

# TurboNews

The Info Magazine of BorgWarner Turbo & Emissions Systems 2/06

## Premiere for Porsche

PORSCHE AND BORGWARNER  
CELEBRATE THE FIRST VTG APPLICATION  
IN A GASOLINE ENGINE



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## Editorial

# Priming for Progress

Dear Readers,

The turbocharger has been around for more than 100 years. Yet there is still no end in sight to its further development. Virtually all modern diesel engines are equipped with a boosting system, so engine developers are now turning their attention to turbocharging for gasoline engines. With the world's first VTG turbocharger application in a gasoline engine, Porsche and BorgWarner have broken through the boundaries of what was previously considered possible – paving the way for significant improvements to gasoline engines in terms of both power output and fuel consumption. You can find more on this topic in our article on the new Porsche 911 Turbo.

Audi is also enjoying great success with its innovative TFSI range of engines, which combine the advantages of turbocharging and gasoline direct injection. You can read about these pioneering new solutions in our reports on the Audi S3 and the Audi global engine.

In the commercial vehicle sector, engine developers are mainly focusing on reducing nitrogen oxide and particulate emissions. The innovative SCR exhaust gas aftertreatment system is an important solution here – combined with a modern charging system. With DaimlerChrysler and DAF, two important commercial vehicle manufacturers are relying on BorgWarner's know-how in this field.

Further exciting topics in this edition of TurboNews include the new diesel engines in luxury vehicles by Land Rover and Hyundai. We also report on the longest rally in Latin America, where the majority of participants crossed the finish line with BorgWarner turbochargers.

We hope you have fun reading!

The editorial team

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## BORGWARNER LAYS A FURTHER MILESTONE IN TURBOCHARGER TECHNOLOGY

# Pioneering Feat

When launched at the start of 2006, the Porsche 911 Turbo was the first ever gasoline engine with variable turbine geometry turbocharger (VTG) to go into serial production. This marks a further milestone in the evolution of turbocharged gasoline engines.

The idea of combining this kind of turbocharger with gasoline engines is something many engine designers have been dreaming of for 20 years. The intensive development work by the engineers at BorgWarner Turbo & Emissions Systems has made this dream a reality. The focus when developing this new system was not just on solving the design challenges of a VTG unit operated under gas engine conditions, but also on developing and industrializing the materials needed. With the BV50G, many new solutions and materials were used for the first time in a turbocharger. These represent the foundations of this important innovation for future gasoline engine development. The use of VTG in gasoline engines opens up great potential for significantly increasing power density, while at the same time improving transient response and lowering specific fuel consumption.

These advantages can be clearly seen in the Porsche 911 Turbo. Yet this only marks the beginning in the development of gasoline engines with VTG turbocharging. So-called downsizing concepts offer many opportunities for the use of VTG in gasoline engines. Here, the engine developers need a char-

ging system that can overcome the low-end torque and transient disadvantages of a smaller engine compared to a larger engine that offers the same power. In terms of space needed and weight, the VTG offers significant advantages over more complex boosting systems, such as combinations of superchargers and turbochargers.

Having already launched the revolutionary R2S regulated 2-stage turbocharging system for diesel engines, the development engineers at BorgWarner Turbo & Emissions Systems have now added another pioneering feat to the rich history of turbocharging by adapting their VTG technology for gasoline engines. This once again underlines the know-how and motivation of the staff at BorgWarner as well as the company's commitment to global product leadership. There is a good reason behind the latest slogan at [www.borgwarner.com](http://www.borgwarner.com): BorgWarner = Innovation in Engine Technology



**Ulli Froehn, Vice President of Business Development & Marketing at BorgWarner Turbo & Emissions Systems.**

PORSCHE AND BORGWARNER CELEBRATE THE FIRST VTG APPLICATION IN A GASOLINE ENGINE

# Premiere for



The Porsche 911 Turbo is a real icon among sports car lovers.

