

TurboNews

The Info Magazine of BorgWarner Turbo Systems 1/04

Powerhouse

NEW BENTLEY CONTINENTAL GT WITH
TWIN-TURBO W12 ENGINE



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CURRENT PROJECTS DOCUMENT THE KEY ROLE OF TURBOCHARGING IN ENGINE DEVELOPMENT

Key Technology

Dear Readers,

In this latest edition of TurboNews we present you with a full spectrum of exciting applications for turbocharging technology: from the incredibly economical yet world record-breaking Opel EcoSpeedster – whose engine is now going into series production in cars by Fiat, Opel and Lancia – through the new and powerful diesel engine for the Audi A2, right up to the high-performance Volvo S60R/V70R and Bentley Continental GT. These are complemented by the futuristic natural gas engines of MAN or the MAN rally truck, which accompanies teams in the legendary Paris-Dakar rally as a service vehicle. The extreme differences between these vehicles and their turbocharger systems clearly demonstrate that there are now virtually no limits to the potential applications of turbochargers – applications that are also becoming increasingly polished and technologically advanced.

An important basis in meeting the technological demands of our passenger car customers now and in the future is the new BV turbocharger generation using the VTG technology. You can read all about the special features and the advantages of the new model line in this edition.

Increasing globalization, severe cost pressure, ever increasing production volumes and the need to further optimize processes and keep organization efficient during growth – these are the organizational challenges we have to face alongside the development of pioneering boosting systems. In an interview, Hans Heyne, Director of Global Purchasing, offers us an insight into how Turbo Systems is facing up to these challenges in procurement.

We hope you have fun reading!

The editorial team

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THE KP SERIES AND BV TECHNOLOGY ARE THE KEY TO SUCCESS OF SMALL DIESEL ENGINES

The triumphant advance of the small diesel engine

With the launch of its 1.2 and 1.4 liter diesel engines in 1999 the Volkswagen group brought high-performance diesel technology to the small car. In the following year came the Smart CDI, which still boasts the smallest diesel engine in the private car market at just 49 cubic inches (0.8 liter) displacement.

However, the most important development for the European market was the introduction of the 1.4 liter DV4 diesel engine in 2001, designed in cooperation between PSA and Ford. It is produced in very large numbers and is the backbone behind the triumphant rise of the small, modern diesel engine market up to 90 cubic inches (1.5 liter) displacement. Coupled with the introduction of the 1.5 liter (90 cubic inch) K9K engine by Renault, these engines started to win large market shares in the small car segment – with their production volume increasing fivefold in two years to a point where almost 1.5 million units were produced in 2003. The full spectrum is now rounded off with the recently introduced 1.3 liter (80 cubic inch) CDTI by Fiat-GM Powertrain and the 1.4 liter (85 cubic inch) Toyota diesel engine used in the new Mini by BMW and the Toyota Yaris. With further increases in power density these engines are likely to be used more and more in the small family or so-called “Golf” segment, where they will undoubtedly find many keen buyers.

the trend towards more compact engines early on and developed pioneering charging systems. The KP series – and in particular the KP35 – meets all the demands of modern small diesel engines. Our turbochargers help the extremely successful small diesel engines of Peugeot, Ford, Renault, Nissan, Fiat and Opel achieve their impressive performance and fuel consumption figures.

We are now looking forward to developing these engines even further with regard to fuel consumption, emissions and performance. The use of turbochargers with VTG technology – already reworked and available to our customers in its third generation – will be increasingly important here. With the new BV technology, BorgWarner once again provides leading technology for the small engines of the future. The first models, such as the Audi A2 with 90 bhp or the K9K with 100 bhp, can already be seen on our streets.



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

One major factor contributing to the success enjoyed by these engines in the market is clearly the turbocharging technology by BorgWarner Turbo Systems. We recognized

BENTLEY CONTINENTAL GT DRAWS POWER FROM TWO BORGWARNER TURBOCHARGERS

Powerhouse



When Walter Owen Bentley presented the Speed Six back in 1928, he stunned the public with a vehicle that was to become one of the great automotive legends of the world. The car was designed both as a road car and potential winner of the 24 hour race in Le Mans – design specs that proved realistic. In the design of the brand new Continental GT the starting parameters were certainly quite different, yet the fundamental principle was basically the same: to develop a vehicle that is sumptuously luxurious, yet loses nothing in excitement.

Following the world premiere of the Bentley Continental GT, Bentley Motors has now published the full technical specifications of the car that is not just one of the fastest road cars available today, but also the most powerful four-seater coupé in the world. Two simple statistics indicate the huge potential hidden beneath the elegant hood: the Continental GT accelerates from 0 to 60 in around 4.5 seconds, achieving a maximum speed of 198 mph. The heart of the car is a 6 liter twin turbo W12 engine with four camshafts and 48 valves.



The Continental GT has the shortest 12 cylinder engine currently in series production.

It produces 560 bhp at 6,100 rpm, and the maximum torque of 480 lb-ft (650 Nm) is available from an impressive 1,600 rpm upwards.

The specifications of the engine impress in all facets. Its outer dimensions make it the shortest 12 cylinder engine currently in series production, despite its full 6 liter displacement. This was made possible by the W configuration, where the cylinders are not arranged in

two long rows as with a conventional V12, but each cylinder block is made up of two V6 units that share a common crankshaft. This design allowed an unusually compact engine to be built.

