

TurboNews

The Info Magazine of BorgWarner Turbo Systems 2/04

Lord of the 5 Continents

NEW LAND ROVER DISCOVERY WITH BV TURBOCHARGER
PROVES ITSELF IN THE 6 MILLION KILOMETER TEST



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BorgWarner sets new standards for passenger car diesel engines

Editorial

GAS ENGINES IN THE LUXURY CAR MARKET ARE FEELING THE PRESSURE FROM THE LATEST DIESEL ENGINES

Diesel Power

Dear Readers,

Powerful gasoline engines with 6, 8 or even 12 cylinders have always been considered the non plus ultra in the world of luxury cars – at least until now. But the latest generation of diesel engines with innovative VTG or R2S™ technology by BorgWarner is now making it its mission to steal market shares from its fellow gas engines by offering smooth running and serious power delivery. While diesel engines have always won friends with their fuel consumption, the new engines also impress with their breathtaking power delivery, silky smooth running and significantly improved vibration damping. With the Audi A6 and A8, the Land Rover Discovery and the BMW 535d in this edition of TurboNews we would like to present you with several vehicles that are currently enjoying great praise.

Decisive factors for the success of an automotive supplier are not merely innovative products and technologies – the ability to maintain know-how and capacities, processes and quality at a high level worldwide is becoming increasingly important for cooperation with demanding customers. The joint development project with International, the launch of BorgWarner turbocharger production in Korea and the system of process management at Turbo Systems are good examples of this – and also interesting topics that we cover in this edition of TurboNews.

We hope you have fun reading!

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BORGWARNER SETS NEW STANDARDS FOR PASSENGER CAR DIESEL ENGINES

Turbos for Tomorrow

With the development of the new VTG Generation BV, Borg Warner Turbo Systems now offers the automotive industry its leading VTG technology for all vehicle and engine types. The BV turbochargers have already been gaining an enviable reputation in small and medium-sized engines from 1.4 to 2.0 liters, and now the units are also setting new standards in the luxury class up to 3.0 liters. Both the already very successful Audi 3.0 liter V6 diesel and the brand new Ford/Land Rover 2.7 liter V6 diesel are profiting from the high performance offered by the BV50 with electrical actuator. Since their introduction, both engines have been regarded as among the best in their class.

However, the crown in the 3 liter diesel class this year undoubtedly goes to BMW. With the new straight six cylinder M57 Top – presented in the 535d – BMW has introduced the first passenger car diesel engine with regulated 2-stage turbocharging (R2S™) by BorgWarner. This charging system opens up a whole new world of opportunities for our customers' engine developers to increase power density and optimize consumption and emissions.

Using two turbochargers of different sizes, flow-optimized guide pieces and refined regulation technology, the R2S™ system of torque generation and starting dynamics allows vehicles to achieve the performance of much larger naturally aspirated engines at low revs – and all this without having to

make the previously unavoidable compromises in terms of nominal output. The R2S™ system still holds potential for further improvement. And the engineers at BorgWarner are currently working at full speed to ensure that in future it will also be possible to combine this system with VTG turbochargers.

We can already announce that the next few months will see the release of further examples of this high performance turbocharging system, both in passenger cars and commercial vehicle applications. So it remains exciting to see what the new advances in boosting technology will offer the engine developers of the future.



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

NEW LAND ROVER DISCOVERY WITH BV TURBOCHARGER
PROVES ITSELF IN THE 6 MILLION KILOMETER TEST

Lord of the 5 Co

With the new Discovery, Land Rover has created an SUV of the highest quality, jam packed with innovative technologies for an exhilarating driving experience. Excellent dynamics and exemplary handling both on the street and offroad were top priorities in developing the new Discovery.

At the heart of the new model is the powerful 2.7 liter V6 turbo diesel engine – another version of the high-tech diesel recently presented in the Jaguar S TYPE, which has received much praise in the industry. Thanks to the latest common-rail injection with piezo technology the TDV6 turbo diesel leads the way with excellent performance and consumption values as well as extremely quiet running. In the new Discovery the engine provides a maximum power of 190 bhp at

4000 rpm and develops an impressive 324 lb-ft of torque from 1900 revolutions. A particular innovation is the engine block made of cast iron with Compacted Graphite Iron (CGI). This material, which to date has hardly ever been used in engine production, is harder, stiffer, lighter and more durable than the gray cast iron typically used for diesel engines.

