

Safety of Electric Vehicles:

How the Right Choice of Polymers
and Flame Retardants Can Help?



Antonio Nerone graduated in Nuclear Engineering in 1983 at the Politecnico of Milan.

Antonio has more than 30 years of experience in engineering polymers working for company DuPont, covering several roles ranging from Product and Marketing Management to Key Account Management. From 2011 to 2019 Antonio was Global Segment Leader for Electric and Electronic markets applications. Antonio joined RadiciGroup in January 2020 as Electrical and Electronic Market expert.



Plastics in electromobility: challenges and opportunities

Antonio Nerone

EE Market Expert

RadiciGroup High Performance Polymers

Radici Novacips



Agenda



- › **RadiciGroup Company profile**

- › New Challenges introduced by xEV penetration for Engineering Polymers

- › Long term reliability of Mechanically recycled polymers vs. fossil based

- › Conclusions

Personnel
roughly **3,000**
employees

2022 Sales*
1,542
million €

Network
>30
production and sales
units in Europe, North and
South America, and Asia

High Performance Polymers - Global presence

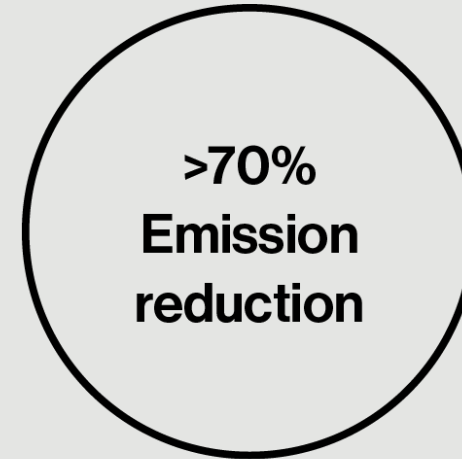


Sustainability in facts

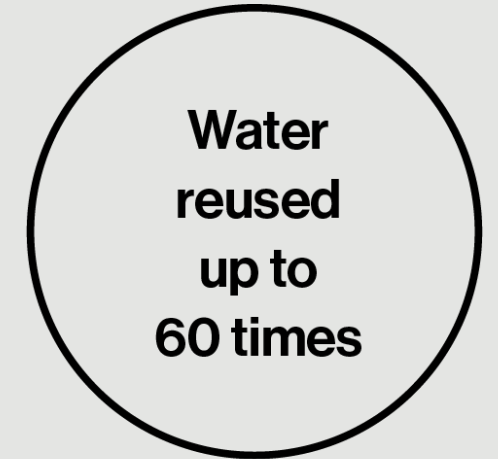
Every day at RadiciGroup we work to **make circularity our business model**. We optimize the use of materials while fine-tuning our processes, reducing waste, promoting recyclability from the earliest product design phases. We are always looking for **low-impact solutions** in the use of **natural resources and energy**. We rely on **certified management systems** for Quality, Health and Safety, Environment and Energy along with a number of product-related certifications and **environmental labels** to keep our companies in line with the highest sustainability standards. At present RadiciGroup companies **can count on roughly 70 certifications**.



GRI, third-party certified **Sustainability Report** covering all RadiciGroup companies worldwide.



Since 2011, in RadiciGroup plants.