When Porsche drivers hear the word "turbo", it instantly conjures up images of real power for pure driving pleasure. The new Porsche 911 Turbo is certain to meet these high expectations and also set new standards. In this latest incarnation, it is the first vehicle ever with a gasoline engine to use a VTG turbocharger.

#### Heat resistant up to 1,000°C (1,830°F)

Up to now, variable turbine geometry (VTG) has been reserved for diesel engines. The technical challenge for its application in a gas engine was to develop materials that can handle the significantly higher exhaust gas temperatures of up to 1,000°C found in these engines. Working together with Porsche, BorgWarner Turbo & Emissions Systems succeeded in developing a turbocharger with VTG technology for the 911 Turbo. The adjustable turbine vanes sit right

at the heart of the turbocharging system. Their major advantage lies in the fact that they can be closed to generate high boost pressure at low revs and low exhaust flow rates. This vastly improves response and pick-up at low speeds compared to conventional turbochargers. And the gas engine with VTG also displays significantly greater efficiency over the entire performance range compared to today's standard turbochargers with waste gate. This in turn leads to further improvements of the specific fuel consumption over a wide rev band.

Despite its similarity to the diesel version, the engineers at BorgWarner had to completely redevelop the cartridge – the most important component of the VTG – to meet the high demands in terms of exhaust gas temperatures. The particular challenge of this task was finding highly heat-resistant materials with the right tribological and

thermal expansion properties that would allow the necessary surface qualities and tolerances to be manufactured reliably. In the course of development, new aerospace materials were also used, some of which had never before been used in auto or turbocharger design.

#### A massive boost

The 3.6 liter (219 cubic inch) engine in the new 911 Turbo has two BV50G turbochargers with electrical VTG actuation. These help the 6-cylinder boxer engine generate just over 470 bhp, some 59 bhp more than its predecessor. Nominal torque has also been increased by 44 lb-ft to over 450 lb-ft. At the same time, the engine developers have been able to expand the rev band in which this massive power is available, to further improve the already legendary performance of the iconic sports car. On the previous model,

# Porsche



**Two BV50G turbochargers with VTG provide excellent performance figures in the new 911 Turbo.**

maximum torque was available between 2,700 and 4,600 rpm. The new engine generates its 457 lb-ft of torque in the entire range from 1,950 to 5,000 rpm.

With manual transmission, the new 911 Turbo sprints from 0-60 in under 4 seconds. And the version with the new Tiptronic S is 0.2 seconds faster. The top speed of both versions is 192 mph. Perhaps more impressive than the increase in power is the lower fuel consumption of the new 911 Turbo. This new package averages an impressive 18 mpg US average (22 mpg UK).

## Driving technology forward with VTG

Following the successful premiere in the Porsche 911 Turbo, BorgWarner expects its VTG technology to find a broader base of gasoline engine applications in the next ten years. "Gasoline engines with exhaust gas

turbocharging and direct fuel injection will enjoy the same kind of success as diesel engines", explains Dr. Hans-Peter Schmalzl, Vice President Technology at BorgWarner Turbo & Emissions Systems. Compared to other boosting concepts, VTG represents the best price-performance ratio after the wastegate turbocharger. Without additional boosting device, it offers the same performance and similar dynamic behavior as larger normally aspirated engines. However, these figures are achieved with significantly lower fuel consumption. "The use of turbochargers with variable turbine geometry will become a new milestone in the development of gasoline engine booster systems", continues Dr. Schmalzl. This is why BorgWarner will continue to drive forward developments in this field.



LION V8 DIESEL ENGINE WITH BV TECHNOLOGY  
ENTERS THE LUXURY CLASS

# Luxury Liner

**S**upreme ride quality, excellent performance and effortless handling – both on and off the road. These properties are what make the new Range Rover by British manufacturer Land Rover stand out from the crowd. A powerful 3.6 liter (219 cubic inch) V8 turbo diesel is now also available to complement the familiar 2.7 liter (165 cubic inch) six-cylinder turbo diesel from the SUV Lion family that BorgWarner developed together with Ford for the offroad specialist.

