

# TurboNews

2/07 Issue

The Info Magazine of BorgWarner Turbo & Emissions Systems

## From slow-burner to diesel racer

SAAB 9-3 1.9 TTID DELIGHTS WITH THE R2S SYSTEM



### VW modernizes million seller

The new TDI with common rail and VTG turbocharger

### Fit for Euro5

Innovative exhaust gas recirculation reduces nitrogen oxide

### Quality offensive

New supplier quality management at BorgWarner

# Innovation in every area

## Dear Readers,

It is often said that market leaders eventually take their success for granted and let their capacity for innovation, flexibility and adaptability wane. This edition of TurboNews demonstrates that this is not the case for BorgWarner Turbo & Emissions Systems.

The technological leader in exhaust gas turbocharging is working intensively on a wide variety of projects across the globe to bring new innovations to the market, meet growing customer expectations relating to processes, production capacities and quality, and to support customers on-site in ever more demanding development projects.

In this edition of TurboNews we introduce five customer projects which exemplify the sheer range of technologies and applications BorgWarner is involved in today. Diesel exhaust gas recirculation and the speed sensor for turbochargers, both of which are covered in this edition, are innovative technologies which BorgWarner will be bringing to the market in the near future. And in our site reports you can find out which activities in the areas of manufacturing and quality management are currently on the agenda for the turbocharger specialist.

We hope you have fun reading!

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## BORGWARNER PAVES THE WAY FOR FUTURE GROWTH

# On course for the future

The global demand for turbocharged diesel and gasoline engines continues to grow and is causing a real boom in the turbocharger industry. This also increases requirements regarding costs, quality and product technology. BorgWarner Turbo & Emissions Systems is preparing for the coming challenges in order to remain competitive and successful for its customers, staff and shareholders.

This doesn't just mean bringing innovative products onto the market, but also creating the ideal infrastructure for increasingly complex development projects and growing production figures. To this end we are currently investing in the modernization and diversification of our plants in Bradford (England) and Pyongtaek (Korea). In our plant in Oroszlany (Hungary), another important construction stage is nearing completion. What's more, we have recently announced the opening of a new plant in Rzeszov (Poland) and the implementation is now in full swing. All these investments enable us to deliver the turbochargers needed by our customers in the desired quantity and quality at competitive prices.

Alongside the extension of our worldwide capacities, we are also concentrating on further boosting quality and reducing costs. Both of these are determined to a large degree by the quality of our suppliers. As such, we employ rigorous and highly professional supplier quality management, which is currently being implemented in our plants in Kirchheimbolanden (Germany) and Campinas (Brazil).

And last but not least, we develop new market-leading solutions for and in cooperation with our customers, which secure our position as a product leader for the future. Examples of this are the new forward-looking R2S applications, the new BorgWarner EGR valve for the incoming EU5 limits and the new twin scroll turbocharger for the Volvo 6-cylinder gasoline engine. Our cooperation with Volkswagen in updating their successful TDI bears particular testimony to the esteem in which we are held as a development partner in the automotive industry. As a result of this BorgWarner was exclusively chosen as the partner for the development of the first generation of common rail engines. We will set the course and pull out all the stops to fulfill our customers' high expectations!



Ulli Fröhn, Vice President Sales & Marketing  
at BorgWarner Turbo & Emissions Systems.

SAAB CELEBRATES ITS 60TH ANNIVERSARY  
WITH THE NEW 9-3 1.9 TTiD

# From slow-burner

This year Saab has reason for celebration: The Swedish car manufacturer turns 60 years old – and the company anniversary is the perfect occasion on which to give its best-selling 9-3 a new look and new, powerful engines. The 1.9 TTiD with the innovative R2S turbocharging system from BorgWarner is amongst the new units.

The new 1.9 TTiD is a modern 4-cylinder diesel engine with 16 valves and regulated two-stage turbocharging, which boasts a performance of 180 bhp. This has been available in the Saab 9-3 since fall of this year and is supplied with automatic or manual transmission. This type of engine is a real innovation for General Motors – the first two-stage turbocharger in series production. The unit, labeled by Saab as TTiD, is on offer for all three body types (convertible, estate and limousine).

## Two turbochargers for optimum torque

The regulated two-stage turbocharging system (R2S) of this lively engine was developed by the turbocharger specialist BorgWarner Turbo & Emissions Systems. It consists of a KP35 and a K04 exhaust gas turbocharger and is

equipped with a self-regulating bypass valve on the compressor side. The turbine casing of the KP35 high-pressure stage is designed as an integrated manifold housing.

The new TTiD engine particularly inspires due to its spontaneous and powerful response. The front-wheel drive transmits its power directly onto the road. The turbo diesel boasts a maximum torque of 295 lb-ft, which enables between 1,850 and 2,750 rpm. In the lower torque range, the exhaust gas propels the smaller exhaust gas turbocharger, and then the larger turbocharger kicks in and works from 3,000 revolutions upward without support from its little brother. This seamlessly regulated load sharing brings a noticeably exceptional torque at any rate of rpm – and correspondingly excellent driving pleasure.