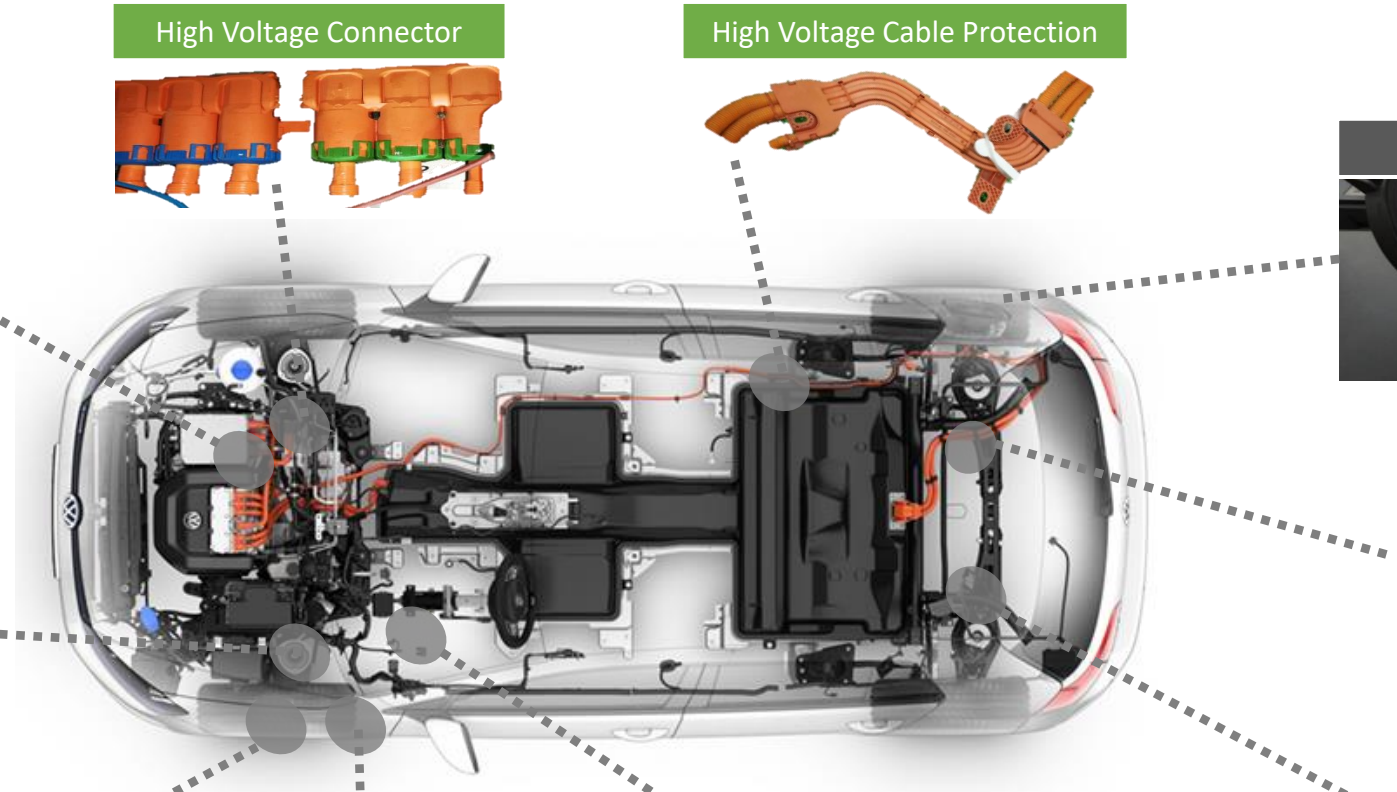
Water reused in RadiciGroup production plants.

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Critical components for Engineering Polymers in xEV



Converter - IGBT



High Voltage Connector



High Voltage Cable Protection



Charger System



Converter/Motor System



Battery Cooling System Components



Power Distribution



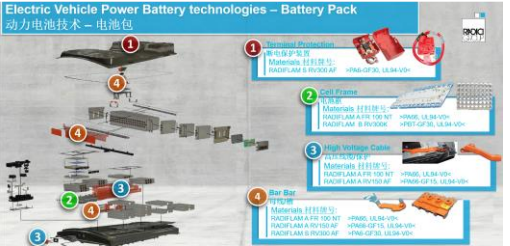
Electronic Gear Shifting



PTC for A/C & Battery



Battery Pack System



Most frequent questions from xEV customers



- › How safety and reliability can be granted by Engineering Polymers during vehicle lifetime?
- › How Recycled Engineering Polymers behave short and long term vs. fossil based?
- › End of life recyclability of Engineering Polymers containing Flame Retardant additives? (Not covered in the presentation)

How safety and reliability can be granted by Engineering Polymers during vehicle lifetime?