In the development of the turbochargers Bentley relied on the experienced specialists at BorgWarner Turbo Systems. The K16 turbochargers have several special features to meet the demands of the charging system. Specially designed cast steel turbine housings ensure that the precatalytic converters are warmed up correctly and thereby offer significant improvements in response due to reduced heat loss. A waste gate, which can be opened almost 90°, is used to further optimize the heating of the precatalytic converters for cold starts. To open the gate, the vacuum present when starting the engine is taken from a reservoir. The boost itself is then controlled conventionally during normal operation using boost pressure. To be able to implement this control strategy, a new so-called Delta-p actuator was developed with an additional position sensor. The recirculation

valve required in gas engines is integrated in the compressor housing.

The turbochargers work with a comparably low boost of 0.7 bar – a complement to the exceptional power of the engine in the Continental GT. This power, the fact that the maximum torque is available from 1,600 rpm and the 6 liter displacement ensure that the only undesirable side effect typically associated with this type of booster system – the notorious “turbo hole” – is safely avoided. A core principle common to all Bentleys since the founding of the company in 1919 is that smooth power delivery is not something Bentley drivers should have to wait or ask for – it must be available at all times. And the impressive performance of the new unit will satisfy even the keenest of drivers, regardless of whether the rev counter is at the low end or touching the red line at 6,100 rpm. The engine also conforms to the future Euro 4 standard for exhaust gases.

Great efforts were made to use an extremely efficient air-air intercooler in the Continental

GT. It was not easy to find room for this in the already tightly-packed space under the hood. But the engineers at Bentley insisted that it be incorporated and, after several months of intensive development, a space was finally found.

The Bentley Continental GT is without doubt one of the most ambitious vehicles ever developed. As a genuine four-seater it offers

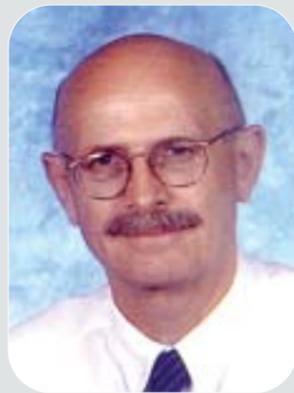
a level of performance that is truly unique, both in terms of quantity and quality. Traditional values and innovative automotive design come together in the Continental GT in a way that any other car would struggle to equal.



Two K16 turbochargers help the unit achieve its maximum torque from just 1,600 rpm.

INTERVIEW WITH HANS HEYNE, DIRECTOR OF WORLDWIDE PURCHASING

Purchasing Management as a competitive factor



The TurboNews editorial team spoke with Hans Heyne about the challenges faced by BorgWarner Turbo Systems in global purchasing management.

TN: *Mr. Heyne, since the start of 2000 you have been responsible for global purchasing at BorgWarner Turbo Systems. How do you define your job?*

H. Heyne: My task is to coordinate our purchasing activities, focusing on global and continental decision-making processes in the Purchasing Department. The aim here is to provide the required materials and services in the correct quantity and quality at the right time and the right place with the best possible conditions.

This also involves implementing the purchasing strategy, which we have developed with the help of the decision makers in the purchasing and quality organizations and which describes our medium and long-term purchasing aims. We define the number, the selection process and the requirements profile of our suppliers with a view to our planned global requirements. The work packages that are then derived from this are implemented by the operative purchasing teams. Of course this kind of purchasing strategy has to be continuously adapted, as our requirement profiles, the suppliers themselves and our potential purchasing markets are all constantly changing.

This leads us to the organizational part of my task – shaping a powerful purchasing organization and establishing the necessary procedures and means of communication. We now have purchasing teams in Europe, the US and South America. In Asia we are represented by our joint venture partner HWTS. And in other Asian countries, such as China, we are in the process of building up a purchasing team. Alongside this we also have employees with global responsibility – our so-called Commodity Champions – who are an integral part of the overall organization.

TN: *What are the greatest challenges of working in Purchasing for a global player like Turbo Systems?*

H. Heyne: Our most important challenge is to keep up with the rapid growth of our group and the corresponding increase in the complexity of our purchasing tasks. For example, we now develop turbochargers in Europe for subsequent manufacture in the US and Asia, while our US team makes application adjustments for products that are then manufactured in South America. For all these activities the Purchasing Department has to make the right purchasing decisions and efficiently manage the flow of materials for production in our plants. Our focus is on providing delivery capacities on time – of course taking into account the best purchase price available worldwide and incorporating our own quality standards.

To compete with the growing cost pressure in the automotive industry the purchasing teams have to work seamlessly with one another, while the responsibilities and targeted results have to be clearly defined. This allows synergies to be created. Examples of this include the concentration of our requirements and thereby the creation of greater purchasing power, the qualification of suppliers from one site for the entire group and the early integration of suppliers into the design stage of materials. Our goal is to

coordinate all our purchasing activities worldwide, incorporating data transparency across purchasing markets and the strengths/weaknesses of our suppliers.