In contrast to the TDV6 engine in the Jaguar, the diesel engine used in the Land Rover is only boosted by one VTG turbo-charger. With the BV50 by BorgWarner the Land Rover meets the ambitious development targets regarding fuel consumption, emissions and performance. As has become almost standard in this engine class, the turbine vanes on the BV50 are also controlled by electrical actuators. As a large number of all Land

Rover models sold across the globe have to prove themselves in the toughest of offroad conditions, the offroad specialist places the highest demands on the dust and water-tightness of its engines as well as their ability to perform on extreme slopes. The BV50 by BorgWarner has therefore been modified for use in these tough offroad conditions.

Before its market launch planned for 2004 the new Land Rover Discovery successfully went through one of the toughest and most rigorous test programs ever seen by a production car, covering an amazing six million test kilometers. The vehicle was subjected to the most diverse of test conditions on all five continents. The Discovery had to prove itself both on racing circuits such as the Nürburgring and in the desert of Dubai. And extreme

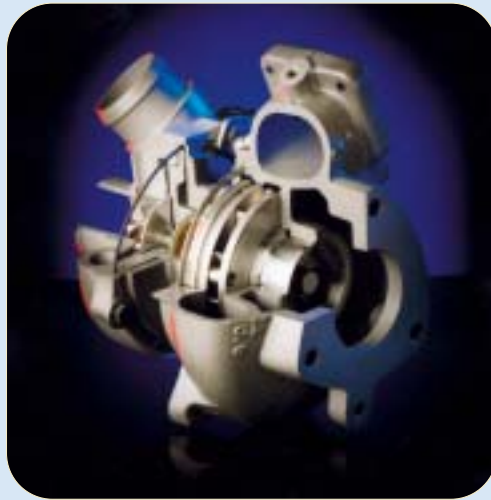
Since its introduction 50 years ago it is hard to imagine the family offroad sector without the Land Rover Discovery.



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conditions in the Australian outback or at military training grounds in South Africa and England were also on the menu. The new model was raced through arctic temperatures of up to minus 40 degrees over frozen Canadian lakes and then tortured in a twelve-week non-stop endurance test at full speed on the Nardo test track in Italy to prove its absolute reliability.

The turbocharger development team at BorgWarner is extremely proud of the fact that the BV50 turbocharger also proved itself in these tough endurance tests.



Together with the Land Rover Discovery the BV50 turbocharger by BorgWarner Turbo Systems passed one of the most rigorous test programs ever carried out.



AUDI PRESENTS ITS FIRST GAS DIRECT INJECTION TURBO ENGINE

Sports Edition



With its 2.0 liter Turbo FSI engine, recently presented in the new A3 Sportback, Audi has taken its FSI engine technology to the next level. For the first time ever, the engine combines direct gas injection with a turbocharging system – thereby uniting the advantages of the FSI combustion process with the dynamics of exhaust gas turbochargers. The result is an extremely agile unit which offers real power at around 200 bhp, an exemplary torque curve (200 lb-ft from 1,800 through 4,700 rpm), excellent pickup and real driver enjoyment with moderate consumption. And the new unit of course meets the EU 4 and ULEV 2 exhaust emission regulations as well as the future OBD provisions.

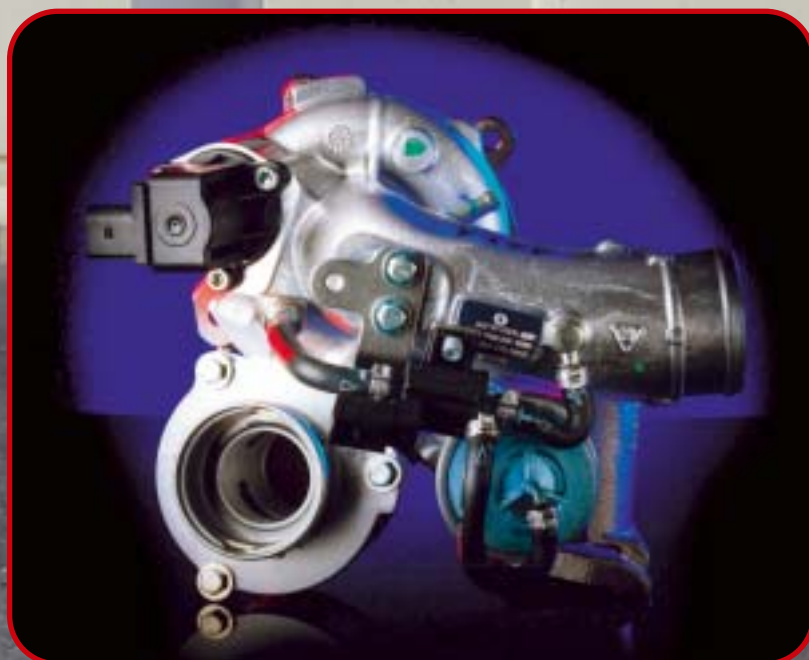
The new engine is to be mounted both longitudinally and transversely within the Volkswagen Group's product range. One focus during development was