## Powerful and economical

This driving machine can certainly be described as powerful. This power enables the Saab 9-3 to sprint from 0 to 60 mph in a little over 8 seconds. And with a top speed of 140 mph it is one of the fastest diesels in the country. Despite this performance the TTiD is incredibly quiet and civilized – you can barely hear that you're driving a diesel.

Consumption is another of the 1.9 TTiD's best features, for it achieves an impressive 40 mpg US (48 mpg UK). With a diesel particle filter fitted as standard it is perfectly prepared for the incoming Euro5 standard.

## Dynamic design

The new Saab 9-3 also inspires from the outside, with a fresh new appearance. The new spoiler gives it a more dynamic, aggressive face. The grill is split into three parts and the stretched headlights contain a narrow band for the daytime headlight, ideas conceived in the Aero X concept sports car.

All in all, the new Saab 9-3 is a car which is particularly desirable to those who value individuality. With the 1.9 TTiD, such discerning customers are also able to combine sportiness and improved economy.



Fitted with the R2S booster system from BorgWarner and diesel particle filter as standard: The new 1.9 TTiD.

# to diesel racer



Saab celebrates its 60th birthday – with the new and improved bestseller 9-3.

INNOVATIVE EXHAUST GAS RECIRCULATION SYSTEM  
REDUCES NITROGEN OXIDE IN DIESEL ENGINES

# Fit for Euro5

**A completely new exhaust gas recirculation system from BorgWarner Turbo & Emissions Systems prepares diesel engines for the strict Euro5 emissions standard. This efficient and economical system offers clear advantages in packaging through its compact size and versatility.**

Auto manufacturers have to constantly improve their solutions for reducing emissions to adhere to the increasingly strict emissions regulations worldwide. The high standard of today's technologies makes this a real challenge. The new Euro5 emissions standard, which comes into force in 2010, further reduces the limits for nitrogen oxide (NOx) amongst other emissions. Exhaust gas recirculation (EGR) is one of the most effective methods of preventing nitrogen oxide during combustion. To enable diesel engines to also stay within future limits, the experts from BorgWarner Turbo & Emissions Systems have now developed a new, highly accurate electric exhaust gas recirculation valve for diesel engines.

## Compact and robust

During the design stage, the turbo-charger and emissions specialist was able to build on its many years of experience with diesel exhaust gas recirculation systems. The system developed is not only more efficient and compact than its predecessor, but also offers a longer service life. In light of the increasing lack of space in the engine compartment, packaging engineers from auto manufacturers will be particularly overjoyed about the compact dimensions of the new EGR valve. Thanks to its robust construction, the new valve can be mounted in front of or behind the EGR

cooler and with single or twin disk valves. In order to lengthen the service life, the engineers have improved the valve's resistance to "sticking" which comes about due to the build-up of exhaust gas deposits. Another advantage of the new EGR system is its ease of integration with the EGR cooler and the cooler bypass valve.

## Monitored exhaust gas recirculation

The exhaust gas recirculation valve is an electromechanical valve for diesel engines which controls recirculation of exhaust gas to the intake system. The

valve has a DC motor with a two-stage gearbox as well as a mechanism which converts the rotations of the electric motor into linear movements of the valve disk. Its special geometry ensures the ideal combination of fast response and a high opening force for the disk. The control unit (ECU) sends a signal to the electric motor, which opens the EGR valve and meters exactly the required amount of exhaust gases. The contactless valve position sensor sends a control signal back to the engine management system



The new diesel exhaust gas recirculation valve from BorgWarner is a vital key to meeting the strict Euro5 emissions standard.

VOLKSWAGEN USES COMMON RAIL TECHNOLOGY AND VTG TURBOCHARGER FROM BORGWARNER IN ITS NEW TDI

## VW modernizes million seller

**When it launched the TDI 15 years ago, Volkswagen began what was to become an extraordinary success story – which is now being expanded with a new chapter: The new generation of diesel engines with common rail injection lays yet another milestone in engine development and will certainly become another best seller.**

On the basis of the tried and tested 2.0 liter four-valve engine, Volkswagen's engine specialists developed a unit that breaks new ground in terms of driving dynamics, performance, fuel consumption and emissions. What's more, the introduction of common rail injection allows significant progress in noise levels and comfort. The new engines make their debut in the recently unveiled VW Tiguan and Audi A4 models in the power categories 140 bhp and 143 bhp. With a torque of 236 lb-ft, both variants offer high performance and low consumption.

and thus provides accurate valve control and the optimum flow of exhaust gas. Because the exhaust gases are recirculated into the combustion chamber, the combustion temperature in the cylinder is reduced, which reduces the formation of nitrogen oxide.

### Strong growth anticipated

Scott Gallett, Vice President of Sales and Marketing at BorgWarner Turbo & Emissions Systems, sees good market prospects thanks to the steadily increasing demand for diesel engines: "Because of their fuel economy benefits, diesel engines will play a key role in many markets in the future. At the same time, exhaust gas recirculation helps manufacturers further minimize their engines' NOX emissions." The enhancement of low-pressure EGRs offers further opportunities to support the reduction of emissions by providing high EGR flow rates while maintaining adequate intake boost pressures. BorgWarner's objective is to continuously improve the performance of exhaust gas recirculation systems, both in high-pressure and low-pressure systems, to reduce emissions still further. The new DEGR valve is to be manufactured in Germany and China, and BorgWarner Turbo & Emissions Systems will use it to equip several OEM's in multiple regions.