#### Maximum power, minimum consumption

The biturbo diesel generates 272 bhp, and its maximum torque of 472 lb-ft is available from 1,900 rpm. The innovative engine gets its power from two BV39 turbochargers with variable turbine geometry developed by BorgWarner Turbo & Emissions Systems. As the name already suggests, these turbochargers are from the latest VTG generation BV, which has now established itself as the technical standard in modern passenger vehicle diesel engines. The two turbochargers use latest generation impellers, which guarantee optimum low-end torque, and are incredibly compact. The turbine vanes are adjusted to changing conditions both precisely and quickly using an electrical servo motor. And this application also has another special feature. The turbochargers are designed

to continue running as normal even if the engine compartment is flooded with water – as can happen when crossing rivers.

The BV technology by BorgWarner was a fundamental prerequisite in enabling the Land Rover to meet its tough targets in terms of fuel consumption, emissions and performance. Thanks to the latest engine technology, emissions are as much as 20 % below the limits stipulated by the strict Euro 4 emissions standard, while average consumption is an impressive 20 mpg US (25 mpg UK). The power on hand gives the almost 3-ton luxury liner sporty performance. The Range Rover sprints from 0-60 in around 9 seconds, achieving a top speed of 124 mph.

#### BV premiere in the luxury diesel class

The 3.6 liter (219 cubic inch) V8 turbo diesel brings the latest BV technology by BorgWarner into serial production for the first time in the luxury V8 diesel class. With this achievement, BorgWarner has laid a further milestone in the development of innovative boosting systems.

The development of the V8 diesel is further confirmation of the effective co-operation between BorgWarner Turbo & Emissions Systems and engine/vehicle designers – in this case Ford and Land Rover. The turbocharger manufacturer from Kirchheimbolanden had already



collaborated successfully with these companies when developing the BV50 for the Lion V6 diesel engine. This turbocharger is used with variable turbine geometry in the Land Rover Discovery 2.7 liter V6 turbo diesel (see also Turbo-News 2/04).

Range Rover: The classic among luxury offroad vehicles.

# a Lion's Heart



Compact powerhouse – The BV39 turbocharger with VTG.



The new Lion V8 turbo diesel guarantees the level of performance expected by drivers of luxury vehicles.

BORGWARNER DEVELOPS TURBOCHARGER FOR HYUNDAI VERACRUZ WITH

# Seven-Seater

**S**uperlative performance meets uncompromising luxury in the Veracruz, the new seven-seater sports utility vehicle by Hyundai. Named after the elegant Mexican bathing resort, the Hyundai Veracruz has all the features you would expect from a luxury vehicle. Positioned as a "luxury utility vehicle", it is set to become the new shooting star in its segment.

## The S-engine

A vehicle such as the Veracruz is deserving of an advanced and exciting engine concept. And this is exactly what the engineers at Hyundai have delivered with the S-engine. The new engine uses several important innovative technologies, which are firsts for Hyundai. Apart from this being the

first V6 diesel that Hyundai has ever produced, it also represents the first use of compacted graphite iron for the cylinder block and the first application of piezoelectric fuel injectors in combination with a VTG turbocharger employing electrical turbine vane adjustment.

Developed at Hyundai's Powertrain R&D Center in Namyang, the S-engine sets new standards of refinement and performance for a diesel. Generating 240 bhp at 3,800 rpm and maximum torque of 339 lb-ft (460 Nm) over the entire rev band from 1,700 to 3,500 rpm, it is hard to imagine a more powerful compact diesel. So it is no wonder that customers test driving the vehicle in Korea simply could not believe that they were driving a diesel. Alongside the high power output and excellent

level of comfort, the engine is also well within the limits of the EURO IV emissions standard.

