

# Designing Air Ducts that Beat the Heat



**As automotive and commercial vehicle OEMs continue to drive more performance from internal combustion engine (ICE) powertrains, reducing the weight of every component is becoming increasingly important. For OEMs, this poses a new challenge.**

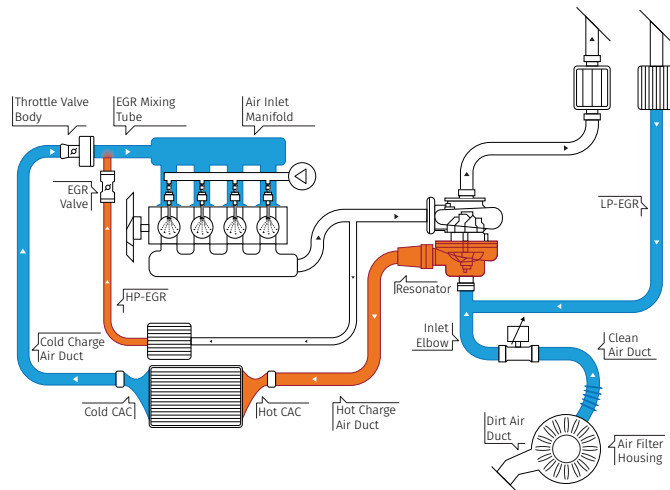
Engineers must leverage turbocharger systems to increase the power and efficiency of ICE powertrains. At the same time, they must also decrease underhood space to accommodate the overall weight reduction of the vehicle.

This combination of reduced space and elevated temperatures is driving the need for advanced lightweight materials that can withstand heat without compromising performance.

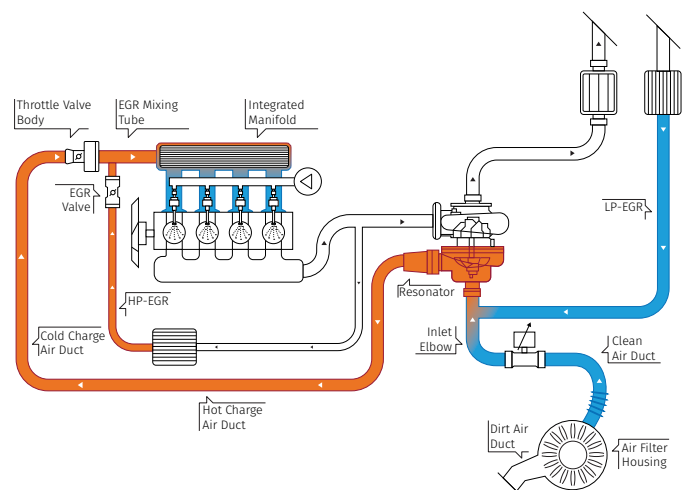
# The Evolution of Turbocharger Systems

A turbocharger is a turbine-driven forced induction device that increases an internal combustion engine's efficiency and power output by forcing extra air into the combustion chamber. They leverage air-to-air (direct) cooling or liquid-to-air (indirect) cooling to prevent overheating.

## Direct (air-to-air) cooling



## Indirect (liquid-to-air) cooling



The latest development in turbocharger systems is to integrate the charge air cooler (CAC) into the air intake manifold (AIM), using liquid instead of air to more effectively cool the air. This drives up the temperature in the AIM (currently up to 230°C), and the mechanical requirements for the materials used.

Integrating the CAC into the AIM also reduces the length of pipe needed to reach the air-to-air cooler at the front of the vehicle. This results in an increase in engine responsiveness, and enables auto makers to deliver higher performing engines that meet emission standards.

In some cases, factors like package space, design or cost prevent OEMs from integrating the CAC into the AIM. In these instances, liquid-to-air cooling can still be implemented by mounting the CAC as a standalone component directly onto the engine, near the AIM.

Moving from air-to-air cooling to liquid-to-air cooling impacts the geometry and material requirements for the hot charge duct. In some instances, the duct design may favor an injection molding process that can adequately manage the overall shorter duct length—while relying on tool action or secondary operations to achieve the tubular cross section. For this design direction, DSM offers a broad range of high-performance materials for injection molding.

In other instances, where the complex routing, cross sectional real estate, and assembly ergonomics favor a blow molding approach, DSM introduces an expanded and optimized portfolio of high-performance, blow-moldable materials.

