TurboNews

TurboNews

The Info Magazine of BorgWarner Turbo Systems 2/05

100 Years of the Turbocharger

History and future prospects of a revolutionary technology

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Focus gets new lease of life

Ford Focus ST now available with powerful turbocharged engine

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Performance Truck

New International trucks with 2-stage regulated charge

Editorial

Paving the way for progress

Dear Readers,

100 years ago, Swiss engineer Alfred Büchi developed the idea of a turbine compressor, little knowing that he was laying the foundations for massive increases in the performance and efficiency of combustion engines. The fascinating thing about Büchi's idea is that even now, after a whole century of rapid technological progress, it still holds the potential for innovative leaps in engine development.

Good examples of this include the first twin-charged direct injection TSI spark-ignition engine of the new Golf GT, and the R2S™ regulated two-stage booster system, which makes drivers of the new CF truck from International feel almost as though they are driving an SUV. Both of these applications are presented in this edition of TurboNews.

This issue focuses on an interesting overview of the history of the turbocharger. It pays special tribute to the visionary Büchi, whose idea paved the way for the huge success of BorgWarner Turbo Systems. Büchi's inventive genius lives on in the engineers and employees of BorgWarner, who are forging new paths within the entire Group to make progressive concepts and ideas reality.

The Engine Systems Group, the winning of the "Best Practice 2005" DIN award or the REFA training course in Kirchheimbolanden are just three of many examples of how the turbocharger specialist is treading new ground for the benefit of its customers.

We hope you have fun reading!

The editorial team

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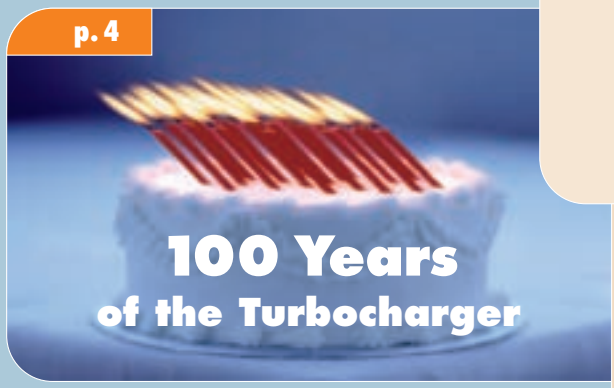

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THE TURBOCHARGER CELEBRATES ITS 100TH BIRTHDAY – AND STILL HOLDS GREAT POTENTIAL FOR THE FUTURE

The saga continues

The 16 November 2005 was a very special day for the automotive industry. It was on this day exactly 100 years ago that the Swiss inventor Alfred Büchi received the patent for his turbocharger. Who could have imagined what triumphs this technology would enjoy, particularly in the last two decades?

After turbocharging had initially established itself in commercial vehicles, the real breakthrough for turbocharged diesel engines in passenger cars came in 1982 with the launch of the Golf Turbodiesel by Volkswagen. Today, almost 50 % of all new cars registered in Europe are turbo diesels. And the diesel engine is also playing an increasingly important role in other regions of the world, such as India and Korea, as a modern, economical and clean powertrain. With rising fuel prices, interest in highly efficient drive systems has grown significantly, even in Japan and the US. Alongside hybrid concepts, the diesel engine is becoming a popular alternative.

Almost 100 % of all diesel engines produced today are turbocharged. And the boosting systems have reached an extremely high technical level. Turbochargers with variable turbine geometry are now available as standard in many segments, and the first engines with regulated 2-stage turbocharging are now on the market.

Following this domination in the diesel arena, engine developers are now turning their attention to turbochargers for gas engines. In particular the combination of gasoline direct injection and turbocharging holds great potential. In contrast to earlier boom periods of gasoline engines, squeezing out more power is no longer the main objective. The goal today is much more to combine performance with lower fuel consumption. And enormous progress has also been made in this field in the last few years, giving a hint of what is to come. Applications with the so-called 1050 °C technology are already in use, for example. And the VW Golf GT with the 1.4 TSI engine presented in this edition clearly shows the potential of downsizing. An absolute highlight for gasoline engines in 2005 was certainly the announcement of the new Porsche 911 Turbo, which will be fitted with turbochargers with variable turbine geometry by BorgWarner.

So even after 100 years, the future remains exciting for turbocharger technology. And innovation seems to be coming faster than ever.

