

TurboNews

Newsletter for Friends and Customers of BorgWarner Turbo Systems 2/00

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TURBONEWS PRESENTS NEW TECHNOLOGIES AND TRENDS

Showing the Way

Dear Readers,

Since the first issue of the TurboNews, the circulation of our magazine has more than doubled. It now also appears in Portuguese. We are proud of the fact that we gain new readers with each new issue. This is due – we hope, as those responsible for writing the articles – in good part to our success in coming up with a steady stream of new topics that interest you. But the biggest driving force is, of course, the constantly growing importance that turbocharging has for advances in engine design. Especially as fuel prices increase dramatically, these days buyers of both passenger cars and commercial vehicles insist on engines with significantly greater fuel mileage – yet without any compromises in terms of performance.

This issue of TurboNews therefore focuses on the technology and applications of our turbocharging systems. In it, we show you interesting examples of our product technology used in series-produced vehicles. We also report on four new vehicles – two passenger cars and two commercial vehicles – that are equipped with turbochargers from BorgWarner Turbo Systems.

It is also increasingly important for turbocharger development efforts to keep pace with new requirements. We therefore take a close look at future technologies and development trends in an interview with the man who is in charge of developing turbochargers for passenger cars at BorgWarner Turbo Systems.

We hope you enjoy reading this latest issue of our newsletter. As usual, if you have any suggestions, praise or criticisms, please let us now – we'll be looking forward to hearing from you!

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Interview with
Hans-Peter Schmalz



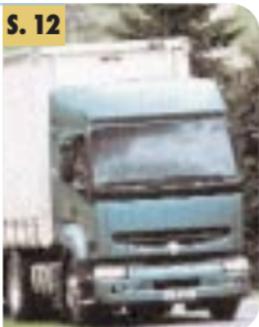
S. 4

The new top-of-the-line model of Porsche's 911 series is once again equipped with a turbocharger from BW TS.



S. 10

No fewer than two K04 turbochargers from BorgWarner Turbo Systems give the Audi RS4 spectacular performance.



S. 12

An S300 turbocharger helps RWI's new 11-liter engine for commercial vehicles comply with the Euro2 norm.

BW TS Inside

BORGWARNER TURBO SYSTEMS
HOLDS A BARBECUE IN
INDIANAPOLIS

After Work



On September 16, 2000 the traditional annual BorgWarner Turbo Systems picnic took place at the company's Indianapolis site. About 80 employees attended this fun and varied event with their families.

In between participating in various sports and games, many of the guests took advantage of the opportunity to have their portraits drawn by a professional artist. The youngest picnic visitors had fun jumping on a magic castle, riding ponies, and trying their hands at fishing, hula-hoop and football throwing contests. A clown was also on hand to entertain them. And there was naturally plenty of good food and drinks for everyone to enjoy.

The weather gods also smiled on the event, which took place on a radiantly sunny day. Thanks to the excellent organization and preparation by a team of volunteers, it turned out to be a complete success.

PORSCHE TURBO – A QUARTER-CENTURY OF SUCCESSFUL TURBOCHARGER HISTORY

Turbiography

Ever since the first Porsche Turbo was built in 1974, BorgWarner Turbo Systems has been a partner to Porsche in all matters pertaining to turbocharging. The over 25 years of this successful collaboration have given rise to vehicles that have constantly set new standards in many respects. The new Porsche 911 Turbo continues this tradition. It is truly an superbly engineered sports car — almost too perfect, if you can believe reports in the car magazines!

The new Porsche 911 Turbo is once again

the top model of the 911 series, featuring outstanding performance in combination with low pollutant emissions. At engine speeds between 2700 and 4600 rpm, it delivers a torque of 560 Nm. This makes it excellently suited for both fast and relaxed driving.

The car attains its maximum engine output of 309 kW (420 HP) at 6000 rpm, permitting a top speed of 305 kph (190 mph). The Porsche 911 Turbo accelerates from 0 to 100 kph (60 mph) in just 4.2 seconds, and only takes 5 seconds to go from 80

to 120 kph (50 to 75 mph) — thus impressively documenting this vehicle's dynamics. But despite boasting even greater performance than the model it has dethroned, this vehicle already conforms to the D4 exhaust standard and has greater fuel mileage.

