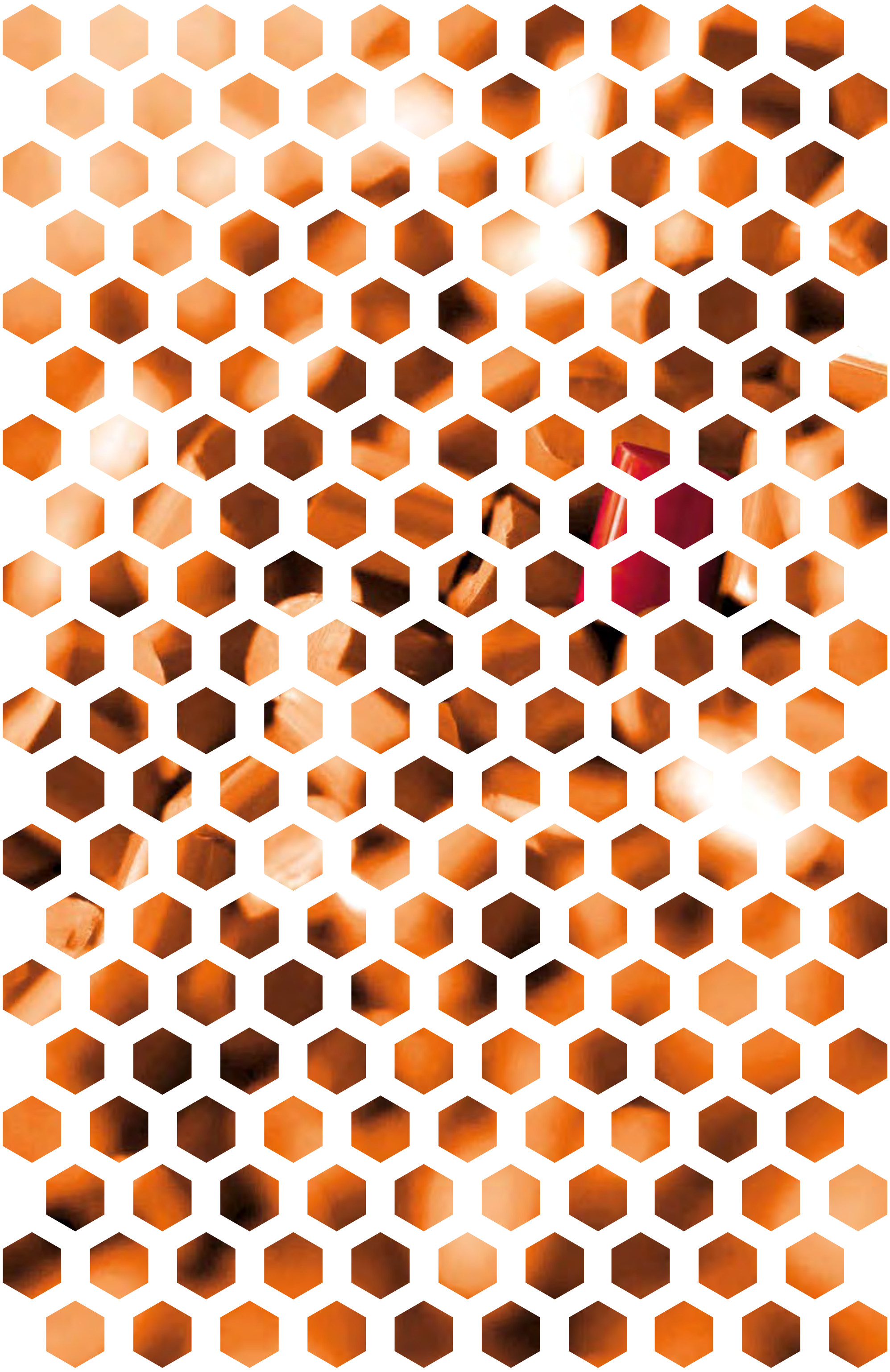


NEW MATERIALS WITH SUPERIOR HEAT RESISTANCE IDEAL FOR METAL AND SPECIAL POLYMERS REPLACEMENT

A new line of PA66 polymers for parts continuously exposed to hot air temperatures of up to 210°C:

Radici Plastics has just launched a new line of PA66 materials, sold under the Radilon® HHR brand name, capable of withstanding continuous use in hot air temperatures of 210°C. This exceptional achievement in terms of heat resistance allows extending the use of PA66 to highly critical applications. Radilon® HHR plastics are competitively advantageous as replacements for both metal and special polymers.

The innovative technology developed by Radici Plastics ensures that these HHR materials still maintain the ease of processability that is typical of PA66, by keeping the moulding temperature at 100°C or lower. The moulding parameters are practically unchanged compared to standard glass-fibre filled PA66.

RADILON® HHR: NEW PA66 ENGINEERING PLASTICS WITH IMPROVED HEAT RESISTANCE

- Radilon® A RV350 HHR 3800 Ner (35% glass-fibre filled for injection moulding)
- Radilon® A BMV150 HHR 3800 Ner (15% glass-fibre filled for blow moulding)
- Radilon® A BMV200 HHR 3800 Ner (20% glass-fibre filled for blow moulding)

POTENTIAL APPLICATIONS

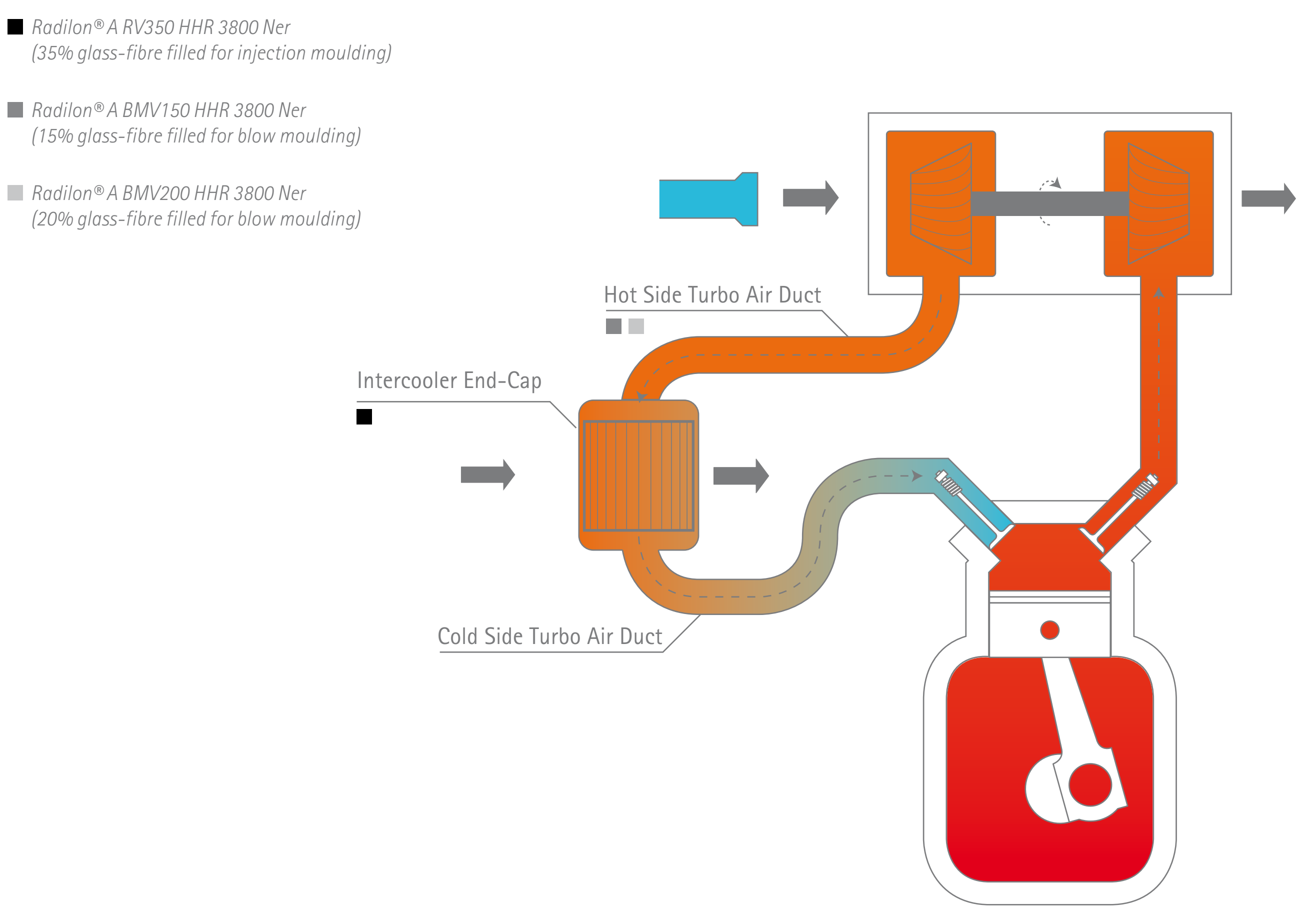
In the automotive market we have observed continual growth in demand for engineering plastics capable of withstanding very high temperatures. This trend is directly related to the mass introduction, during the last few years, of turbocharged engines that develop greater power with smaller displacement. In this area, HHR products can be applied in the manufacture of components that are still mostly made of metal, such as:

- Turbo manifolds
- Turbo resonators
- EGR valve housings
- Intercooler end-cap

The injection moulding version of Radilon® HHR is suitable for applications in the electrical/electronics and consumer goods sectors for parts under thermal stress up to 210°C in continuous operating conditions, at times under very high static or dynamic loads.

Radilon® HHR products also have excellent chemical resistance against engine oil, gearshift oil and engine coolants. High hydrolysis resistance, together with superior heat resistance, makes these materials suited to components subjected to mechanical stress and vibrations in water/glycol mixtures.

FIG.1 – TURBO SCHEME



For comparison purposes, Figures 5 and 6 show cross-sections of Radilon® A RV350 HHR 3800 Ner and PA66-GF35 specimens, respectively, after heat ageing in air at 210°C for 1000 hours. As we can see in Figure 5, the Radilon® HHR specimen appears only slightly damaged on the surface, while its interior remains intact. In contrast, in Figure 6 we see how deep the heat degradation is in the standard PA66 specimen cross-section, about 70% of which is carbonized.

FIG.5 AND 6 - STRUCTURES MORPHOLOGY COMPARISON

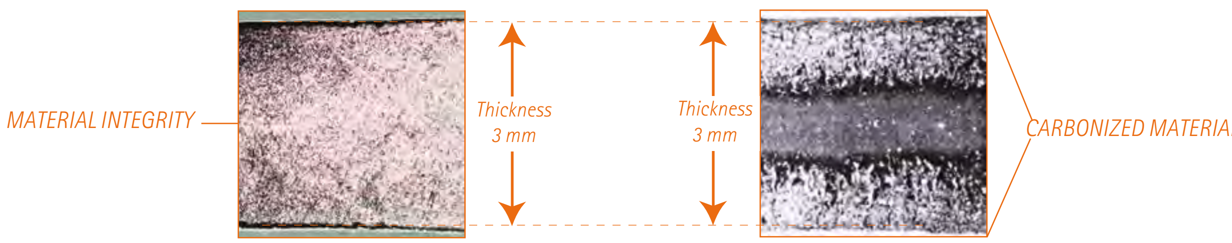


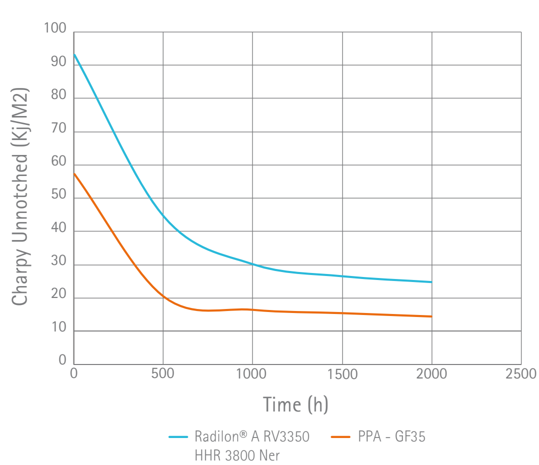
Fig.5 Fig.6

As we can observe from the cross-section in Fig.5, after 1000 hours of heat ageing at 210°C, the Radilon® A RV350 HHR specimen has remained practically intact, except for slight degradation on the surface. In contrast, as we see in Fig.6, the heat stabilized PA66-GF35 specimen exhibits a deeply degraded structure after the same heat ageing process: about 70% of the specimen thickness is destroyed.

PROPERTY COMPARISON WITH SPECIAL POLYMERS