## Improved performance through new turbo technology

The new S-engine from Hyundai is equipped with a BV50 turbocharger from BorgWarner Turbo & Emissions Systems that uses electrically adjustable turbine vanes – the same unit already being used in many market-leading luxury vehicles with diesel engines. The excellent characteristic thermodynamic values and the fast, precise turbine vane adjustment of this turbocharger allowed the Hyundai engineers to achieve their target power density without having to sacrifice efficiency or transient response.

**With its pure luxury, elegant design and excellent performance,  
the Hyundai Veracruz is targeted as a "luxury utility vehicle".**



V6 DIESEL

# er Luxury



## Coop with Kibo

Without the intensive cooperation between the development teams in Kirchheimbolanden and the BorgWarner engineers on site, this engine could never have been developed. This is yet another demonstration of how BorgWarner Turbo & Emissions

Systems uses its global resources with local customer teams to achieve customer goals.

With the BV50 of the S-engine in the Hyundai Veracruz, another turbocharger with variable turbine geometry goes into serial production at the Pyongteak

facility. This modern plant offers its customers in Korea the best quality, short logistics paths and first class on-site customer support with Sales & Applications teams, design and prototyping capabilities. It is a great example of BorgWarner's continued success story in Korea, as it follows the philosophy of combining global resources and abilities with the strengths and skills of local teams to meet customer targets.



**With innovative materials, piezoelectric fuel injectors and a BV50 turbocharger, the V6 diesel uses the latest technology to deliver high performance.**

BORGWARNER SUPPLIES TURBOCHARGERS FOR NEW AUDI 1.8 LITER TFSI ENGINES

# World Engine

**A**udi recently presented its new 1.8 liter (109 cubic inch) TFSI engine, which was developed in close cooperation between the Audi engineers and BorgWarner Turbo & Emissions. The new unit not only embodies the consistent further development of the TFSI concept, but also marks the beginning of a completely new range of engines.

When designing the turbocharger for the new engine, BorgWarner Turbo & Emissions Systems was able to use its experience from the development of the 2.0 TFSI engine, which was first seen in the Audi A3 Sportback in 2004. When it came down to the selection of the boosting system, the engineers therefore again decided to opt for the tried and tested, water-cooled K03, which has numerous interesting features in its current stage of evolution.



**An engine for the world: The new Audi 1.8 liter TFSI four-cylinder with K03 turbocharger by BorgWarner.**



## Spontaneous and efficient

The 1.8 TFSI also uses a compact integrated turbocharger module. Since the manifold and turbine casings are combined to form a single component made of a highly heat-resistance material, this system not only saves space, it also offers thermodynamic advantages. The electrical recirculation valve, which is also integrated into the compressor casing, guarantees fast response times when closing the throttle valve. The use of a "latest generation" turbine wheel helps increase the efficiency of the turbocharger significantly, while optimized thermodynamics have led to further improvements in fuel consumption and transient behavior, i.e. the acceleration of the engine at full throttle. All these features come together to offer balanced power delivery in an engine that runs smoothly over its entire rev band. With the additional developments to the K03 turbocharger, the new Audi 1.8 liter TFSI engine combines the advantages of turbocharging and direct gas injection.

The effectiveness of the improvements to the K03 turbocharger are clearly reflected in the engine's performance and consumption figures. The 1.8 TFSI engine is capable of delivering 121 lb-ft of torque at just 1,000 rpm, offering its maximum torque of 184 lb-ft in the range from 1,500 to 4,200 rpm. The maximum power output of 160 bhp is available constantly

between 5,000 and 6,200 rpm. This forms the basis for sporty, yet economical driving. Indeed, the A3 with manual transmission offers an impressive 32 mpg US average (38 mpg UK).

## Global team work for a global engine

The team of developers was not only successful in reducing fuel consumption. The 1.8 TFSI also has the potential to meet the stricter emissions standards to be introduced in future. And it is equipped to deal with the different fuel qualities found in markets such as the US and South America. With the compact dimensions of both the K03 turbocharger and the four-cylinder 1.8 liter TFSI, the unit is suitable for longitudinal or transverse mounting in the engine compartment. This flexibility is a decisive advantage, since the new range of engines is to be used in various models on all five continents.