therefore to use as many standard and identical components as possible. One particular challenge during development of the exhaust manifold and the exhaust gas turbocharger was meeting the package stipulations. The aim of the engineers was to develop a single module for all drive versions to be fitted longitudinally and transversely, while also taking into account the tight spaces of the right-hand drive version with transversely mounted engine.

To meet Audi's ambitious aims, the team of engineers at BorgWarner were closely integrated in the development of the engine itself. This cooperation brought about an innovative integrated module which represents the consistent further development of the K03 turbocharger from the extremely successful 1.8 liter turbocharged engine. The optimization of the design, the integration of functions and the use of high-grade materials led

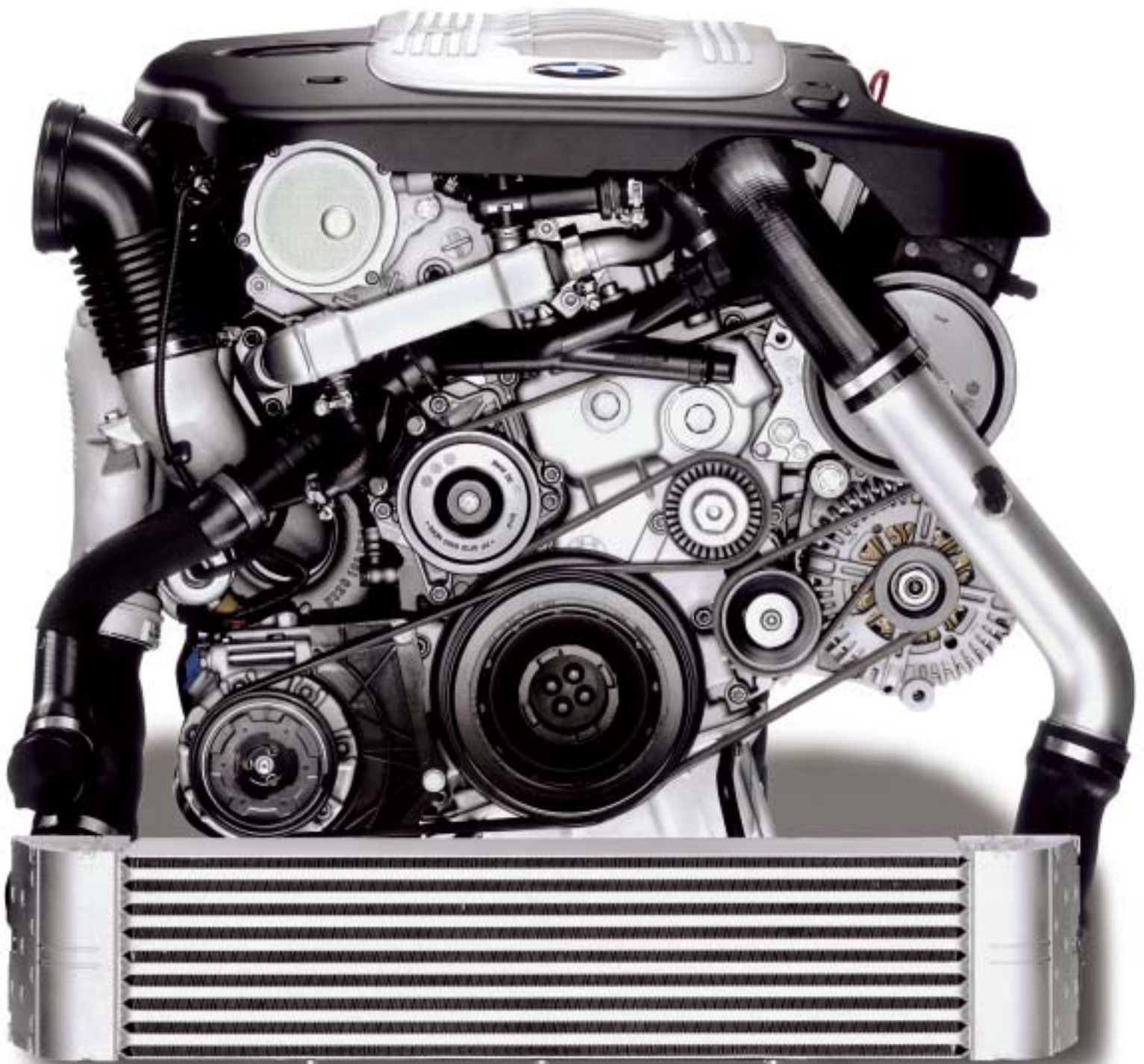
to a charging system which both incorporates new concepts and takes all the best features of the tried and tested K03 to the next level. For example, the virtually symmetrical manifold allows 30 percent greater flow than the previous 1.8 liter turbo engine with 175 bhp. The exterior surface area has also been reduced by around 16 percent, which in turn lowers the thermal load placed on the neighboring components. And it was even possible to reduce the level of plastic deformation common to the cold-hot cycle by 32 percent relative to the 1.8T engine.

