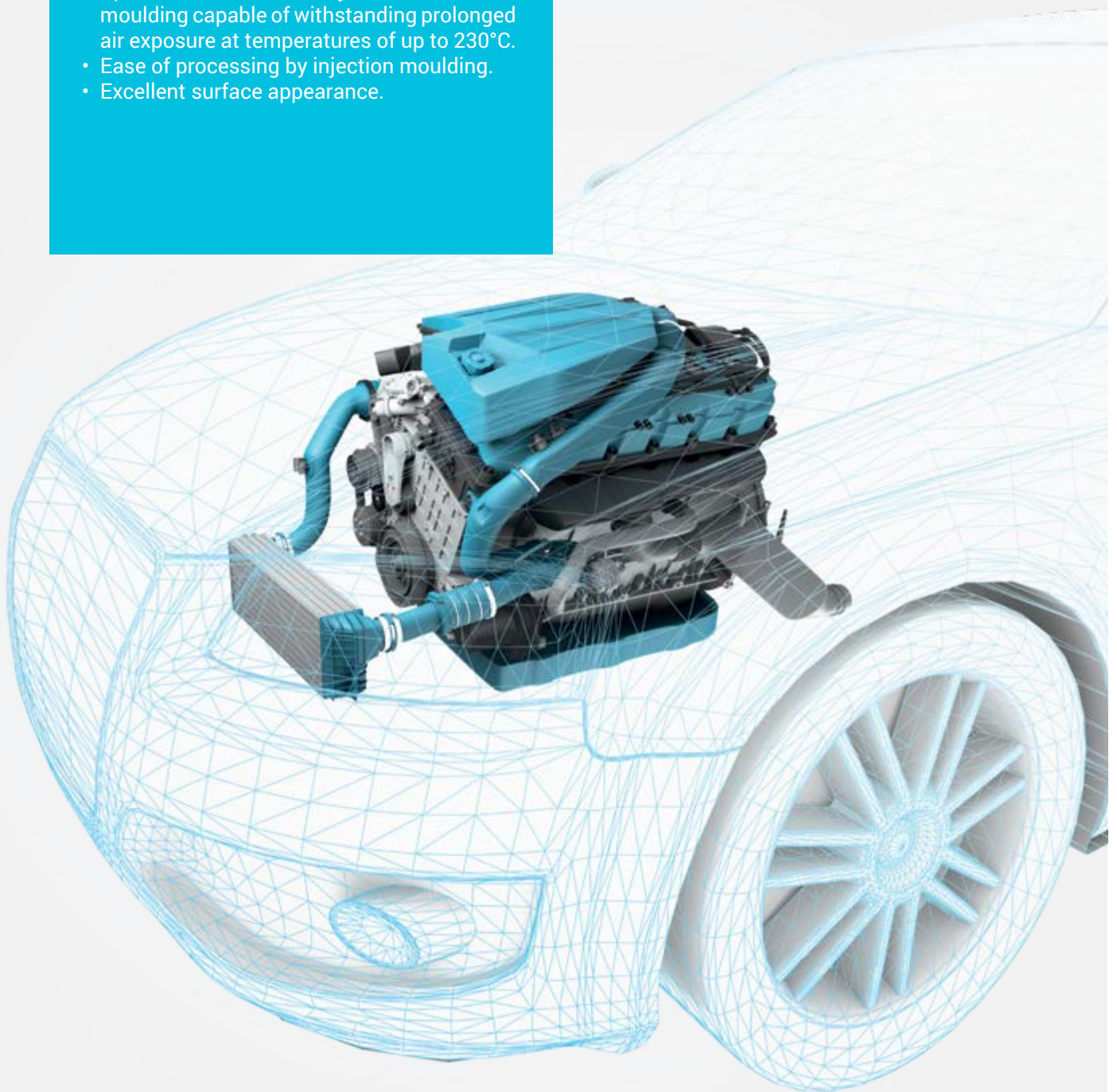


PERFORMANCE PLASTICS

RADILON® XTREME

- Specialty polyamides for high temperature applications.
- Specialties for both injection and blow moulding capable of withstanding prolonged air exposure at temperatures of up to 230°C.
- Ease of processing by injection moulding.
- Excellent surface appearance.



