

New Polymer “SHIELD” Technology Protects High-Performance Nylon and PPA Polymers to Replace More Metal - For Weight and Cost Savings - Under the Hood

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ABSTRACT

The multitude of megatrends influencing today's auto industry has clearly defined the need for new high performance thermal plastic composite materials that will extend product life under harsh conditions. In response a new family of nylons from DuPont which combines the ease of processing of conventional nylon resins with groundbreaking levels of resistance to chemicals, hot air, oil and coolant were developed. Comprehensive research shows that, in comparison to traditionally stabilized nylons, the lifetime of components can be significantly extended. This, along with other benefits, such as low warpage and an excellent surface appearance, make the new polyamides ideal for a range of applications, which to date have been reserved for metals or considerably more expensive high-performance thermoplastics. The initial emphasis for application developments will be on automotive engine and exterior components, although the encapsulation of sensors, electronic components, household equipment and general industry also offer great potential. This paper reviews the new material's enhanced performance characteristics compared to standard nylon products while conveying the notion of value extraction in automotive power-train components.

INTRODUCTION

For more than 25 years, heat stabilized nylon 6 and 66 composite grades have been the material of choice for automotive under-the-hood applications. In contrast to more expensive alternatives such as the specialty nylons 46, 6T and PPA or the high performance thermoplastics such as PEEK and PSU they are easy to process, ductile and impact

resistance. The first applications in these materials were simple cover caps, fan guards and coolant tanks. Today they are used for air duct components around the turbocharger, for cylinder head covers, resonators, water pump housings, oil pans and exhaust mufflers ([Image 1](#)).

With higher performance engines and a reduction of air flow passing through the engine compartment, under-the-hood temperatures are expected to increase from 150 °C to 180 °C with peaks of 230 °C. This, along with the simultaneous exposure to humidity, lubricants, fuels and aggressive road salts will pose a challenge beyond the performance capabilities of conventional polymer materials.

BODY

In response a portfolio of new cost-efficient, easily processible PLUS nylon polymers that reliably withstand the rigorous engine compartment environment, for the entire lifetime of the vehicle have been developed. Leading OEMs currently demand that these materials retain at least half of their original properties, such as tensile strength or strain at break, after 1,000 hours of hot air aging at 210 °C, an increase of up to 40°C. Similarly high demands are made with regard to aging resistance in hot oil and hot coolant.

Taking advantage of a new enabling additive technology these new nylon grades, cost efficiently, increase thermal and chemical resistance to unprecedented levels, very likely doubling the life of a component. Their major benefits, in terms of their low specific weight, high-flow and therefore ease of processing at moderate temperatures way below their decomposition temperature, are fully retained. New PLUS

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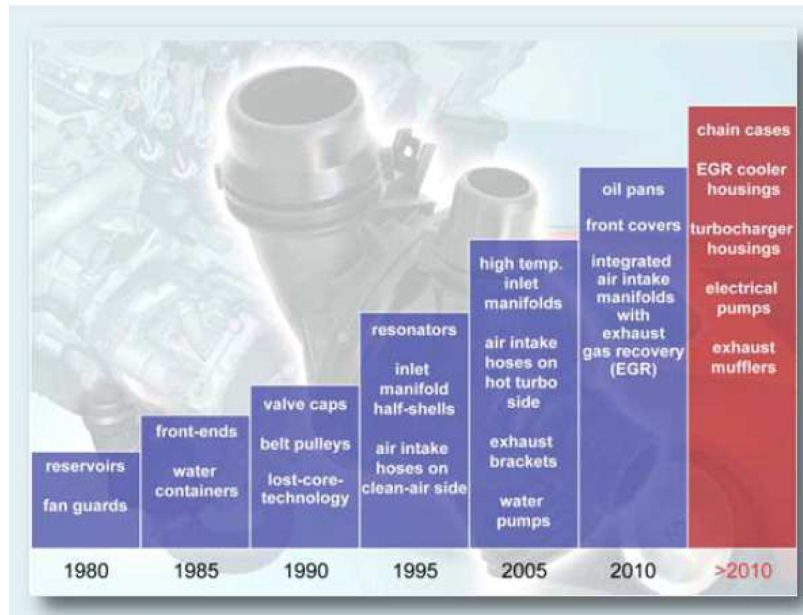


Image 1. Nylons have 25 years of use in the engine compartment behind them, with many more to come

nylon receives its endurance boost from SHIELD Technology. SHIELD Technology combines several innovations, including a new polymer backbone, polymer modifications and a special set of additives, to enhance many performance characteristics. Using an exact combination of base material and additives, multifaceted benefits are delivered which, depending on the targeted application, meet resistance requirements far better than nylons commonly available today. The efficiency of this technology is best illustrated by the microscopic images of two heat-stabilized, glass fiber reinforced PA66 grades ([Image 2](#)). They show microtome sections through samples with an initial thickness of 4 mm, after exposure to a temperature of 210 °C for 1,000 hours. The resulting damage to the traditionally-stabilized PA66 is shown above, the lower image shows a grade of PLUS nylon, which has been stabilized with the new technology. Whereas surface carbonization of the standard grade is considerable, the PLUS nylon sample is almost unscathed, and the damaged layer is only a few hundredths of a millimeter deep.

The excellent long-term temperature and chemical resistance of the new, high-flow PLUS nylons means that they can cost-effectively fill the wide gap between standard nylons and many typical high performance thermoplastics such as PPA and PPS ([Image 3](#)).