The new BorgWarner turbocharger thereby meets all demands placed by Audi on the turbocharging system for the advanced 2.0 liter turbo FSI engine. The new Audi unit is not merely the first engine in the world to use both direct injection and a turbocharger, it also sets the standard by which all turbochargers must be measured.



The K03 turbocharger by BorgWarner Turbo Systems was revised specially for the turbocharging system of the Audi FSI engines.

Power



The 3 liter inline six diesel with regulated 2-stage turbocharging R25™ from BorgWarner Turbo Systems guarantees that the 535d from BMW is a dream to drive.

BMW PRESENTS FIRST EVER PASSENGER CAR DIESEL ENGINE
WITH REGULATED 2-STAGE TURBOCHARGING

from Bavaria

A BMW is a BMW – no matter what fuel it uses. BMW used slogans like these years ago to make its diesel engines more acceptable to the keen driver. With the new Variable Twin Turbo engine, the manufacturer of particularly dynamic automobiles has now given us a diesel which puts everything we have seen so far to shame in terms of performance and smooth running. The new unit, which is the first ever standard road car diesel engine in the world to employ a regulated 2-stage turbocharging system, was first seen at the Geneva automobile show in March and is now celebrating its premiere in the new BMW 535d.

The new engine is a 3 liter straight six unit with the BorgWarner Turbo Systems regulated 2-stage turbocharging system R2S™. The maximum power output is 272 bhp. It also generates an impressive 410 lb-ft of torque, all of which is available from just 2,000 rpm. With approximately 90 bhp and 137 lb-ft of torque per liter displacement, the new BMW 6-cylinder diesel thereby sets new benchmarks for passenger diesel vehicles. And the engine of course meets the strict EURO4 emissions standard and is also fitted with a zero-maintenance diesel particle filter.

The new unit catapults the 535d from 0 to 60 in under 6.5 seconds, allows a maximum speed of 155 mph and offers impressive gas mileage of around 30 mpg. The engine runs amazingly quietly and pulls smoothly from very low revs right up to the rev limiter, which the driver is unlikely to ever reach given the power and torque on hand.

In developing this masterpiece of engine building expertise, the BMW engineers worked closely with the experts at BorgWarner Turbo Systems. The development team decided to use one small KP39 high-pressure turbocharger combined with a larger K26 low-pressure turbocharger. The high-pressure turbocharger provides excellent response at low revs (up to 1,500 rpm) and eliminates the infamous “turbo hole”. As the revs increase (above 1,500 rpm) the larger low-pressure turbocharger then starts to kick

in – initially as a precompressor. It ensures a smooth and continuous increase in power and then from 2,500 rpm it takes over the full boosting task up to the maximum of 4,400 rpm, whereby the compressor bypass is opened to avoid the high-pressure compressor altogether. And according to the trade press the result can not only hold its own, it also sets new standards for passenger car diesel engines.