The design of the engine as a so-called world engine represented a special challenge for the teams at Audi and BorgWarner: Production of the 1.8 liter four-cylinder engine is set to start simultaneously in the fall of 2006 at the Audi engine factories in Györ, Hungary and Dahlean, China. In parallel to this, BorgWarner turbocharger production will start up at the Hungarian facility in Oroszlány and the new facility in Ningbo, China.

DAF PRESENTS MX ENGINES WITH  
B3 TURBOS FROM BORGWARNER

# Fit for



The new Euro 4 emissions standard has been in force in Europe for all commercial vehicles since October 2006. Many engine manufacturers have therefore taken the opportunity and modernized their engines to improve performance while reducing fuel consumption and emissions. The Eindhoven-based Dutch truck manufacturer DAF, which is part of the American PACCAR Group, saw this as a good time to introduce its new MX engine series. This series replaces the XEC series, which met the old Euro 3 emissions standards. Modern exhaust gas turbocharging and an exhaust gas aftertreatment system based on SCR technology are the special features of the new MX units. The DAF team was supported in the development of these engines by the experts at BorgWarner Turbo & Emissions Systems

## Low end power

The new 6-cylinder engine has a displacement of 786 cubic inches (12.9 liters) and is available with four different power ratings. It uses the new B3 generation turbocharger. The 355 bhp (265 kW) version of the MX engine uses a B3 turbocharger without waste gate, while the 400 bhp (300 kW) and 455 bhp (340 kW) versions each use a B3 turbocharger with waste gate. On the top model with just over 500 bhp (375 kW), the engineers decided to use a B3 turbocharger with boost pressure controlled by the engine management system. This version generates its maximum torque of 1,840 lb-ft (2,500 Nm) between 1,000 and 1,410 rpm.

The drivers of DAF's new trucks can therefore expect dynamic power delivery. With the fast response of the B3

turbochargers, the engines offer real grunt at very low revs. And this performance all comes with impressively low fuel consumption. The new XF driver cab, which is to be launched at the same time as the MX engines, is also likely to be well received. With a high level of comfort, an optimized chassis that offers excellent safety features, and more power, the new generation of DAF trucks sets new standards among trucks with a maximum permitted weight of up to 12 tons.

## The best of Schwitzer and 3K

As already mentioned, one special highlight of the MX engines is their use of the new B3 turbocharger series from BorgWarner. By combining the best Schwitzer and 3K components, it was possible to create a pioneering new generation of turbochargers for commercial vehicles with impressive mechanical efficiency, low oil consumption and long service life.

## A first in commercial vehicle design

The three turbocharger versions used by DAF each have a milled aluminum impeller to cope with the load placed on modern truck engines. And all versions employ an exhaust manifold integrated in the turbine casing. Although this technology has already been used in millions of passenger vehicles, it represents a completely new concept for commercial vehicles. It was selected due to its compact dimensions. Although creating the turbine casing with integrated exhaust manifold represented a great challenge for the designers at Turbo Systems and their FEM calculation (simulation), they ultimately mastered it brilliantly. It was also vital to ensure

Fully modernized: The DAF trucks with XF driver cab and MX engines.

that this kind of turbine casing could be cast under serial production conditions. These steps were crucial, as around 40,000 of these engines are ultimately to be built per year. And the module has to perform its duties reliably at an exhaust temperature of approximately 700°C for one million miles.

The B3 turbochargers are produced for DAF in Kirchheimbolanden, where an ultra-modern production line has been set up. With a production target of approximately 40,000 units per year, this is one of the facility's largest ever commercial diesel projects.



Premiere in a truck: On the B3 turbochargers, the exhaust manifold is integrated in the turbine casing.

