In the automotive market there has been continual growth in demand for engineering polymers capable of withstanding high hot air temperatures. This is directly related to the majorvalorisation, the fast five years of which has driven that demand up with severe development tolls in this area. To meet these needs Radiclip® HH products can be used as replacements of components that are currently made of metal, which have very high temperatures.

- Turbo air ducts
- Turbo resonators
- Intercooler end cap
- Cold side turbo air ducts
- Glass-filled Torzen®
- Glass-filled Radilon®

Figure 1 | Standard heat stabilized polyamide (left) vs. Radilon®
Figure 2 (right-hand side): Radilon®

RADILON® HHR ensures that these high-temperature-resistant polymers are suitable for use in components that are exposed to continuous operating temperatures of up to 100°C or lower. The moulding parameters are practically unchanged compared to standard glass-fibre filled PA6.6.

The innovative technologies used on Torzen® Marathon, Radiflam® HHR and Radilon® HHR ensure that these high-temperature-resistant polymers are suitable for components that are exposed to continuous operating temperatures of up to 210°C. Medium stiffness.

Flame retardant

High temperature PA6.6-GF15, Halogenated. Product rated UL V-0 at 0.4 mm. Suitable for ducts exposed to continuous operating temperatures up to 150°C. Slightly elongated thermal properties.

High temperature PA6.6-GF15, Halogen and red phosphorous free. Rated UL V-0 at 0.4 mm. Suitable for EE applications with higher thermal exposure.

RADIFLAM® HHR

Suitable for parts exposed to continuous operating temperatures of up to 120°C. Excellent electrical stability and improved heat distortion temperature.

HHR polymer

Flame retardant

High temperature PA6.6-GF15 Suitable for parts exposed to continuous operating temperatures of up to 150°C. Medium stiffness.

Radiflam® HHR

Suitable for EE applications (e.g., connectors) with higher thermal exposure.

Product Name | Product Description | Main Characteristics
---|---|---
High temperature PA6.6-GF15 | Suitable for parts exposed to continuous operating temperatures
of up to 150°C. Excellent electrical stability and improved heat distortion temperature. | Flame retardant

Radiflam® HHR

Suitable for EE applications (e.g., connectors) with higher thermal exposure.

Radiflam® HHR

Suitable for parts exposed to continuous operating temperatures of up to 150°C. Excellent electrical stability and improved heat distortion temperature. | Flame retardant

Radiflam® HHR

Suitable for parts exposed to continuous operating temperatures of up to 150°C. Excellent electrical stability and improved heat distortion temperature. | Flame retardant

High temperature PA6.6-GF15 | Suitable for EE applications with higher thermal exposure.

High temperature PA6.6-GF25, Marathon FRG2500XHL NC01 | Suitable for parts exposed to continuous operating temperatures of up to 120°C. Excellent electrical stability. | Flame retardant

High temperature PA6.6-GF35 Suitable for parts exposed to continuous operating temperatures | Suitable for parts exposed to continuous operating temperatures of up to 120°C. Excellent electrical stability. | Flame retardant

High temperature PA6.6-GF35 | Suitable for parts exposed to continuous operating temperatures of up to 120°C. Excellent electrical stability. | Flame retardant

High temperature PA6.6-GF35 Suitable for parts exposed to continuous operating temperatures of up to 120°C. Excellent electrical stability. | Flame retardant
very high temperatures. This trend is directly related to the mass introduction, during the last few years, of turbocharged engines, which generates ever more stringent requirements for the air cooling system and design. In this latter area of high-temperature applications, RadiciGroup has developed a range of high performance materials that offers a superior value added in terms of heat resistance and life.

In the electrical and electronics industry, components must be capable of withstanding increasingly more severe service conditions, while meeting the need for further miniaturization. Moreover, to improve economic and environmental performance and reduce the size of components, the generation of heat due to the efficiency of alternators is becoming a real issue and therefore a new material has been developed for high temperatures of up to 180°C.

The innovation technology used in the "Marathon" Radiflam® HHR and Radiflam® HHR ensures that these high temperatures are maintained without changing the size of the parts. Marathon is in fact made up of high-performance materials in terms of hot resistance and life.