Radilon® XTreme: designed to withstand prolonged exposure to high temperatures

The RadiciGroup Performance Plastics portfolio includes a range of polyamide materials, sold under the Radilon® XTreme brand name, capable of withstanding continued exposure to hot air at temperatures of up to 230°C.

Radilon® XTreme contains a semi-aromatic component that ensures an exceptional level of protection against thermal oxidation, when combined with other special additives commonly used in many formulations for the same purpose.

The achievement of these results for heat resistance have allowed RadiciGroup to extend the range of applicability of its PAs to include highly critical applications and offer customers a competitive advantage in metal and special-

ty polymer replacement.

RadiciGroup Performance Plastics technology has enabled the creation of a family of materials that can be processed with moulding temperatures no higher than 100°C, thus eliminating the need for oil or high-pressure water conditioning. Furthermore, by virtue of its high fluidity, Radilon® XTreme can easily fill even relatively thin-wall cavities with complex geometry. Additionally, a number of specific formulations with excellent surface appearance have been developed.

The range of products currently available comprises glass-fibre-filled grades for injection moulding and specially modified materials for blow moulding, allowing for ease of processing when using parison-suction technology.

Radilon® XTreme: developed for automotive uses and others...

The automotive industry is seeing growing demand for engineering plastics resistant to very high temperatures. The trend is a direct consequence of the engine evolution in recent years, which has witnessed the massive introduction of turbocharged car engines capable of delivering greater power from less displacement.

Radilon® XTreme products feature excellent resistance to chemicals such as engine oil, gearshift oil, cooling system fluids and fuels.

In lab tests with the specimen immersed in pH2 acid solutions, XTreme products do not exhibit significant degradation. These tests were requested by many OEMs in order to evaluate the aptitude of the material for use in new-generation engines.

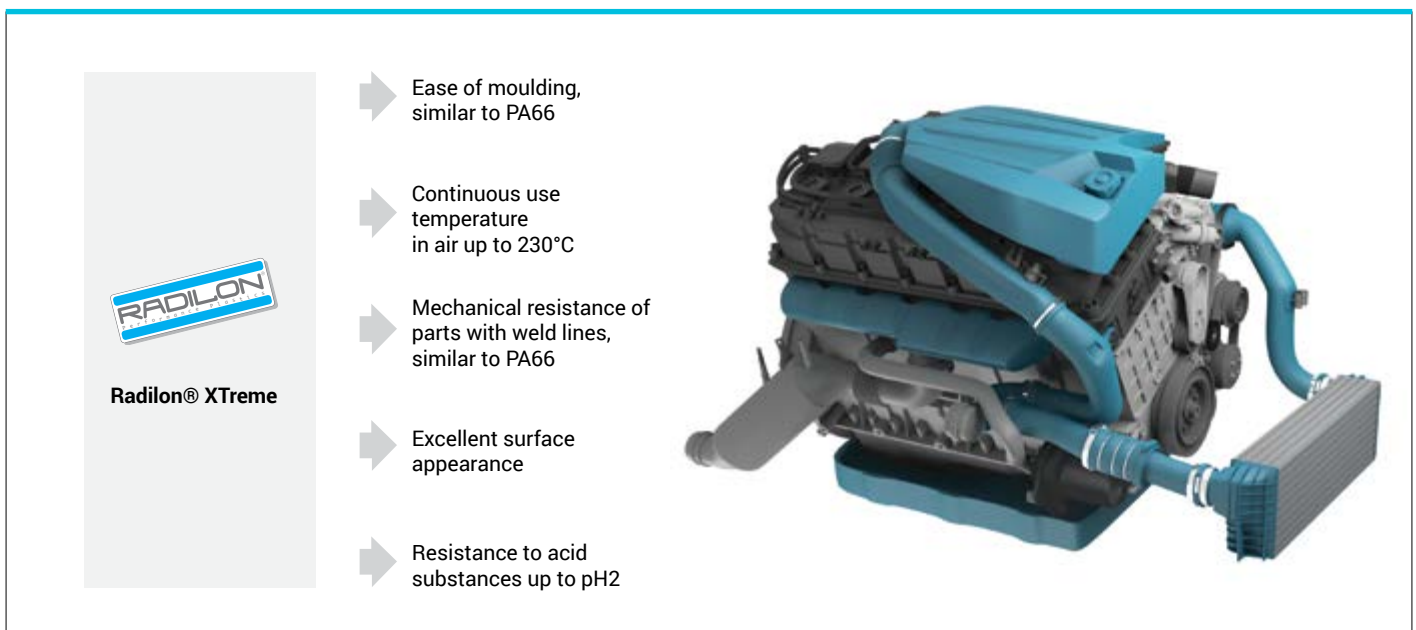
Just a few typical automotive applications:

- Turbo resonators for operation at temperatures of

up to 220-230°C

- Hot-side pipes for turbo engines, manufactured both by injection and blow moulding, at operating temperatures of up to 230°C
- CAC end caps for continuous use temperatures of up to 230°C
- Fastening clips for under-bonnet applications

Moreover, some grades of Radilon® XTreme for injection moulding are suitable for applications in other industries, such as muffler and engine covers for portable gardening tools. For this specific use, RadiciGroup developed a customized product in a variety of colours featuring high-quality surface appearance and excellent impact resistance, along with high heat resistance. The Group has also developed a filament extrusion specialty targeting applications in severe operating conditions at high temperatures.



The infographic features a central image of an engine with various blue plastic components. To the left, a grey box contains the Radilon logo and the text 'Radilon® XTreme'. To the right of this box, five grey arrows point to a list of properties:

- ➔ Ease of moulding, similar to PA66
- ➔ Continuous use temperature in air up to 230°C
- ➔ Mechanical resistance of parts with weld lines, similar to PA66
- ➔ Excellent surface appearance
- ➔ Resistance to acid substances up to pH2

Chart 1 | Radilon® XTreme properties

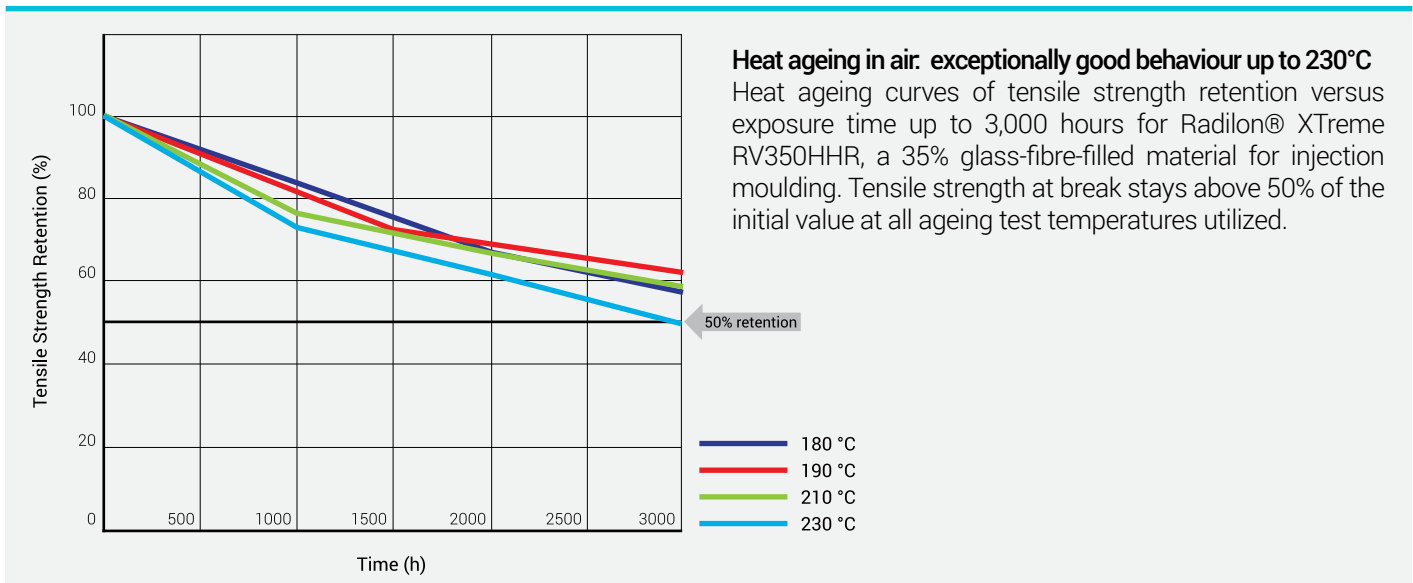
Radilon® XTreme: distinctive characteristics that make a difference