For millions of drivers all over the world, TDI stands for power at minimal consumption.

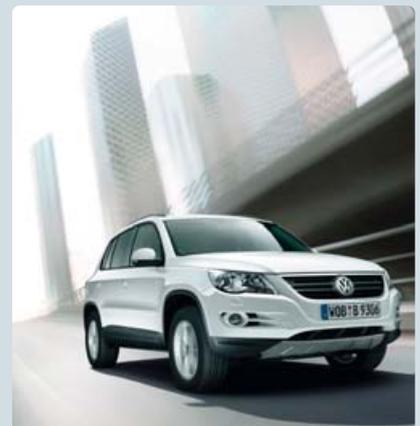
BorgWarner was chosen as the development partner for turbocharging the new common rail engines. BV43 turbochargers with third-generation variable turbine geometry are used. They were precisely matched to Volkswagen's requirements and were then enhanced by the turbocharger specialist. Alongside improved efficiency, these turbocharging systems exhibit several special features. The turbine vanes are now adjusted by pneumatic actuators using position feedback, the impellers are now milled rather than cast from aluminum and a specially developed pulsation muffler is fitted directly to the pressure socket of the turbocharger.

Alongside the high technological requirements, the million seller also constitutes a particular challenge due to the sheer production volume. BorgWarner therefore made preparations at its Kirchheimbolanden site for a smooth start to production at an early stage, and developed and realized the necessary processes for the volume manufacturing of milled impellers. This step not only constitutes a step forward in turbocharger technology for the customer – with all the advantages associated with it – but also underlines BorgWarner's outstanding position in manufacturing technology.

The new 2.0 liter common rail diesel engine will – like its predecessor – power a variety of models from Volkswagen, Audi, Seat and Skoda. It doesn't just combine the TDI's typical features of driving pleasure and economy, but also offers a markedly improved noise level and undercuts the EU5 emissions standard, expected to come into force in 2010.

### VW Tiguan

With the Tiguan, Volkswagen presents the first vehicle which exclusively uses turbocharged engines. Both the diesel and gasoline turbochargers were brought to you by BorgWarner Turbo & Emissions Systems.



BORGWARNER OPENS NEW TURBO PLANT IN PYONGTAEK

# Korea set for growth

The demand for eco-friendly, fuel-efficient technologies in the automotive industry is growing unabated. Turbochargers that prepare engines for strict new emissions standards are more sought-after than ever – particularly by Asian vehicle manufacturers. This is why SeohanWarner Turbo Systems, in which BorgWarner owns a majority stake, opened a new manufacturing facility in Korea in September.



The new building of SeohanWarner Turbo Systems, Ltd. in Pyongtaek



Many prominent guests were present at the large opening ceremony for the new plant. Amongst these were the Director of the Kyonggi Province Investment Promotion Center, H. S. Lee (3rd from left), HMC Vice President S. H. Park (4th from left), the President of BW Turbo Systems, Roger Wood (3rd from right) and Brady Ericsson, Managing Director of SeohanWarner Turbo & Emissions Systems (2nd from right).

## Two million turbochargers

Alongside the production facilities, the new plant also includes office buildings and depots, all equipped with the latest technical facilities. The test installations here will first become operational for turbochargers this year, with production set to begin at the start of 2008. With a surface area of almost 54,000 square foot in the Eoyeon Hansan Industrial Park, SeohanWarner Turbo Systems should produce around two million turbochargers here in the next five years. The company plans to employ up to 130 staff in order to hit this target.

## A successful link between strong partners

The company's recipe for success is the combination of experts from Korea Flange Co., Ltd (KOFKO), who know the local market conditions inside out, and turbocharging specialists from the technological leader BorgWarner. Numerous prominent corporate and political representatives as well as over 100 guests attended the grand opening of the new plant in Pyongtaek on September the 18th 2007. The ceremony began right on time at 11:00 am, but was moved indoors due to poor weather conditions. The speakers praised the operating results obtained in Korea so far, which have led to the creation of

new jobs at the site, as many of the materials were purchased from local suppliers. All the speakers looked to the future with optimism. The President of BorgWarner Turbo & Emissions Systems, Roger J. Wood, firstly thanked the employees for their efforts, which made the move to the new site possible. He spoke of another milestone in the company's worldwide success.

## Technology of the future

The joint venture between BorgWarner and KOFKO in Korea has been active since 2004. "We are looking forward to working towards further growth with the team from SeohanWarner in this facility." In particular Wood recognized Messrs. Park and Kim from the Hyundai-Kia Motor Company (HMC) for being farsighted enough to integrate BorgWarner turbocharger technologies into their family of engines. The HMC Vice President Park used his speech to highlight the future-oriented concept of exhaust gas turbocharging. "The Hyundai-Kia Motor Company will further strengthen its cooperation with BorgWarner to remain competitive in the future", said Park.