The continual increase in temperature poses a major challenge for engineering polymer manufacturers but, at the same time, seems to offer a wide range of possibilities to maximize the performance and efficiency of medium and high voltage electrical equipment. The introduction of high performance materials, with resistance temperature indices (RTI) of up to 190°C, has therefore been developed to meet the needs of the EE sector with RTIs of up to 160°C.

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### Torzen® Marathon key features

- Excellent property retention up to 170-180°C. The graph illustrates that, after heat benchmark reference commonly used at temperatures HHR 3800 BK under heat ageing at 190°C and 210°C is during heat ageing. The behaviour of Radilon tensile strength retention decreases as a function of time respectively, for blow moulding; and two 15% glass-fibre filled,

- Strength at break caused by the thermal oxidation of the and 210°C temperatures, exhibits a fast decline in tensile while PA6.6-GF35 heat stabilized at the standard 190°C HHR 3800 BK still remains above 50% of its initial value, while the best choice depends on the application. These materials are well suited to blow moulding. These materials are mainly used in automotive parts, particularly when the shape of the components is complex or impossible to make using traditional methods.

- The main characteristics of this material are:
  - Radison® HH® for blow moulding
  - Two materials can be processed and injection moulding permits the use of a wide range of temperatures and pressures.
  - This material is specifically designed to withstand the demanding conditions of blow moulding.
  - The best choice depends on the specific requirements of the part and the manufacturer’s specifications. The best choice depends on the specific requirements of the part and the manufacturer’s specifications.

### Radison® HH® key features

- Excellent property retention up to 210°C in contact with hot air. Excellent property retention up to 210°C in contact with hot air

- Excellent weld line resistance

### Chart 1

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Time (h)</th>
<th>PA6.6-GF35, standard heat stabilized PA6.6-GF35 (3000 h in air).</th>
</tr>
</thead>
<tbody>
<tr>
<td>150</td>
<td>0</td>
<td>100%</td>
</tr>
<tr>
<td>180</td>
<td>200</td>
<td>95%</td>
</tr>
<tr>
<td>190</td>
<td>1000</td>
<td>90%</td>
</tr>
<tr>
<td>200</td>
<td>2000</td>
<td>85%</td>
</tr>
<tr>
<td>210</td>
<td>2500</td>
<td>80%</td>
</tr>
</tbody>
</table>

### Chart 2

- Tensile strength at break retention

- Chart indicates the retention of tensile strength retention as a function of time for the Torzen® Marathon G3500XHL compared to the benchmark. The best choice depends on the specific requirements of the part and the manufacturer’s specifications.

### Chart 3

- Flame retardancy retention after 3000-hour exposure

### Chart 4

- Charpy notched impact strength retention is still more than 50% of its initial value.

### Chart 5

- Charpy unnotched impact strength for the HHR (High Heat Resistance) blow moulding products is clearly less than for the benchmark.

### Chart 6

- Tensile modulus ISO 527

### Chart 7

- Max CUT in air. Criteria: 50% TS retention after 3000 h exposure.

### Chart 8

- Torzen® Marathon for the EE market

### Table 1

<table>
<thead>
<tr>
<th>Property</th>
<th>Standard</th>
<th>Torzen® Marathon G3500XHL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tensile strength at break (MPa)</td>
<td>ISO 527</td>
<td>86  98</td>
</tr>
<tr>
<td>Tensile modulus</td>
<td>ISO 527</td>
<td>4  15</td>
</tr>
<tr>
<td>Charpy unnotched impact strength</td>
<td>ISO 527</td>
<td>66  69</td>
</tr>
<tr>
<td>Density</td>
<td>ISO 527</td>
<td>1.20 1.23</td>
</tr>
</tbody>
</table>

### Table 2

<table>
<thead>
<tr>
<th>Property</th>
<th>Standard</th>
<th>Torzen® Marathon G3500XHL</th>
</tr>
</thead>
<tbody>
<tr>
<td>HDT (1.8 MPa)</td>
<td>ISO 75</td>
<td>215 225</td>
</tr>
<tr>
<td>Hrsm (200 MPa)</td>
<td>ISO 297</td>
<td>90  100</td>
</tr>
<tr>
<td>Density ISO 1183</td>
<td>1.20 1.23</td>
<td></td>
</tr>
<tr>
<td>Flame retardancy</td>
<td>14%</td>
<td></td>
</tr>
</tbody>
</table>

### Chart 9

- Flammability retention after 3000-hour exposure

### Chart 10

- Chemical resistance: engine oil and cooling system liquids.