PROPERTY	PA6.6	PA6	XTREME	PPS	PPA	PPA-2	PA46	PA46-2
MELTING T	260	220	280	280	308	300	282	295
WATER ABSORPTION	8.5	9.0	7.0	0.1	7.0	7.0	13.0	13.0
TG	70	60	90	90	110	120	70	70
DENSITY	1.14	1.14	1.15	1.35	1.15	1.15	1.18	1.18

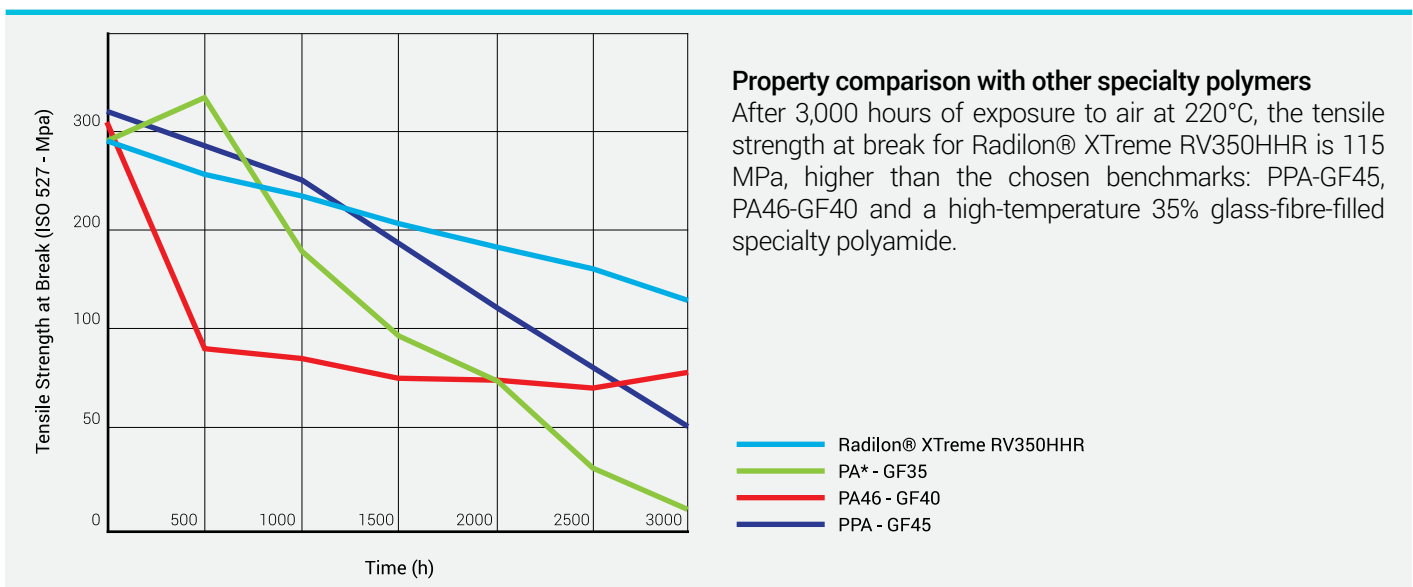
Radilon® XTreme: property comparison (base polymer)

Some key properties of Radilon® XTreme obtained from measurements performed on the base polymer are listed below.

