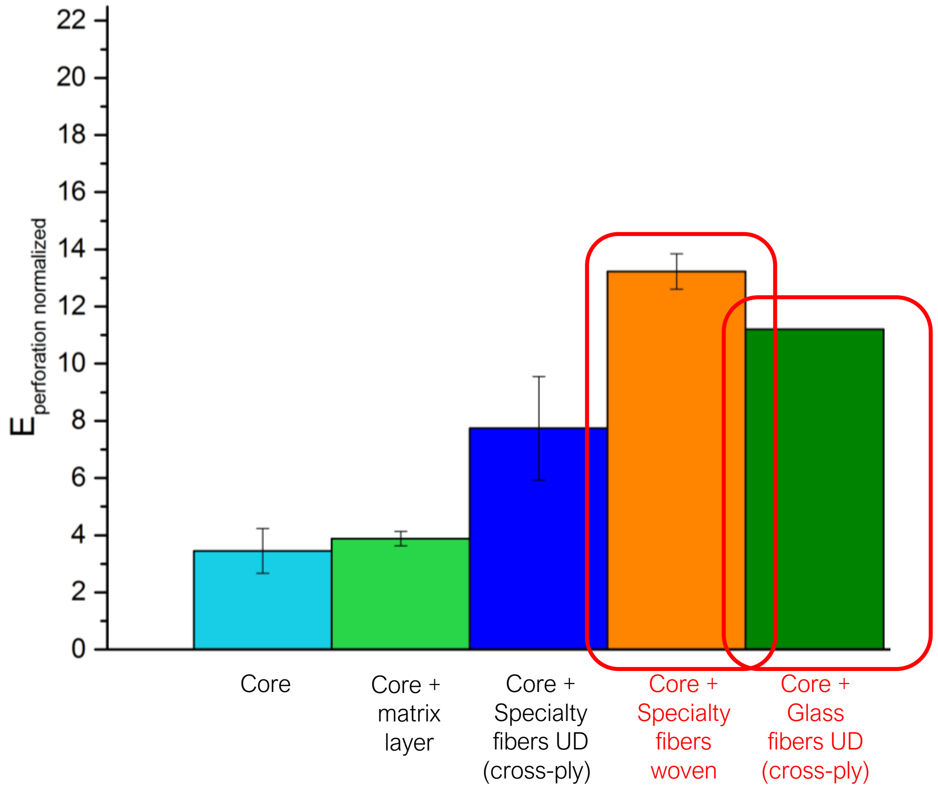
Impact energy for fracture is significantly improved with specialty fibers and glass fibers.

Core only :
BRITTLE BEHAVIOUR



Sandwich structure
(specialty fibers woven):
NO PARTS SHUTTERING

Sandwich structure:
(glass fibers UD)
NO PARTS SHUTTERING



Key takeaways

The evolution of the electric car towards a battery system with higher power density and greater autonomy requires materials with high and multiple characteristics.

Durability, reliability & components safety are non-negotiable features.

Polyamides, thanks to their good mechanical and durability characteristics, are suitable for extensive use in electric cars. Polyamides, unlike amorphous polymers and PP, are particularly suitable for being modified with additives capable of conferring properties such as flame resistance.

The severe technical performance required by electric mobility may require the introduction of multifunctional materials with specific characteristics (tailor made solutions).

For this reason, RadiciGroup High Performance Polymers makes available to its customers and partners all the necessary resources to face these new challenges together.

HIGH PERFORMANCE POLYMERS

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Auto sector: new polyamides for use at high temperatures

Davide Roncato

Marketing & Application Account Manager

HIGH PERFORMANCE POLYMERS

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

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- RadiciGroup's offer for high temperature applications
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  - Torzen® Marathon
- Radilon® S LX20076 – PA6-GF35 HT
  - Mechanical and thermal properties
  - Mechanical properties after thermal ageing at 170°C
  - Mechanical properties after thermal ageing at 190°C
  - Comparison vs other materials
  - Strengths & weaknesses
  - Other peculiarities
- Conclusion

Automotive trends

- Electrification
- Engine downsizing
- Turbocharging
- Thermal management for ICE, hybrid vehicle and BEV

- Increase air temperature
- Higher chemical resistance
- Integrated cooling system (WCAC)
- Auxiliary heat exchanger for electric systems

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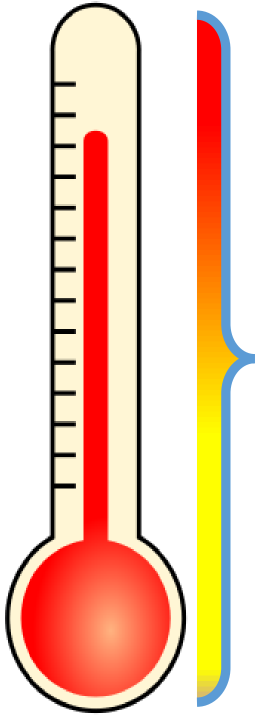
RadiciGroup’s offer for high temperature applications



230°C	Radilon® NeXTreme
210°C	Radilon® A RV…HHR (HT PA66-GF)
190°C	Torzen® Marathon G….XHL (HT PA66-GF)
180°C	Radilon® S LX20074 (HT PA6-GF) **NEW**
160°C	Radilon® A RV…W 333BK (PA66-GF HS)
120°C	Radilon® S RV…W 333BK (PA6-GF HS)

Radilon® NeXTreme: CUT up to 230 °C

- Radilon® NeXtreme

  PA based, contains a semi-aromatic component that, in combination with the additives used against thermo-oxidation, further raises the continuous service temperature. This product line represents the higher level of thermal protection.

Key features

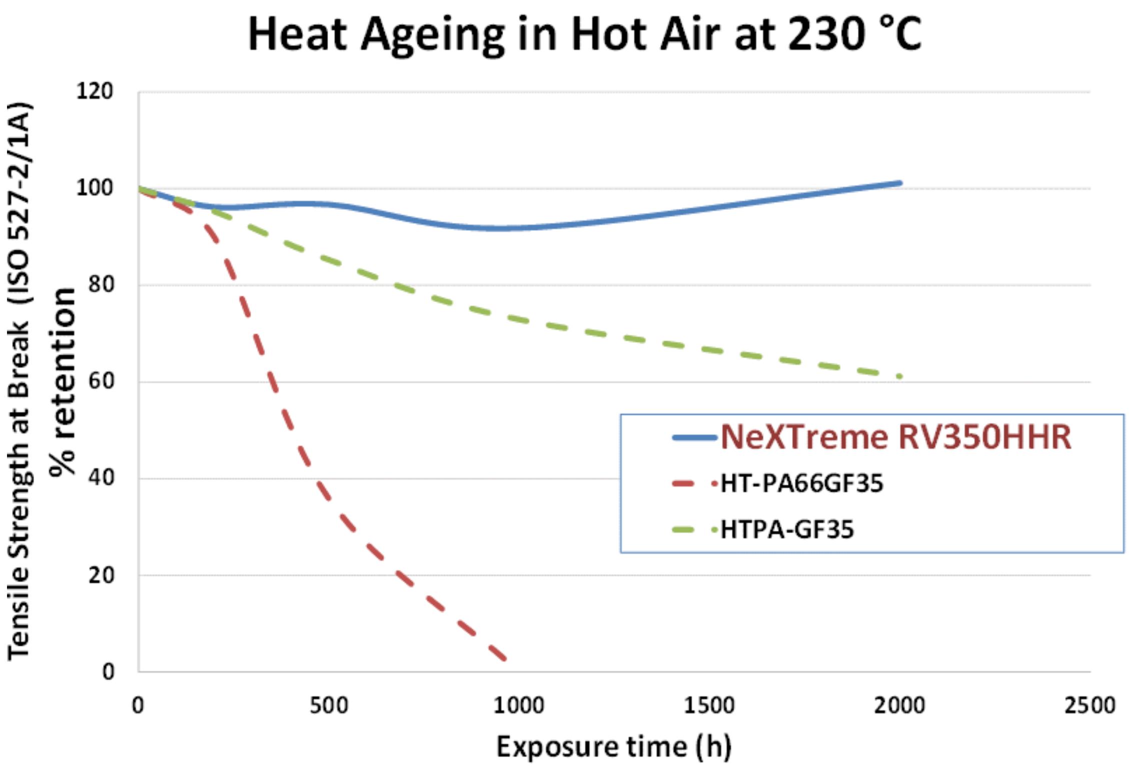
- Excellent properties retention up to 230 °C in contact with hot air
- Improved chemical resistance
- Lower moisture absorption versus PA66
- Easy moulding

Radilon® NeXTreme RV350HHR

Exposure at 230°C :

› After 2000 hrs the value of tensile strength at break remains unchanged.

› The special high temperature polyamide used as a benchmark shows instead a reduction of about 40%.



Radilon® HHR: CUT up to 210 °C

- Radilon® HHR (High Heat Resistant) :

  PA66 based, a blend of special additives has been incorporated to limit the thermal oxidative process

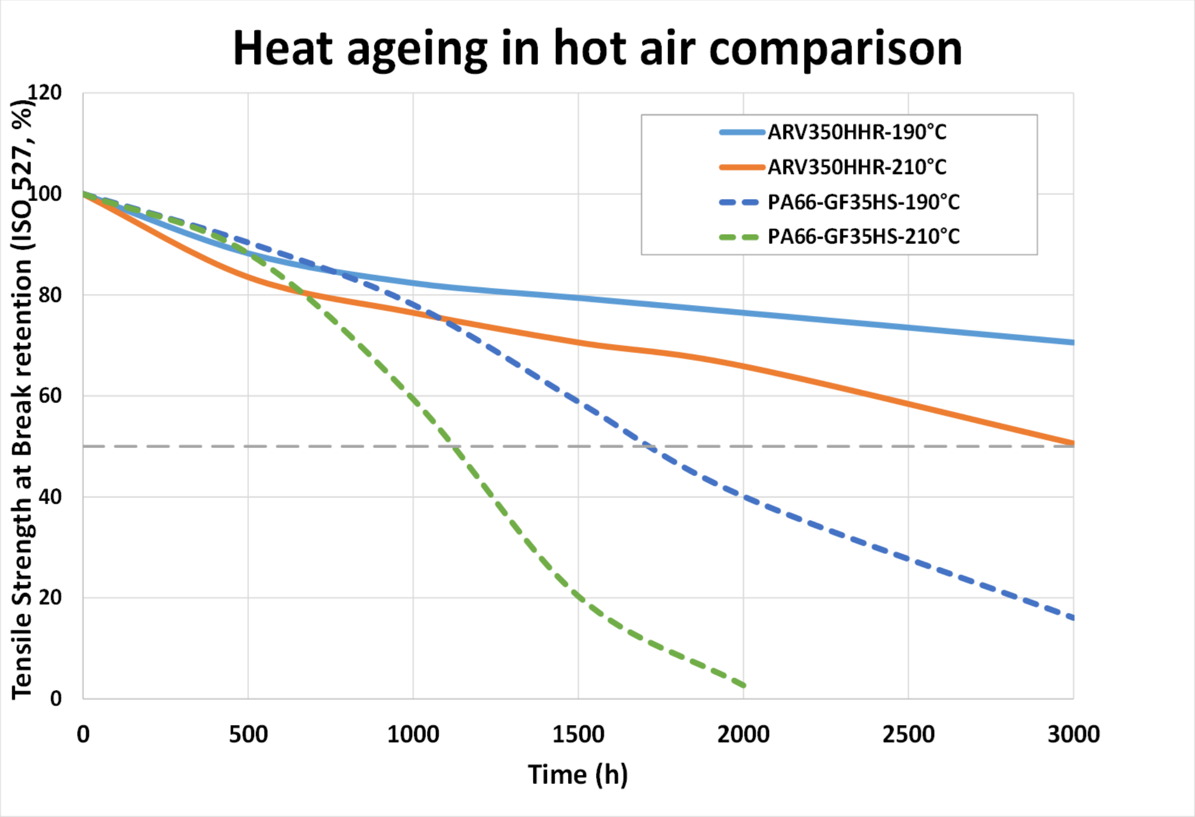
Key features

- Excellent properties retention up to 210 °C in contact with hot air
- Excellent welding line resistance