For temperatures of up to 200-210°C, the heat resistance characteristics of Radilon® HHR are superior to polyphthalamide (PPA). This is illustrated in the graphs in Figures 7 and 8, which show Charpy unnotched impact strength and tensile strength at break as a function of time for specimens subjected to heat ageing in air at 200°C. The superior performance of Radilon® HHR specimens indicates that these materials can be used in many applications as replacements for special polymers (PPA and PA4,6) without jeopardizing component integrity, while benefiting from the potential advantages of injection moulding as a manufacturing process.

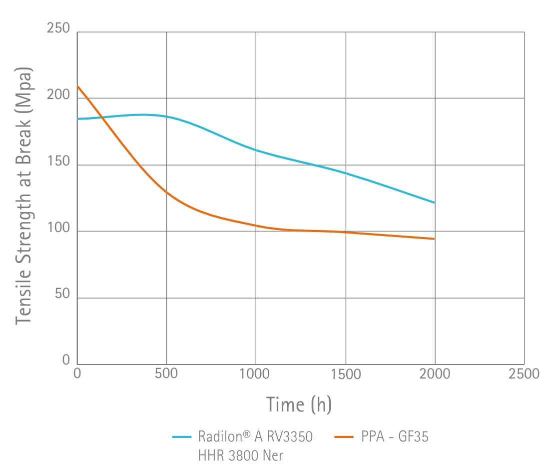
FIG.7 - HEAT AGEING IN AIR AT 200°C



After 2000 hours of heat ageing in air at 200°C, Radilon® A RV350 HHR 3800 Ner (High Heat Resistance) exhibits Charpy unnotched impact strength degradation comparable to polyphthalamide (PPA):

- *Radilon® A RV350 HHR 3800 Ner: 27% of initial value*
- *PPA GF35: 26% of initial value*

FIG.8 - HEAT AGEING IN AIR AT 200°C



After 2000 hours of heat ageing in air at 200°C, Radilon® A RV350 HHR 3800 Ner (High Heat Resistance) exhibits less tensile strength at break degradation than polyphthalamide (PPA):

- *Radilon® A RV350 HHR 3800 Ner: 66% of initial value*
- *PPA GF35: 48% of initial value*

PROPERTIES OF RADILON® A RV350 HHR 3800 NER FOR INJECTION MOULDING: COMPARISON WITH BENCHMARK VALUES

This 35% glass-fibre filled material is suitable for injection moulding. Other materials, with different fill percentages - some of which are modified to increase their impact strength – are now being launched. Radici Plastics is also willing to collaborate with customers in the development of custom products, including products with flame-resistant properties. The data presented below are the results of tests carried out at the Radici Plastics Laboratories.