› Main Polymers EE Safety standards:

› For Fire Safety:

- › UL 94 for flame resistance (V0,V1,V2) and FMVSS 302
- › IEC 60695-2-10-11-12-13 for resistance to fire from glow wire (650°-960°C vs. thickness mm)

› For Insulation Properties:

- › IEC 60112, UL 746 A for surface insulation properties (CTI:V)
- › IEC 62631-3-1-2 & IEC 60243-1 for dielectric properties (Resistivity: Ohm/Ohm m and Electric Strength: kV/mm)
- › ASTM D2303/IEC 60587 for Electrochemical Erosion (Inclined Plain Tracking Test: kV vs time)

› For Long Term Performance:

- › IEC 60216 and UL 746 B for maximum continuous working temperature (TI and RTI)

How safety and reliability can be granted by Engineering Polymers during vehicle lifetime?

› Questions regarding fire Safety:

- › Is UL 94 V0 really always needed?
- › UL 2594 for charging units requires min. V1 for enclosures and to comply with requirements in below table for enclosures carrying live parts.

Hot wire ignition (HWI) and high-current arc resistance to ignition (HAI) ratings of insulating materials

Flammability classification ^a	HWI ^{b,d}		HAI ^{c,d}	
	Mean ignition time (sec)	PLC	Mean no. of arcs	PLC
V-0, VTM-0	7 and up to 15	4	15 and up to 30	3
V-1, VTM-1	15 and up to 30	3	30 and up to 60	2
V-2, VTM-2	30 and up to 60	2	30 and up to 60	2
HB	30 and up to 60	2	60 and up to 120	1

^a Flammability Classification – described in the Standard for Tests for Flammability of Plastic Materials for Parts in Devices and Appliances, UL 94.
^b Hot Wire Resistance to Ignition – described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.
^c High-Current Arc Resistance to Ignition – described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.
^d Mean ignition time and mean no. of arcs to be used to evaluate filament wound tubing, industrial laminates, vulcanized fiber, and similar polymeric materials only. All other materials are to be judged using the performance level class values.

- › IEC 62196-1 and 2 for charging plugs and sockets requires GWFI $\geq 850^{\circ}\text{C}$.

How safety and reliability can be granted by Engineering Polymers during vehicle lifetime?

› For Insulation Properties:

› Is CTI of 600V or even 1000V really needed?

- › IEC 62196-1 and 2 for charging plugs and sockets requires $PTI \geq 175V$
- › UL 2594 requires min CTI category 3 (175-250V), as shown below:
 - › 7.4.2.1 A polymeric material used for enclosures of live parts shall comply with the requirements in Sections 70 – 72.
 - › Exception No. 1: A polymeric material having a maximum Comparative Tracking Index (CTI) performance level class of 3 need not comply with the Comparative Tracking Index Test, Section 70