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

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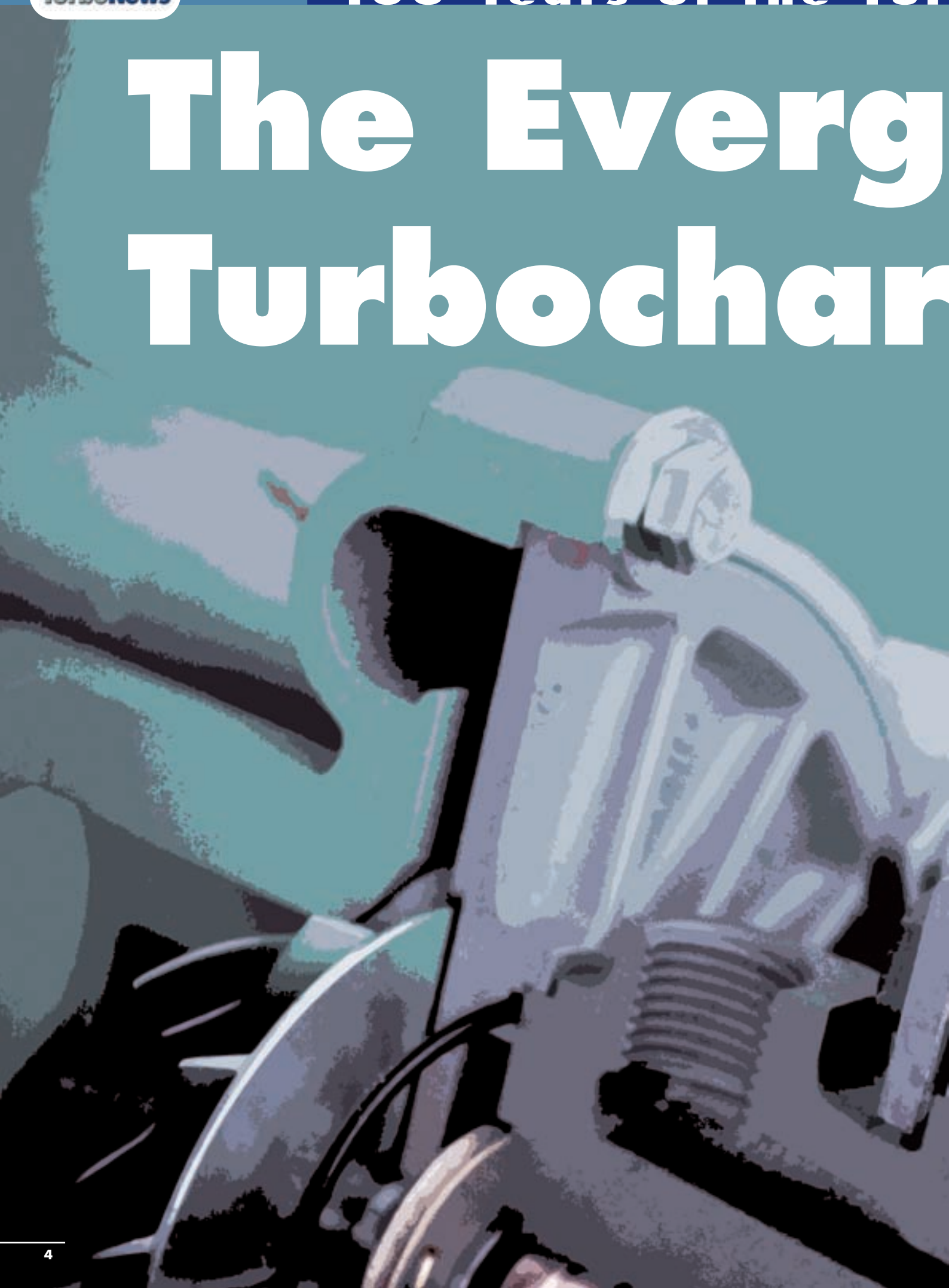

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100 YEARS OF BOOST

Whether modern sedan or agricultural machine, luxury yacht or commercial truck: it is impossible to imagine the modern combustion engine without the exhaust gas turbocharger. Yet from its very beginning, right up to modern developments such as variable turbine geometry or regulated two-stage turbocharging, the turbocharger has had a rocky path to get where it is today. TurboNews invites you to take an exciting journey through 100 years of turbocharger history.

How it all started ...