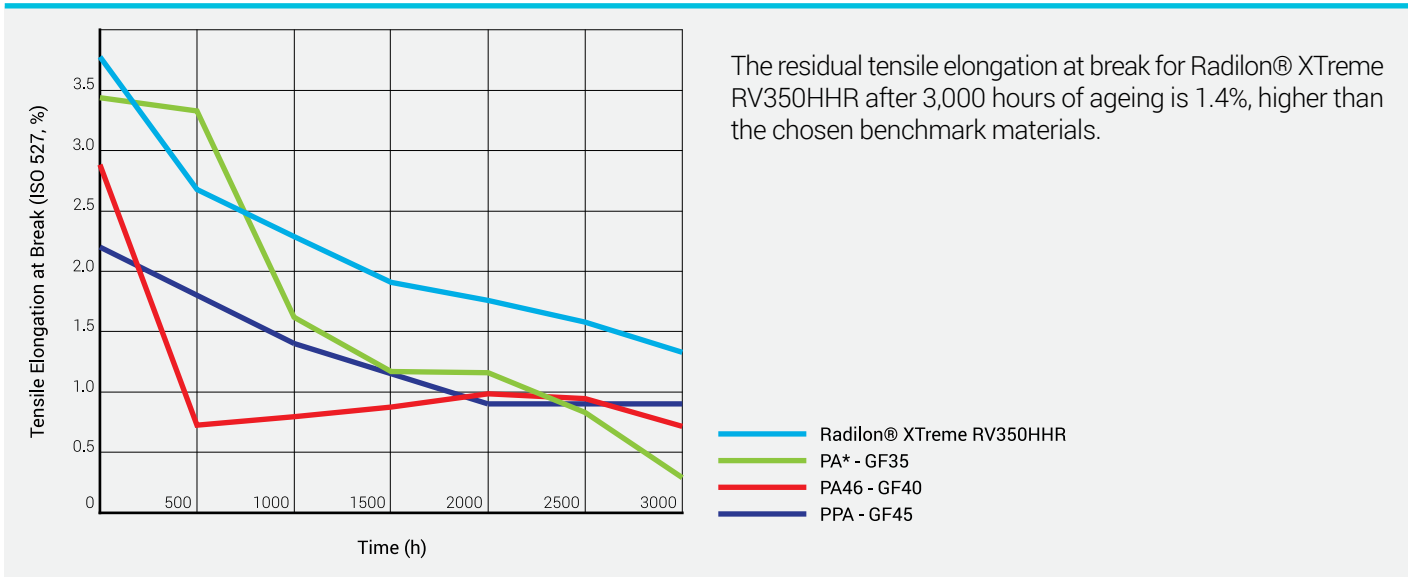
- Melting temperature: same as PPS; lower than PPA.
- Water absorption at saturation: same as PPA; much lower than PA46; higher than PPS, which, however, is a polymer belonging to a different family.
- Glass transition temperature (Tg): same as PPS; higher than PA46; lower than PPA.
- Density: lower than PPS and slightly lower than PA46.