It is not least thanks to this good partnership that BorgWarner brought the first electrically regulated turbocharger with variable turbine geometry

## BorgWarner in Korea

### March 2004

Foundation of the joint venture between BorgWarner and Korea Flange Co., Ltd. (KOFKO): SeohanWarner Turbo Systems

### January 2005

Opening of the first production site in Pyongtaek

### March 2005

The first turbochargers are supplied

### August 2006

ISO/TS 16949 certification (DNV)

### September 2007

Opening of the new site of SeohanWarner Turbo Systems Ltd. in Pyongtaek

## BORGWARNER PRESENTS ACOUSTIC TESTING METHOD AT SIMEA 2007

# Quality you can hear

The Simpósio Internacional de Engenharia Automotiva (International Automobile Engineers Symposium, or SIMEA), which took place in São Paulo in Brazil from the 2nd to the 4th October of this year, covered technological trends in the automotive industry. BorgWarner was present with an interesting contribution.

(VTG) onto the market in the Hyundai Diesel V6 engine of the Hyundai Veracruz. The electronic regulation allows improved fine-tuning of the engine, which enables even higher performance at a low rate of fuel consumption and with significantly reduced emissions. The V6 diesel engine thus sticks to the strict Euro4 guidelines. SeohanWarner Turbo Systems also produce turbochargers for the Hyundai Grand Starex, Kia Sorento and Kia Grand Carnival models.

The automotive industry is one of the strongest areas of the Korean economy, with the fifth-largest share of the global automobile market. Korea's most important trading partners are China, the EU and the USA.



The Hyundai Veracruz, the "Luxury Utility Vehicle" with the first electronically regulated turbocharger with variable turbine geometry.

The symposium was organized by the AEA – a forum for the exchange of ideas between engineers and technicians, and brought together technological experts from all over the world for the 15th time. The goal of this initiative is to boost the transfer of knowledge between auto manufacturers, universities, research establishments and other experts in order to further drive forward technological progress in Brazil.

BorgWarner Turbo & Emissions Systems also participated in the symposium. Paula O. Nomura, BorgWarner engineer in Campinas, presented a procedure for turbocharger noise identification, which was developed together

with Unicamp (Campinas University). As "noise" is a subjective parameter that depends on the evaluator, there was the necessity of an objective method based on microphones and accelerometers. The program to analyze these results was developed in the Matlab software and the tests were performed at Campinas plant.

The innovative testing procedure sparked great interest amongst the attendees. It is a good example of how BorgWarner Turbo & Emissions Systems utilizes its vast experience as a technological leader to tread new paths and improve customer benefit in a proactive way.

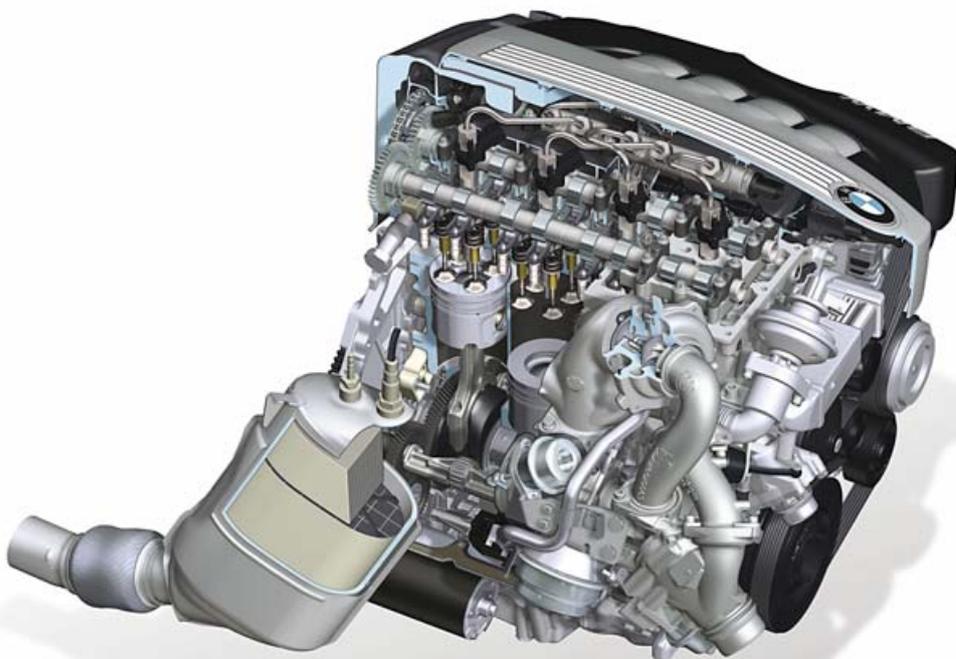


Paula O. Nomura presented a procedure for turbocharger noise identification.

BMW 2.0 LITER DIESEL ENGINE WITH  
R2S SETS ANOTHER NEW RECORD

# Bavarian Power 2

In 2004 the regulated 2-stage turbocharger (R2S) from BorgWarner celebrated its world debut in the BMW 535d with 3.0 liter 6-cylinder engine. Now the turbocharger specialist's most powerful boosting system is entering mass production in the Bavarian luxury car maker's 2.0 liter 4-cylinder diesel engine. And once again the engine sets new standards.



High performance at 45 mpg US (54 mpg UK):  
The BMW turbo diesel with R2S system makes it possible.