It is therefore likely that the lifetime of certain components in the engine compartment can be doubled compared to those made of standard, heat-stabilized nylon. As a result, there are a multitude of opportunities to replace metal components in the engine compartment or to replace existing polymer applications with more lightweight constructions. In turn, this

will help vehicle manufacturers to not only reduce their costs but also weight, thereby helping to reduce both fuel consumption and emissions. The new, highly-resistant nylons, which demonstrate mechanical properties over a wide temperature range and are as ideally suited to long flow distances as they are to thin wall sections, also offer new perspectives in the design of applications such as electric and electronic components, sanitary equipment or parts for industrial facilities.

EIGHT NEW MATERIALS

The initial product development comprises eight chemical, heat and oil-resistant grades, optimized according to targeted applications.

- PA66 CP GF35 H1 is a high flow nylon co-polymer core product, displaying outstanding properties, even after long-term exposure to high air temperatures of up to 210°C (short-term peaks of up to 230°C) with very good surface quality and high resistance to hot motor oil and calcium chloride solutions. Principal applications will be in the area of air ducting components.
- PA66 CP GF50 H2 is a high-flow nylon co-polymer with an increased glass fiber content of 50 percent. It combines very good resistance to the long-term effects of high temperatures up to 210 °C (short term peaks of up to 230°C) with increased stiffness and creep resistance at high temperatures, thus making it ideal for applications under-the-hood.
- PA6 GF35 H1 offers a low melt temperature of 224 °C (other grades range from 265 °C to 310°C) and combines good long-term retention of properties when exposed to heat, oil and chemicals with very good weld line and burst pressure

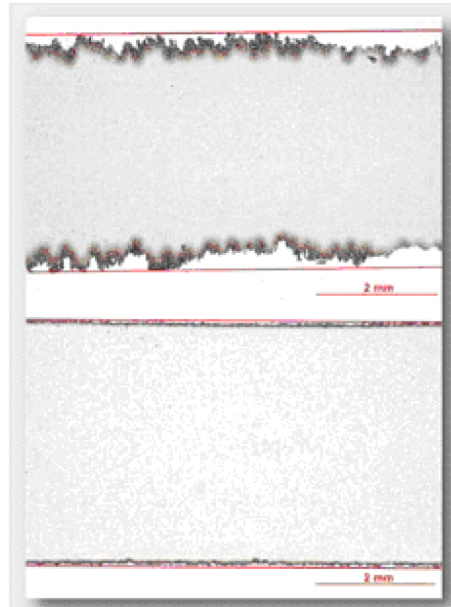


Image 2. In comparison to traditionally-Stabilized PA66 grades (above), the long-term exposure to high temperatures (in this case: 1000 h at 210 °C) causes considerably less damage to the new PLUS grades

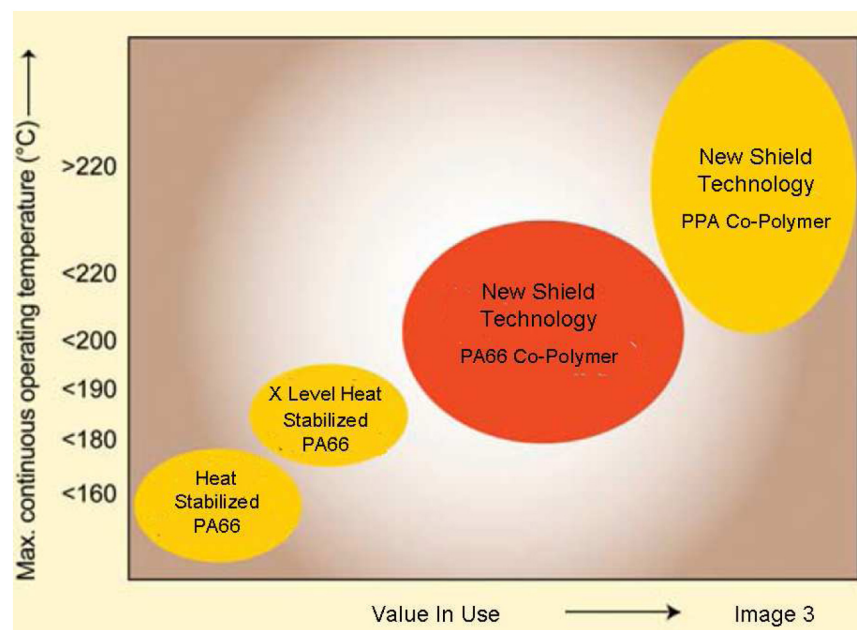


Image 3.

strength. Typical applications are components exposed to hot air.

- PA66 GF30 DR is notable for its outstanding resistance to hot engine coolant and hot water, and is ideal for the production of radiator end tanks, thermostat housings and other components that come into direct contact with coolants.
- PA66 CP GF40 T H1 nylon co-polymer offers toughness, formulated specifically to meet existing aluminum stone

impact and hot oil-aging requirements, it outperforms traditional nylons on the market today to help ensure a component such as an exhaust muffler or oil pan withstands impact from gravel and road debris, while maintaining critical sealing function.

- PA66 CP GF45 H3 nylon co-polymer shows virtually no drop off in performance despite 5000 hours exposure to 150°C hot oil, making it attractive for other hot-oil