DAIMLERCHRYSLER IS READY FOR UPCOMING EMISSIONS STANDARDS

# A clean Future



With the introduction of the Euro 4 and Euro 5 emissions standards, the limits for environmentally harmful nitrogen oxides and particulates have been made even stricter. As one of the most important manufacturers of commercial vehicles, and the largest commercial vehicle customer of BorgWarner Turbo & Emissions Systems, DaimlerChrysler has gone to great lengths to optimize the combustion process of its engines. One important aim here is the reduction of particulate emissions. Unfortunately, the measures needed for this inevitably lead to higher combustion temperatures – and thereby also to increased nitrogen oxide emissions. To combat this, DaimlerChrysler decided not to use exhaust gas recirculation, instead relying on SCR exhaust gas processing.

## SCR to prevent NOx

SCR stands for selective catalytic reduction and will allow the innovative commercial vehicle manufacturer to meet not only Euro 4, but also the upcoming Euro 5 emissions standard. This technology, which DaimlerChrysler has introduced under the BlueTec brand, will be used in all Actros and Axor trucks.

All the engine needs to use SCR is "Adblue" – a fluid that is kept in a separate tank – and an SCR catalytic converter. The primary constituent of Adblue is ammonium hydroxide. This liquid is injected directly into the hot exhaust gas downstream of the turbocharger, where the heat promotes the formation of ammonia gas. This gas is used as a reducing agent in the SCR catalytic converter, a rigid ceramic

element with a large surface needed for the catalytic reaction to take place. During this reaction, the harmful nitrogen oxides are converted into harmless water and nitrogen.

## Powered by BorgWarner

Another key element in the new generation of engines is turbocharging. BorgWarner has been the preferred development partner of DaimlerChrysler in this field since the introduction of the Euro 2 standard almost 10 years ago.

The current engines in the Actros vehicles are the OM501 and OM502LA. The OM501LA is a V6 engine with a displacement of 728 cubic inches (11.95 liters). It generates between 315 and 470 bhp (235–350 kW). For ratings up

# re

to around 400 bhp it is equipped with a tried and tested S400 turbocharger, while versions with 430 to 470 bhp use an efficient K31. It has a pneumatically controlled waste gate and a milled aluminum compressor wheel to meet the reliability and service life requirements. The OM502LA is a V8 engine with a displacement of 971 cubic inches (15.93 liters). It is rated between 500 and 590 bhp (375–440 kW) for those Actros trucks where extra performance is needed. It uses an S410 turbocharger with waste gate and milled aluminum impeller.

The Axor is the second heavy duty truck in the DaimlerChrysler product range. To optimize cab space, the Axor models were fitted with inline 6-cylinder engines. The engine range is made up of the 390 cubic inch (6.4 liter) OM906LA with a rating of

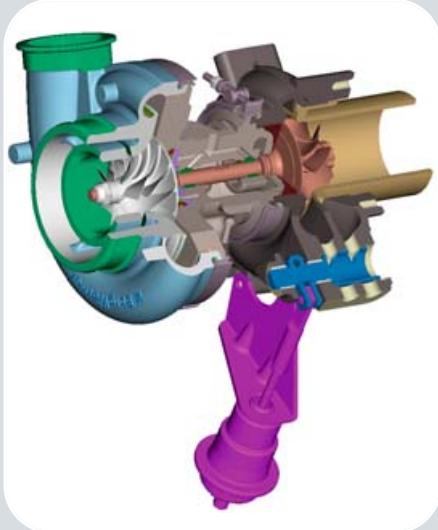
between 235 and 280 bhp (175–210 kW), the 439 cubic inch (7.2 liter) OM926LA with 322 bhp (240 kW) and the 732 cubic inch (12 liter) OM457LA engine with 355 to 422 bhp (265–315 kW). As has been the case since the Euro 2 standard, all engines are equipped with BorgWarner turbochargers. The OM906LA and OM926LA models employ K27.2 and K27 turbochargers. The OM457LA engine is intended for use in the more powerful Axor models, and an S410 turbocharger offers this unit its above average performance. Just like their V6 brother, all Axor engines have pneumatically controlled waste gates and milled aluminum impellers, ensuring a long service life.