### Chart 11

- The excellent chemical resistance of these materials in engine oil and boiling system liquids, even at high temperatures, is key to their high demand for the manufacture of water and oil ducts.

### Chart 12

- The same type of behaviour is seen in Chart 4, where Charpy notched impact strength retention is shown as a function of exposure time at 190°C and 210°C. Considering the excellent chemical resistance of these materials in engine oil and boiling system liquids, even at high temperatures, they are highly recommended for the manufacture of water and oil ducts.

### Chart 13

- Flame retardancy retention after 3000-hour exposure

### Chart 14

- Flame retardancy retention after 3000-hour exposure

### Chart 15

- The best choice depends on the specific requirements of the part and the manufacturer’s specifications.

### Chart 16

- The best choice depends on the specific requirements of the part and the manufacturer’s specifications.

### Table 3

<table>
<thead>
<tr>
<th>Property</th>
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<td>ISO 527</td>
<td>1.20 1.23</td>
</tr>
</tbody>
</table>

### Chart 17

- Tensile modulus ISO 527

### Chart 18

- Charpy unnotched impact strength for the HHR (High Heat Resistance) blow moulding products is clearly less than for the benchmark.

### Chart 19

- Tensile modulus ISO 527

### Chart 20

- Charpy unnotched impact strength for the HHR (High Heat Resistance) blow moulding products is clearly less than for the benchmark.

### Chart 21

- Tensile modulus ISO 527

### Chart 22

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### Chart 35

- Tensile modulus ISO 527

### Chart 36

- Charpy unnotched impact strength for the HHR (High Heat Resistance) blow moulding products is clearly less than for the benchmark.
The same type of behaviour is seen in Chart 4, where Charpy notched impact strength retention is shown as a function of exposure time at 190°C and 210°C.

Despite the excellent mechanical resistance of these materials in engine oil and cooling system liquids, even at high temperatures, they are highly recommended for the manufacture of water and oil ducts.

The heat ageing effect on elongation at break, Charpy unnotched impact strength and tensile strength at break is described in Charts 5 and 6. As expected, the elongation at break shows the best performance in R-35% glass-fibre reinforced materials, while the tensile strength at break. After 1500 hours of heat ageing the bend samples show a property retention of 55%, while the bend samples for melting strength of 85% and 55% of the initial value respectively.

By using two grades of glass fibre, the Radilon® A RV350 BMV150 HHR and BMV200 HHR families of products are dramatically less than for the benchmark.

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The same type of behaviour is seen in Chart 4, where Charpy notched impact strength retention is shown as a function of elongation at break at 190 °C and 210 °C. A 1.2-m duct with both an elbow and bellows, blow moulded using parison suction technology, is shown in Figure 4.

The data in Chart 5 show that the HHR materials perform very well in blow moulding. These materials are, overall, used in manufacturing parts when the shape of the components is too complex to make using traditional and conventional methods. The main characteristics of this material are:

- Excellent appearance and high fluidity
- Easy moulding and low viscosity
- High fluidity (220°C)
- Easy moulding grade with high productivity
- Excellent mould flow

The HHR family of products comprises:

- Radilon® A RV350 HHR (15% glass-fibre filled) for moulding and S BMV150K for blow moulding
- Radiflam® HHR for engine covers
- Radilamp® HHR for blow moulding

The high-performance characteristics of these materials make them ideal for the manufacture of water and oil ducts.

A key feature of the HHR materials is their excellent stress retention properties. After 1500 hours of heat ageing in air at 210°C, the degradation of tensile strength for the HHR (High Heat Resistance) blow moulding products is clearly less than for the benchmark. A key feature of the HHR materials is their excellent stress retention properties. After 1500 hours of heat ageing in air at 210°C, the degradation of tensile strength for the HHR (High Heat Resistance) blow moulding products is clearly less than for the benchmark.

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The Radilon® HHR key features:

- Excellent property retention up to 210°C in contact with water
- Excellent weld line resistance
- High electrical properties and RTI values for the flame retardant version
- Excellent appearance and high fluidity
- Flame retardant properties (UL 94 V-0 rated at 0.8 mm)
- Dimensional stability up to 210°C
- Benchmark: 21% of initial value.