Radilon® A RV350HHR

Exposure at 210°C and 190°C :

- After 3000 hrs @ 190°C and 210°C the value of tensile strength reach the target of 50% of retention.
- Standard heat stabilized PA66-GF35 shows a strong degradation at both temperature and the residual tensile strength is close to zero



Serial application: Turbo Resonator

Torzen® Marathon: CUT up to 190 °C

› Torzen® Marathon :

PA66 based, improved thermal ageing resistance versus standard PA66 through the use of special additives capable of slowing the degradation process at high temperature in the presence of oxygen

Key features

› Excellent properties retention up to 190 °C in contact with hot air

› Easy flow grade, high productivity

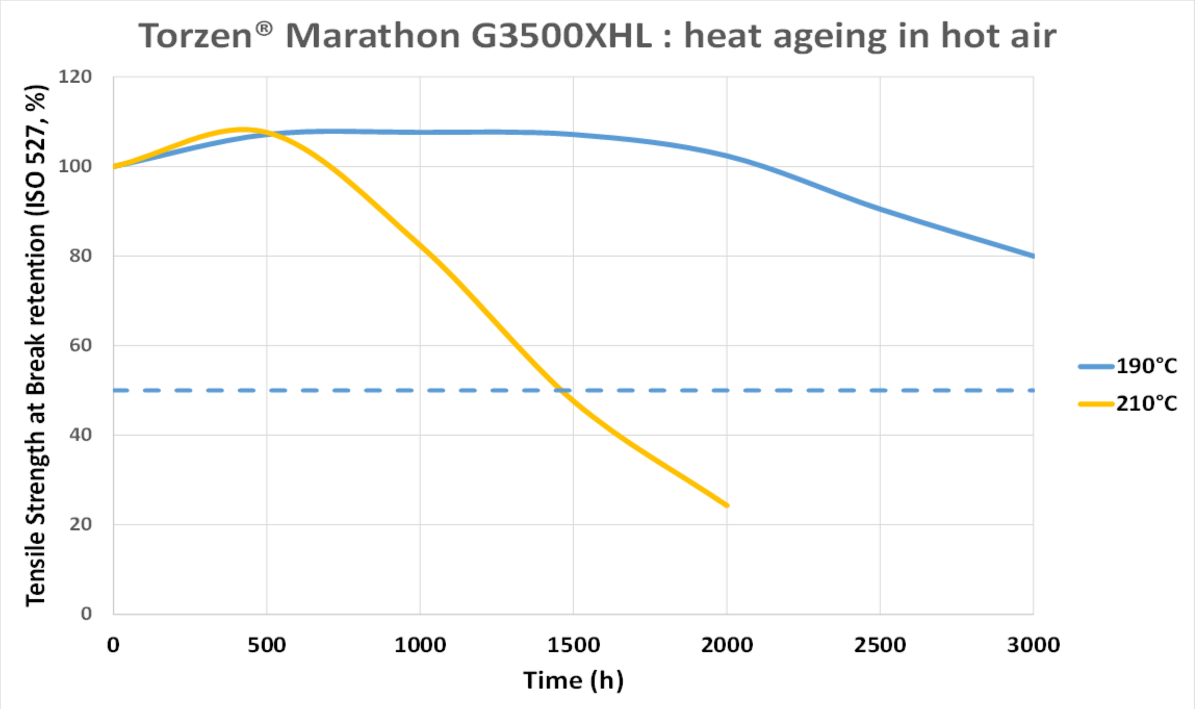
› Excellent welding line resistance

› Electrical neutral

Torzen® Marathon G3500XHL

Exposure at 190°C :

- After 3000 hrs @190°C the value of tensile strength at break remains abundantly above 50%



Serial application: Charge Air Cooler
Torzen® Marathon G3500XHL

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Radilon® S LX20076 – PA6-GF HT

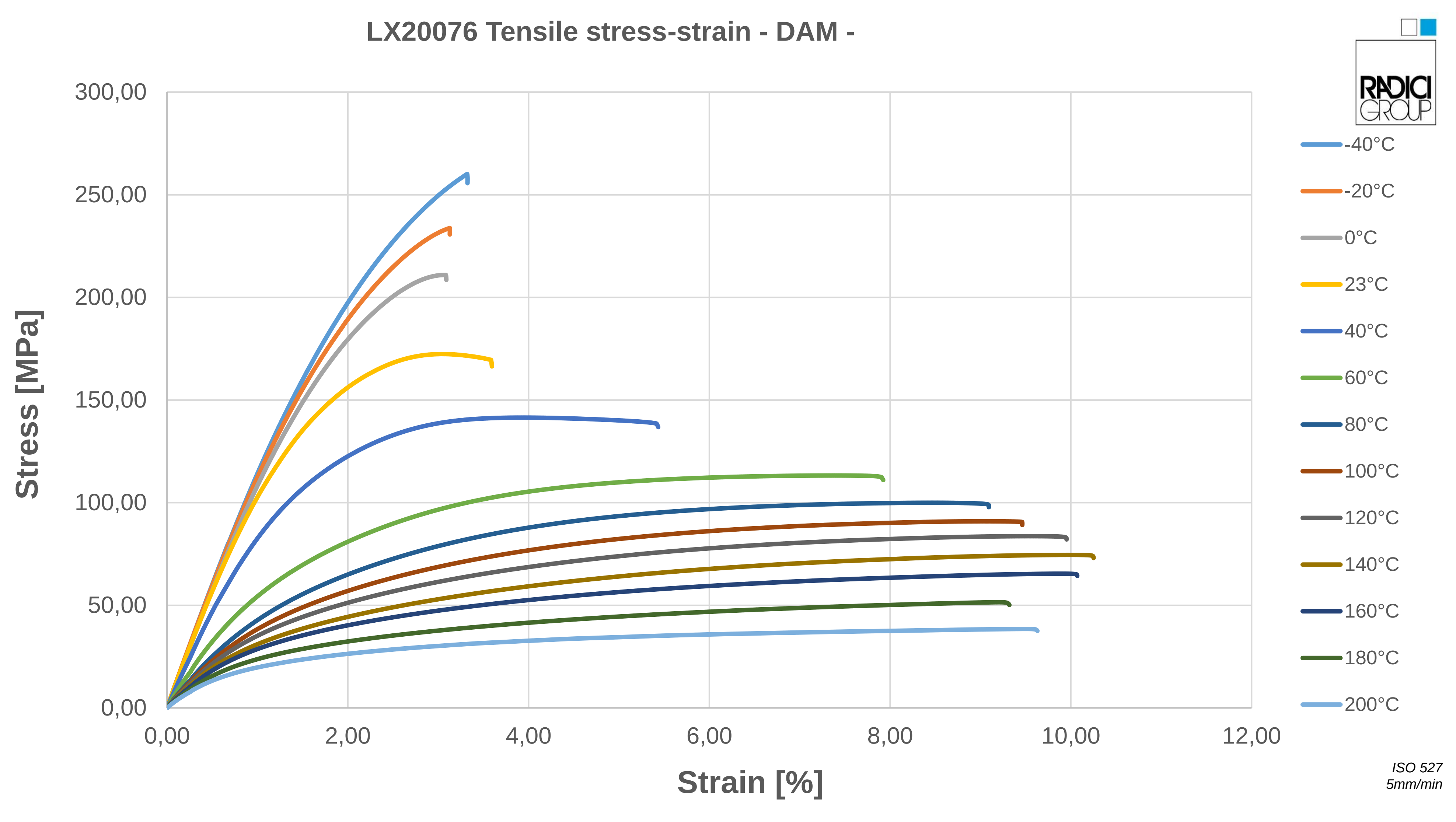
Why PA6-GF for high cut?