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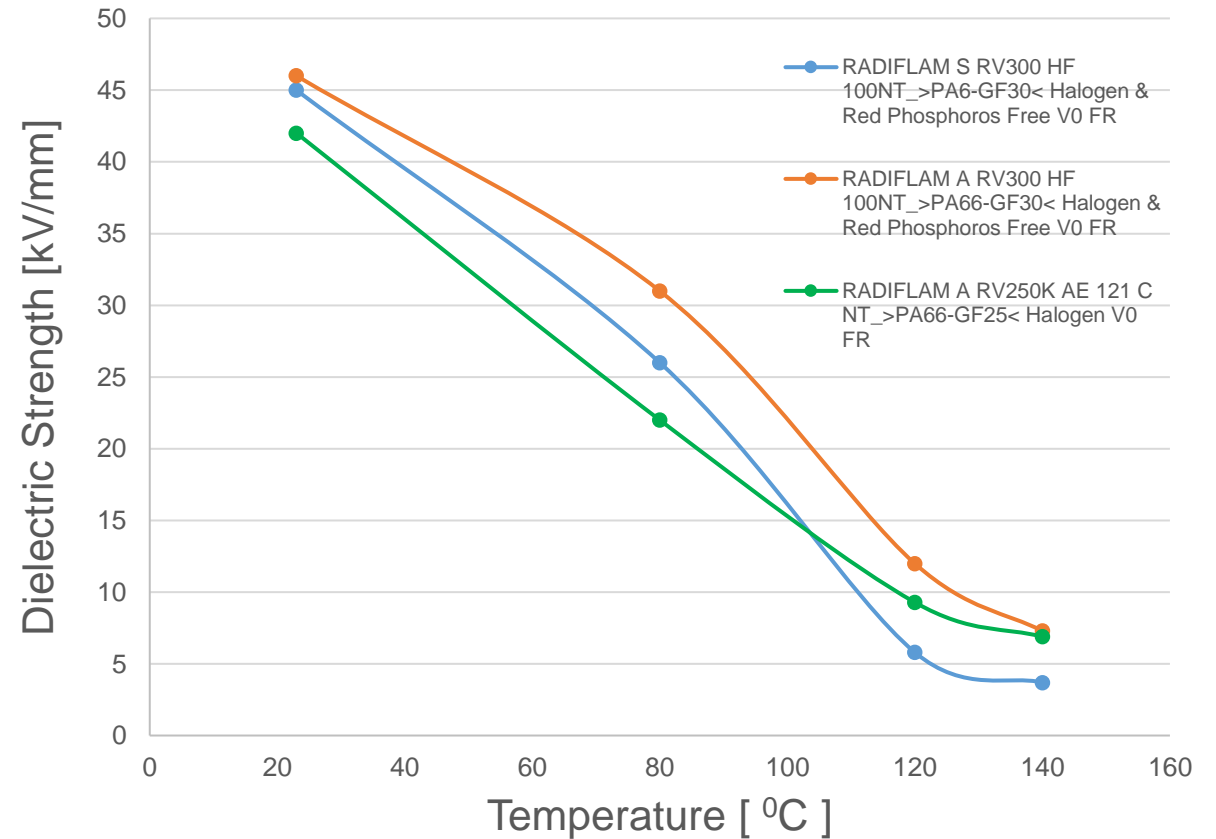
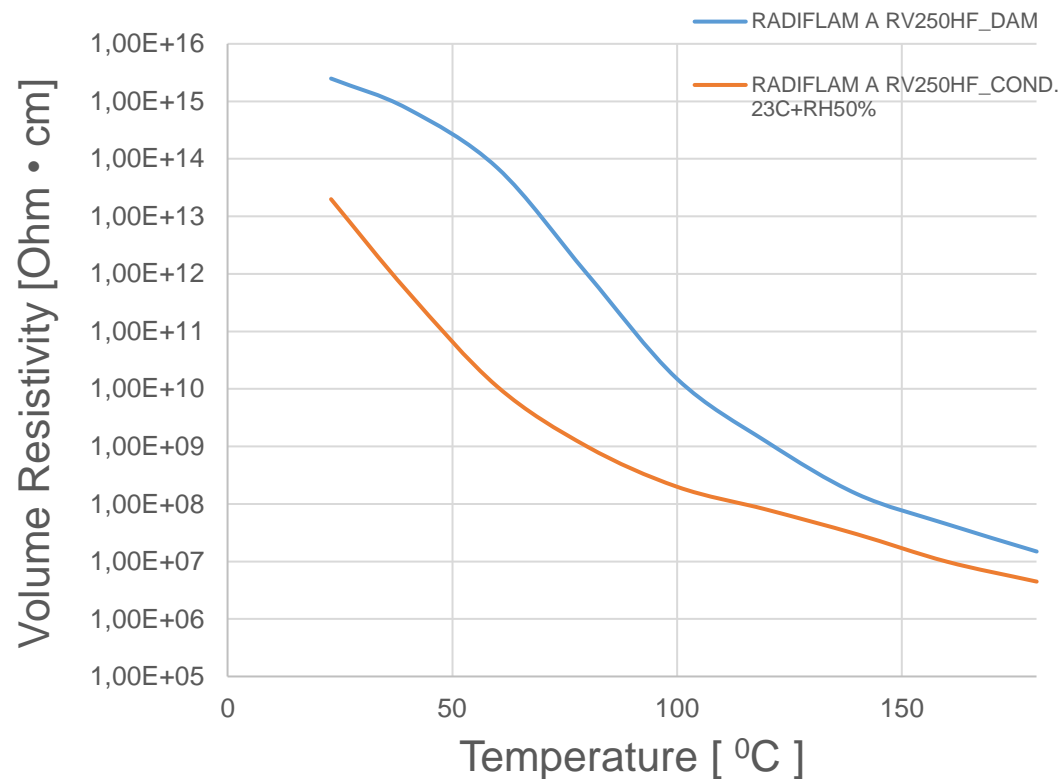
How safety and reliability can be granted by Engineering Polymers during vehicle lifetime?