The new BMW engine shows the great potential of BorgWarner Turbo Systems’ regulated 2-stage turbocharging system R2S™. Further manufacturers are also set to introduce engines with R2S™ systems in the next few months – both in the passenger car and commercial vehicle field. The editorial team here at TurboNews is extremely excited to learn of the further development, and we will of course keep you informed.



For the regulated 2-stage turbocharging, a KP39 turbocharger was combined with a low-pressure K26 turbocharger.

BORGWARNER'S BV TECHNOLOGY CONQUERS AUDI'S LUXURY MODELS

Climbing into the Luxury



Thanks to the BV turbocharger from BorgWarner Turbo Systems, Audi's luxury diesel class can also enjoy the benefits of turbocharging.



With the introduction of the 2.5 TDI in 1989 Audi presented the first direct injection passenger car diesel engine. This engine became the trendsetter of DI diesel technology. The 3.0 liter V6 TDI now represents the first diesel engine from the new Audi V-engine family (with a distance of just 90 mm between the cylinders) to go into series production. The new engine employs solely internal engine measures to allow luxury cars with automatic quattro drive to meet the extremely strict EU 4 exhaust gas emis-

sions standard. Since its introduction in the Audi A6 and A8 the new V6 has been considered one of the best diesel engines in its class and enjoyed great success in the market. It is also set to gain even further in popularity when used in the Volkswagen models Touareg and Phaeton.

The new V6 TDI engine produces up to 233 bhp and a maximum torque of 330 lb-ft. It uses 4 valves per cylinder, a turbocharger with variable turbine geometry and is the first unit in the world

HIGH-RANKING REPRESENTATIVES AND CUSTOMERS OF BORGWARNER MEET IN BRAZIL

y Class

Summit meeting

to use the 3rd generation Bosch Piezo Common Rail System with a maximum injection pressure of 1,600 bar. The new engine excels with its impressive performance figures and smooth running. With a particularly compact design and many new technical solutions, Audi is once again setting milestones in TDI technology.

One important aim for the engine developers was to generate a high level of torque at low revs and in particular to achieve a responsive torque delivery. The turbocharger for the high-tech engine therefore comes from the latest VTG Generation BV by Borg Warner Turbo Systems. In the rear section of the inside V there is a BV50 with variable turbine geometry whose turbine vanes are adjusted quickly and precisely to the given operating conditions via an electric actuator. To provide the maximum possible exhaust gas energy to the turbine, the manifolds and the compensator pipes are of an air-gap insulated design. A temperature sensor at the turbine input ensures that the permitted exhaust gas temperature of 820° C is not exceeded. This allows increased engine output without subjecting any individual components to too much stress.

With the 3.0 liter V6 TDI by Audi, the latest VTG turbocharger generation BV by BorgWarner is now also available in the luxury car class for the first time. This engine has many new features and builds on the market-leading performance of the BorgWarner BV series to set new standards in turbocharger design.

On September 28, 2004 BorgWarner held a technology workshop in São Paulo in Brazil. A total of 70 representatives from customers such as Volkswagen, DaimlerChrysler, Scania, General Motors, Mitsubishi, International, MWM and Cummins traveled to the event to learn more about the automotive component supplier's current strategies and technologies.

This workshop, the third of its kind to take place, dealt with the organization and growth strategies of BorgWarner Turbo Systems, current developments and – for the large number of engineers among the guests – the latest BorgWarner technologies.

Speakers included Ulli Fröhn (Vice President Sales and Marketing), Hans-Peter Schmalzl (Vice

President Technology), Wolfgang Schneider (Director Quality Systems and Processes), Werner Bender (Director Commercial Diesel Charging Systems – Product Development) and Dr. Helmut Förster (Director Quality Americas), who offered their listeners an exciting and interesting presentation.

To sum up the event, Sergio C. Veinert, General Manager Brazil, forecast that the engines of the future would be smaller, more powerful and more environmentally friendly – a challenge that the automobile industry will only be able to master with the help of highly-developed boosting technologies.

Both host and visitors of the workshop rated the event as a great success.



Ulli Fröhn welcomes participants to the technology workshop in Brazil.