Give a new opportunity for high temperature applications avoiding the use of over-engineered materials in the range temperature of 160°c to 180°c

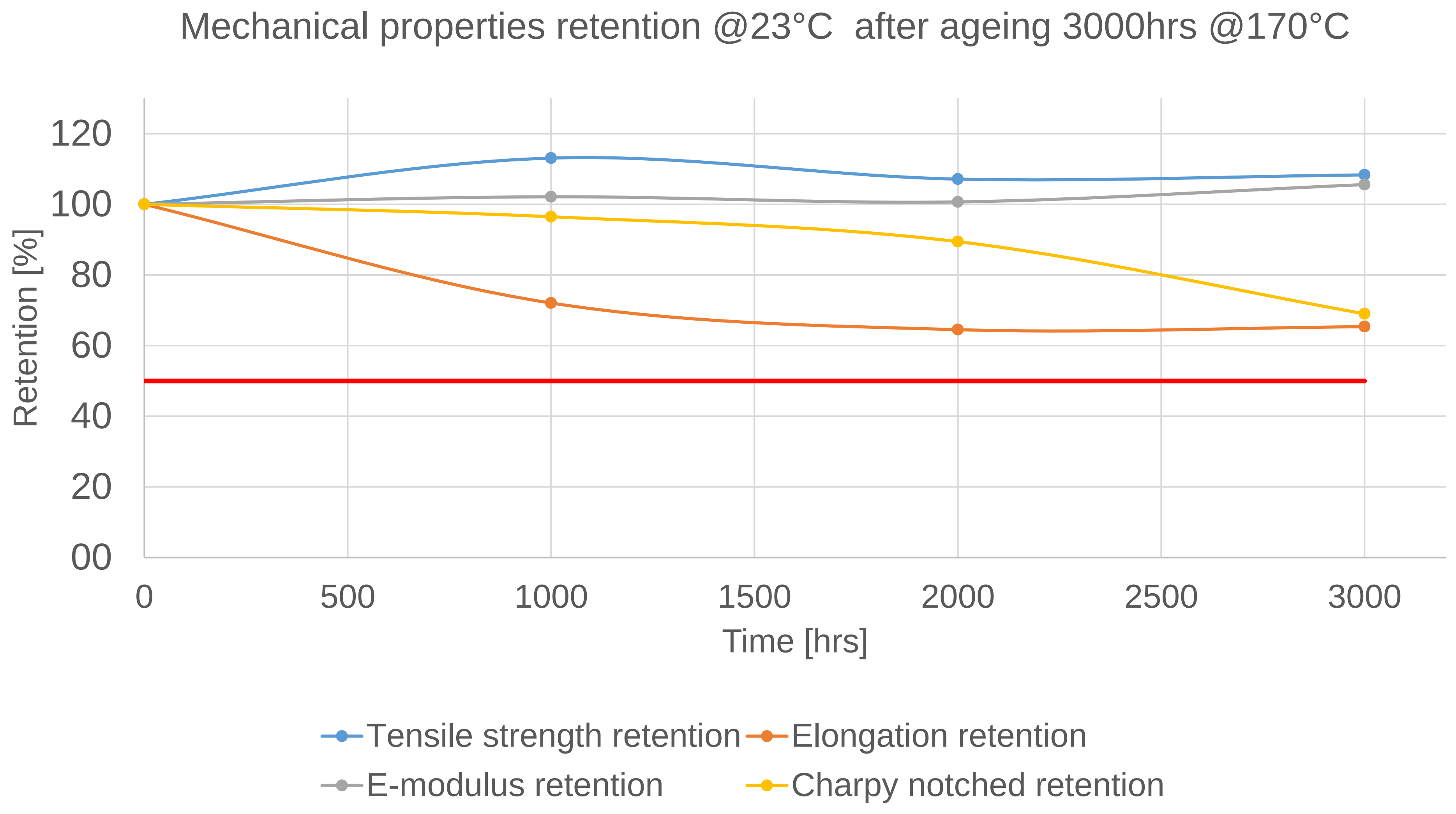
Radilon® S LX20076 - Mechanical and thermal properties

Radilon® S LX20076 (PA6-GF35)			
		DAM	COND
Properties	Unit		
HDT @1,80MPa	°C	200	
Density	g/cm3	1,405	
Melting temperature	°C	216	
Charpy notched @23°C	KJ/m2	14,2	20,8
Charpy notched @-30°C	KJ/m2	10,1	15,9
Charpy unnotched @23°C	KJ/m2	89,5	99,9
Charpy unnotched @-30°C	KJ/m2	68,5	90,5
Tensile modulus	MPa	11720	7310
Tensile strenght	MPa	168	111
Tensile elongation	%	3,58	7,76
Flexural modulus	MPa	9180	6405
Flex Strenght	MPa	265	155

Radilon® S LX20076
Tensile curves different temperature

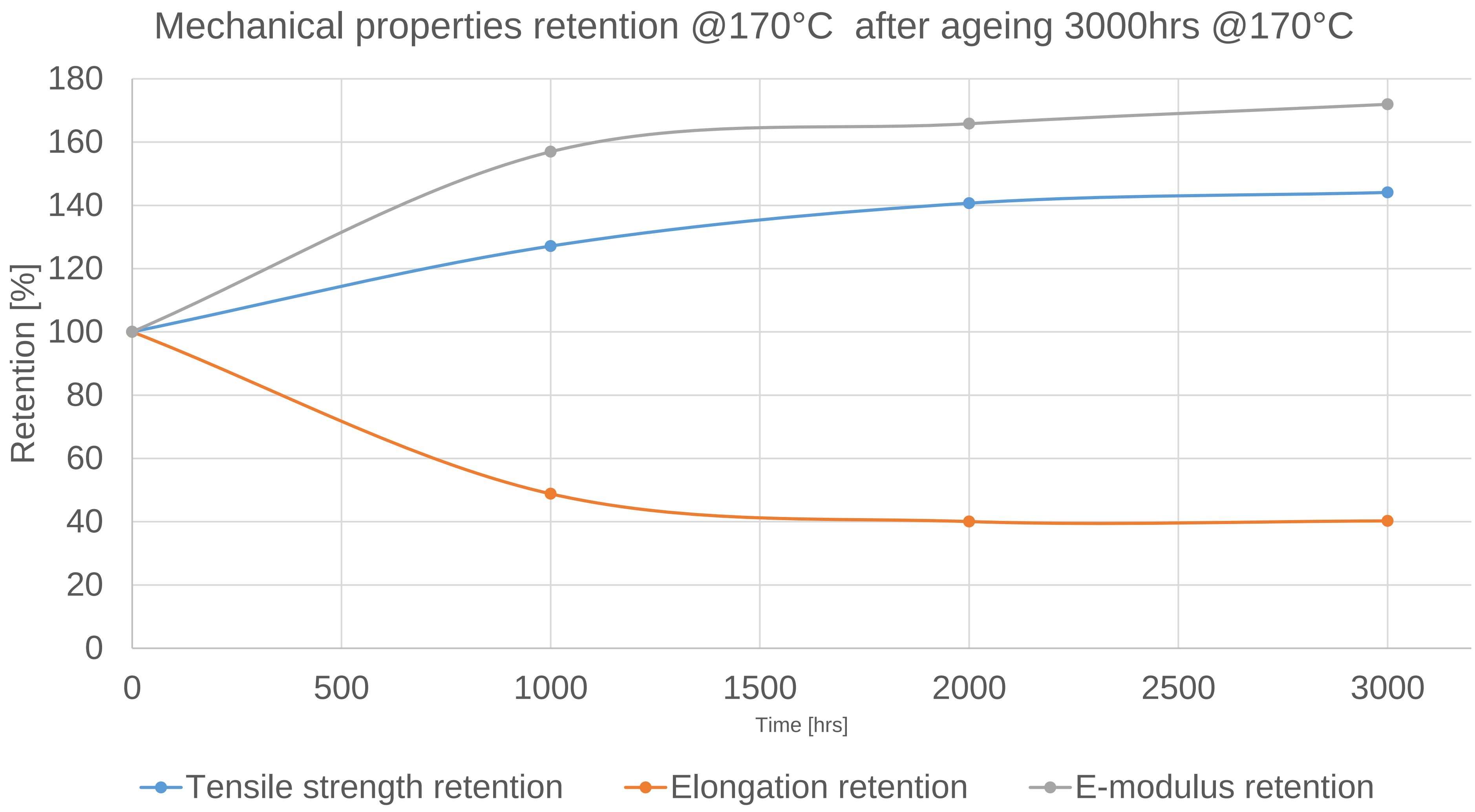


Radilon® S LX20076
Mechanical properties after ageing @170°C



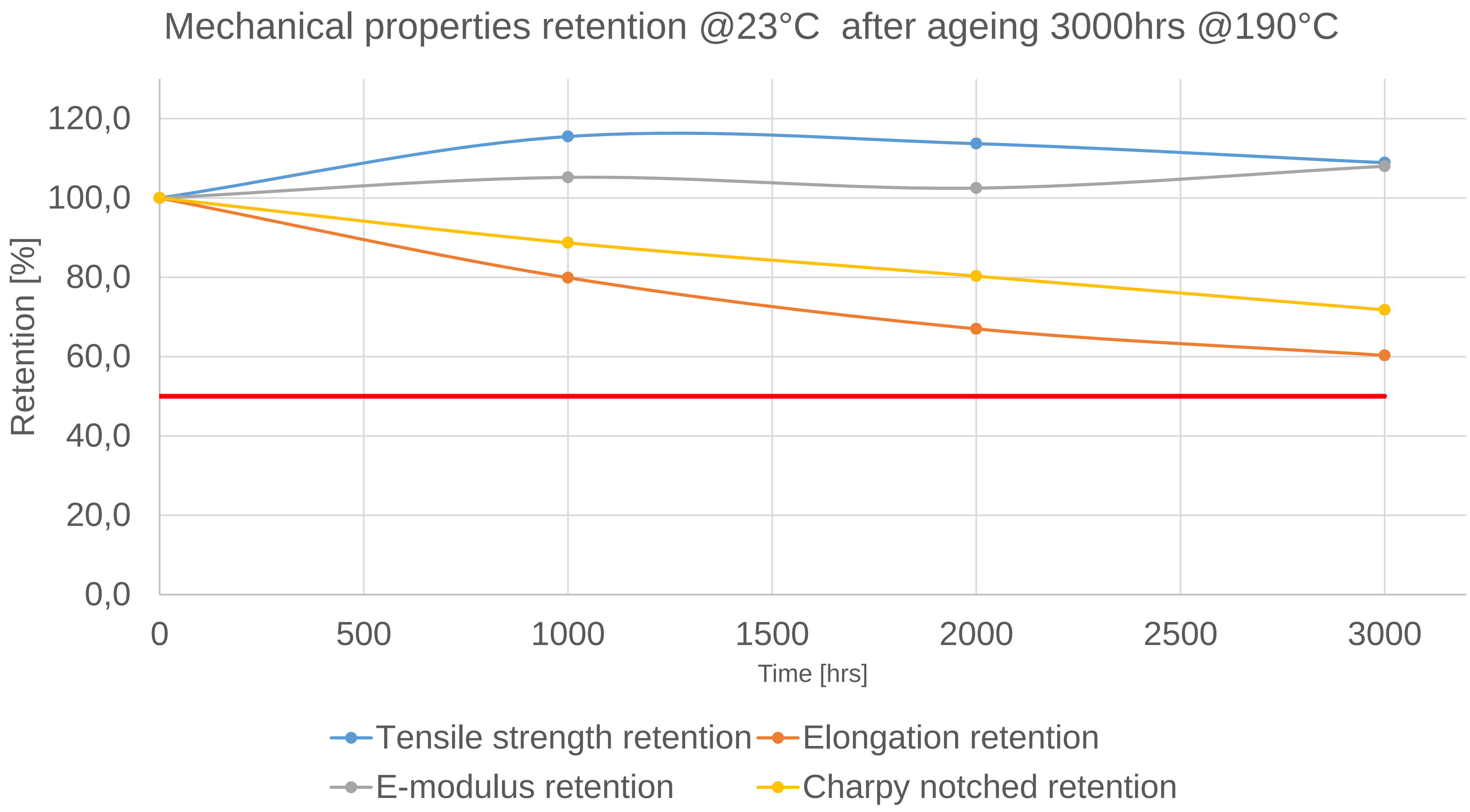
After thermal ageing all the mechanical properties are above the limit of 50%