CTI evolution after 1008Hrs at 130°C of materials with Recycled content vs. Virgin

		CTI (V) initial Value	CTI (V) after ageing	CTI (V) initial Value	CTI (V) after ageing
Grade Name	Polymer Type	Regrind Content 0%	Regrind Content 0%	Regrind Content 100%	Regrind Content 100%
Radiflam® A RV300HF OR	PA 66 Virgin (FR40)	600	600	600	600
Radiflam® S RV300HF OR	PA 6 Virgin (FR40)	600	600	600	600
Renycle® S GF 2501HF0 BK	PA 6 with 50% PCR polymer content (FR40)	550	500	Not tested	Not tested

How safety and reliability can be granted by Engineering Polymers during vehicle lifetime?

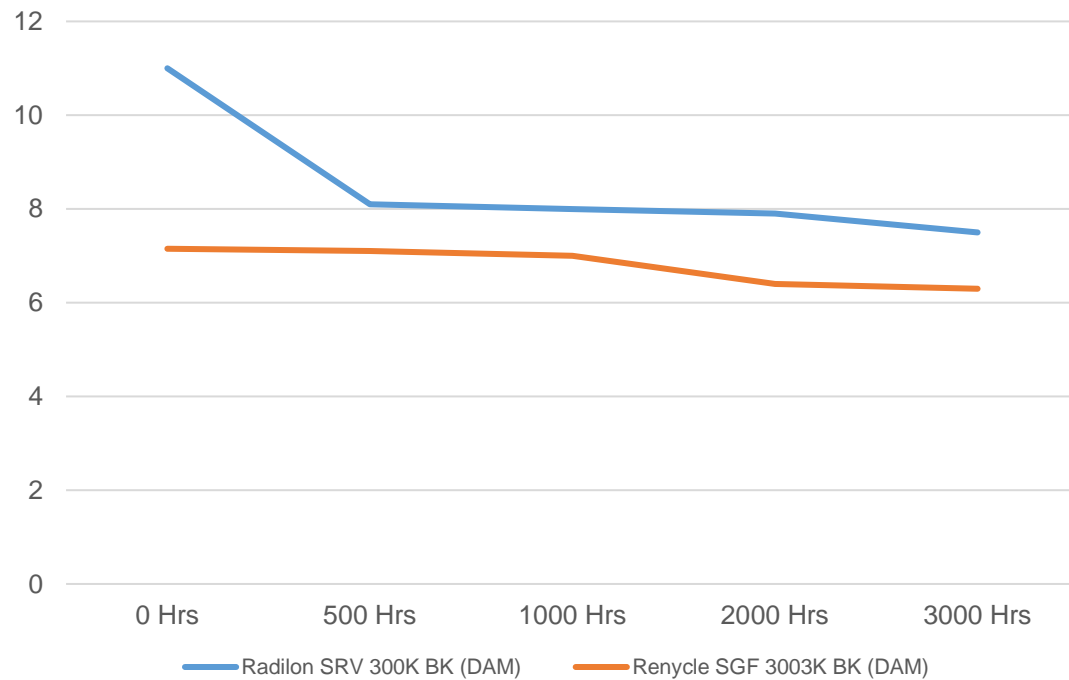
VR (Volume Resistivity) and DS (Dielectric Strength) vs. Temperature of Polyamides