Alongside optimized turbocharging, another highlight is a fully variable valve train. The intake and exhaust valve timing is varied, and so is the stroke of the intake valves.





BorgWarner Turbo Systems has once again improved on its K16 turbochargers, which had already demonstrated their performance and reliability in the preceding model. The turbine housings have been redesigned to optimize their weight, and the wastegate is now controlled by an actuator using a PWM signal.

The new Porsche engine boasts even more power, with better fuel mileage and lower emissions.



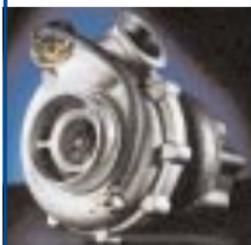
History of Models:

1974 - 1977	3.0 l with 260 HP / 191 kW	3LDZ
1978 - 1989	3.3 l with 300 HP / 221 kW	3LDZ
1991 - 1992	3.3 l with 320 HP / 235 kW	K27.2
1993 - 1994	3.6 l with 360 HP / 265 kW	K27
1995 - 1998	3.6 l with 408 HP / 300 kW	2 x K16
2000 -	3.6 l with 420 HP / 308 kW	2 x K16



VOLVO D6A COMPLIES WITH EURO3 STANDARD WITH TURBOCHARGER FROM BORGWARNER TURBO SYSTEMS

Norm Conformist



It took only 18 months to take the K27.2 turbochargers for the Euro3 version of the Volvo engine from the drawing board to maturity.

As new laws bring down maximum permissible exhaust gas levels lower and lower, the makers of commercial vehicles are being forced to redesign their engines for lower emissions. With the Euro3 version of the D6A engine, which is built at the Skövde motor works in Sweden, Volvo Truck is bringing its vehicles into line with the newest emission regulations while simultaneously improving fuel mileage and performance. This six-cylinder in-line engine displaces six liters and is deployed in the vehicles of the FL series.

In April 2000, BorgWarner Turbo Systems began supplying Volvo Truck with two turbochargers specially developed

for this engine type. For the 162 kW output class, the turbocharger specialist is supplying a K27.2 turbocharger, and for the 186 kW version a regulated K27.2 turbocharger. Both turbocharging systems boast outstanding performance and quality and make a significant contribution toward complying with the Euro3 emission regulation.

Following initial contacts in 1997 between Volvo Truck, which is one of the world's largest makers of commercial vehicles, and BorgWarner Turbo Systems, it was possible to begin series production just 18 months after the start of the project. This short lead time was due to excellent cooperation between Volvo Truck and

the project team in Kirchheimbolanden. In the future as well, it is planned to equip Volvo engines with innovative, high-performance products from BorgWarner Turbo Systems.

As Europe's leading maker of commercial vehicle turbochargers, it is only natural for BorgWarner Turbo Systems to be a partner to leading makers of commercial vehicles. Many manufacturers involve the company at an early stage in engine development efforts in order to shorten development times and achieve ambitious goals with the aid of the technological competence of its engineers.

WHY THE FUTURE OF ENGINE MANUFACTURING BELONGS TO TURBOCHARGERS

Turbo or Not To Be

The TurboNews interviewed Hans-Peter Schmalz, the man in charge of developing passenger car turbochargers at BorgWarner Turbo Systems, about recent technology trends and current development activities.

TN: *What has impressed you most at BorgWarner Turbo Systems?*

Schmalz: The company's consistent and dynamic way of seizing market opportunities. A fresh wind is blowing in the company, and everybody is pitching in enthusiastically. Thanks to the investments made in the Development Center and our motivated, committed employees, we're excellently positioned to achieve our goals.