Radilon® S LX20076
Mechanical properties after ageing @ 170°C



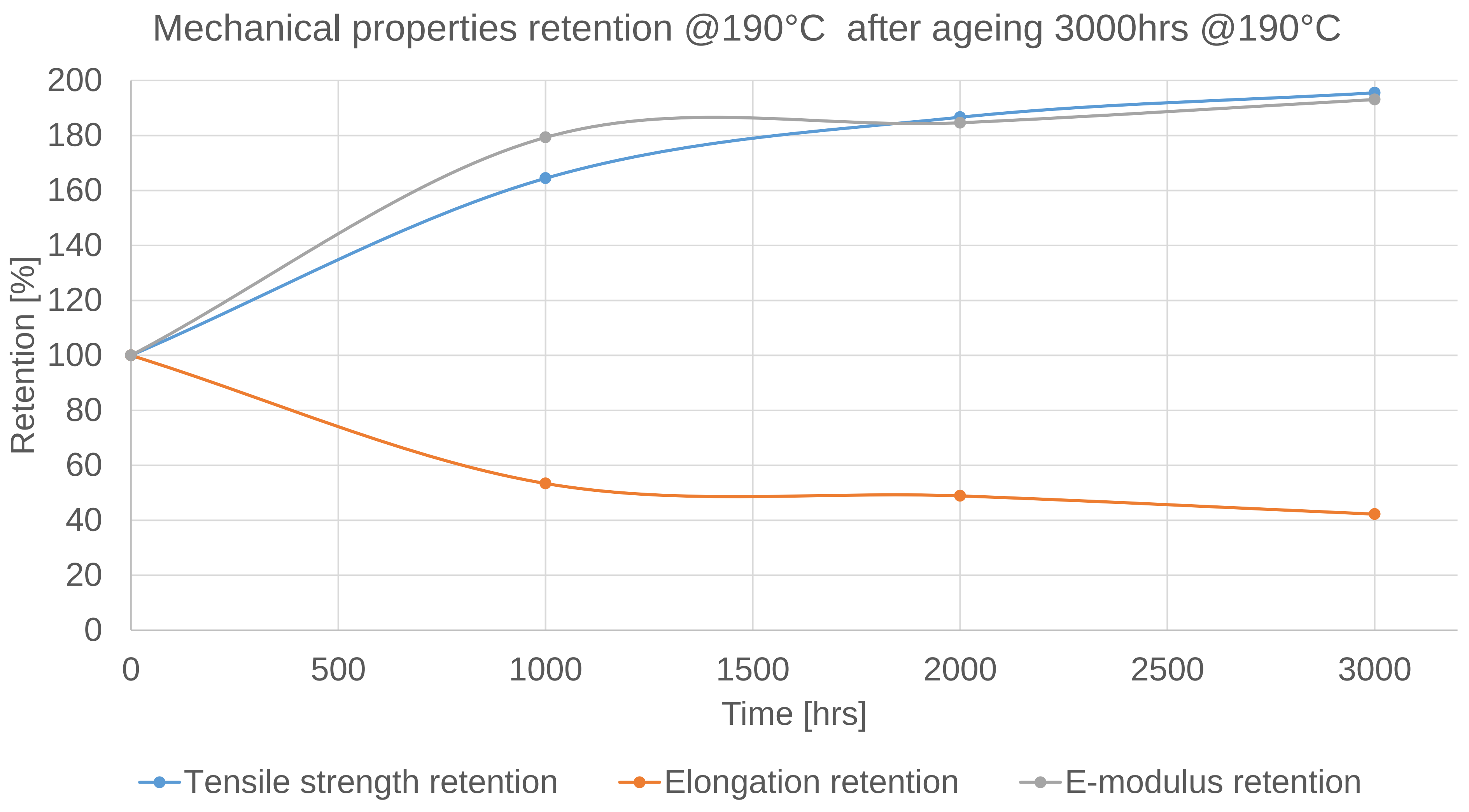
The mechanical properties in temperature after ageing show very high retention performances

Radilon® S LX20076
Mechanical properties after ageing @ 190°C



After thermal ageing all the mechanical properties are above the limit of 50%

Radilon® S LX20076 - Mechanical properties after ageing @ 190°C



The mechanical properties in temperature after ageing show very high retention perfomances

Radilon® S LX20076 - Comparison vs other materials

Radilon® S LX20076 - strenghts & weaknesses

	Radilon® S LX20076 VS PA6-GF HS	Radilon® S LX70076 VS PA66-GF HT
Mechanical performances	=	- (possible solution add GF)
Mechanical performances in temperature after ageing	+	- (possible solution add GF)
Resistance to temperature	++	+
Creep	=	-
Fatigue	=	-
Processability	=	+
Weldability	=	=

Radilon® S LX20076 - Other peculiarities

- Electrical neutral → suitable for applications in e-vehicles
- Colourable → orange for high voltage applications in e-vehicles
- DPPD free → health safety
- Very low powder formation on surface after thermal ageing in hot air

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Conclusion

- RadiciGroup can offer a complete range of materials suitable for high temperature applications
- Each grade has its peculiarity in terms of maximun CUT
- The new grade Radilon® S LX20076 has shown higher temperature resistance than PA66-GF HT (up to 190°C) – max operating temperature suggested 180 – 185°C
- The mechanical weaknesses of Radilon® S LX20076 can be improved, if necessary, adding glass fiber and/or improving the component design
- Radilon® S LX20076 with its mechanical, thermal and physical properties is ready to be used in all type of Vehicles (ICE, HYBRID, BEV)

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HIGH PERFORMANCE POLYMERS

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Effective structural part design optimization

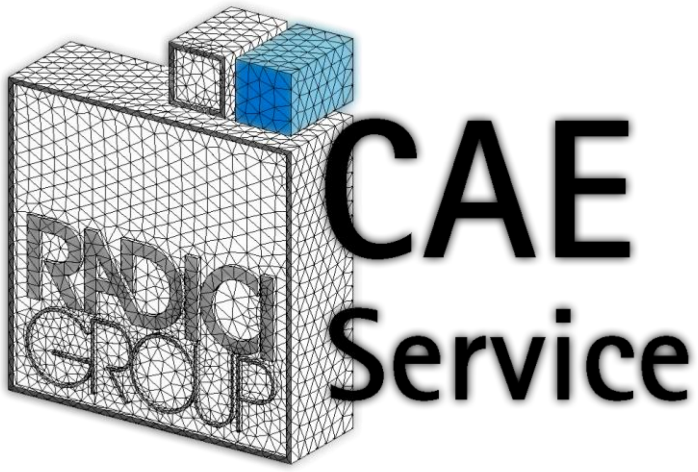
Carlo Grassini

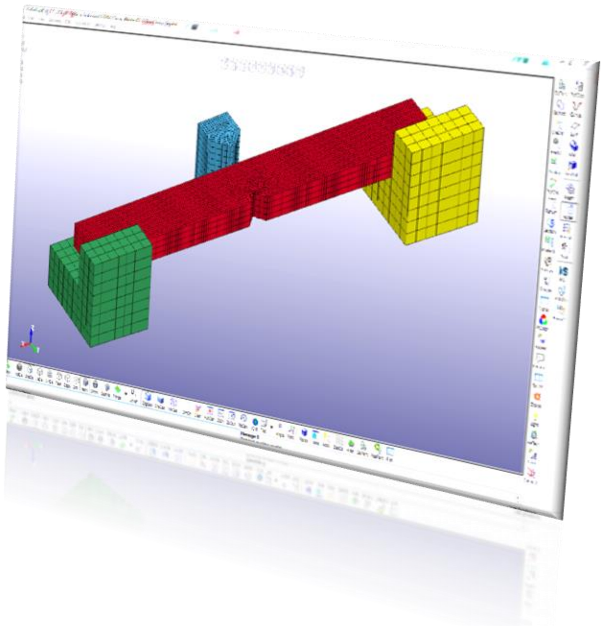
Technical Service & Market Development, CAE Global Team Leader

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

Summary

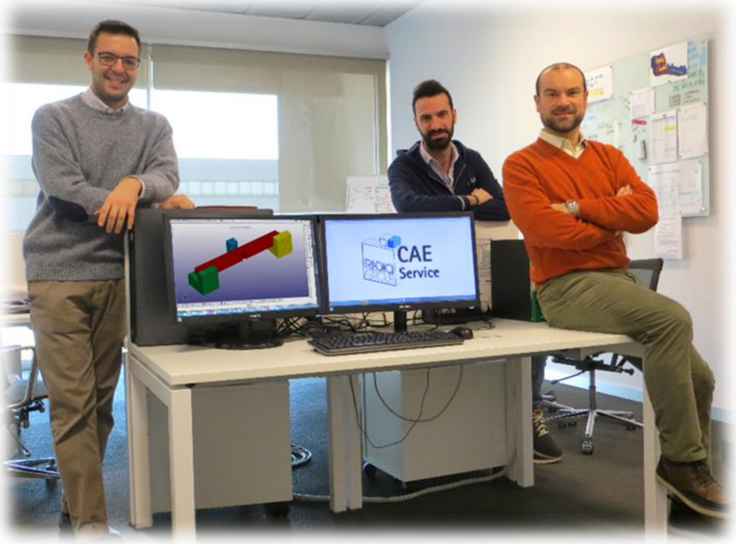
- RadiciGroup HPP as a partner for design
- Metal Replacement, Eco-Design and CAE Service
- Advanced approach to simulations: integrating technology and performance
- Case study: anisotropic modeling of creep/stress relaxation for an automotive safety component





RadiciGroup HPP as a partner for design

- Through its Global ***Marketing and Applications Development*** team and capillary ***Sales Network***, Radici HPP provides **professional support to customers** through **all phases of the design process**:
  - **Concept** phase: proposals and consulting
  - Translation of **Functional Requests** into **Material Properties**
  - Preliminary **Material Selection**
  - Support and consulting for comparative **cost estimation**
  - Support and consulting during **re-design** phase
  - Support with **CAE analysis**, process simulation and structural simulation, with **integrated** approach
  - **Environmental impact**: certified support for material LCA
  - **Technical service** support during prototyping, molding trials, test on final parts



Metal Replacement – Key concept

RADICI GROUP

› Change **MATERIAL**, maintain **FUNCTIONALITY,** gain **ADVANTAGES**

"Metal to **Technopolymer**"