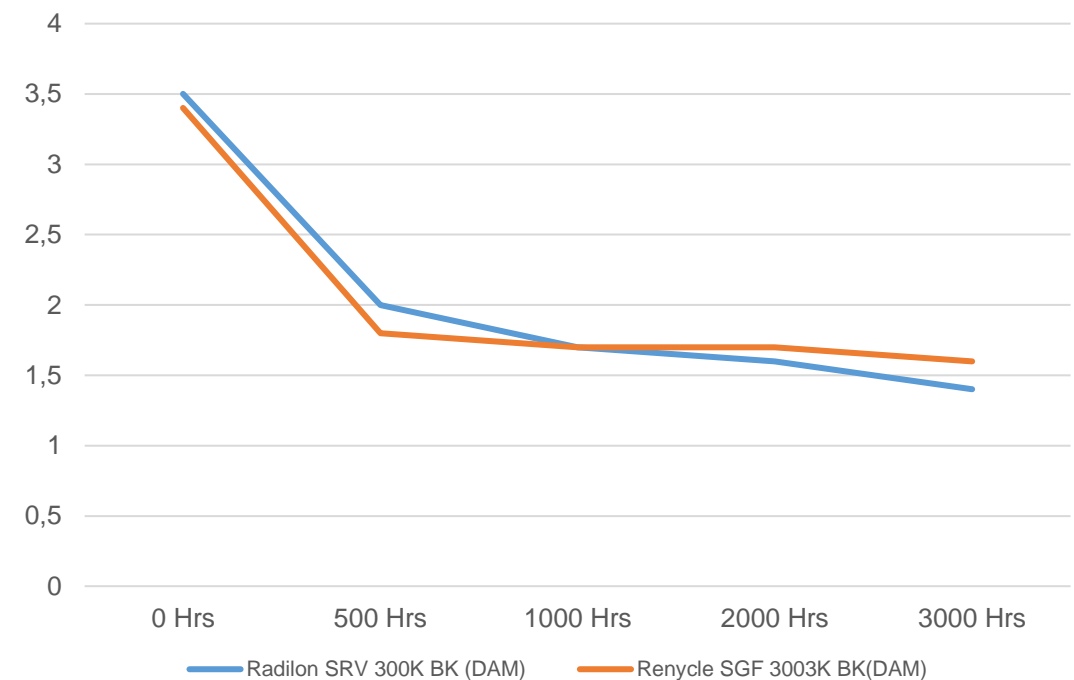
How safety and reliability can be granted by Engineering Polymers during vehicle lifetime?

Air Oven ageing Virgin vs. Recycled PA6 30% GR: 3000 Hrs at 150°C

Notched Charpy (kJ/m²)



Strain at Break (%)