TN: *What trends do you see in the design of passenger car engines?*

Schmalz: These days, if you want to develop an engine you have to constantly keep your eye on the rules on emissions and fuel mileage, which keep getting stricter. Turbocharging has been state of the art in diesel engines for passenger cars for a few years now. In terms of fuel mileage and torque, these diesel engines are already clearly superior to naturally aspirated gasoline engines. This trend will continue, and significant advances are definitely still in store where performance is concerned. The emission requirements aren't an insurmountable obstacle for diesel engines – they can be complied with by appropriately designing the inside of engines and by treating the exhaust gases.

Where the spark-ignition engine is concerned, today we're at the start of a wave of innovation similar to what we've already experienced with the diesel engine. The pressure to increase fuel mileage and bring down carbon dioxide emissions is inevitably going to lead to charged spark-ignition engines. Direct injection and



Hans-Peter Schmalz wants to consolidate the technology leadership of BW TS by introducing an even greater customer focus and promptly addressing new development trends.

lambda=1 operation won't lower fuel consumption far enough; it's also vital to cut down on engine size while increasing specific power output further. We need engines with a smaller displacement volume but the same output. Charging is the only way to accomplish this!

TN: *What requirements must passenger car turbochargers meet today and in the future?*

Schmalz: Where turbochargers for diesel engines are concerned, to match the still-increasing output of these engines there's going to be a need for higher boost pressures and an extended throughput range. At the same time, control of the turbocharger needs to be improved within the overall, increasingly complex system of the drive train and engine. I predict that we'll see a shift away from the pneumatic actuators that are standard today toward electric actuators instead.

For spark-ignition engines, there's a need

for turbochargers that can cover a greater throughput range compared to diesel engines. Turbochargers will also have to be more heat-resistant. The top exhaust gas temperatures will climb from about 970°C, which is usual today, to levels around 1050°C. We can only achieve this by using new materials and thoroughly redesigning the chargers.

Another important theme is vehicle starting behavior. A lot needs to be done before the performance of vehicles with charged, downsized spark-ignition engines will rival that of cars fitted with larger naturally aspirated engines.

TN: *What solutions is BW TS developing for this?*

Schmalz: We've consistently geared our internal development goals to the engine development strategies I just described. For diesel engines, we'll be launching a new generation of compressors able to meet all requirements for improved performance.

The variable turbine geometry (VTG) technology we're series-producing today is state of the art, and we are also working successfully to cut costs. At the same time, we're working hard to improve the efficiency, throughput range and reliability of the VTG chargers even further.





For performance areas where we now see limits on VTG turbochargers, we can offer another system, regulated two-stage turbocharging, to satisfy the technical needs of engine developers. We're already collaborating with several major vehicle manufacturers to implement this system.

We've set up a new department specifically to work on improving the controllability of charging systems. It's cooperating with several large electronics companies to develop electrical actuators and control systems.

We're doing even more in the area of turbochargers for spark-ignition engines. In this category we're already the market leader in Western Europe – in terms of both unit volumes sold and technology. And we're channeling all the experience we've gained from producing such large volumes and working in this field for many years into our development efforts.

Our variable sliding ring turbine (VST) offers our customers a variable turbine geometry for spark-ignition engines. And right now we're in the process of extending it for applications involving exhaust gas temperatures up to 1050°C.

We're also staying on the ball with VTG technology – which is state of the art in diesel engines – and developing it further to enable its use in spark-ignition engines as well. Among other things, we're working on ways to achieve greater heat resistance and extend the throughput ranges of turbines and compressors.

To eliminate the startup weakness of

"downsized" spark-ignition engines, we're working in dedicated customer projects to develop what we call the "eBooster". This is a compressor driven by an electric motor. The eBooster switches on during the short time when the turbocharger is still running up to speed, in other words when not enough boost pressure is available yet.

Emission requirements are also getting more stringent for spark-ignition engines, so we're working on a solution that will make it possible to build turbocharged spark-ignition engines to comply with the ultrastrict emission laws in California. The tests are coming along quite promisingly. This is another opportunity for us to lastingly extend our technological leadership.