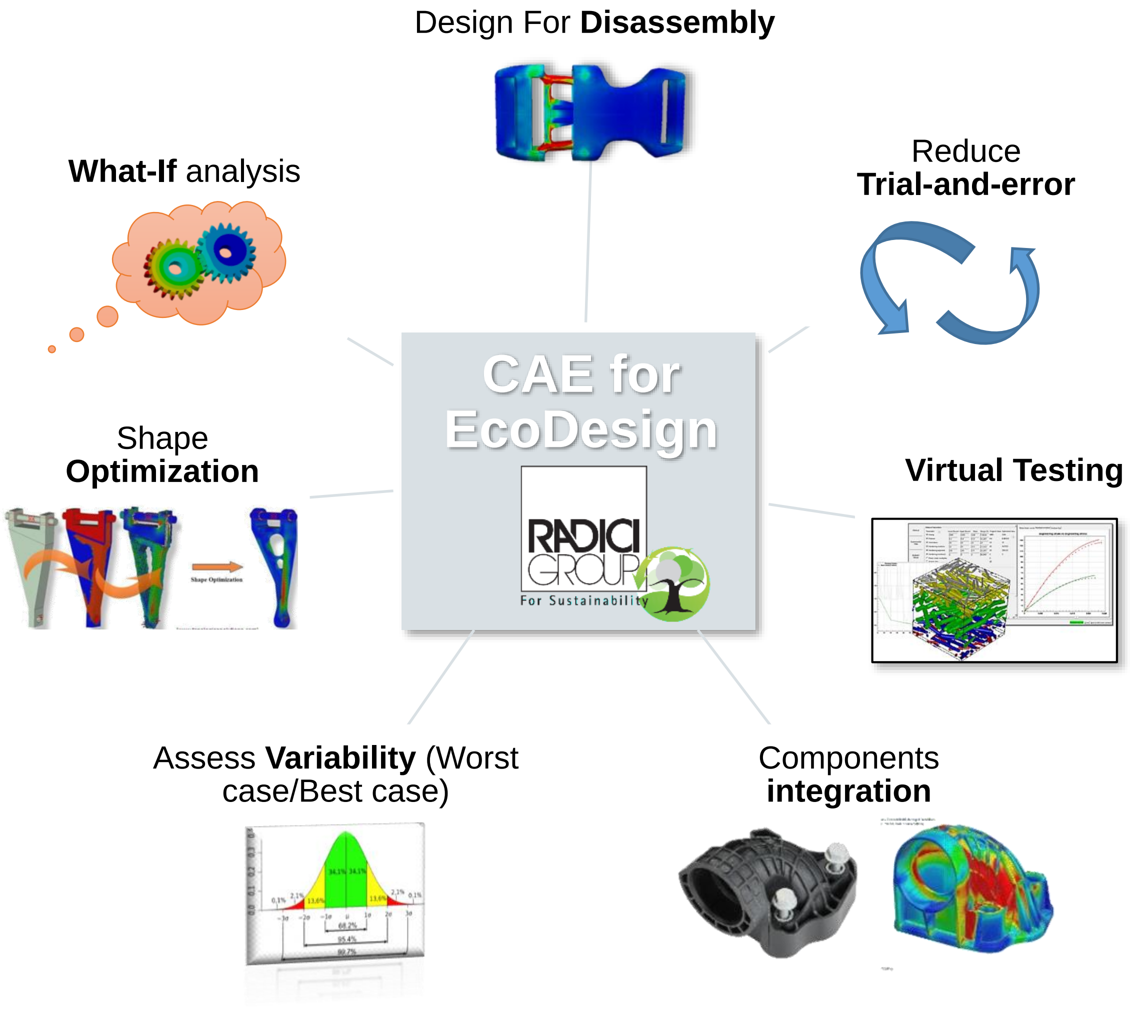
Not a "volume refilling" but a **re-engineering process**!

- ✓ **Weight** reduction
- ✓ Form design **freedom**
- ✓ **Integration** of functions
- ✓ Reduction of **post-manufacturing**
  Aesthetics, color
- ✓ Total **cost** of part (*≠ cost per kg!!!*)

START	Functional analysis	Re-design	CAE validation	Prototyping	Scale-up
Identification of part(s) to be replaced	Identification of part requirements	Integration of functions	**Processability** (Injection Molding)	Rapid prototyping / Soft tooling /…	Definitive tooling
Preliminary cost analysis	Identification of desired material properties	Plastic design (guidelines)	Mechanical performance (**Structural**)	Functional tests on prototypes	Functional tests on pre-series
Definition of targets and goals	Pre-selection of Material and Technology	Design for Manufacturing, for Assembly…	Design Modifications (iterative process)	Validation and finetuning	Validation and production
	Comparative cost analysis				

CAE Service

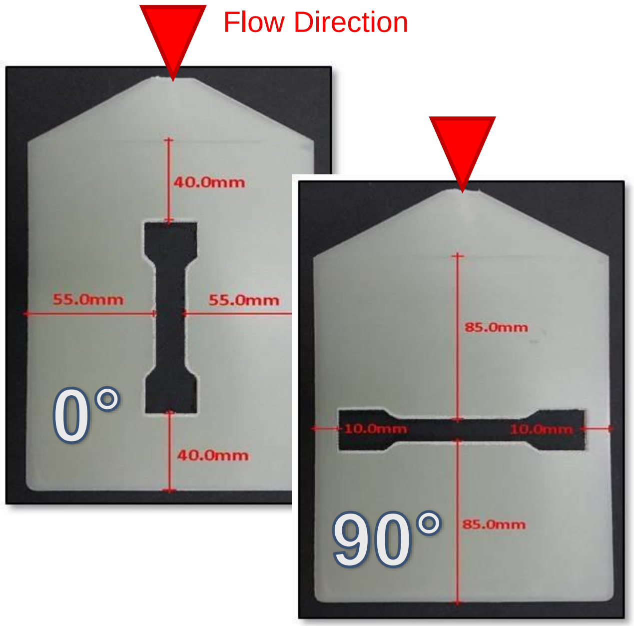
CAE for EcoDesign

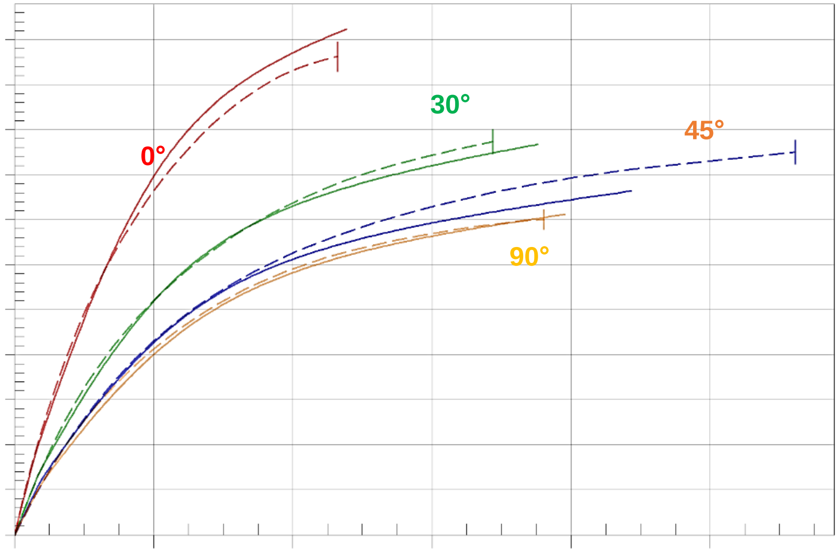


- **Design for Disassembly**: be able to easily dismantle the item at end-of-life, making easy to recover recyclable parts
- **Trial-and-error minimized**, saving time and material for disruptive trials and prototyping
- **Formulation** of new materials made quicker by use of multi-scale **virtual testing**
- Possible to reduce the number of components by **integrating** in few multi-functional parts
- Assessing **variability** which is intrinsic in recycled materials, evaluating best/worst cases
- **Optimize** the shape of items by fully exploiting the potential of materials
- Explore **alternative solutions** (what-if?)

Integrated Approach to Simulation

- **Short Glass Fiber reinforcements** have a <u>significant aspect ratio</u> (>20)
- Mechanical properties of GFRP heavily depend on the **orientation of fibres** with respect to loading direction (anisotropy): **PROPERTIES = f(MICROSTRUCTURE)**

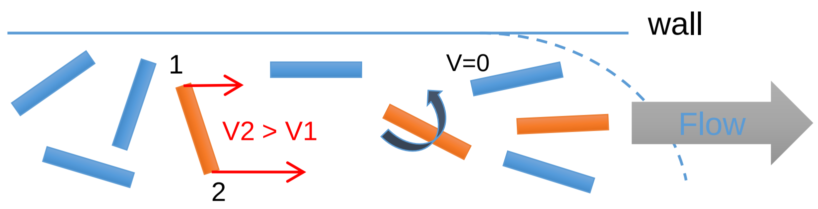




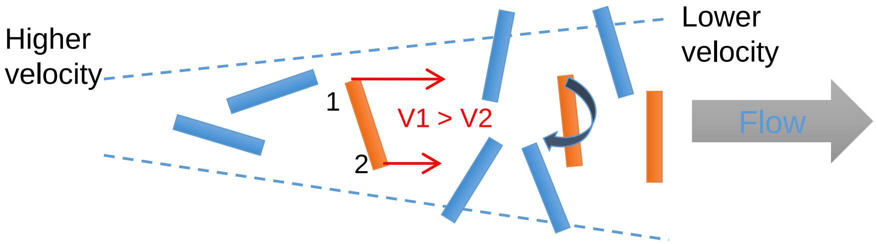
Integrated Approach to Simulation

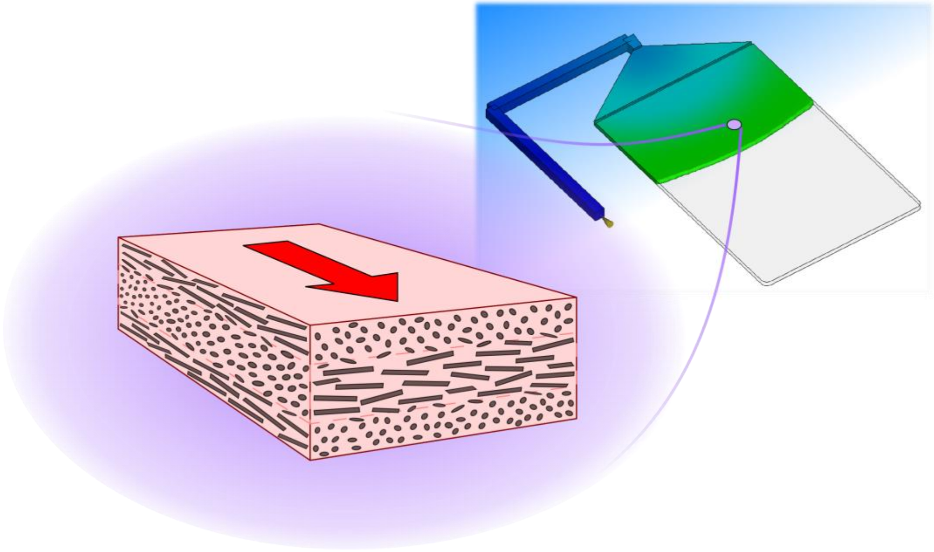
- Such orientation is a consequence of the phenomena which occur during the **mould filling phase**, thus they are related to part's geometry and transformation process: MICROSTRUCTURE = f(PROCESS)
- Therefore PROPERTIES = f(PROCESS)