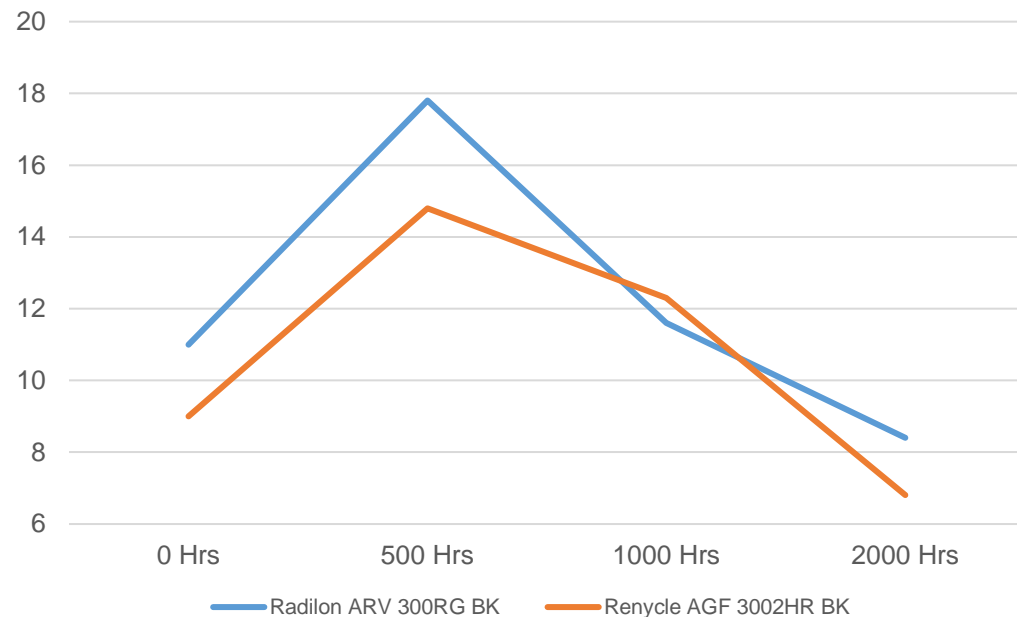


Renycle® SGF 3003 HR contains ≥50% recycled Polymer

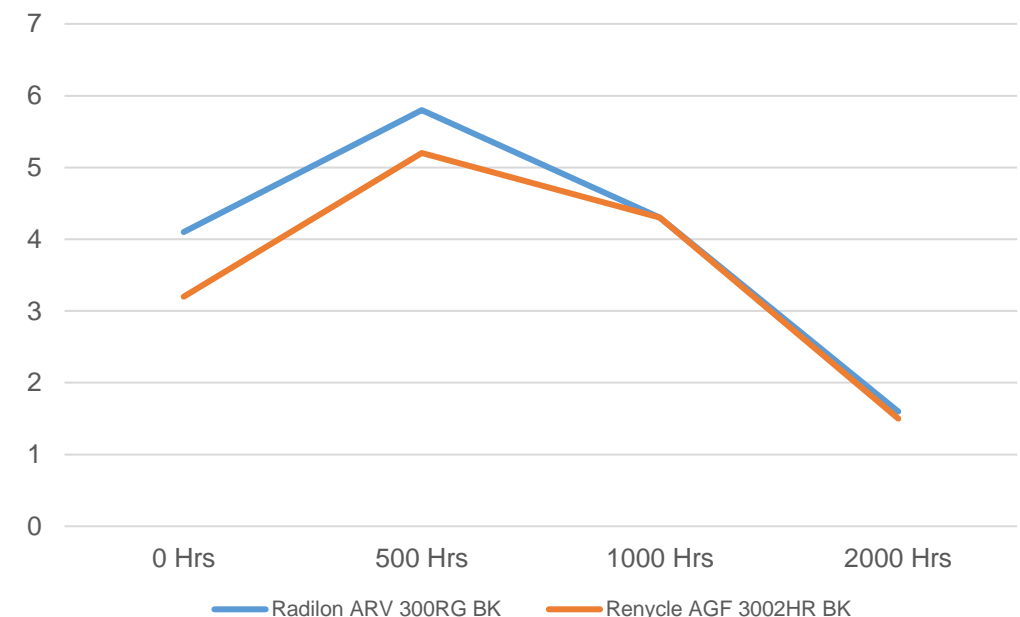
How safety and reliability can be granted by Engineering Polymers during vehicle lifetime?

Chemical resistance 50/50 Water Glycol Virgin vs. Recycled PA66 30%GR: 2000 Hrs at 120°C

Notched Charpy (kJ/m²)



Strain at Break (%)



Renycle® AGF 3002 HR contains <50% recycled Polymer

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Conclusions

- › Polyamide Flammability properties (UL, Glow Wire) are pretty stable and independent from polymer source or recycled content.
- › Polyamide resistance to tracking CTI (Comparative Tracking index) is also very stable after heat ageing both in virgin and recycled sources, however **Insulation properties (Resistivity, Dielectric Strength) are very depending on temperature with heavy losses above 120°C.**
- › Thermal ageing and chemical resistance of Polyamides with recycled content are similar to virgin.

Thank you.

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About Cefic

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