TN: *What are you doing to cut time to market and be more innovative?*

Schmalz: Looking ahead, it's going to be crucial for us to define ourselves more aggressively as our customers' development partners and service providers. We can't afford to wait for customers to tell us what they need. We have to be proactive in helping them find the right solutions



for their development projects, and then jointly define the required technology.

Looking further down the road, our development projects will be tied even more intensively to specific customer projects, and our people will team up with project groups in Sales to conduct them. I expect everyone working in Development to adopt an even greater customer focus and actively seek out a dialog with our clients.

We've also created a new department called "Advanced Development", whose job is to look into new trends as soon as they emerge and come up with sugges-



tions. I see this as key for our continued acceptance as a competent partner, and for keeping pace with the steadily shortening engine development cycles.

TN: *What role do the new, expanded resources of the Technology Center in Kirchheimbolanden play in this context?*

Schmalz: The Technology Center is an important instrument – at the risk of overextending the metaphor, it's going to let us play along capably in the big industry orchestra. The new test benches and other facilities now let us keep up with the fast pace of today's projects much better. Now we can carry out simulations and tests much more quickly to evaluate new versions within the context of development projects. When we're busy matching turbochargers to engines in customer projects, our new Development Center gives us all the technical resources we need to achieve useful, informative results faster.

The new Technology Center places everything we need at our fingertips for taking advantage of the truly extraordinary opportunities the global automotive market offers us.

Events

BORGWARNER WOVES CUSTOMERS WITH AN EXCLUSIVE FORMULA 1 EXPERIENCE.

An Eventful Race



After a break of nine years, Formula 1 has finally visited the United States again. Indianapolis – famous for North America's largest racing event, the Indy 500 – was an outstanding venue for the Formula 1 exhibition. Roughly 250,000 spectators from all over the world gathered at the Indy motor speedway to witness the spectacle.

The BorgWarner Group took advantage of this opportunity to present itself to the many customers who attended at the invitation of BorgWarner companies. But above all, the guests were treated to an unforgettable racing experience. Six escorted buses took customers and employees to the stadium. The "Skybox" on the straight stretch gave everyone a first-class, exclusive view of the course. Refreshments galore were provided for

everyone. But, of course, the real highlight of the day was the exciting race itself, driven by seasoned Formula 1 pilots.

Michael Schumacher steered his Ferrari resolutely through the course and won without having to fend off a single serious challenge to his lead. His victory paid off by lifting him to the top of the world ranking list. After crossing the finish line, he was enthusiastically celebrated by the corps of "Ferraristi" on hand, who were joined by many members of the audience.



AUDI RS4 ACCELERATES WITH BI-TURBO POWER
FROM BORGWARNER TURBO SYSTEMS

Take Two



The successful history of spark-ignition engine turbocharging is closely tied to two names: BorgWarner Turbo Systems and Audi. For 21 years now, these two companies have been closely collaborating to develop charged spark-ignition engines, an alliance that began with the unveiling of the Audi in September 1979. In many respects, the

pinnacle of this cooperation is marked by the new RS 4 bi-turbo assembly.

In March 1999, Audi commissioned BorgWarner Turbo Systems to develop a new turbocharging system. The plan was to use the known 2.7 l V6 engine with 5-valve technology to achieve an output of 280 kW (380 HP) and a maximum

torque of 440 Nm at 2500 rpm and above. The challenge was to ensure the required thermodynamics without modifying the S4 turbochargers' installation geometry.

The K04 turbochargers used are based on the well-known K0 series with water-cooled bearing housings, which has demonstrated its reliability a million times over. But the ambitious goals of this particular project made a specific matching and even better design necessary.

To accommodate the considerably greater air intake requirements of a performance-enhanced RS4 assembly, its thermodynamics had to be reworked – but without deviating from the geometry required for installation in the S4. To meet this requirement, the engineers of BorgWarner Turbo Systems devised a special compressor housing scroll that would ensure adequate flow between it and the engine. In defining the contour of the compressor wheel, special attention was



Audi's new V6 engine has more than enough torque for every situation.



paid to ensuring favorable performance at the surge line. Despite the package restrictions, the resulting compressor yields a large map with good efficiencies.