TN: *What special situations came about from the merger of the two former competitors Schwitzer and 3K?*

H. Heyne: We have to purchase materials for two lines of turbochargers with a similar range of performance. This often means a proliferation of parts and small batch sizes, which results in higher material prices and logistics costs.

Our Turbo Systems organization is still young, and it is important for us to standardize the specifications sent to suppliers as fast as possible. Due to the way they have been built up over time, the manufacturing methods used at the various sites are not matched to one another. Standardization is needed in the core processes. It is therefore also part of our responsibility to get together with our product managers, manufacturing managers and selected suppliers to implement this in the near future.

Merging the two former competitors of course means that we now have more suppliers in our portfolio than we really need for several types of material. Reducing this to the necessary level and at the same time building on partnerships with strategically important suppliers in joint projects is a further facet of our strategy. A smaller number of suppliers ultimately means lower administration costs and saves resources. In doing this, of course, we have to take into account continental requirements as well as our planned global growth.

I would also like to touch on another point here – working in line and matrix management structures. This is new for everyone involved – yet indispensable for a company which operates globally with key positions and responsibilities spread out over different

countries that wishes to control functional core processes, such as purchasing, centrally.

TN: *So how do you deal with such a dynamic market in the Purchasing Department? You are caught between ever increasing requirements and the introduction of the latest technology.*

H. Heyne: We are pursuing a kind of parallel strategy. The basis of our information is the Long Range Plan with several updates a year on the one hand and our regular development and operational reviews on the other. Our LRP shows us requirement trends in the necessary product groups. This also makes it clear in geographical terms where our company will have material requirements in the future.

The continuous development reviews and additional regular coordination meetings between Development and Purchasing help indicate technological trends. The operational reviews and regular meetings with the manufacturing areas at our sites clarify the requirements with regard to materials management, outsourcing and so on. All this together gives us a very good idea of the short-term and long-term requirements to be covered by Purchasing.

In parallel to this the Purchasing Department is also proactive, assessing new suppliers independent of current requirements and signing capacity agreements with existing suppliers. Due to the cost pressure already mentioned and to achieve additional growth in Asia we are currently going to great lengths to find potential suppliers in countries where we have no purchasing experience to date. Our focus in this respect is on countries whose economic situation can offer us cost advantages.

Increases in demands from our customers mean that we now have to spend significantly more on developing new suppliers

than in the past. Our strategy is therefore to build up long-term business relations with competent suppliers and, wherever possible, call on these partners for all material requirements at all our sites across the globe. We use four basic principles here: generation of the required supply capacities for our future requirements, production of the quality we require, cost advantages over our current level of material costs and – if possible – a development partnership.

Several of our current suppliers also supply our competitors. It has therefore never been more important for us to create long-term agreements to secure both the capacities we need and our technological requirements of the supplier's processes.

In the case of new materials or technologies we often find ourselves in a position where potential suppliers can offer basic knowledge, but do not have any real experience in series manufacture. Added to this is the fact that we and our customers often have to initiate our purchasing activities with incomplete specifications. Close cooperation with selected suppliers and a continuous exchange of information are vital here. These allow all facts and experience gained to be assembled into a final requirements profile.

In certain cases we check whether we can patent the results of this cooperation. We also often sign exclusive contracts to prevent our competitors from accessing any knowledge gained. Depending on how our requirements develop in these sectors, Purchasing then looks for and assesses further potential suppliers to provide alternatives and competition.

TN: *What is your idea of a successful Purchasing Department?*

H. Heyne: The demands of our business segments are constantly changing, as are

the markets in which we purchase. New suppliers appear and others disappear if they cannot meet our requirements. A dynamic, flexible approach and the ability to adapt to changing situations and procedures are vital. Constantly striving to find improvements in the global structures of cooperation is also a key factor that contributes to our success.

Allow me to mention a few examples, such as the SAP implementation in Bradford which will make purchasing in Europe faster and more powerful, our cooperation in the BW Global Supply Chain Council (GSCC) and European Purchasing Council (EUPC), the introduction of organizational improvements, such as system-generated processes for debit memos or creation of a credit memo procedure for consignment stock levels, purchasing by credit card, the planned projects for optimization of MRO purchasing and the introduction of an Internet-supported inquiry system (eRFQ).

Successful purchasing strengthens our competitiveness by employing strategic aspects when selecting suppliers, including these suppliers in the development of materials at an early stage and giving preference to those suppliers who have engineering experience where we need it.

As globalization becomes more and more prevalent it also becomes increasingly important to effectively manage the relationships between suppliers and our specialist departments – particularly for suppliers from different cultural spheres. Our purchasing staff today also need to feel comfortable when dealing with other cultures and successfully achieve set targets in this environment.

OPEL ECO-SPEEDSTER WITH BORGWARNER TURBOCHARGER SETS 17 NEW WORLD RECORDS

Record breaker

27 July 2003 will go down as a very special day in Opel's rich history. It was at 12:44 pm on this day that the record breaking journey of the ECO-Speedster was completed on the high speed circuit at Opel's test center in Dudenhofen. Over a period of 24 hours the 112 bhp prototype set a total of 17 international records for special vehicles with turbocharged diesel engines in the class from 1.1 to 1.499 liters displacement. The tested ECO-Speedster uses a completely new

1.3 liter CDTI-ECOTEC diesel engine of the latest generation – with common rail direct fuel injection, multijet technology, four valves per cylinder and a BV39 turbocharger with variable turbine geometry by BorgWarner Turbo Systems.