Figure 2 shows how tensile strength decreases as a function of time during heat ageing at different temperatures in the 170 to 210°C range. In Figure 3 Radilon® A RV350 HHR 3800 Ner behaviour under heat ageing at 210°C is compared with two PA66-GF35 special polymers (Comp 1 and Comp 2), taken as benchmark references, and a heat stabilized PA66-GF35 commonly used at temperatures of up to 170 – 180°C. This behaviour is also confirmed by the degradation of Charpy unnotched impact strength (Figure 4). Radilon® A RV350 HHR 3800 Ner has twice the residual impact strength as the benchmark. On the other hand, PA66-GF35 has a residual value of close to zero.

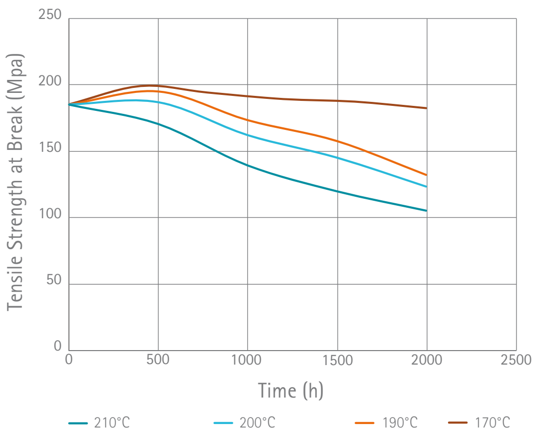


FIG.2 – RADILON® A RV350 HHR 3800 NER: HEAT AGEING IN AIR

Radilon® A RV350 HHR polyamide tensile strength measured on ISO specimens at temperatures of 170, 190, 200 and 210°C. After 2000 hours at 210°C, the tensile strength is still more than 50% of its initial value.

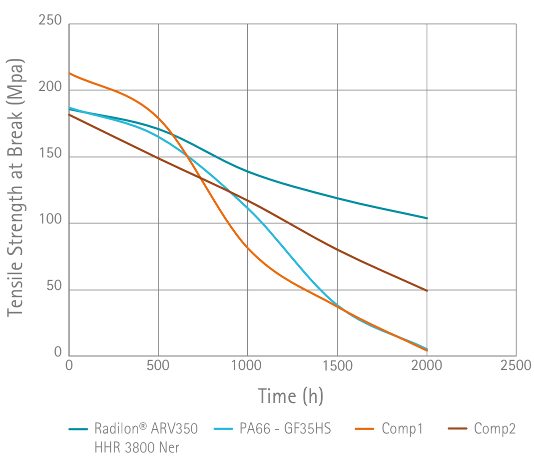


FIG.3 – HEAT AGEING IN AIR AT 210°C

After 2000 hours of heat ageing in air at 210°C, Radilon® A RV350 HHR 3800 Ner (High Heat Resistance) exhibits significantly less degradation of tensile strength at break (ISO 527) compared to the reference benchmarks:

- *Radilon® A RV350 HHR 3800 Ner: 56% of initial value*
- *Comp1 (benchmark 1): 0% of initial value, specimen completely carbonized*
- *Comp 2 (benchmark 2): 27% of initial value*
- *PA66-GF35 Heat Stabilized: 0% of initial value, specimen completely carbonized*

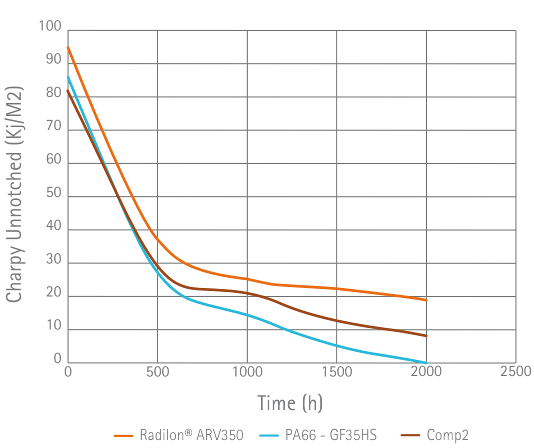


FIG.4 – HEAT AGEING IN AIR AT 210°C

After 2000 hours of heat ageing in air at 210°C, Radilon® A RV350 HHR 3800 Ner (High Heat Resistance) exhibits much higher residual impact strength than the benchmark:

- *Radilon® A RV350 HHR 3800 Ner: 20 KJ/m²*
- *Comp 2 (Benchmark 2): 10 KJ/m²*
- *PA66-GF35 Heat Stabilized: 2 KJ/m²*

RADILON® HHR FOR BLOW MOULDING

Two materials that can be processed using blow moulding and can withstand continuous use temperatures of up to 210°C have just been introduced:

- Radilon® A BMV150 HHR 3800 Ner (15% glass-fibre filled)
- Radilon® A BMV200 HHR 3800 Ner (20% glass-fibre filled)

Besides their superior heat resistance, both materials are well suited to blow moulding. These materials are mainly used in manufacturing turbo manifolds/ducts, particularly when the shape of the components is complex or impossible to make using individual moulded parts welded together. A 1.2-m duct with both elbow and bellow, blow moulded with parison suction technology, is shown in Figure 9. The materials were designed to achieve the best rheological properties, which make them suitable for 3D-blow moulding (materials with improved melt strength).

FIG.9 - TURBO AIR DUCT MADE FROM RADILON® A BMV200 HHR USING SUCTION BLOW MOULDING

Radici Plastics offers two solutions: 15% and 20% glass-fibre filled.
The best choice depends on the geometric configuration of the duct and the manufacturer's specifications.
The main properties are listed in the table below.

Property	Standard	Radilon® A BMV150 HHR	Radilon® A BMV200 HHR
Tensile strength at break	ISO 527	86	98
Tensile modulus	ISO 527	4900	5900
Elongation at break	ISO 527	4	3.5
HDT (1.8 MPa)	ISO 75	218	226
Charpy unnotched impact strength	ISO 179	66	69
Density	ISO 1183	1.2	1.22