The development team offset the expected larger thermal loads by using new, considerably more heat-resistant materials for the turbine housing and the wastegate. For this purpose, a special process for casting a steel turbine housing had to be developed very quickly.

Additional development work is now ongoing at BorgWarner Turbo Systems to enable the use of this technology in large series. This is important, since customers will very soon be insisting on the ability to withstand exhaust gas temper-



atures up to 1050°C (1922°F). After receiving the order, BorgWarner Turbo Systems had a deadline of just 12 months to complete the project. So that the turbochargers would be ready for installation in the vehicles on time, it was essen-

tial to closely collaborate with Audi, efficiently manage the project, and leverage state-of-the-art development and rapid prototyping methods. And the results have made the whole effort worthwhile. It has given rise to an extraordinary vehicle that sets new standards in terms of high-tech motorization. BorgWarner Turbo Systems has thus once again confirmed its technology leadership in spark-ignition engine turbocharging.



It's impossible to overlook how powerful the RS4 is.



RENAULT COMBINES CUTTING-EDGE ENGINE TECHNOLOGY WITH
BW TS TURBOCHARGERS

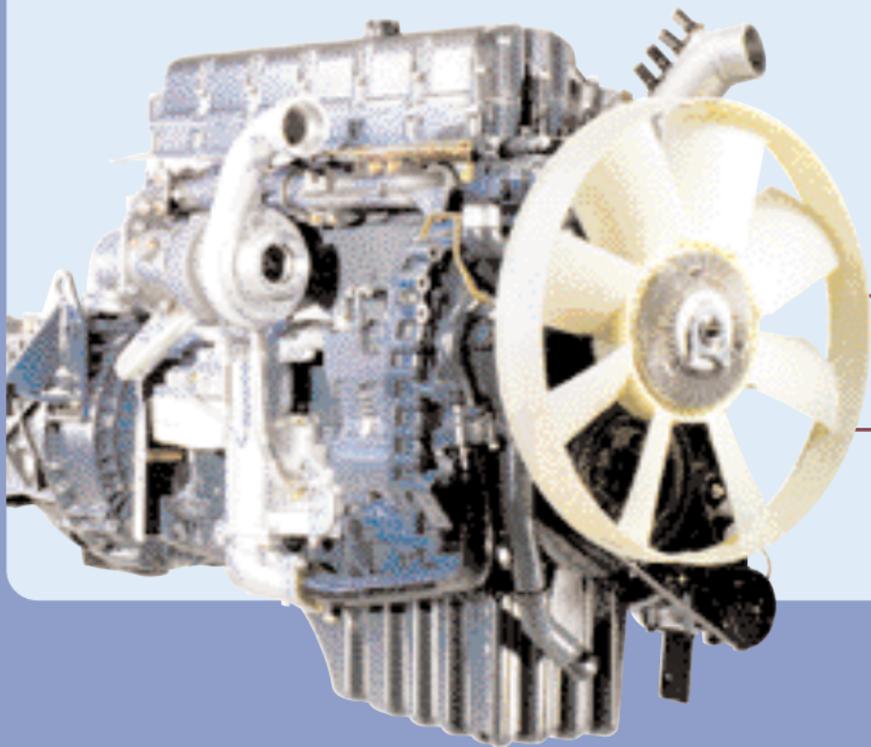
High-Tech

A new era of engine technology has begun at Renault Vehicules Industriels (RVI) with the presentation of a new 11-liter, six-cylinder engine for commercial vehicles called the cDi 11. Cutting-edge common-rail injection, coupled with V-MAC III electronics and four-valve technology as well as a turbocharger from BorgWarner Turbo Systems guarantee compliance with the strict Euro3 pollutant emission norm. With 303 kW (412 HP) at 1900 rpm and a constant torque of 1870 Nm between 1050 and 1350 rpm, the new assembly offers superb performance and

fuel mileage. The engine will be sold in the all-new Premium truck tractor.