The average speed of the round-the-clock test clearly demonstrates the efficiency and power on offer from the new 1.3 CDTI engine: At just under 140 mph the old record was broken by an

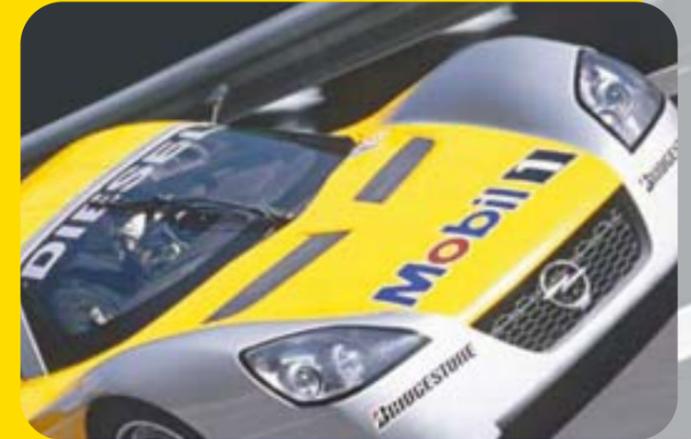
impressive 61 mph. In the fastest lap of the 24 hour test the ECO-Speedster averaged an impressive 159.37 mph. And over one kilometer with a flying start it achieved a top speed of 159.66 mph.

International journalists were also presented with an identical sister vehicle at the same time for testing on public roads, with impressive results: the ECO-Speedster's average consumption during the test was a record breaking 92 mpg US (110 mpg UK).

With its 17 new records the vehicle follows in the footsteps of a prototype that made headlines worldwide some 31 years ago. On 01 June 1972 a modified Opel GT using a 95 bhp 2.1 liter turbo diesel engine also set a number of world records for diesel vehicles at the test track in Dudenhofen, achieving a top speed of just under 123 mph.

Opel's new 1.3 liter common rail diesel engine that helped the ECO-Speedster to its record-breaking run is celebrating its introduction in Opel's series models Corsa and Agila in a few weeks. In terms of consumption, exhaust gases and smooth running the new ECOTEC engine is one of the best diesel engines around today. In the standard series models it produces 70 bhp and develops a maximum torque of 125 lb-ft (170 Nm).

This makes the two Opel models both decidedly quick and environmentally friendly: the Corsa 1.3 CDTI makes the dash from 0 to 60 in around 14 seconds and achieves a top speed of 102 mph, while the Agila takes around half a second longer and achieves a top speed of 92 mph. In terms of consumption,



however, both models are genuinely economical: the Agila achieved the impressive figure of 45.2 mpg US (54 mpg UK) – corresponding to a CO₂ emission of just 225 grams (8 oz) per mile. The Corsa 1.3 CDTI went even further, with 52 mpg US (62 mpg UK) – corresponding to just 195 grams (7 oz) of CO₂ per mile. And the modern diesel engine of course meets the stipulations of the Euro 4 standard.



The new 1.3 CDTI engine is soon to celebrate its series launch in the Opel Corsa und Agila.

VOLVO AND TURBO SYSTEMS POOL THEIR KNOW-HOW
ON THE DEVELOPMENT OF THE R-LINE

The R Team



In October 2000 Volvo Car presented its first concept for a high-performance automobile at the Paris Motor Show. The Volvo PCC (Performance Concept Car) was based on the Volvo S60, which formed the platform for today's Volvo S60R. Then in 2001 came the PCC2, which was based on the Volvo V70 with the same 300 bhp engine and the same ultra-modern chassis technology.

From the first glance under the hood it is clear that the engine is something special. The characteristic blue R is found on both the engine itself and the cam belt covers, while the intake manifold has a special aluminum cover with the R logo. And the exposed section of the boost air line from the turbocharger in the engine compartment has been produced in the same style. This progressive engine design suggests great things can be expected – and the specifications of the turbocharged engine do not disappoint. With 300 bhp and a full 295 lb-ft (400 Nm) of

torque on offer between 1,950 and 5,250 revs, the B5254T by Volvo sets new standards in the luxury car category. Yet it is not merely the nominal power figure of 300 bhp and the 120 bhp per liter displacement that impresses, but rather the way in which the power is delivered. The S60R sprints from 0-60 in around 5.5 seconds – clearly demonstrating the great agility the car has to offer. The combination of the turbocharging, two efficient charge air coolers and the so-called “Dual Wide Range CVVT” – an inlet and outlet camshaft adjustment for altering the valve timing – guarantees both high performance and excellent emission values. The engine meets both the Euro 4 and the American LEV standards.

BorgWarner Turbo Systems was involved in the development of the pioneering 2.5 liter five-cylinder turbocharged engine from the outset. The specialists at Volvo Car relied on Turbo Systems' comprehensive know-how

in the field of gasoline engine turbocharging. The development teams of both companies decided on a K24 turbocharger with waste gate and integrated recirculation valve on the compressor side, which has been optimized not only for the nominal output, but also to improve the acceleration and transient behavior. The aim was to provide a sporty driver feeling without compromising comfort. For the first time ever, the turbocharger now contains components that permit peak exhaust gas temperatures of 1,700 °F (1,050 °C). These include a bearing housing with optimized water cooling, a new turbine wheel shaft connection and turbine casing made of cast steel with high temperature stability.