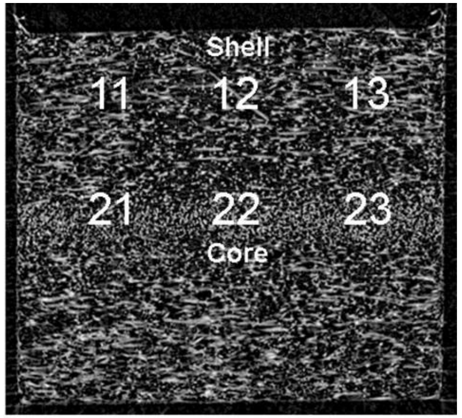
Shear Flow → Fiber // Flow direction

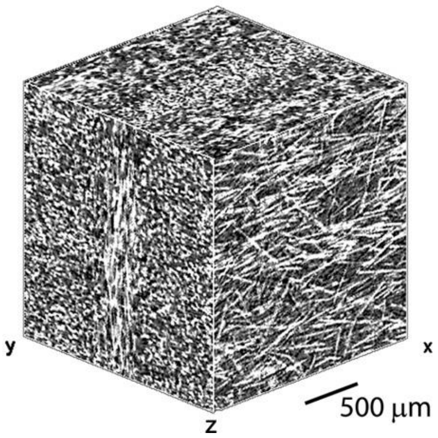


Expansion Flow → Fiber ⊥ Flow direction







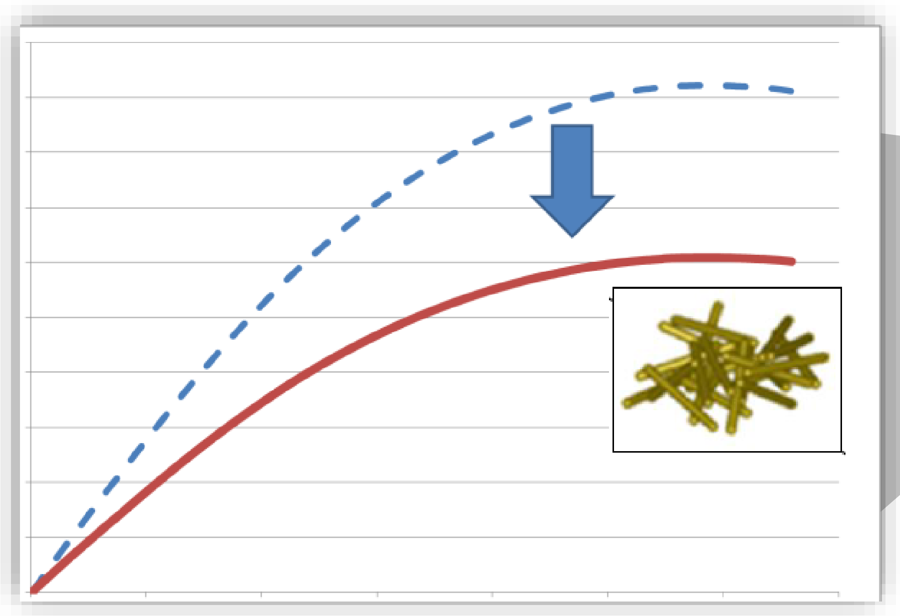


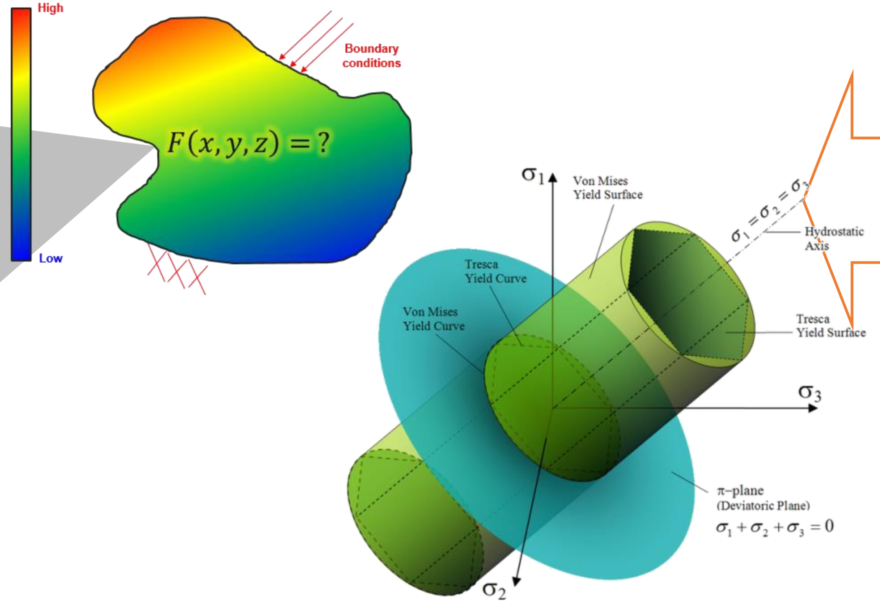
Typical "sandwich" microstructure of an injected plate

«Classic» CAE: pseudo-isotropic approximation

› Simplifying assumption: material is treated as homogeneous and isotropic, with characteristics equivalent to fibres oriented in a random manner

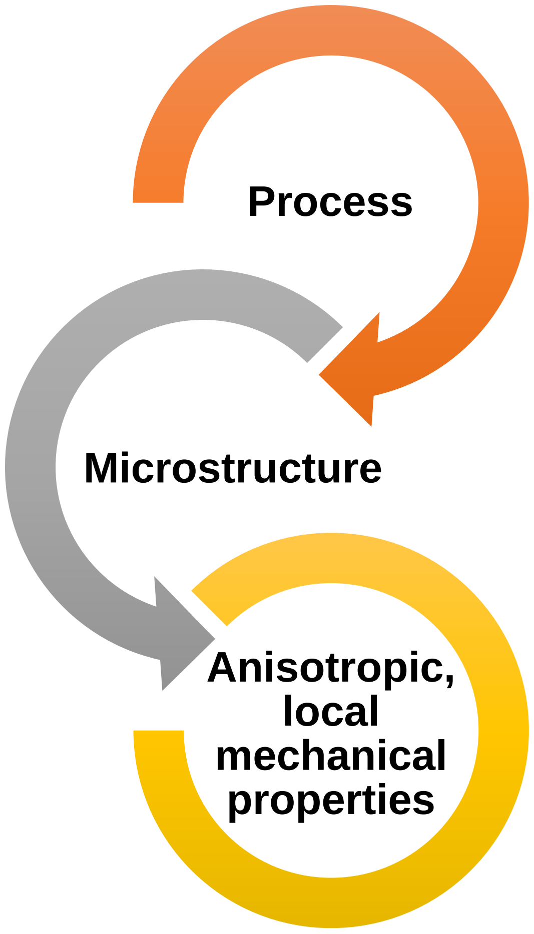
› This is practically done by **rescaling** ISO-527 data (from TDS), obtained on very oriented specimens, with an appropriate **penalty factor** which is accounted by analyst’s experience





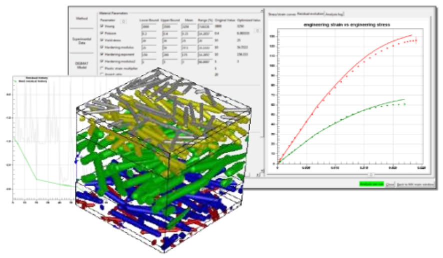
In pseudo-isotropic analysis, **Von Mises Equivalent stress** is typically used as failure criterion, vs uniaxial **stress at break** in tension

Advanced CAE workflow: Integration

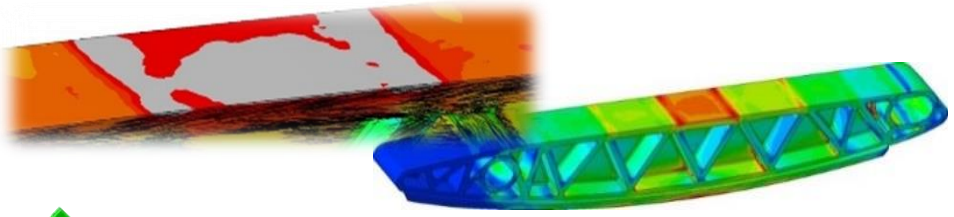


Injection simulation:
Warpage,
Gf orientation, weld lines…

FEA model



Advanced material modeling



INTEGRATED NONLINEAR FEM ANALYSIS

Higher **ACCURACY** and **REALIABILITY** in predicting elasticity and failure
More in-depth understanding of the **MATERIAL BEHAVIOR**
Reduced **OVERENGINEERING** and use of high **SAFETY FACTORS**
Less need for **PROTOTYPE TESTING**

Advanced CAE workflow: more fields of simulation

› **Weldlines** – Taking into consideration strength reduction according to formation conditions

› **Warpage** – Applying the deformation induced by injection molding to the structural mesh

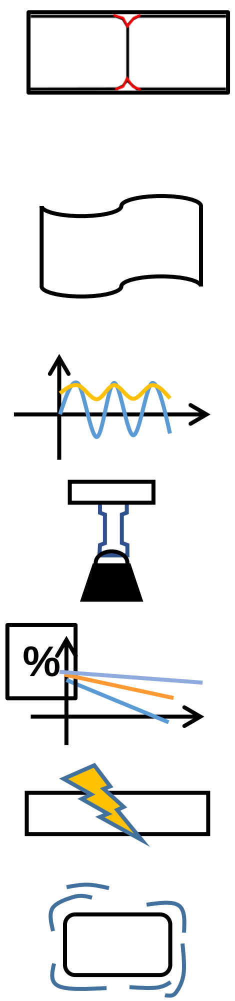
› **Fatigue** – Prevision of Critical N to failure on the part