BorgWarner Turbo Systems was involved from the outset in developing the new engine. A modern turbocharger optimizes the engine's air supply to ensure efficient, clean combustion. The growing importance of turbocharging places increasing demands on the skills of employees at BorgWarner Turbo Systems, making it more imperative than ever before to cooperate closely with customers. Hugh Adams and his team came up with a solu-

tion in the form of an optimized S300 turbocharger from the tried-and-true S-Hundred series. The special shape of the compressor housing, which has an axial discharge compressor cover, posed particularly difficult design and production challenges. The turbocharger is manu-





factured at the BorgWarner Turbo Systems plant in Bradford, which specializes in producing turbochargers for commercial vehicles, including the S-Hundred series.

The launch of the RVI cDi 11 marks yet another milestone in the successful alliance between the two companies, which began several years ago. BorgWarner Turbo Systems has again demonstrated its leadership for commercial vehicle applications in Europe.

With common-rail injection and S300 turbocharger, RVI leaves other commercial vehicle makers behind in the dust – in terms of both environmental friendliness and economy.

JOHN DEERE AND BORGWARNER TURBO SYSTEMS
AGREE ON LONG-TERM PARTNERSHIP

Partners in Excellence



The signing of the six-year supply deal means that John Deere agricultural machines will be equipped with BW TS turbochargers from now on.



On August 11, 2000 Deere & Company and BorgWarner Turbo Systems signed a six-year supply contract for turbochargers. BorgWarner Turbo Systems is thus assuming the role of main supplier and development partner of John Deere. James P. Olsen, Director of Supply Management at Deere, Udo Schwerdel, VP & GM for Commercial Diesel, and James Verrier, VP & GM for North America (both of BW TS) all signed this contract, which has such great significance for both sides.

John Deere, the globally leading maker of agricultural and construction machinery, is now relying worldwide on its new partnering arrangement with BorgWarner Turbo Systems. The John Deere prod-

uct line incorporates both diesel and gas engines with outputs ranging from 15 kW to 373 kW. Only one potential partner was in a position to supply products for the entire spectrum and support Deere's global activities: BorgWarner.

What ultimately cinched the deal was the fact that the both enterprises define themselves as global players. Looking ahead, globally operating manufacturers like John Deere are going to need globally organized suppliers in order to meet the burgeoning requirements of the world market. The product technology, R&D capabilities and worldwide production facilities of BorgWarner Turbo systems also convinced John Deere that it was choosing the right partner.

KIRCHHEIMBOLANDEN DEVELOPS INTO A
CENTER OF EXPERTISE FOR TURBOCHARGERS

Prime Address for Turbochargers

The Kirchheimbolanden plant in figures:

	1960	2000
Employees	25	1,400
Annual output	1,300 turbochargers	2 mill. turbochargers
Total floorspace	312 m ² (3,350 sq ft)	29,500 m ² (317,500 sq ft)

In 1960, the turbocharger division of Kuehnl, Kopp und Kausch (KKK) built a turbocharger production facility in Kirchheimbolanden, Germany. There, 25 employees produced about 1,300 turbochargers during the first year of operation. Over subsequent decades, the site was continually expanded to create an ultramodern automotive parts supply company. Today the plant is regarded as one of the world's most advanced and largest turbocharger factories.

In 1998 the site celebrated two special achievements. That year production exceeded one million turbochargers for the first time, and the plant's ten-millionth turbocharger was also built. After the turbocharger division of KKK passed to the BorgWarner Group, in 1998 the decision was made to concentrate all activities in Kirchheimbolanden. And just a year later, the sales and application departments as well as the company's administration moved into a newly constructed build-

ing at the site. At the same time, construction of the Technology Center began, which now houses the World Development Center of BorgWarner Turbo Systems. This now has a reputation as the world's most advanced turbocharger development center.

Highly trained employees use advanced machines and techniques to produce over 7500 turbochargers for passenger car and commercial vehicle applications



BorgWarner Turbo Systems has both its largest production facility and its World Development Center for turbochargers in Kirchheimbolanden.