The Radilon® HHR family of products comprises:

- Radilon® A BMV150 HHR
- Radilon® A BMV200 HHR

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 products. To complement the traditional PA6-GFs (Radilon®), RadiciGroup High Performance Polymers offers a range of polyamides that can withstand hot air temperatures of up to 210°C.

Radilon® HHR key features:

- Excellent property retention up to 170°C due to contact with hot air
- High mechanical properties
- Easy flow grade with high productivity
- Excellent weld line resistance

To complement the traditional PA6.6-GFs (Radilon®), RadiciGroup High Performance Polymers has introduced Torzen® Marathon FR for engine covers. Radilon® HHRs for blow moulding still retain 70% and 90% of their initial values, respectively.

The Radilon® HHR family of products comprises: 15% and 20% glass-fibre filled grades. The best choice depends mainly on the end use application: the highest value must be made using individual moulded products. The main characteristics of this material are:

- Excellent property retention up to 170°C due to contact with hot air
- High mechanical properties
- Easy flow grade with high productivity
- Excellent weld line resistance

To complement the traditional PA6-GFs (Radilon®), RadiciGroup High Performance Polymers has introduced Torzen® Marathon FR for engine covers. Radilon® HHRs for blow moulding still retain 70% and 90% of their initial values, respectively.
Better part performance at high hot air temperatures

In the automotive industry, there has been a clear growth in demand for engineering polymers capable of withstanding very high temperatures. This trend has been directly related to the move toward electrification, the last few years of which have seen engine designs that develop greater power with less displacement. In this area, RadiciGroup’s Torzen® HHR products can be used to the advantage of car manufacturers that, in recent years, have opted for lighter and more aerodynamic bodywork, which, in turn, has increased the under-the-bonnet temperature. All this requires the development and use of materials with enhanced performance and greater stability during the service life of the vehicle.

The car manufacturers in temperature zones face a major challenge for engineering polymer manufacturers. So, the same time frame exists: a lower moulding temperature, increased service life conditions, while meeting the need for further miniaturization. Moreover, to improve economic and environmental performance, the development of alternative technologies is mandatory, therefore a research and development for a new generation of high-temperature materials could be needed by the vehicle manufacturers.

In the electrical and electronics industry, components must be capable of withstanding increasingly more severe service conditions, while meeting the need for further miniaturization. Moreover, to improve economic and environmental performance, the development of alternative technologies is mandatory, therefore a research and development for a new generation of high-temperature materials could be needed by the vehicle manufacturers.

In Euro 6 engines, which are designed to comply with ever more stringent norms and regulations on the environment and safety aspects, there is an increase in under-the-bonnet temperature. All this requires the development and use of materials with enhanced performance and greater stability during the service life of the vehicle.

The provided cases are just a few examples of how high performance materials in terms of heat resistance and life can be used in challenging applications. The information provided in this document corresponds to our knowledge on the subject as of the date of publication. The information may be subject to revision as new knowledge and experience become available. Data provided fall within the normal range of product properties and relate only to the specific designated material. The data may not be valid for such material if used in combination with any other material or additive, or in any process, unless otherwise expressly indicated. The data provided should not be used to establish specification limits. Such assumptions in data shall be made by the end user of the material. Nothing in this publication is to be considered as a licence to operate under, or a recommendation to infringe, any patent rights. RadiciGroup High Performance Polymers assumes no liability in connection with any use of the above information.

The Torzen® range offers the advantage of high performance under high hot air temperature conditions, while meeting the need for further miniaturization. Moreover, to improve economic and environmental performance, the development of alternative technologies is mandatory, therefore a research and development for a new generation of high-temperature materials could be needed by the vehicle manufacturers. The information provided in this document corresponds to our knowledge on the subject as of the date of publication. The information may be subject to revision as new knowledge and experience become available. Data provided fall within the normal range of product properties and relate only to the specific designated material. The data may not be valid for such material if used in combination with any other material or additive, or in any process, unless otherwise expressly indicated. The data provided should not be used to establish specification limits. Such assumptions in data shall be made by the end user of the material. Nothing in this publication is to be considered as a licence to operate under, or a recommendation to infringe, any patent rights. RadiciGroup High Performance Polymers assumes no liability in connection with any use of the above information.