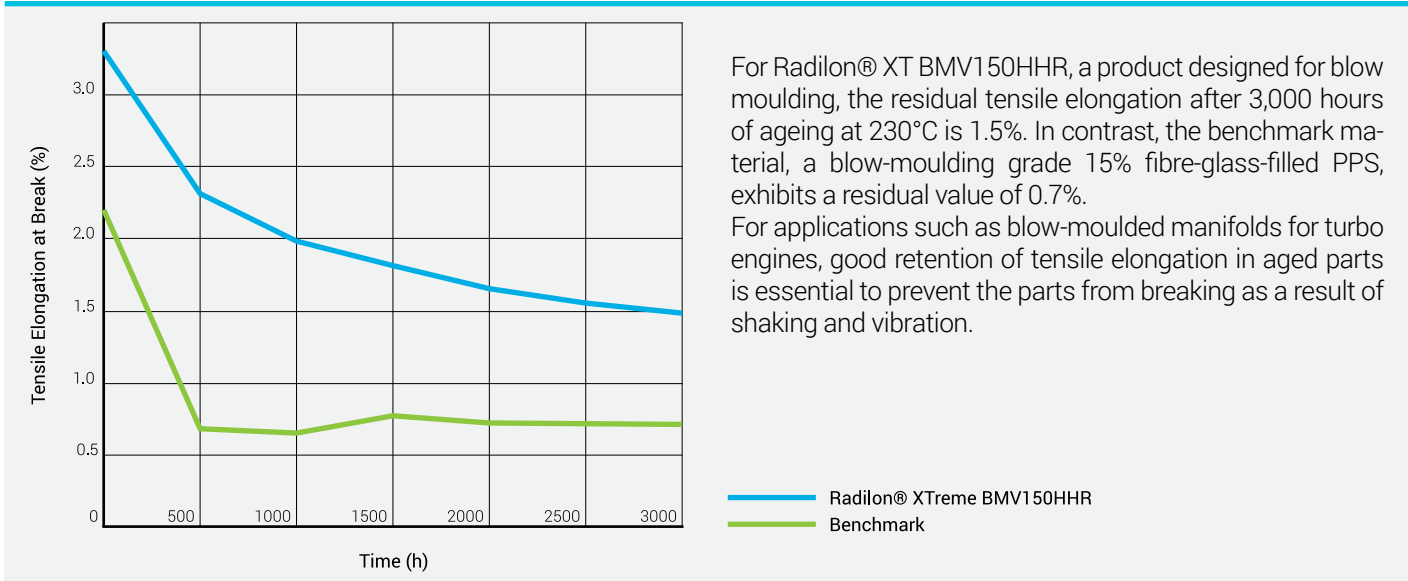
Graph 1 | Radilon® XTreme RV350HHR



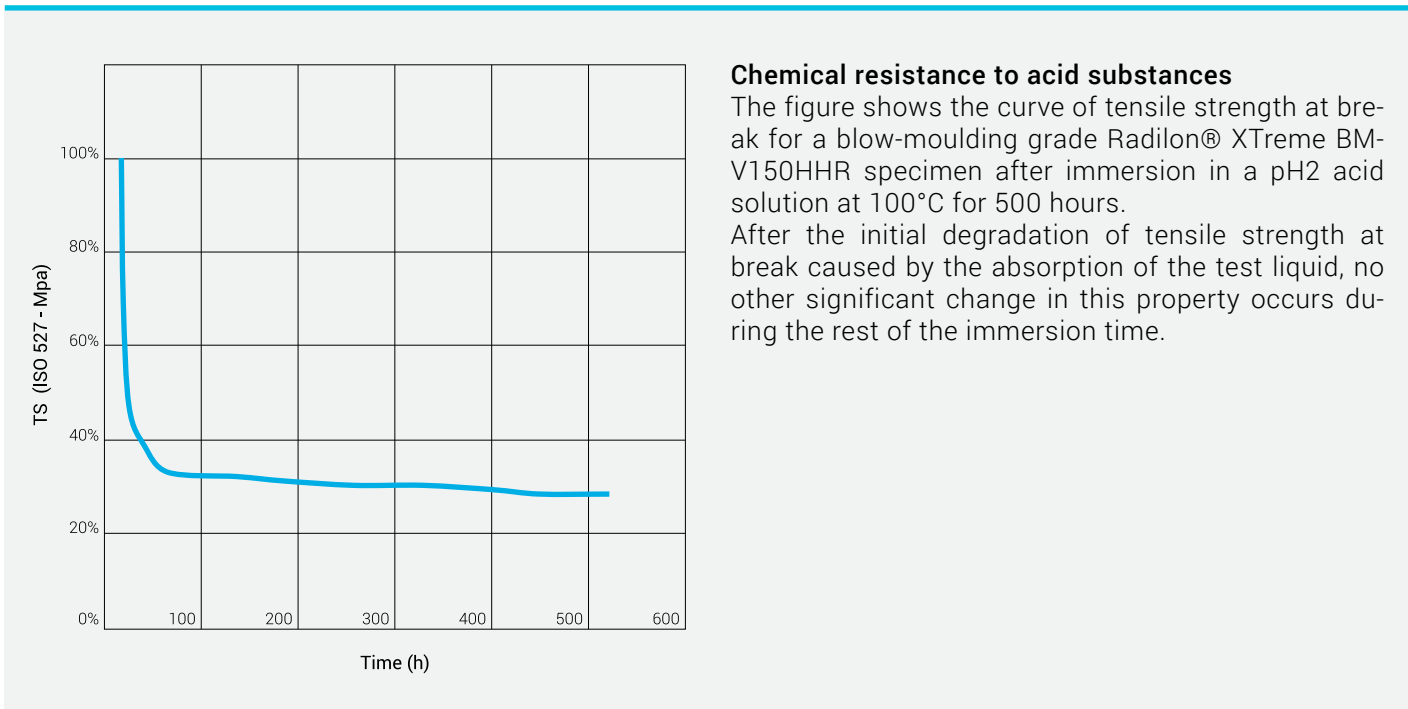
Graph 2 | Heat Ageing in Air at 220 °C



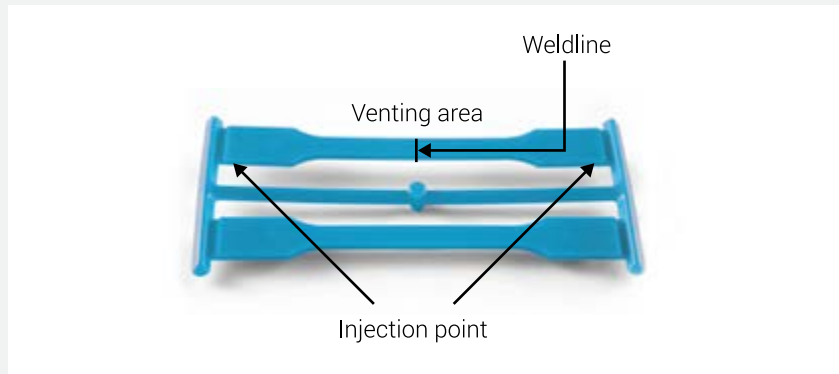
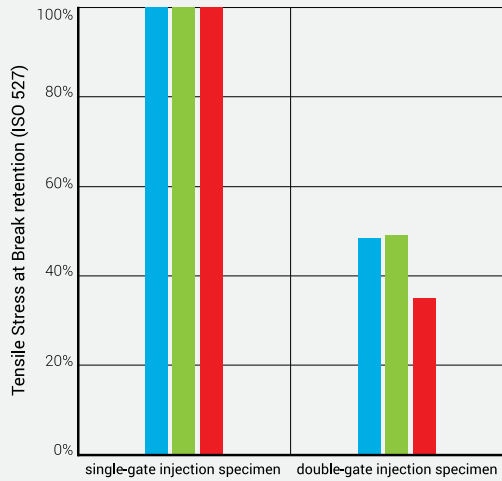
Graph 3 | Heat Ageing in Air at 220 °C



Graph 4 | Radilon® XTreme BMV150HHR versus Benchmark: Heat Ageing in Air at 230 °C



Graph 5 | Tensile Strength at Break: Radilon® XTreme BMV150HHR - 100°C - PH2



— Radilon® XT RV350HHR
— Radilon® XT RV350W (PA66-GF35)
— PPA-GF33

Excellent mechanical behaviour of moulded parts with weld lines

Weld lines may form in moulded parts where two fronts of the melt flow meet. Weld lines are critical areas in the moulded part because they may break easily under high and/or repeated stress. Therefore, it is important to know the properties of the material when weld lines are present in the moulded part. The graph shows the tensile stress at break values for ISO 527 specimens prepared by double-gate injection from two opposite sides, so as to form a join line at the centreline of the specimen. As seen in the graph, the tensile stress at break for Radilon® XTreme RV350HHR is 50% compared to the ISO 527 specimens prepared by single-gate