One particularly interesting feature of the OM457LA EURO4 engine is its use of DaimlerChrysler's so-called turbobrake tech-

nology. This technology uses a sliding ring in the turbocharger to increase exhaust back pressure before the turbine and thereby increase its speed. This in turn generates greater air throughput in the engine, helping to increase the effect of engine braking by up to 30 percent. This technology, which was developed jointly by DaimlerChrysler and BorgWarner, has already been used successfully in the North American market and will certainly find users in other markets.

With the product range and expertise that BorgWarner Turbo & Emissions Systems offers, DaimlerChrysler is perfectly prepared for the introduction of Euro 5 – and beyond.

**The S410G turbocharger  
of BorgWarner.**



**The OM900, OM500 and OM457 models  
have more than enough power in reserve.**



NEW AUDI S3 WITH BORGWARNER TURBOCHARGER

# Refined Power

**D**ynamic, sporty and with a touch of luxury – the Audi A3 has assumed a powerful position in the premium compact class. And the market is now getting excited about the launch of the top model. The new Audi S3 generates an impressive 265 bhp and uses Audi's quattro permanent all-wheel-drive system. With its performance it remains true to the ideal of pure driving pleasure combined with everyday usability – just like all the "S" models by Audi.

The S3 redefines standards in its class, raising the bar to the level of a sports car. It sprints from 0-60 in approximately 5.5 seconds and has an electronically limited top speed of 155 mph. The powerful two-liter (122 cubic inch) four-cylinder engine with FSI direct fuel injection and turbocharging is a free-revving unit that delivers exceptional performance and sounds fantastic.

## Two-time winner of "Engine of the year"

With the introduction of the 2.0 liter TFSI engine in 2004, Audi became the first manufacturer worldwide to combine turbocharging with a direct injection gasoline engine. The developers at Audi trusted the know-how of BorgWarner Turbo & Emissions Systems from the outset, using the K03 turbocharger for this very first engine. The engine then celebrated its premiere in the Audi A3 Sportback and has since been voted "Engine of the year" in both 2005 and 2006. Its amazing combination of high power, sportiness and low consumption can now also be enjoyed in the Audi A4, A6 and S3, the VW Passat, Golf GTI and Jetta, as well as the Seat Leon FR.



The 2.0 liter TFSI engine in the S3 gives drivers the performance they expect of the top model in the range. It delivers its maximum power output of 265 bhp at 6,000 rpm, while its stunning 258 lb-ft of torque is available constantly from 2,500 rpm right up to 5,000 rpm. As if this wasn't enough, it is also extremely economical. With average consumption of just over 25 mpg US (31 mpg UK), the engine clearly demonstrates the impressive efficiency of Audi's TFSI technology.

## Fully optimized

The version of the engine used in the S3 is far more advanced than the model in the standard A3. The new K04 turbocharger by BorgWarner generates up to 1.2 bar of boost pressure, and is combined with BorgWarner's proven 1050°C technology. Comprehensive development work was needed here, not just to increase the temperature resistance up to 1050°C, but also to optimize the catalytic converter flow. Thanks to several changes in the design, it was also possible to optimize the manufacturing process for the integrated module. The turbocharger in the S3 is the first ever model to use a specially developed, milled impeller. With this new impeller, which is the same size as in the standard model, BorgWarner has succeeded both in increasing the operational range and further improving the efficiency in all key characteristic performance fields.



The new S3 by Audi is the undisputed sports king in the compact class.

The new Audi S3 TFSI quattro will help Audi further expand its leadership in the field of high-tech engines. We can all be excited to see what innovations the successful co-operation between Audi and BorgWarner will bring in future.