Manufacturers will benefit from working with these materials that deliver weight reduction through metal and rubber replacement, while also increasing engine efficiency, reducing emissions and noise and decreasing system cost.

# The Diablo Portfolio of Blow-Moldable Materials for Air Management Systems

DSM has partnered with its customers to develop the Diablo portfolio of blow-moldable materials. This enhanced blow molding portfolio incorporates glass-reinforced grades capable of withstanding peak operating temperatures up to 250°C—while delivering long-term and reliable performance over a broad range of more moderate temperatures. These robust materials have an inherently high strength to weight ratio, allowing for thin-walled designs that can reduce the total system mass by up to 40%.

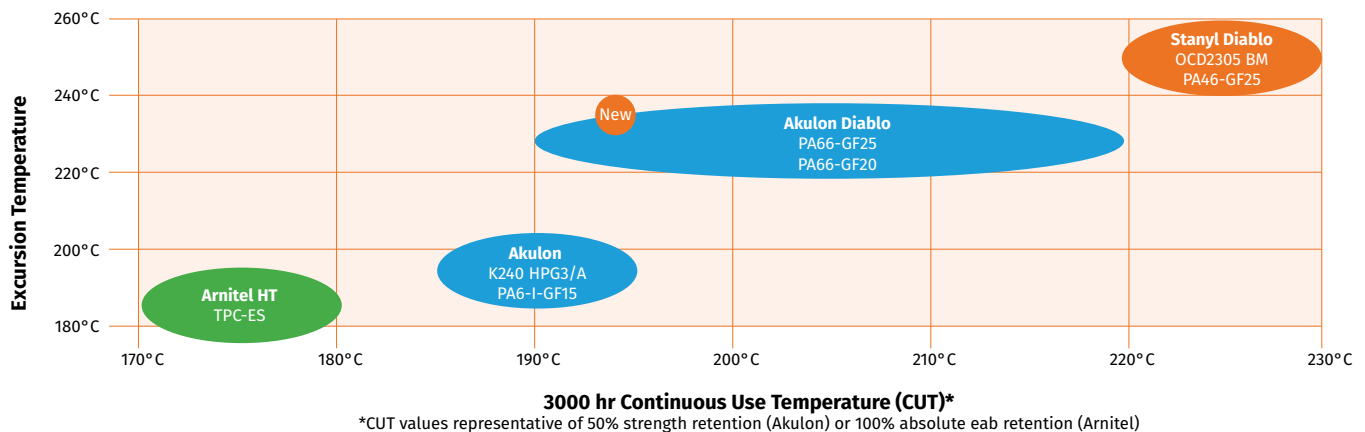
On the flexible side, Arnitel HT TPC offers best-in-class heat ageing performance. This makes it an ideal, lower mass and lower system cost alternative to acrylate-based rubber hose. While Arnitel HT cannot match the temperature extremes achievable with glass-reinforced DSM materials, it represents an enhancement of approximately 30°C for the continuous operating temperature compared to traditional TPC grades.

**STANYL® DIABLO PA46-GF25** demonstrates high performance at extreme peak and continuous use temperatures, meeting even the most stringent turbocharged diesel requirements.

**AKULON® DIABLO PA66-GF25/GF20** is a state-of-the-art, heat-stabilized thermoplastic that delivers best-in-class specific strength and property retention in both extreme and moderate temperature conditions.

**AKULON® PA6-I-GF15** provides robust processability and performance/cost balance to meet the requirements of positive pressure cold charge and some hot charge air duct applications.

**ARNITEL® HT TPC-ES** delivers extreme flexibility for rubber replacement. It was recognized as a runner-up in the Enabling Technology Innovation category at the 2019 Altair Enlighten Awards.



Property	AKULON DIABLO HDT2505 BM	AKULON DIABLO HDT2504 BM	STANYL DIABLO OCD2305 BM	PA66 GF15 (Super stabilized)
	New	New		Competitor
Material type	PA66 GF25	PA66 GF20	PA46 GF25	PA66 GF15
E modulus 23C (Mpa)	8200	7050	8500	5500
Tensile strength 23C (Mpa)	145	135	150	115
Strain at break 23C (%)	3.2	3.5	3.3	5
T <sub>m</sub> (°C)	254	255	284	260
HDT 1.8MPa (°C)	218	218	244	220
Density (g/cm <sup>3</sup> )	1.31	1.27	1.33	1.18
Specific strength (tensile strength/density)	111	106	113	97



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