The development of the B5254T formed the start of an intensive cooperation between the Volvo engine designers and the engineers at BorgWarner. Two proven specialists in the field of turbocharging gas engines came

together and produced an exceptional engine in the form of the R-Line. This most powerful engine in Volvo's entire range whets our appetite for what may lie ahead in the cooperation between Volvo Car and BorgWarner Turbo Systems.



The K24 turbocharger can take exhaust temperatures of 1050 °C.



BORGWARNER CATAPULTS BV TURBOCHARGERS FROM THE DRAWING BOARD TO SERIES LAUNCH IN JUST 15 MONTHS

Development in record time

In June 2002 there was talk that the competitor Honeywell was set to take up a patent suit against BorgWarner Turbo Systems. The point at issue was the current design of BorgWarner's VTG Technology for passenger cars, where Honeywell believed to have found similarities to their own products.

At that time Turbo Systems was already in the development stage of the future VTG design – the so-called "VTG 3rd Generation". And in light of the impending patent suit the management at Turbo Systems then decided to give this development project top priority. The aim was to take the new 3rd Generation units from the initial development stages to series launch in record time. While the schedule was certainly tight, the development team was not prepared to make any compromises regarding the functionality and testing of the cutting edge product.

The components for the first prototype were purchased more or less overnight in close cooperation between the developers, suppliers and prototype builders, who then managed to complete first combustion chamber tests before the end of June. The new design passed the first tests with flying colors, allowing the series development of the new products christened "BV" to start immediately. For the full development of the series units a project team of experienced experts was assembled, the size of which had never been seen at Turbo Systems.

The design team took the design from the prototype to the series production stage. This had to be done simultaneously for all models, from the BV35 to the BV50, as the team at BorgWarner wanted to have a wide range of products available for the customers from the very start. Purchasing, quality assurance, pro-

duction and sales were integrated in the team from the outset. This was the only way to ensure that the tight procurement window could be met, that the parts could be qualified at the future suppliers and that the coordination with running customer projects would work. The staff at the Prototype Center in the Kirchheimbolanden plant also had an important task during this time. They had to produce a large number and variety of prototypes in the shortest time possible to ensure there were enough BV systems for internal testing and all customer projects.

This project was also a trial run for the development structures that Turbo Systems wishes to use in future – keeping design and testing separate. Alongside the internal engine and combustion chamber test benches, external partners were also commissioned to perform tests and four endurance test vehicles were also sent on their merry way. Following comprehensive internal and external tests BorgWarner Turbo Systems is now in a position to offer its customers a broad range of BV turbochargers using the latest generation of VTG technology.

The first BV39 series turbochargers finally left the Kirchheimbolanden plant in August 2003 for the new 1.4 liter three-cylinder engine in the Audi A2. All the other BV units are set to go into series production in the next few weeks and months - for use in engines such as the recently presented Audi 3.0 liter V6 diesel with 233 bhp. Switching over Volkswagen's 4-cylinder engines from the old technology to the new BV technology is a real challenge that BorgWarner looks forward to in 2004. These engines will be built in very large numbers.

The 3rd generation of BorgWarner's VTG technology for passenger cars is a powerful and proven solution right from the series launch. It also forms an excellent basis for the next generation, which already exists in concept form. The aims for the next generation are further reductions in costs and the expansion of all technical functionalities that will be needed to keep up with increasing demands on emissions and the power density of future diesel engines.

In the new BV units the turbocharger specialists at BorgWarner Turbo Systems



The largest project team ever at Turbo Systems mastered its tasks brilliantly.



The new BV turbocharger generation is well prepared to meet the challenges of the future.

have taken a pioneering design concept from the drawing board into series production in an extremely short time – thereby demonstrating how they are more than capable of successfully handling the technological and organizational challenges of the future.



The new BV generation offers significant advantages over the 2nd generation. These include:

- reduced wear
- greater temperature stability
- improved hysteresis
- resistance to soiling from exhaust air
- largely immune to deformation of the turbine casing
- simplified and accelerated final assembly
- reduction in costs

NEW BV TURBOCHARGER GENERATION WITH VTG TECHNOLOGY CELEBRATES PREMIERE IN THE AUDI A2 1.4 TDI

Athlete with high-tech heart



The new 1.4 TDI with 90 bhp helps the small Audi achieve athletic performance.

With the A2, Audi introduced an innovative and extremely attractive car in the year 2000. Thanks to its "Audi Space Frame" this new vehicle is lighter and thereby more agile and economical than a standard road car. The Audi A2 is particularly popular in the 1.4 TDI guise with 75 bhp – but this model is now getting a big brother. As of November an upgraded A2 with 90 bhp is set to extend the model line and make the small Audi a real front runner. Delivering a maximum torque of 169 lb-ft (230 Nm) between 1,900 and 2,200 rpm, the compact three-cylinder unit catapults the A2 from 0 to 60 in just over 10 seconds, with a maximum speed of 116 mph. The new top TDI in the A2 series meets the strict Euro 4 European exhaust emissions standard and will delight its owners with a full 54 mpg US (65 mpg UK).