BORGWARNER EQUIPS RALLY CHAMPION

# Samba on the Racetrack

The Brazilian summer is hot! With temperatures exceeding 100°F, the 14th international Rallye Dos Sertões presented its participants with a real challenge. However, the heat didn't seem to hold back the drivers or BorgWarner's turbochargers, which again proved their great efficiency and performance in the adverse conditions of this extremely taxing race.

## Race of superlatives

The longest rally in Latin America runs for almost 2,500 miles through the west and northwest of Brazil, with the teams crossing 6 states in 10 days, traveling from Goiâna to Porto Seguro. A race of superlatives – in which BorgWarner demonstrated its expertise. Indeed, some 80% of the competing vehicles were fitted with BorgWarner turbochargers, including the official teams of Mitsubishi, BMW, Mercedes-Benz, Volkswagen and Ford.

A foreign team also took part for the first time. BMW brought an X3 into the race, equipped with a BorgWarner R2S regulated 2-stage system – a unit already familiar from serial production. The Mitsubishi L200RS and L200 EVO pick-ups used K16 and K26 turbochargers respectively, while the Ford F-4000 truck with Cummins engine used a K24. Mercedes-Benz and Volkswagen chose the K27 and K29 units for their vehicles.

## BorgWarner leads the field

Even teams such as BMW X-Raid, who are used to extreme conditions after competing in the Paris-Dakar Rally, were surprised by the adversities of the Rallye Dos Sertões. The extremely high temperatures and the dry climate of the Brazilian desert were clearly a challenge for all teams.



Yet the final results could not have been better for BorgWarner Turbo & Emissions Systems. In the car category, the turbocharger specialist won the first nine places with Mitsubishi. In trucks, Ford was the leader, followed by Mercedes-Benz. A wonderful conclusion to a South American tour of endurance.



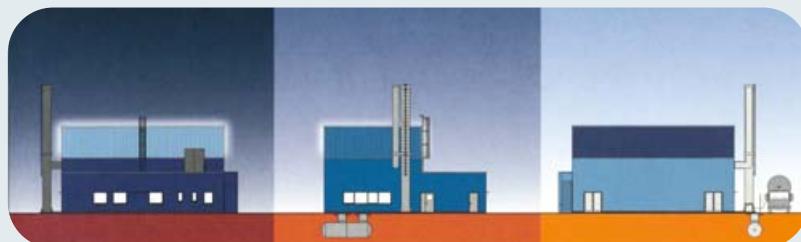


# Green light for the TurboAcademy

Innovation is happening at an incredible pace. Technologies are becoming increasingly complex. And customer requests are getting more and more specific. To prepare the next generation of engineers – and also our own staff members – for these growing challenges in the field of turbocharging, BorgWarner Turbo & Emissions Systems has decided to help establish and finance a TurboAcademy.

The Academy, which is currently being set up on campus at Mannheim University in Germany, is set to open its doors in January 2007. Several

engineers from BorgWarner have already taken part in training sessions designed and held by the TurboAcademy at the Kirchheimbolanden site. In five modules they refreshed their knowledge of combustion engines and turbochargers. The goal is for graduates of the Academy to be able to set up turbochargers independently to meet precisely defined requirements.



## Three Years and No Accidents



In August 2006, BorgWarner's Campinas facility in Brazil set a new record. For three years there has not been a single accident that required a staff member to take time off work. As it does for all plants that set new safety records, the Group will donate \$5,000 on behalf

of Campinas to a local charity – and a further \$10,000 for a total of two million working hours without any accidents. This success at the Brazilian facility is the result of regular safety training, a safe working environment and excellent team work at the site.

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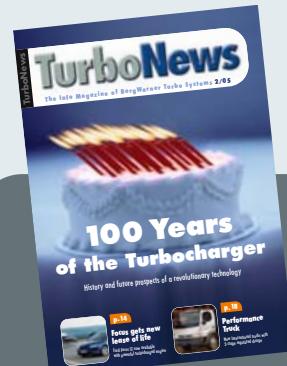
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