injection, which are free of weld lines. The value for Radilon® XTreme is very close to that for standard PA66-GF35 and markedly higher than the value for PPA-GF33, a 33% glass-fibre-filled polyphthalamide for which the tensile stress at break falls by 65%.

Graph 6 | Mechanical properties comparison

Radilon® XTreme products currently available

BRAND NAME	MAIN CHARACTERISTICS	TYPICAL APPLICATIONS
XTreme RV150HHR	PA-GF15, enhanced thermal protection	Engine covers
XTreme RV350HHR	PA-GF35, enhanced thermal protection	Turbo pipes, turbo resonators, clips, ring sets
XTreme RV400HHR	PA-GF40, enhanced thermal protection	CAC end caps
XTreme RV500HHR	PA-GF50, enhanced thermal protection, high stiffness	CAC end caps, electric motor parts
XTreme BMV150HHR	PA-GF15, enhanced thermal protection, for blow moulding	Turbo air pipes
XTreme RV200UK	PA-GF20, heat and UV protection, excellent surface appearance	Brushcutter muffler cover
XTreme ERV200TUK	PA-GF20, heat and UV protection, enhanced impact resistance, excellent surface appearance	Chainsaw housing
XTreme HSK 364 M. BK	PA unfilled, excellent thermal protection	Under-bonnet clips
XTreme HSW 100 NAT	PA unfilled, suitable for high temperature exposure	Monofilament