› **Creep** – Deformation under continuous steady load

› **Thermal / Chemical ageing**

› **High Speed loading** (crash, impact…)

› **Vibrations / damping**

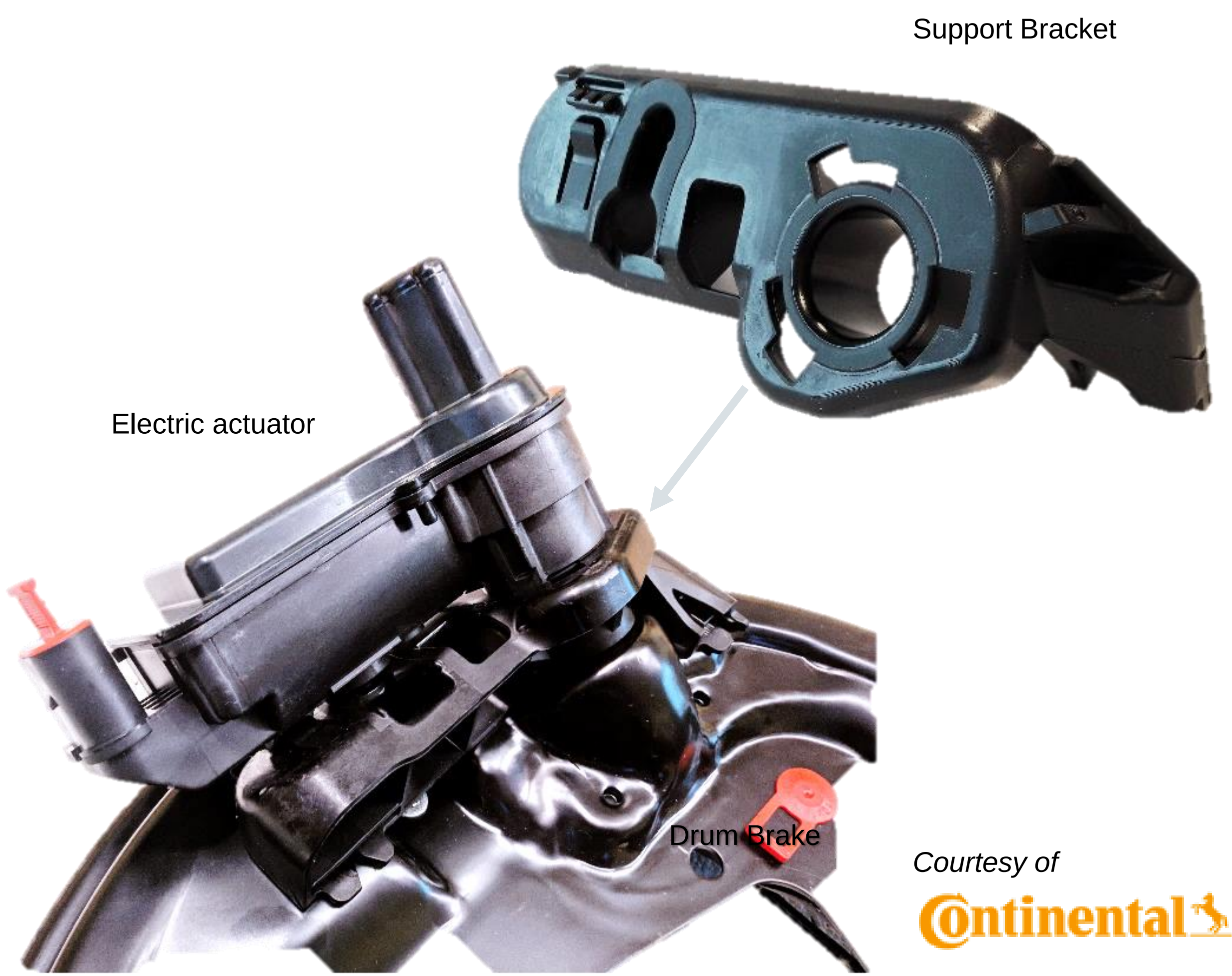


Process-induced local properties (other than GF orientation)

Long-term behavior of materials

Dynamic behavior of materials

Industrial case: Electric Parking Brake (EPB) fixation support bracket



Courtesy of

Continental

HEV and EV tend to increase the use of **drum brakes** vs **disc brakes**:

- Less need of maintenance
- Environmental impact - no loss of particulate/powder on the road
- Need less break-in period
- Cheaper constructive solution
- The lower need of HEV for braking power overcomes most of the cons of drum brakes

Lightweight, **modular** solutions to integrate electronic-controlled actuators to brake assembly

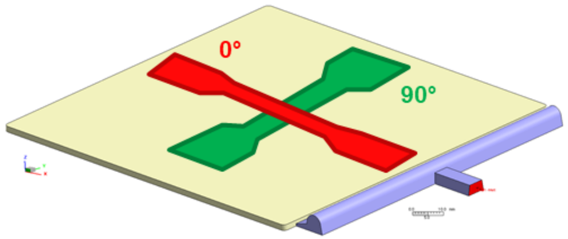
- Form freedom
- Adaptability / Standardization
- Minimum increase in weight to keep under control consumption and emissions

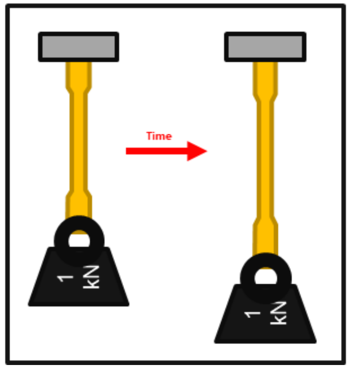
- Material chosen: **Radilon® A RV500RW 339 BK** (PA66 GF50)

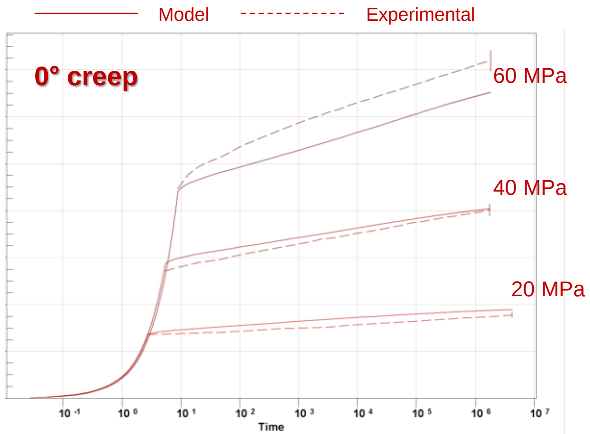
Industrial case: Creep/Relaxation modelling

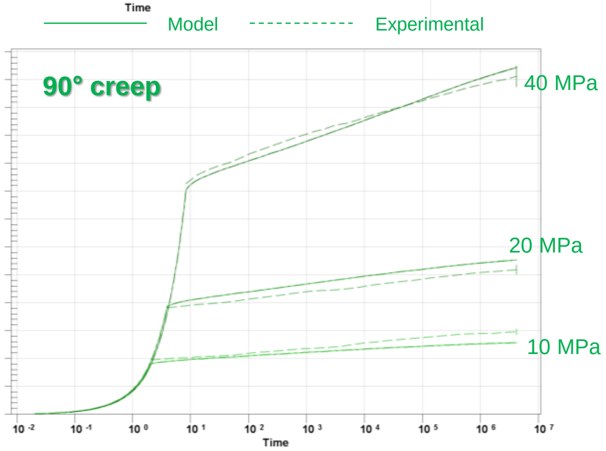
› Park brake maintained for long periods of time -> Loss of braking force (**stress relaxation**)?

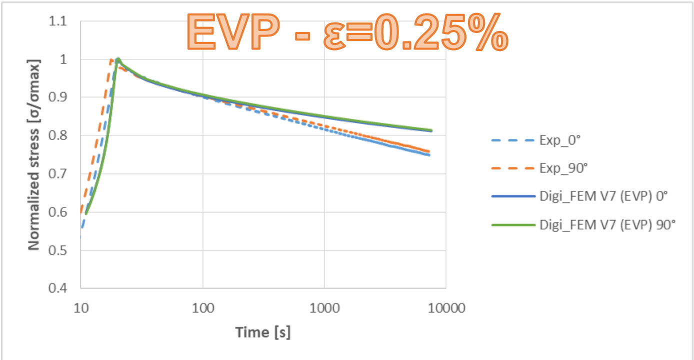
› Need to characterize and model the material's visco-elastic response (**creep**)