## Highest power output per liter displacement

With 204 bhp the new BMW turbo diesel, as the first series-produced diesel engine, can attain a performance of 102 bhp per liter displacement, and with a torque of 295 lb-ft also offers real driving pleasure. So it's all the more pleasing that the new powerhouse also sets standards in consumption: The BMW 123d averages an impressive 45 mpg US (54 mpg UK).

The requirements for the development of the new high-tech unit were correspondingly high. The challenge for BorgWarner's engineers was in the

design and specification of the turbocharging system, as BMW's engine specialists had set demanding guidelines with regard to unit size and performance. The result of the development work is a very compact R2S system which fulfills all the demands relating to performance and compactness.

## Optimum engine management

The small KP35 turbocharger was selected as the high-pressure stage. It guarantees fast buildup of boost pressure, giving a dynamic response, while a K16 turbocharger kicks in at high speeds and, as a low-pressure stage, is responsible for the high end perfor-

mance. In the innovative R2S system, the turbine bypass, the waste gate in the low-pressure stage and the integrated compressor bypass ensure that the turbocharging is seamlessly adapted to all the engine operating points.

In order to give the efficiency and economy of the R2S system a decisive boost, the developers turned their attention to more than just the selection of components. Taking installation conditions into account, they attached great importance to the perfect design of the connecting pipes to optimize the flow of exhaust fumes and fresh air.

## Driving pleasure with low consumption

The new 2.0 liter 4-cylinder diesel engine from BMW shows that it is quite possible to combine driving pleasure and ecology. A modern turbocharging system which is perfectly adapted to the engine is a vital element of this. Efficient dynamics – there is surely no better demonstration of this slogan than the new 2.0 liter turbo diesel with R2S technology.

POWERFUL 6-CYLINDER ENGINE  
FOR VOLVO'S NEW PREMIUM MODEL

# Swedish power

The Volvo brand used to symbolize safety. However, in the last few years the Swedish car manufacturer has demonstrated that it can also develop exceptionally elegant vehicles – with a very dynamic yet pleasantly reserved design. These qualities are particularly evident in the premium models S80 and V70, in which a new series of 6-cylinder gasoline engines makes its debut.

Volvo offers the very compact straight 6-cylinder engine, designed to be fitted transversely, in two variants. Even the naturally aspirated variant boasts a performance of 238 bhp and offers a torque of 236 lb-ft at 3,200 rpm. The turbocharged T6 version reaches a performance of 285 bhp and an excellent torque of 295 lb-ft from a displacement of 3.0 liters, and can call on a wide torque range of between 1,500 and 4,000 rpm. In comparison to the previous series with 2.9 liter displacement, this constitutes an improvement of 5 percent – despite the fact that the new engine now only has one turbocharger instead of two. Naturally both engines fulfill the EU4 emissions standard.



Elegant design, powerful drive: The new Volvo V70 meets the highest demands without appearing brash.

## Two become one

Volvo's requirement for the developers at BorgWarner was to replace the bi-turbo boosting of the previous engine with a new unit with single-turbo boosting. The new 6-cylinder engine also had to possess at least the same transient response as its predecessor, and of course fuel consumption and emissions needed to be brought up to date.

The engineers decided on the water-cooled K16 turbocharger with Twin Scroll technology and this system enabled them to meet the customer's high expectations. Comprehensive detailed work on the design of the two scrolls of the turbine casing and on the turbine wheel made a particularly large contribution to this. Similarly, the entire current in the manifold or turbine infeed area was painstakingly optimized. The BorgWarner engineers' vast experience

with twin scroll technology, which has already been used in numerous engines from PSA/ BMW and GM, provided an important basis for the development work.

## Technology made to measure

With the K16 used in the Volvo 6-cylinder engine, BorgWarner unveils the first in a wide range of gasoline engines from 1.6 to 3.0 liter displacement or between 150 and 285 bhp with twin scroll turbochargers. As the technological leader in this area, the turbocharger specialist is able to offer its customers a wide range of solutions, from highly efficient turbochargers with waste gates, through turbochargers with twin scroll technology, right up to VTG turbochargers.



The K16 turbocharger with twin scroll technology helps the Volvo 6-cylinder reach a torque of 295 lb-ft.

## BORGWARNER ESTABLISHES UNCOMPROMISING SUPPLIER QUALITY MANAGEMENT

# Quality offensive

Away from troubleshooting, towards preventive quality management – with this motto in mind, BorgWarner Turbo & Emissions Systems is introducing a sophisticated system to significantly improve supplier quality.

The competitive pressure in the automotive industry has been spiraling for years. The highest quality is demanded at the lowest prices with a zero error rate. A trend towards outsourcing can therefore be observed throughout the supply chain - a measure through which many companies hope to improve their profitability or get new technologies at low cost. This trend does not stop at the direct suppliers of the vehicle manufacturers, but also encompasses OEMs, tier 1 suppliers and sub-suppliers.