The gain in power and torque enjoyed by the engine is predominantly thanks to the new BV39 turbocharger by BorgWarner Turbo Systems with variable turbine geometry and 2.3 bar (absolute) boost pressure. This makes the small Audi the first vehicle to profit from the advantages of Turbo Systems' latest VTG technology. Like all their modern diesel

engines, Volkswagen/Audi have integrated an exhaust manifold with the BV39 turbocharger.

A new charge air cooler with significantly improved efficiency, a redesigned piston recess and the optimization of the combustion chamber geometry all contribute to the increased performance of the 1.4 liter engine. The compression ratio has been reduced to 18.0:1.

To ensure that the new A2 meets the strictest emission standards currently available, the engineers performed further detailed work on the engine and high-pressure fuel injection system. The results of this work include an electrically controlled, cooled exhaust gas recirculation system with significantly improved cooling capacity and the performance-controlled closing valve on the intake manifold to support the formation of an optimal mixture. Even the pump nozzle elements have been modified, now employing an altered injection angle and offering increased throughput.

The series launch of the BV39 turbocharger in the Audi A2 marks the first step towards the introduction of the pioneering BV product line that is set to continue in the next few months.

The BV products by BorgWarner Turbo Systems offer improved thermodynamics and an optimized control response with significantly greater reliability. They form the next generation of VTG turbochargers that offer engine manufacturers significant advantages over their predecessors.



The new BV39 turbocharger ensures a true increase in performance and torque.

OPEN DAY IN KIRCHHEIMBOLANDEN

An insight into BorgWarner



More than 6,000 visitors flooded into the Kirchheimbolanden plant on 13 September.

On 13 Sept. 2003 BorgWarner Turbo Systems opened its factory doors to the public for the first time in three years. More than 6,000 visitors used the opportunity to take a look behind the scenes of the turbocharger specialists at the Kirchheimbolanden plant.

Those attending also enjoyed the opening ceremony of the expanded training center and were offered detailed information on the broad range of training courses offered by Turbo Systems. There was also plenty of time to have a look around the development center and manufacturing facilities. BorgWarner specialists presented the engine and combustion chamber test benches and gave the visitors interesting insights into their development work on the complete turbocharger system. And in the manufacturing area staff members and info boards at various stations offered visitors information on the latest manufacturing methods and technologies. BorgWarner's environmental protection program and workplace safety activities also aroused much interest among the visitors.

A diverse program of fringe events – with live music by Relax in the marquee and children's entertainment with magic and face painting – accompanied the visitors through the day. There was also a good selection of food and drink. As expected the car exhibition on the works premises drew a huge amount of attention. Turbo Systems presented a selection of cars, vans and trucks equipped with their turbochargers. These included such impressive vehicles as a Porsche GT Street S by TechArt, the world record-breaking Opel Eco-Speedster and a Porsche 911 Turbo, Mercedes S600 and Audi RS6.



The car exhibition proved particularly popular among fans of sports cars.



The employees of BorgWarner explained the technology and production processes to the visitors.

FIAT-GM POWERTRAIN PRESENTS THE SMALLEST FOUR-CYLINDER DIESEL ENGINE IN THE WORLD

Compact Powerhouse

At the Geneva Motor Show in 2003 Fiat-GM Powertrain presented the first results of their joint development work – a compact 1.3 liter common rail diesel engine. The extremely economical and clean diesel engine is set to whip up a storm in many Opel and Fiat models. The Opel models Corsa and Agila mark the introduction of the new engine in series models, alongside the Lancia Y and Fiat Panda, Idea and Punto. Opel is starting its diesel offensive with the market launch of the small diesel engine. The new power unit documents the progress of the last three decades and the incredible rise of the diesel engine in the private car sector.

The small unit is not just extremely compact, it is among the best diesel engines produced today in terms of fuel consumption, exhaust emissions and quiet running. Users can expect to use around 10 percent less fuel than with other modern engines offering similar power, while the exhaust gases are around 30 to 40 percent cleaner – a level even lower than the strict Euro 4 standard. At just 1,251 cm³ the unit, which is badged ECOTEC by Opel and Multijet 16V by Fiat, is the smallest four-cylinder diesel engine in the world, although its

performance can stand up to significantly larger units. With 70 bhp and a maximum torque of 125 lb-ft (170 Nm) available from 1,750 rpm the high-tech diesel engine offers an almost sporty performance in this vehicle class, coupled with extremely low consumption.

The basis of the ultra-modern design behind the new unit is a weight-optimized high-duty cast iron cylinder block with an alloy cylinder head. The engine has four valves per cylinder which are controlled by two chain-driven overhead camshafts via roller-type cam followers. The latest generation of multijet direct fuel injection used is also worthy of particular mention. This system injects the fuel from a common rail supply line at a pressure of 1,600 bar.

The fuel injection of the five-hole injection nozzles is controlled by an ultra-modern solenoid valve. The response time for the injection is less than 20 microseconds, which allows extremely precise metering of the fuel volume and the use of up to five actual injections per cycle. This not only provides extremely low consumption and clean exhaust air, it also ensures quiet and smooth running.