KIRCKHEIMBOLANDEN A
CENTER OF EXCELLENCE

State of the Art



each day. The plant has easily kept pace with the growing requirements of the automotive industry, thanks to continual process improvement and the use of the latest production and quality management methods. The site has become a "Center of Excellence" for producing passenger car and commercial vehicle turbochargers. From the smallest turbocharger, the KP 31, to the largest, the K54, a broad pallet of turbocharging systems is made for innumerable applications and customers. Certified as complying with the ISO 9001, QS 9000 and VDA 6.1 standards, the Kirckheimbolanden plant of BorgWarner Turbo Systems meets all of its customers' quality requirements. Also where environmental protection is concerned, the company lives up to its responsibilities – this year the plant received environmental certification under EN 14001.

With its roughly 1,400-strong workforce, the company is one of the entire region's largest employers. New employees are trained in a highly modern training workshop. Currently there are about 45 trainees in Kirckheimbolanden.

The Kirckheimbolanden plant is a "Center of Excellence" for the production of turbochargers for passenger cars and commercial vehicles. Here, new techniques, methods, and ways of organizing shaft and wheel assembly production developed in order to improve production routines at all sites.

In 1998, for example, thought began to be devoted to ways of restructuring shaft and wheel assembly production for passenger cars to achieve greater flexibility, shorten turnaround times, and reduce stocks on hand. A team of workers from this department tackled the problem and successfully solved it by introducing a cell scheme in October 2000.

A completely new layout was devised for the production hall concerned. And now

a total of about 7,500 shaft and wheel assemblies a day can be produced in three specialized production cells. Another focus was on restructuring the routines and optimizing the work done in groups. External consultants were brought in to help accomplish this. For optimum results, special attention was paid to harmonizing the work routines within the newly created cells. The declared goal of these measures is to achieve smooth material flows and low stock levels. A major contribution was also made by the development of a new balancing technology. In a special project conducted with machines suppliers, a new approach to balancing rotors was developed and put into practice.



On a beautiful day late this summer, people flocked to view the BW TS plant in Kirchheimbolanden.

BORGWARNER TURBO SYSTEMS OPENS ITS DOORS TO VISITORS

A Look Behind the Scenes

More than 3,500 visitors took advantage of the open house at BorgWarner Turbo Systems in Kirchheimbolanden on September 9 to take a close look at the World Development Center for turbochargers. The first of its kind in four years, the event drew a large crowd of technology fans, college students, industry novices, and families with children. The visitors got a chance to inspect the latest technologies for producing turbochargers as well as the Development Center, which is setting new standards in the automotive industry.

At various points, employees explained the individual steps of production stretching from blanks all the way to the finished product. In the Development Center, vis-

itors learned about the company and the entire BorgWarner Group. A presentation was also given on environmental protection in the BorgWarner family of companies. But the main focus was on showing off the engine and combustion chamber test benches in the new Development Center. There, visitors were able to ogle advanced test benches for turbocharger development. The training department also presented its multifaceted program.

Plenty of entertainment was provided, including live music, child care with a giant slide, magic tricks in a circus tent, and other highlights. A generous spread of food and drinks made sure that the visitors felt right at home. A small exhibit showcased a selection of passenger cars,

vans and trucks in which turbochargers from BorgWarner Turbo Systems are installed.

Both the visitors and employees confirmed that the event was an all-round success. It provided everyone with interesting glimpses of what goes on in a modern automotive supply plant.



About This Publication

TurboNews – Issue 2/2000

Published by
BorgWarner Turbo Systems

Copywriting, editing and coordination
Günter Krämer, Marketing Europa,
3K-Warner Turbosystems GmbH
Marnheimer Strasse 88,
D-67292 Kirchheimbolanden

Photographs
BorgWarner Turbo Systems, Audi, John Deere, Porsche, Volvo

Concept, design and layout
Hoas Werbeagentur GmbH, Mannheim

Prepress
Gutfleisch & Frey GmbH, Mannheim

Printing
Druckerei Peter Dewitz GmbH, Ketsch

Translation
Anglo American Ad, Heidelberg

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Kirchheimbolanden, Germany
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changes without notice. Printed in Germany

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