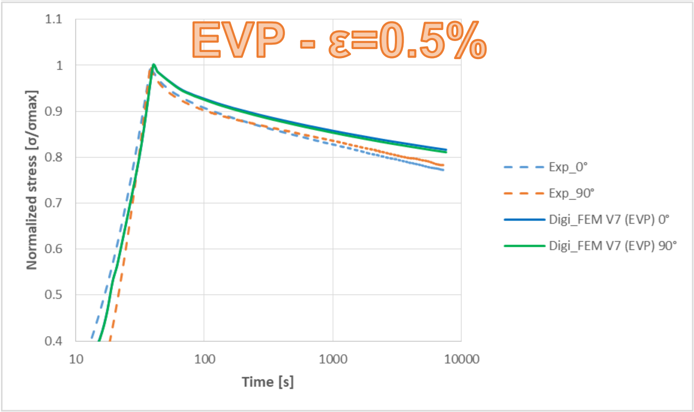




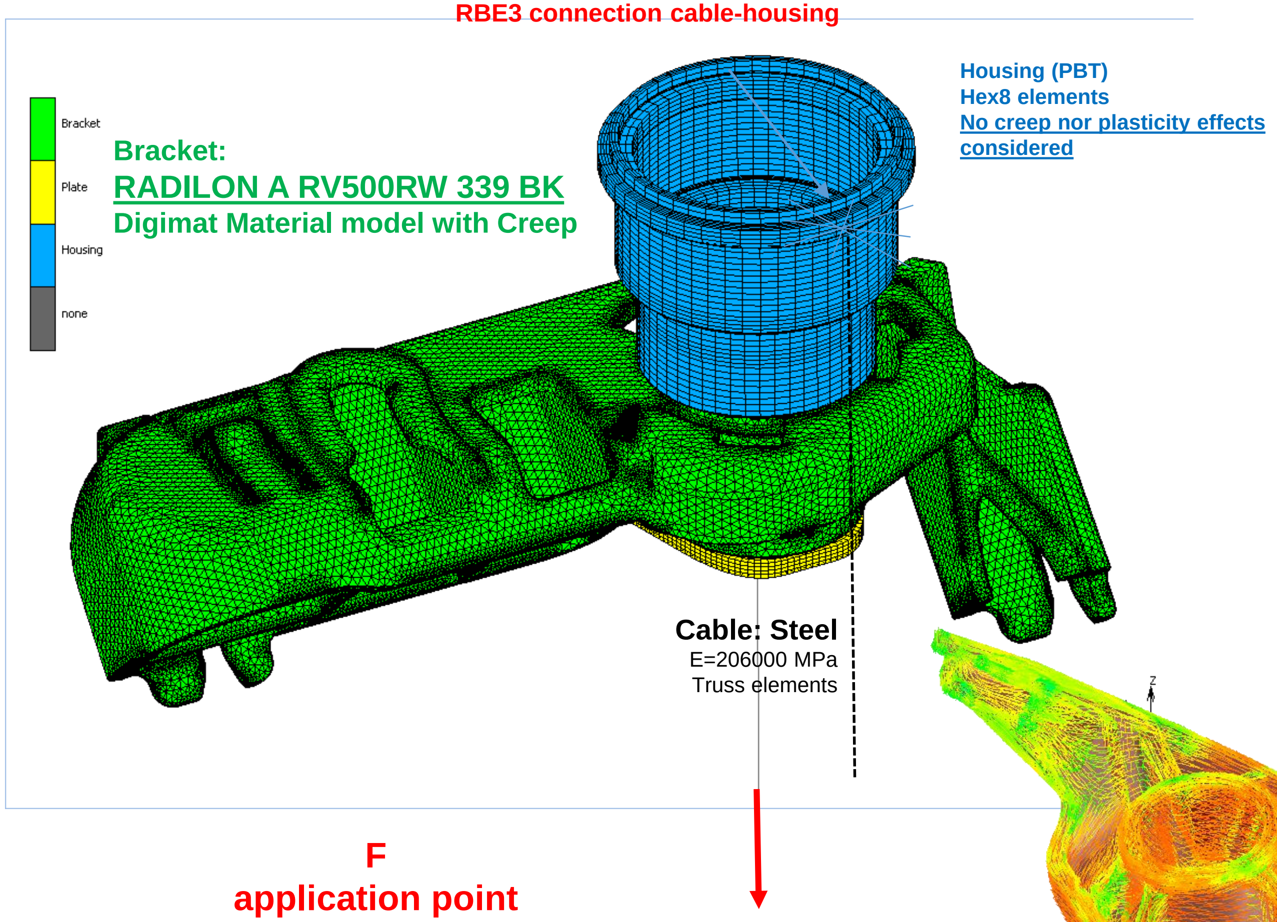


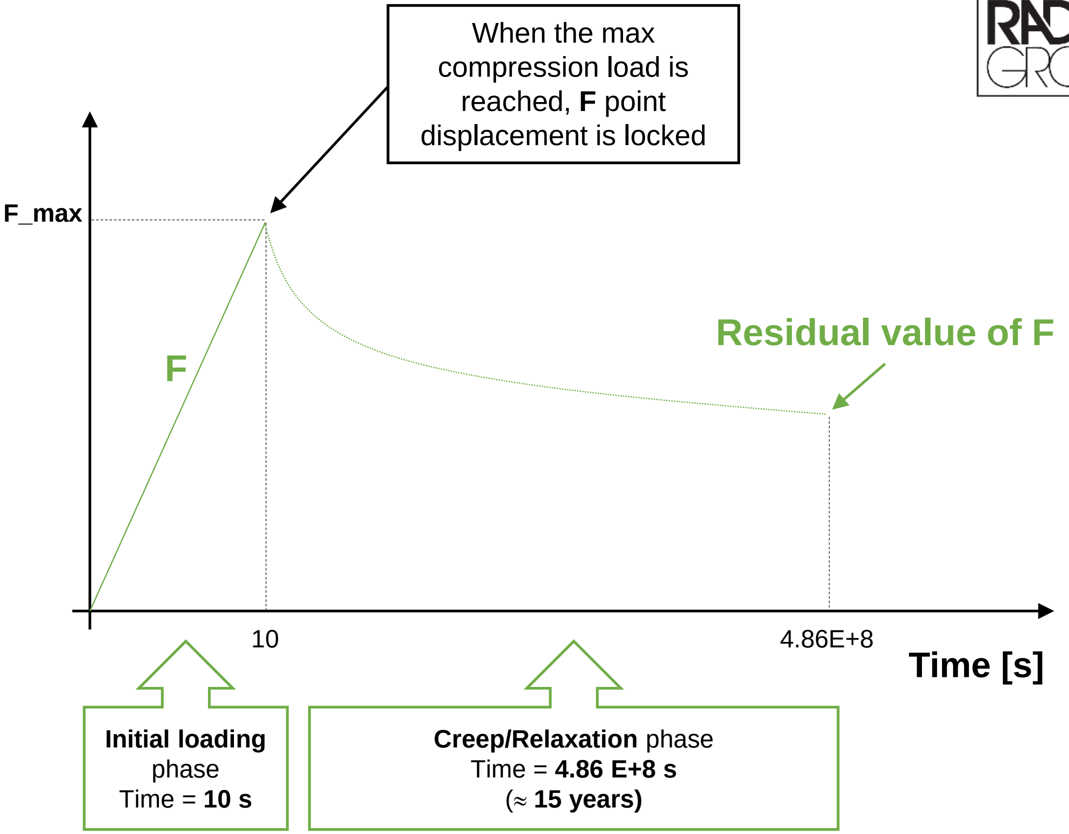


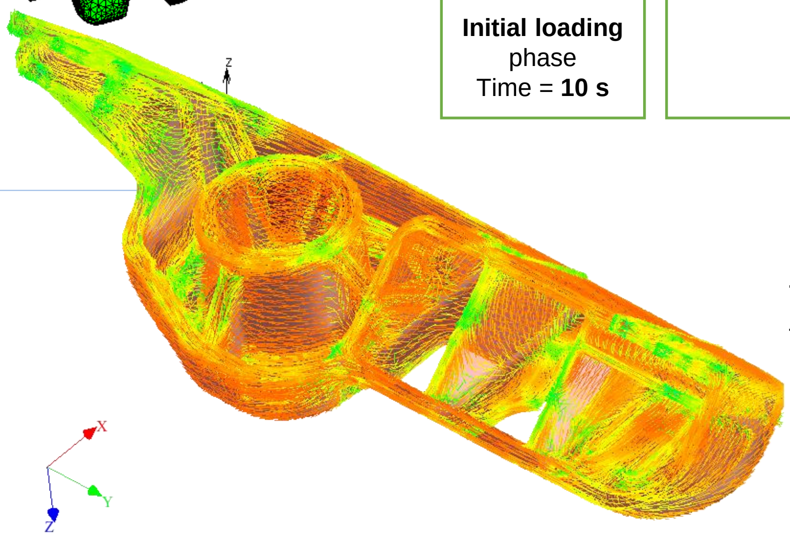




Industrial case: FEM model





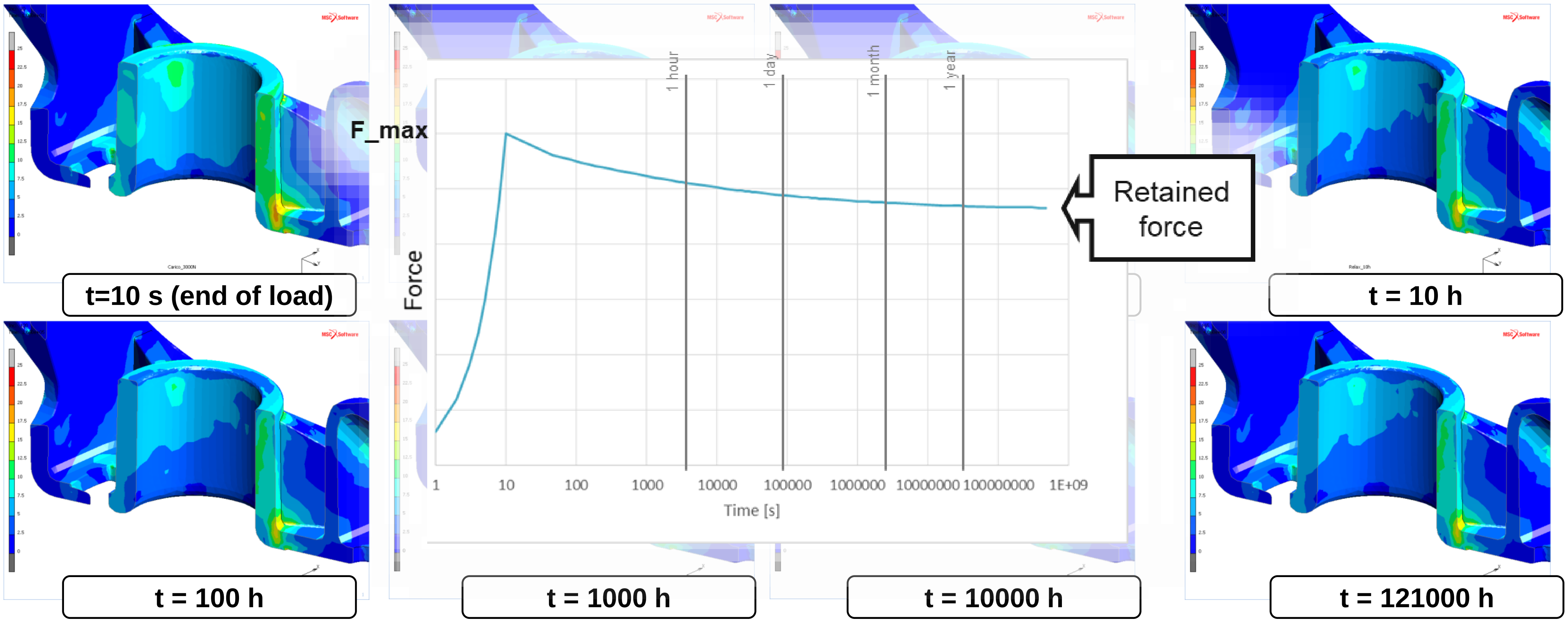


GF orientation mapping

The zone of interest show a mainly transversal orientation with respect to compression direction

Industrial case: Stress Relaxation results

VM Stress through time



Conclusions

- In today's competitive scenario, being able to accurately **predict** the structural behavior of **technopolymer**-made items since the earliest phases of **design** is essential for timely and successful projects
- An **advanced approach to CAE**, which unites a deep understanding of **material** science, an accurate know-how in **technology**, and a faithful representation of working **structure**, is the key to achieve such accuracy
- Through a close collaboration with its Customers, **RadiciGroup High Performance Polymers** is able to provide state-of-the-art support and expertise to reach demanding targets in metal replacement and performance-driven projects

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HIGH PERFORMANCE POLYMERS

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QUESTIONS???