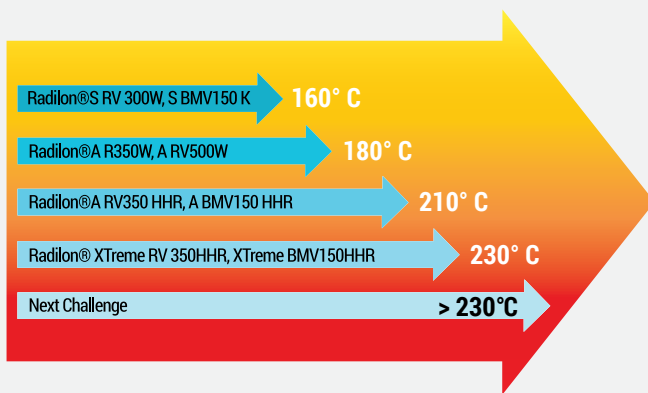
Meeting the most critical challenges

The evolution in the transport industry towards smaller, more efficient engines fitted into smaller spaces requires materials offering better performance, heat resistance and durability.

The introduction of Euro V and Euro VI engines, designed to comply with the ever more stringent regulations on fuel consumption reduction and environmental performance, has led to a constant increase in pressure in turbo powered engines and increased engine exhaust gas recirculation (EGR), with a consequent rise in under-bonnet temperatures. As mentioned above, all these factors point to the

need for materials that ensure higher performance and reliability during the entire life of the vehicle.

The constant temperature rise poses a major challenge for manufacturers of engineering plastics, but it also presents a great opportunity for the research and development of special products to meet the new specifications, which are, by necessity, much more demanding than the previous ones. In this perspective, RadiciGroup Performance Plastics has developed a range of polyamides meeting market requirements up to 230°C and is ready to take on even greater challenges, in order to be ready to offer solutions delivering higher levels of performance in the coming years.



Radilon® XTreme rounds out the RadiciGroup Performance Plastics range of polyamides, which now covers the needs of applications with continuous use temperatures (CUTs) in air of up to 230°C. By way of example, in the chart below are indicated a few materials from the current product portfolio together with the corresponding continuous use temperatures. They all are glass-fibre-filled materials for injection and blow moulding applications. Different grades, with glass-fibre-fill percentages other than the ones included in the chart, are also available.

Chart 2 | Continuous use temperature in air

CODE	DESCRIPTION
Radilon® S RV300W	PA6-GF30, heat stabilized, for injection moulding
Radilon® S BMV150K	PA6-GF15, heat stabilized, for blow moulding
Radilon® A RV350W	PA66-GF35, heat stabilized, for injection moulding
Radilon® A RV500W	PA66-GF50, heat stabilized, for injection moulding
Radilon® A RV350HHR	PA66-GF35, high heat stabilized, for injection moulding
Radilon® A BMV150HHR	PA66-GF15, high heat stabilized, for blow moulding
Radilon® XTreme RV350HHR	PA-GF35 specialty, high heat stabilized, for injection moulding
Radilon® XTreme BMV150HHR	PA-GF15 specialty, high heat stabilized, for blow moulding)

Radilon® XTreme: sample applications

Radilon® XTreme BMV150HHR's high melt strength makes it especially apt for blow moulding with parison suction. By using this material with this technology, pipes of constant thickness and excellent internal surface quality can be obtained. Compared to PPS-GF15, Radilon® XTreme makes it possible to attain a 15% weight reduction in the moulded part, together with an increase of about 70% in Charpy unnotched impact strength. This component has been approved for continuous use temperatures at 230°C under pressure pulsation.

Excellent results in the design of new-generation brushcutters have been achieved with the use of Radilon® XTreme. Although the material is subject to higher heat stress on these tools due to the presence of a catalytic converter, the improved performance of Radilon® XTreme RV200UK, compared to other previously used products, made it possible to design a more compact, lighter machine. The material was specially designed for this particular application in a variety of colours, with high resistance to weathering and excellent aesthetic appearance.



Figure 2 | Blow-moulded turbo pipe made with Radilon® XTreme BMV150HHR



Figure 3 | Muffer cover for new-generation brushcutters made with Radilon® XTreme RV200UK

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