The innovative technologies used in the Torzen® Marathon, Radilon® HHR and Radilon® HHR ensure that these high temperature materials can meet the annual increase of over 1°C in the temperature at 105°C known. The resulting parameters are practically unchanged compared to standard Glass Fibre filled PA 6.6.

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**Figure 2 (left-hand side)**: Standard heat stabilized polyamide. Its performance in the under-the-bonnet area, after heat ageing at a high temperature (190°C at 2000 h) does not significantly affect the mechanical and thermal performances.

**Figure 2 (right-hand side)**: Standard heat stabilized polyamide. Its performance in the under-the-bonnet area, after heat ageing at a high temperature (190°C at 2000 h) does not significantly affect the mechanical and thermal performances.

**Table 1**

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Product Description</th>
<th>Main Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-temperature PA6.6</td>
<td>Suitable for ducts exposed to continuous operating temperatures of up to 190°C.</td>
<td>Good melt strength.</td>
</tr>
<tr>
<td>High-temperature PA6.6</td>
<td>Suitable for ducts exposed to continuous operating temperatures of up to 210°C.</td>
<td>Excellent surface appearance. For covers.</td>
</tr>
<tr>
<td>High-temperature PA6.6</td>
<td>Suitable for ducts exposed to continuous operating temperatures of up to 190°C.</td>
<td>Halogen and red phosphorous free. Rated UL V-0.</td>
</tr>
<tr>
<td>High-temperature PA6.6</td>
<td>Suitable for ducts exposed to continuous operating temperatures of up to 195°C.</td>
<td>Excellent surface appearance. For covers.</td>
</tr>
<tr>
<td>High-temperature PA6.6</td>
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<td>Halogen and red phosphorous free. Rated UL V-0.</td>
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</table>
Better part performance at high hot air temperatures

In the automotive industry, there has been a trend in recent years for engineers to develop polymers capable of withstanding very high temperatures. This trend is directly related to the more rigid regulations, both in Europe and other regions, which mandate that engines develop greater thermal stability. In this sense, it is not surprising that Radici Group products are used to manufacture components that meet these demands, and are ready to take on demanding challenges.

In the electrical and electronics industry, components must be capable of withstanding very severe service conditions, while meeting the need for further miniaturization. Moreover, to improve performance and environmental sustainability, the demand for the use of alternatives to replace thermoset materials in medium-voltage electrical equipment is growing. In the automotive industry, components must be capable of withstanding increasingly more severe service conditions, while meeting the need for further miniaturization. Moreover, to improve performance and environmental sustainability, the demand for the use of alternatives to replace thermoset materials in medium-voltage electrical equipment is growing.

The evolution towards greater engine efficiency, reduced dimensions and engines fitted into a more limited space requires ready to take on demanding challenges. RadiciGroup High Performance Polymers offers HHR polymer brand names – capable of withstanding requirements of up to 210°C and special materials for the EE sector with RTIs of up to 160°C. The continual increase in temperature poses a major challenge for engineering polymer manufacturers but, at the same time, there is an increasing demand for new materials with higher thermal exposure. The innovation techniques used in "Torzen® Marathon", Radilon® HHR and Marathon® ensure that these high temperature PA6.6-GF35 polymer matrixes are suitable for parts exposed to continuous operating temperatures up to 210°C. Stable melt strength and stiffness, excellent surface appearance. For covers.

The Torzen® Marathon range also assumes no liability in connection with any use of the above information. The information provided in this document corresponds to our knowledge on the subject as of the date of publication. The information may be subject to revision as new knowledge and experience are gained. The information is provided in good faith, but we do not guarantee its accuracy or completeness, and we assume no liability in connection with any use of the above information. The information is provided in good faith, but we do not guarantee its accuracy or completeness, and we assume no liability in connection with any use of the above information.

Marathon, Radiflam® and Radilon® are brand names of RadiciGroup High Performance Polymers. The information provided in this document corresponds to our knowledge on the subject as of the date of publication. The information may be subject to revision as new knowledge and experience are gained. The information is provided in good faith, but we do not guarantee its accuracy or completeness, and we assume no liability in connection with any use of the above information.