TURBO SYSTEMS ACTIVATES ALL RESOURCES FOR NEW INTERNATIONAL RANGE OF

Global Teamwork



In February 2004 International Engines released a new inline 6 cylinder range of engines to meet the stringent emission requirements. These new engines, labeled DT 466, DT 570, and HT 570, are available in International's 4000, 7000, and 8500 series trucks. The developers' goal with this improved series of engines was to provide International truck owners with greater reliability, durable performance, and driving responsiveness. To assist in providing greater value, International and BorgWarner worked together to develop an air management system that provides improved fuel economy and overall engine performance.

One of the most critical features required to achieve this performance is the variable turbine geometry (VTG) turbocharger by BorgWarner. The electronically controlled adjustable vanes not only provide the driver with better throttle response, they also play a critical role in the exhaust gas recirculation (EGR) system. These two areas are decisive in providing the end user with an engine that not only meets the emissions requirements but also provides excellent drivability performance. Other important features in this new engine group are the electro-

hydraulic generation 2 (G2) fuel injection system, the 4 valves per cylinder, and an optional integrated engine brake.

The VTG turbocharger S300V developed for International also offers the latest technology. One decisive feature required was the titanium compressor wheel to allow the higher horsepower engine ratings to achieve the performance goals. An additional key component necessary to provide the right level of control and response of the VTG turbocharger is the electronically controlled and driven actuation system. This system allows the engine control module to optimize the overall engine performance through the tightly monitored and controlled vane position. One of the greatest challenges in meeting customer wishes with regards to fuel consumption, emissions and performance was the efficiency of the turbocharger compressor stage. This required BorgWarner Turbo Systems' development group to provide a customized design to meet International's ambitious performance and efficiency goals.

The ambitious performance aims were equaled only by the tight time scale for implementing the customer requests.

The aggressive development and timing targets set by International required BorgWarner Turbo Systems to assemble a team that had not only the engine and turbocharger performance expertise but also the project management skills to deliver the right product at the right time. This team consisted of a first class application team located at Turbo Systems' North American technical center in Asheville and headed up by Brock Fraser. Development support was required to achieve the tight performance goals. A team led by Patrick Sweetland with development engineers from both the North American and the European Turbo system technical centers provided this support. The final piece to the puzzle was the overall management of the program to ensure a successful launch. This was accomplished through a global cross-functional team, which included representation from manufacturing, purchasing, logistics, quality, engineering/design and human resources. Brady Ericson, a dedicated program manager, was appointed to lead this team.

The cooperation between the BorgWarner Turbo Systems and the International Engine team was the most important factor in ensuring a successful launch. To achieve the ambitious timing and performance targets, both companies had to work together with a new level of openness. Turbo Systems recognizes the importance of this type of partnership in moving forward within today's demanding market. This project is an excellent example of how the BorgWarner Turbo Systems team continues to meet and exceed our customer's requirements through the utilization of our global talent as well as our commitment to product leadership.

ENGINES

for International



The commercial vehicle series 4000, 7000 and 8500 are equipped with the new inline six-cylinder units from International, for which the S300V turbocharger from BorgWarner Turbo Systems was specially developed.



TURBO SYSTEMS BEGINS TURBOCHARGER PRODUCTION FOR HYUNDAI & KIA MOTORS

Turbos for Korea

The major Tech Review event, which BorgWarner held in July 2002 in Korea (see TurboNews 2/02), is now starting to bear the first fruits for BorgWarner Turbo Systems. In February 2004 the turbocharger specialist founded the joint venture "Seohan-Warner Turbo Systems Ltd." together with the Korean auto supplier Korea Flange Company Ltd. This new company will produce BV43 and BV50 turbochargers for the new generation of Hyundai & Kia Motors diesel engines.

The planning work for the new assembly line began in January 2004, and July saw the completion of the line in Korea. Turbo Systems selected the BorgWarner Engine Group plant in Pyongtaek as the production site. This new

plant was only opened one year ago and already houses the production of timing chains for Hyundai & Kia Motors by the MorseTec division. Some 9,500 square feet of modern production hall space will initially be available to BorgWarner Turbo Systems to enable SOP in December 2004.