A pilot injection system reduces the dreaded cold start “knocking” during the warm-up phase to a level where it is scarcely even perceptible.

BorgWarner is the development partner and supplier of the turbocharger used in the engine. The Turbo Systems specialists were incorporated into the development of the compact four cylinder engine very early on. In the KP35 with waste gate the 1.3 CDTI ECOTEC engine utilizes probably the highest performance turbocharger for diesel engines smaller than 1.6 liters. The main reasons for choosing the KP35 included its small dimensions and excellent thermodynamic performance characteristics – strengths that also benefit the DV4 engines by PSA and K9K engines by Renault.



The compact 1.3 liter (80 cubic inch) common-rail diesel is the heart of an entire generation of Opel, Fiat and Lancia models.



MAN PRODUCES HIGH-PERFORMANCE LEAN-BURN NATURAL GAS ENGINE WITH BORGWARNER TURBOCHARGER

Clean MAN

Natural gas is already well established as a means of heating buildings. It is popular because it is comparatively cheap and produces significantly less carbon dioxide and harmful emissions than oil. But natural gas has now found a new home, as more and more motor vehicles, and commercial vehicles in particular, are turning to this clean fuel for their power.

MAN has been offering economic and environmentally sound natural gas engines for several years. And with the E 2876 LUH01 the company now presents a new and particularly powerful lean-burn natural gas engine. The E 2876 LUH01 is based on the same design as the well established E 2866 LUH lean-burn natural gas engine, which is already produced in large numbers, and meets the



strict EEV exhaust gas standard (Enhanced Environmentally-Friendly Vehicle).

The turbocharged engine with charge air cooling works on the principle of the internal combustion engine, using a throttle valve and an ignition system. To achieve the strict EEV exhaust gas standard the so-called lean-burn concept is used. In the underload range the engine is driven with the traditional air-fuel ratio of 14.7:1. From a certain load the mix is then made leaner. This guarantees that the exhaust gas temperatures remain fairly low both at full-load and the range just below full-load, which also ensures low engine compartment temperatures - an enormous advantage for the durability of other components fitted here.

The pressure of the highly compressed natural gas is reduced via two pressure regulator



The new MAN engine is to be used in the most diverse commercial vehicles.

valves to the operating pressure of 8.5 bar. The charge air is then added centrally after the throttle valve and directly before the charged mixture distribution pipe. This takes place in a gas mixer unit, which is equipped with 12 electrically operated gas metering valves. The valves are arranged in four blocks of three, evenly distributed around the mixer pipe. The electrically actuated throttle valve is also located on the gas mixer unit. The gas mixer unit is located directly at the charge air pipe of the engine, meaning that the path traveled by the natural gas-air mixture to the cylinders is very short. The final ignition stages and dual ignition coils of the transistor ignition system are fitted on the charged mixture distribution pipe to offer improved cooling. Short H.T. leads connect the ignition coils to the spark plugs. The exhaust gas from the engine is processed in a catalytic converter, which is integrated into the exhaust muffler.

The MAN lean-burn engine has a dual flow S300 BorgWarner Turbo Systems turbocharger. This boosting system is equipped with a waste gate to give powerful torque delivery when accelerating from low revs and limit the nominal power. A special feature employed by the Turbo Systems engineers here is a waste gate that controls both channels of the turbine casing. This solution has a key advantage, as it ensures that all cylinders receive an evenly reduced mixture in controlled lean-burn

operation. With a single flow blower the varying exhaust gas back pressure would not allow a uniform mixture, thereby providing sub-optimal combustion in all cylinders. Due to the special thermal requirements, the bearing housing of the turbocharger is equipped with water cooling.

The high-performance MAN natural gas lean-burn engine is an impressive example of the broad range of applications covered by BorgWarner turbochargers today. These turbos are proving to be important building blocks for the engine concepts of the future.



A dual flow S300 exhaust gas turbocharger ensures high performance and low consumption.

BORGWARNER TURBOCHARGERS PROVE THEIR TOUGHNESS IN THE WORLD OF RALLY

Long-standing success



The teams at Mitsubishi and DaimlerChrysler mastered the trials and tribulations of the rally with class.



This year was the 11th anniversary of the most adventurous stage of the Brazilian Championship of Cross-Country Rally, the Rally dos Sertões, which led participants 4,000 kilometers right across three Brazilian states from 23 July to 02 August. This is the most important rally in the whole of Latin America. And BorgWarner was there to provide the three top teams Mitsubishi, DaimlerChrysler and Volkswagen with turbochargers and offer technical support on site.

The cooperation between BorgWarner Turbo Systems and the official Mitsubishi rally team began at the start of this year for the South Route Rally. The prototypes of K26 turbochargers that the Turbo Systems engineers developed for the 2.8 liter engine of the L200 Evolution exceeded the team's expectations both in terms of performance and reliability.

For its rally trucks L1418, 2428 and 915C DaimlerChrysler relied on unmodified K27 and K24 turbochargers – the exact same models used in the four and six cylinder engines of Volkswagen trucks.