### Supplier Quality Engineers support suppliers

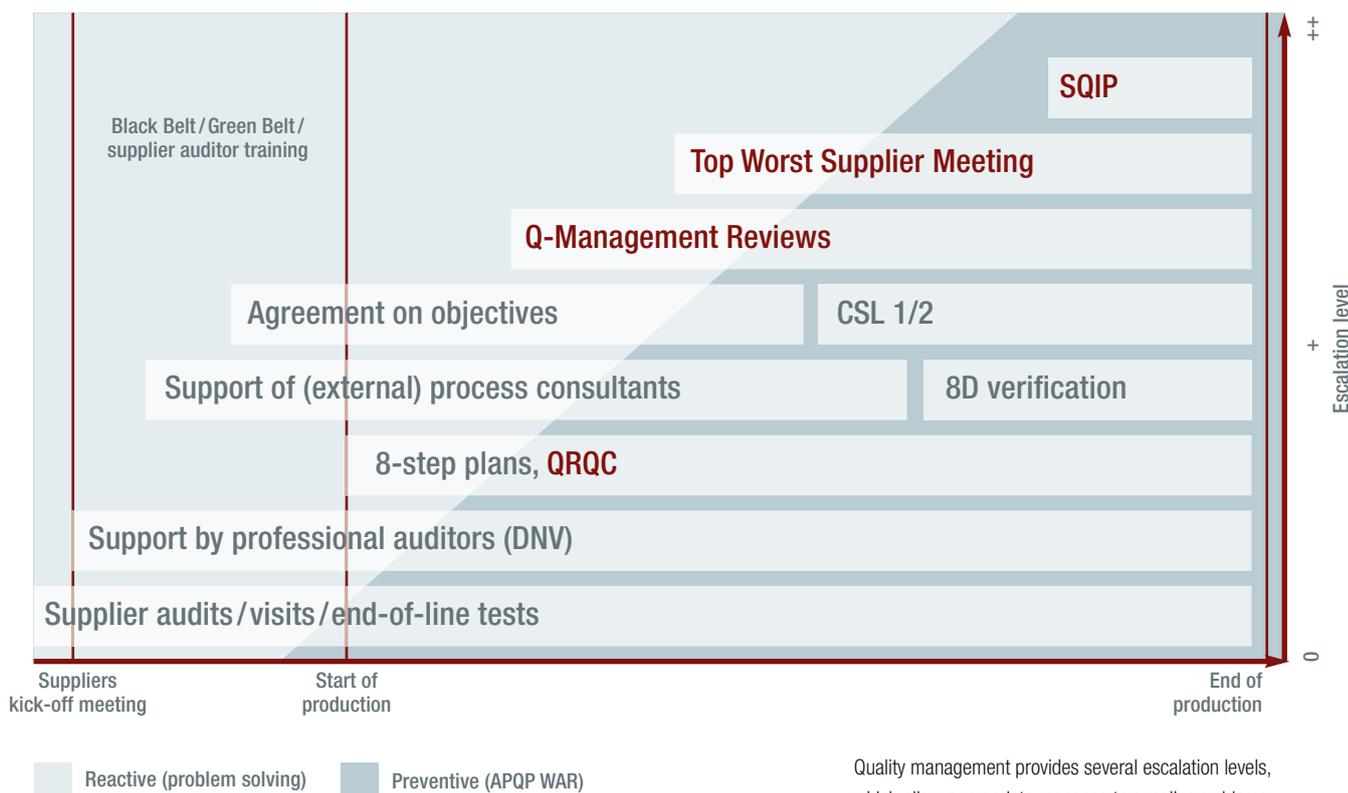
Outsourcing is, however, associated with new challenges and risks. Quality issues

with sub-suppliers can lead to difficulties for the suppliers and, in the worst case, to complaints to the auto manufacturer. In addition, different perceptions of quality standards have to be adapted to the needs of OEMs and tier 1 suppliers, particularly in low-cost economy countries. BorgWarner Turbo & Emissions Systems are tackling this situation preventively with an entire department dedicated to supplier quality management. The goal of this department is to support sub-suppliers and their sub-contractors by deploying exceptionally skilled Supplier Quality Engineers (SQE), to establish excellent quality control systems with all suppliers, and thereby to eliminate complaints resulting from supplier errors.

All Supplier Quality Engineers at BorgWarner are in training or have been trained to a special qualification such as Black Belt, Green Belt or Auditor, and have also been trained in special methodic and social competencies, and technologies relevant to the affected suppliers (e.g. foundry technology).

### Early involvement of suppliers

To guarantee high quality in the early project stages, the corresponding suppliers are involved as early as the product development phase. The manufacturer and supplier of the prototypes should also be the series supplier of the component in question later on and therefore provides comprehensive





Daily Quick Response Quality Controls check compliance with defined quality standards and, if necessary, put into place the relevant remedial measures.

knowledge of the production-related requirements. This means that the SQEs also manage the suppliers' APQP (Advanced Product Quality Planning).

#### Auditing for all

All relevant suppliers of Turbo & Emissions Systems in Kirchheimbolanden (Germany) are audited. Suppliers with whom problems arise are audited at least twice annually and must participate in monthly Quality Management Reviews. What's more, monthly Top Worst Supplier Meetings (where the Managing Director/owner and the Quality Manager are invited to agree the imposed short and long-term corrective measures directly with the top management) and daily Quick Response Quality Controls (QRQC) have been introduced. These measures ensure that any quality issues are fundamentally tackled and processed in a structured manner until the desired result is achieved.