To ensure smooth procedures and top production quality from the outset, the new colleagues from Korea have already taken part in a 5-week training course at BorgWarner Turbo Systems in Kirchheimbolanden. The content of the training included both getting to know the new turbochargers and understanding the corporate structure and processes at Turbo Systems. In parallel to this an intensive

training session was held at the Kirchheimbolanden plant for the Korean fitters, to ensure they all were able to gain the knowledge and skills needed for final assembly of the VTG turbochargers.

Within the scope of their training the fitters spent 3 weeks working in Center 7 and another 2 weeks at Turbo Systems' assembly equipment supplier. This made sure they not only knew all about the "process", but also became acquainted with the actual workbenches they would be using. The training was overseen by Dirk Baumgärtner from Center 7, who together with manufacturing specialist Thomas Fitting also supported the installation of the line and further training at the new plant in Pyongtaek.



The new employees from Korea prepared for their work in Pyongtaek in Kirchheimbolanden.

BORGWARNER EXPANDS ITS VTG MANUFACTURING FOR RENAULT AND VOLKSWAGEN/AUDI

Production Capacity Boosted

More and more auto manufacturers are using the latest VTG turbocharger generation BV by BorgWarner. To meet the growing demand from Renault and Volkswagen the turbocharger specialist has significantly expanded its manufacturing capacity while simultaneously improving its quality control.

In the K9K series of engines by Renault the BV39 THP is used in the 100 bhp version for the Renault Clio, Megane and Scenic. The production line on which the turbocharger is assembled was revised in May 2004 to increase output. The manufacturing specialists at BorgWarner worked together with the employees from production to develop the layout for a new "assembly island". The job contents were then optimized in a Kaizen workshop. Quality control procedures were introduced to accompany the increase in production numbers and to help improve the processes in conjunction with the employees. The new plant concept allows turbochargers to be assembled in the minimum amount of space.

Turbo Systems also put a fully automated assembly line into operation for Volkswagen/Audi. This has increased capacities and optimized processes.



The components were checked and measured using cameras and laser technology.

In a design and start-up phase of just 2 months it was possible to significantly increase daily production while maintaining the high quality typical of all BorgWarner products. The components of BV39 turbochargers are aligned fully automatically on the individual stations then assembled using the latest gener-

ation of screw bonding technology. State-of-the-art camera systems are used to monitor the individual assembly steps. To optimize the processes and the availability of the required material, the assembly line is equipped with an EDP system which guarantees automatic in-time feed of parts.

Following an intensive planning and preparation stage, the first inspection station for checking compressor wheel vanes has now been put into operation. The inspection is performed during the free time in compressor casing assembly. The employees simply have to place the partially assembled turbocharger into the station. The machine then performs the inspection without any operator intervention. A fixed laser measures the compressor wheel while it is turned in the compressor casing via a drive. Damaged compressor wheels are thereby immediately detected and ejected. This is one step further toward optimizing the reliability of BorgWarner's turbocharging systems.



The staff of the new assembly line.

BORGWARNER LAYS THE FOUNDATION FOR SEAMLESS COOPERATION

Success Through Efficient Process Management



The process navigator is the heart of Process Management at BorgWarner Turbo Systems.

In the automotive industry the processes of manufacturers and suppliers interact as in no other sector. The stipulations in the international standards VDA 6.x, QS9000 and TS16949:2002 underline how closely the procedures are linked with one another. With an efficient system of process management BorgWarner Turbo Systems has therefore laid the foundations for seamless cooperation with automotive manufacturers across the globe. The turbocharger specialist's aim is not only to be the first choice for innovative charging systems,

but also to set new standards in cooperation with its customers. The fact that the company this year received global certification in line with TS 16949:2002 shows that it is already on track to making this aim a reality.

For Turbo Systems this initially means building up global cross-site awareness for its internal processes and also synchronizing its internal processes with those of the global players it can count among its customers. The "process navigator" plays a key role in this venture. It describes all significant processes that contribute to corporate success. Using defined measurable variables alongside fixed inputs and outputs it is, for example, possible to monitor the efficiency and effectiveness of the processes throughout the entire company. This in turn allows the company to determine reliably where there may be potential or need for improvement of processes.

The system of process management at BorgWarner Turbo Systems is a powerful tool that supports the company in developing technologically advanced products together with the customer and getting these ready for series production more quickly. The aim is to offer the customer significant quality advantages while simultaneously speeding up processes and reducing costs.

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