READY TO TAKE ON EVEN MORE DEMANDING CHALLENGES

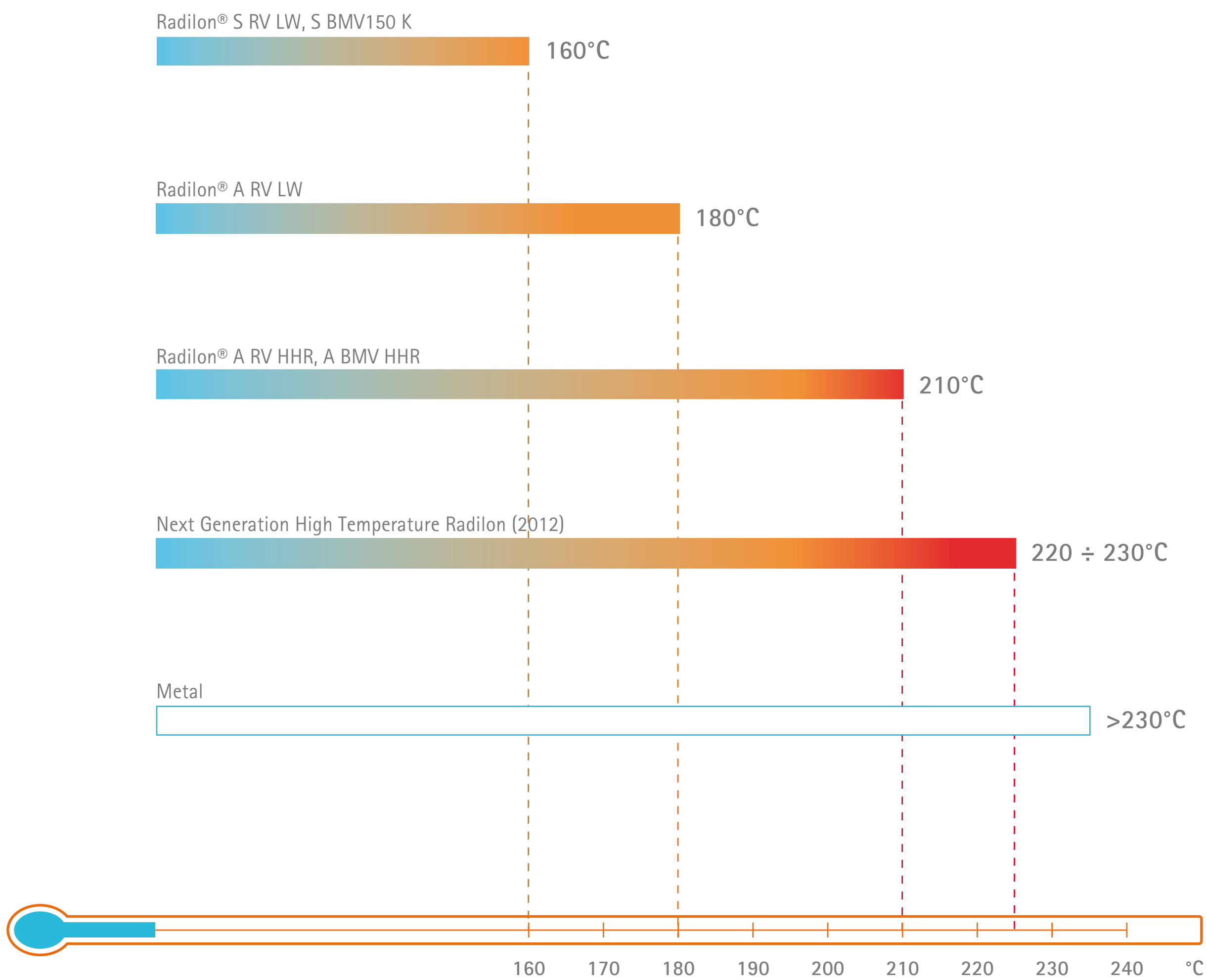
The evolution towards greater engine efficiency, reduced dimensions and engines fitted in a more limited space requires the use of high performance materials in terms of heat resistance and life.

In the new Euro V and Euro VI engines, which are designed to comply with ever more stringent norms and regulations on the environment and fuel consumption, increased pressure is generated in the turbo system and the recirculated exhaust gas (EGR) causes an increase in under-the-bonnet temperature. All this requires the development and use of materials with enhanced performance and greater reliability during the entire life of the vehicle.

The continual increase in temperature poses a major challenge for engineering plastics manufacturers but, at the same time, creates a great opportunity for the research and development of special products that meet the new specification requirements, which are always much more stringent than the previous ones. Working with this perspective, Radici Plastics has developed a range of polyamides that can meet market requirements up to 210°C.

However, this achievement is only a mid stage goal. Radici Plastics is already studying materials that are heat resistant up to 230°C, as well as easy to process, in order to broaden the field of application of RadiciGroup engineering plastics even further.

FIG.13 - CONTINUOUS USE TEMPERATURE IN AIR



Today Radici Plastics offers a range of polyamides that can withstand hot air temperatures of up to 210°C.
To complement the traditional PA6-GF (Radilon® S RV LW for moulding and S BMV150K for blow moulding) and the heat stabilized PA66-GF (Radilon® A RV LW), Radici Plastics has introduced PA66-HHR polyamides for continuous use at temperatures of up to 210°C, which are the result of an innovative RadiciGroup technology. A new generation of polyamides for continuous use temperatures of up to 230°C are presently in the experimental phase.

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