#### Escalation levels as preventive measures

The introduction of preventative escalation levels, which end with the SQIP level as the highest instance, has been

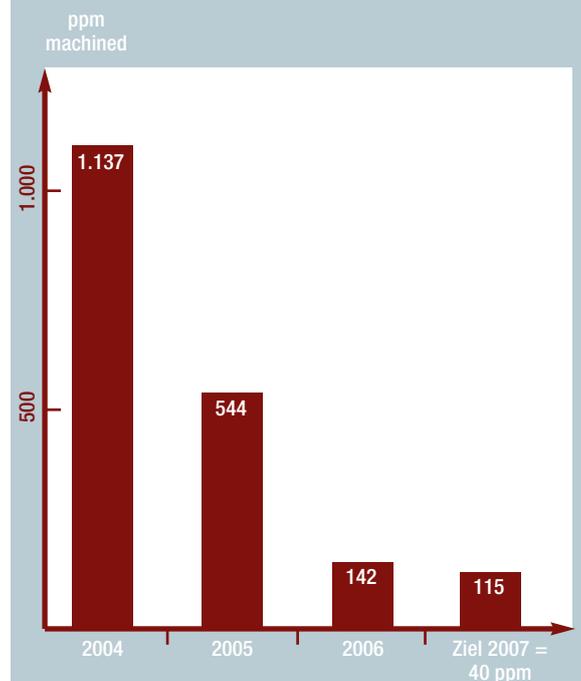
another significant factor in the success of BorgWarner's supplier quality management. SQIP stands for Supplier Quality Improvement Program. Under this program, any supplier suffering from continuing quality issues is allocated an external advisor for three to six weeks who improves the relevant processes at the cost of the supplier. Since 2004 five SQIPs have had to be carried out, something that was not easy for us to implement with the suppliers. On completing the respective improvement projects, however, the affected companies recognized the benefit this carried, as the improvement in quality not only benefits BorgWarner, but all the supplier's other customers too, boosting its competitiveness as a result.

#### Errors per million parts significantly reduced

The new measures put into place by BorgWarner Turbo & Emissions Systems have already resulted in significant improvements. The number of errors per million parts (ppm – parts per million) in Kirchheimbolanden was drastically reduced from a four-digit figure in 2004 to a two-digit number for machined vendor parts. The practice of filing a

complaint for every individual error which was introduced in mid-2004, and which initially caused the number of reclamations to rocket, was a completely new experience for many sub-suppliers. However BorgWarner believed these measures were necessary to achieve the target of just 40 errors per million parts by the end of the year.

#### Results of the supplier quality management



Thanks to the new supplier quality management, the number of errors per million has been dramatically reduced between 2004 and today.

REGULATED TWO-STAGE TURBOCHARGING SYSTEMS  
PREPARE COMMERCIAL VEHICLES FOR EPA07

# Daimler uses the R2S

On January 1, 2007, the new EPA07 emissions legislation came into force in the USA, bringing with it very strict emissions limits. For this reason, Daimler and BorgWarner have been jointly developing a turbocharging concept since 2004 to update the tried and tested OM926LA commercial vehicle engine with a displacement of 7.2 liters in terms of performance, fuel consumption and emissions.



The new 7.2 liter commercial vehicle diesel engine from Daimler adheres to the strict EPA07 standard.



The R2S boosting system from BorgWarner captivates through its compactness.

Nitrogen oxide emissions had to be reduced by around 55 percent and particle emissions by approximately 90 percent for the new commercial diesel engine to fulfill the EPA07 standard. The engine specialists at Daimler decided to optimize the exhaust gas recirculation system already developed for the OM926LA and in addition install an exhaust gas treatment system consisting of a diesel oxidation catalytic converter and a diesel particle filter.

## More efficiency through two-stage turbocharging

The next task for the engineers from BorgWarner Turbo & Emissions Systems was to significantly increase the boost pressure of the turbocharger in order

to improve the efficiency of the exhaust gas recirculation. However this required some boost pressures which could not be achieved with a single-stage boosting system. The turbocharger experts therefore suggested the use of a regulated two-stage R2S turbo system for Daimler's more powerful engine variants (from 250 bhp).

The newly developed turbocharging system consists of a compact B2 turbocharger as high-pressure stage and a larger B2 charger, which operates as the low-pressure stage. The R2S system also has a bypass valve, which is made of a new, higher-quality metal alloy and is electronically controlled. The developers seized the opportunity of using electrical adjustment, as there was no compressed air source available on the

North American market with which they could realize pneumatic control. What's more, the use of an electric actuator now makes it possible to accelerate the response time of the system, control the valve opening more accurately and regulate it regardless of the current boost pressure. BorgWarner's use of an electric actuator to regulate the bypass valve in a turbocharger is a world first.