To offer the rally teams the best possible support, application engineer Rodrigo Costa from BorgWarner accompanied them on their testing and exciting journey. The participants had to get to grips with stony and dusty roads and negotiate their way through rivers, mud and over sand dunes – all taking place in tropical temperatures of over 40 °C.

At no point did the BorgWarner turbochargers let the rally teams down. And the results really could not have been better: In the car and truck categories Mitsubishi and DaimlerChrysler both dominated the proceedings. And in October the same teams were crowned overall winners in the Brazilian Championship of Cross-Country Rally 2003.

The outstanding success of the Mitsubishi and DaimlerChrysler rally teams further demonstrates the effectiveness and reliability of BorgWarner's booster systems under the toughest of conditions.

DEUTZ 1015 ENGINE WITH BORGWARNER TURBOCHARGERS POWERS PARIS-DAKAR SUPPORT VEHICLE

Powerful support



They drive probably the toughest rally in the world – yet never win a prize: the support vehicles that accompany the participants in the Paris-Dakar rally. The KTM motorbike team once again chose a MAN rally truck as support and service vehicle. But to keep up with the rally competitors this truck had to offer the performance, capacity and reliability of a racing truck.

This was made possible with the water-cooled V8 diesel engine from Deutz's 1015 model line. Fitted with two S300 BorgWarner Turbo Systems turbochargers the engine develops 544 bhp and a maximum torque of 1887 lb-ft (2559 Nm) at 1200 rpm and has a theoretical top speed of 105 mph. Speeds of up to 80 mph are possible in the sandy rally conditions – an impressive figure given the total weight of 24 tonnes! Although the engine is tuned primarily for performance, it even meets the Euro 2 emissions standard.

The MAN rally truck with its Deutz engine is a further example of the reliability that BorgWarner turbochargers provide under the toughest of conditions. It is also a model example of how high performance, reliability and low exhaust emissions can go hand in hand, even in the world of motorsport.

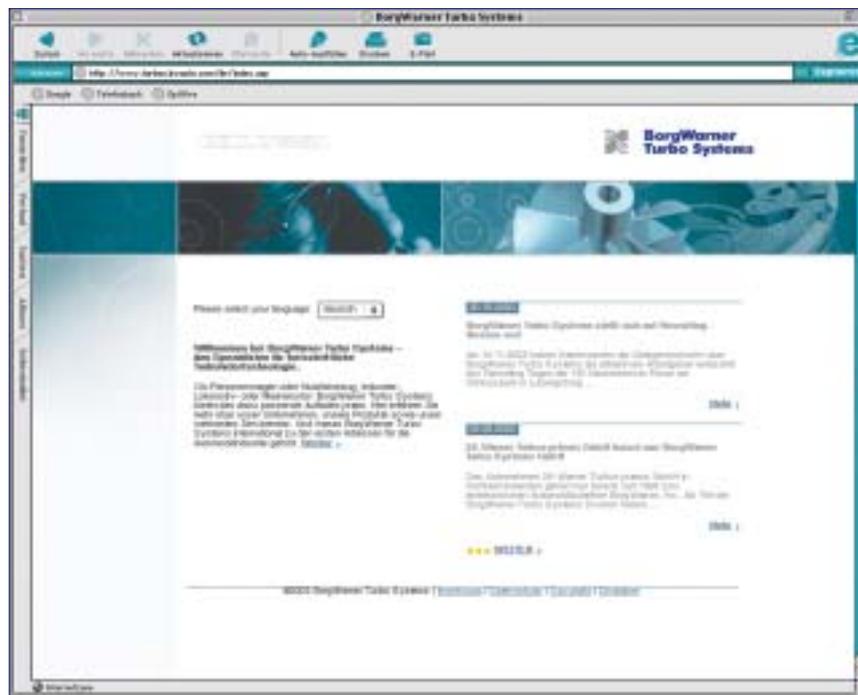
TURBO SYSTEMS REVISED WEBSITE IS ONLINE

Online Turbos

The new BorgWarner Turbo Systems website has been up and running since July 2003. The site at "www.turbos.bwauto.com" is now easier to navigate and offers even more information and services. The highlights of the new website include a detailed description of the history behind the turbocharger and its technology, as well as a library of knowledge with articles on interesting topics in and around innovative charging systems.

Customers, partners and anyone interested can now learn all about the company and its products online. The information on offer includes brief profiles of the sites, details of the company's visions, goals, quality policy and environmental policy – with many downloads. The product overview has also been improved. This feature allows Internet users to gain a comprehensive overview of the products and expert services offered by BorgWarner Turbo Systems. In the "Service" area there is a wide range of articles and brochures available for download. Our aim is to provide all new articles and brochures here in future.

A further expansion of the Internet site is already being implemented. Turbo Systems is also set to provide information in a secure extranet area, allowing its partners to access all the specific details they need. Alongside this, there are plans for an online supplier application system to simplify



Get service and info around the clock: www.turbos.bwauto.com

initial decisions regarding the selection and assessment of partner companies.

To ensure that the information on the Turbo Systems website is always up-to-date, an editorial system has been integrated. This allows Turbo Systems' staff members to make changes in defined sections online. Decentralizing content and updates in this way makes it easier to keep the site

completely up-to-date with all new developments.

Why not take a look? We look forward to receiving your comments and feedback.

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