## Advanced design

The greatest challenge for BorgWarner's developers was to integrate the R2S system into Daimler's commercial vehicle diesel engine. The somewhat larger two-stage system had to fit into the engine space previously occupied by a single turbocharger. So the BorgWarner

## BRADFORD BECOMES A HIGH-TECH PRODUCTION LOCATION

# Transformation

One of BorgWarner Turbo & Emissions Systems' longest-established manufacturing facilities is situated in Bradford, in northern England. This is where the turbocharger specialist produces turbocharging systems for European commercial vehicle manufacturers. To meet the ever-growing customer demand, the production process has now been dramatically modernized.

The transformation of the Bradford site into an ultra-modern high-tech production location was the idea floated by the management of BorgWarner in order to stay on top of the customers' ever-greater technological demands and growing production volumes. The extremely ambitious plans for modernizing the manufacturing process took around two years to realize.

### Forward-looking manufacturing processes

Efficiency and quality were the top priorities in designing and implementing the new manufacturing units. The layout of the factory was completely overhauled. It is now fully geared towards modern manufacturing processes. This has enabled the company to decisively improve the material flow and

productivity of the individual stations, significantly increasing the manufacturing capacity. New flexible and – where necessary – highly automated manufacturing processes have been introduced, which are oriented to the special requirements of the commercial vehicle industry.

### Modern times – even in administration

The wave of modernization also hit the office buildings. Staff members from management, marketing and sales, and administration now work in the most up-to-date conditions and the outer appearance of the entire factory now clearly indicates that the latest products are manufactured in Bradford. This investment means that Bradford is well-equipped for the future.

engineers developed an unusually compact design for the boosting system – which is why the exhaust manifold is integrated into the high-pressure turbine casing, for example. The development of the engine, which meets the EPA07 standard, required a great deal of teamwork with Daimler's Engine and Vehicle Design Center in Stuttgart. The complexity of the turbocharger made it necessary to carry out comprehensive simulations relating to thermal stress and response, for which the support of BorgWarner's specialists from Kirchheimbolanden was needed.

Other technological features which mark out the new R2S system include a milled titanium impeller wheel in the high-pressure turbocharger and compressor casing made of gray cast iron. This was chosen due to the high compressor intake temperatures that are generated at certain operating points, which Daimler opted not to counter with an interstage cooler.

### An engine for all applications

BorgWarner's new OM926LA commercial vehicle engine with R2S turbocharging system will run in a whole series of commercial vehicles from Daimler on the US market until the end of 2009. This also includes medium-sized freight vehicles from Freightliner and Sterling, mobile homes and also special uses such as emergency vehicles for the fire service.



TURBOACADEMY OPENS ITS DOORS  
FOR A NIGHT OF SCIENCE

## Science live

On 10 November, the Nacht der Wissenschaft (Night of Science) took place in the Rhein-Neckar region in Germany. A variety of renowned colleges, companies and research establishments threw open their doors between 6.00 pm and 2.00 am to give science enthusiasts an exciting insight into many different scientific areas.

The TurboAcademy jointly founded by BorgWarner Turbo & Emissions Systems and the Mannheim University of Applied Sciences also invited interested parties to experience turbocharging technology for gasoline and diesel engines live. Around 600 students and other technology enthusiasts seized this unique opportunity to visit the exhibition on how the turbocharger works and the two ultra-modern test benches for development trials and student laboratories.

During the "Full throttle and high performance" lecture, an engine test bench and combustion chamber were demonstrated in action. And with the lecture "A journey through the history of turbocharging", the exhibitors gave their visitors an exciting overview of the history of turbocharging development, which spans over 100 years but has only begun to make rapid progress in the last three decades. Following the lectures, the turbocharger experts had thousands of questions to answer. By the end, exhibitors and visitors were of the same opinion: The Night of Science was a resounding success!



The TurboAcademy has imparted the latest knowledge in the area of exhaust gas turbocharging since the start of 2007.

CAMPINAS INTRODUCES GUIDELINES  
FOR COOPERATION WITH SUPPLIERS

## Setting the benchmark

A clear definition of quality and process standards is vital for ensuring successful cooperation between a company and its external partners. For this reason BorgWarner has compiled a Supplier Manual, which is now in use at all the company's divisions.

The new Supplier Manual was introduced at a workshop held at BorgWarner Turbo & Emissions Systems in Campinas (Brazil) on September 21. In addition to suppliers of the Brazilian plant, those invited to attend the event included BorgWarner customers and certification institutes.

During the workshop, representatives from Mercedes Benz and Ford illustrated the requirements that have to be fulfilled in the process chain, from the sub-supplier right through to the auto manufacturer. A representative of the renowned DNV certification institute used his presentation to demonstrate the current status of supplier quality at various vehicle manufacturers. These contributions clearly demonstrated how important communication and product development on the part of sub-suppliers is to the automotive industry.

An important goal of the event was to strengthen the existing relationships between BorgWarner Turbo Systems and its suppliers. Sergio C. Veinert, Managing Director of BorgWarner in Campinas, emphasized the high value BorgWarner attaches to respectful and constructive cooperation with its suppliers. The new Supplier Manual, which is available online and takes immediate effect, thus provides a set of guidelines for partnership.



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#### Editing and coordination

Günter Krämer, Global Marketing,  
BorgWarner Turbo Systems

#### Authors

Steven Bell, Brad Weingust, HS Uh,  
Andy Clayton, Sabine Bossert,  
Nicole Weber, Roger Schwaninger

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