The inventor himself: Alfred Büchi

Most of you have probably never heard the name Alfred Büchi. However, this Swiss engineer was something of a visionary. In 1905 he developed an idea for an "internal combustion engine, consisting of a compressor (impeller), a piston engine and downstream turbine". Unfortunately, he did not actually have the materials to make his dream a reality – so he developed the entire concept on paper. The concept was clearly convincing, as on 16 November 1905 Alfred Büchi received the patent of the German empire for his invention with the number 204630. The turbocharger was born.

Büchi's idea was based on a simple observation of combustion engines. He had noticed that these engines seemed to waste around two thirds of their energy input via cooling and exhaust gases. Only one third was actually used to generate power. Büchi's thought was to make the system more economical – he was Swiss after all. He wanted to make use of the temperature and kinetic energy in the exhaust gas to increase the performance of the engine. The concept was to position a turbine wheel in the exhaust gas stream. This turbine would then be connected to a shaft that would transfer power to an impeller to increase the pressure and volume of air blasted into the cylinders.

This turbocharging principle remains basically the same today, although technical advances and new materials have created new opportunities that seemed impossible 100 years ago. Variable turbine geometry, where the turbine vanes are electrically adjusted, and space-age materials that allow temperatures of up to 1050 degrees Celsius are innovations that even a man with such visionary power as Büchi could not have dreamed of.

The first regulated 2-stage turbocharging system for a passenger car diesel engine by BorgWarner Turbo Systems and the 100,000th turbo by Schwitzer – milestones of impressive development

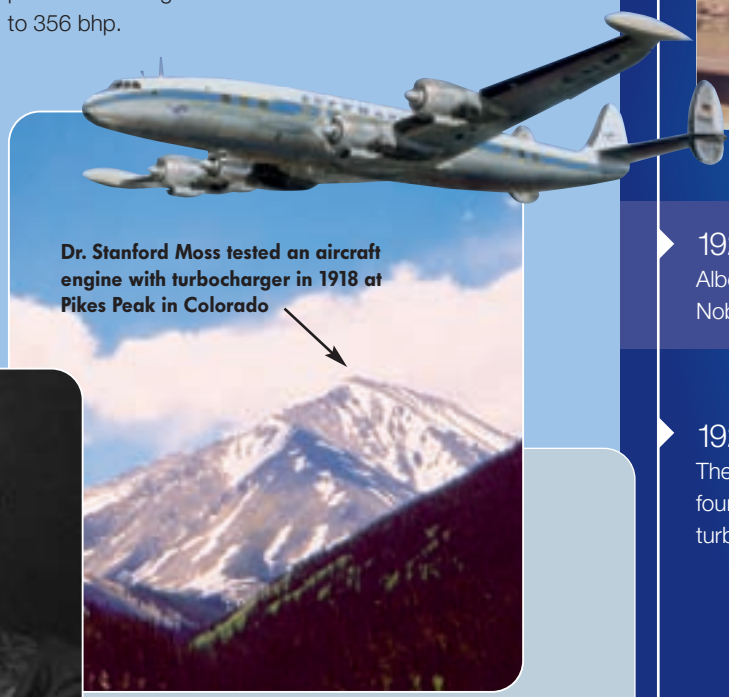
Photo A. Büchi: ETH-Bibliothek Spezialsammlungen, Bildarchiv, Zürich

Turbos on the ocean waves

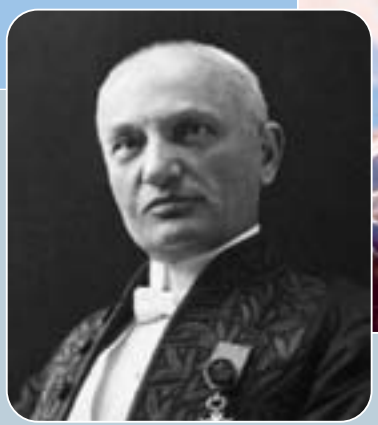
Alfred Büchi first came closer to actually realizing his dream some 10 years later. In 1915, when the engineer had been working at "Sulzer" in Winterthur for six years, he built the first prototype of a diesel engine with turbocharger – for a ship. Ship engines were typically very robust and operated at a fairly constant low speed – perfect conditions for increasing feed pressure with turbo boost. Indeed, it was in ships that the turbocharger was first put into series production. And when the German transport ministry commissioned the passenger ships "Danzig" and "Preußen" in 1923, the turbocharger really came to the fore. Both of these vessels were fitted with ten-cylinder diesel engines, whose performance was increased from a standard 1,750 bhp to an impressive 2,500 bhp using turbochargers.

Above the clouds

In 1917 the turbocharger then found a new application, aviation. This would become a huge factor in driving development forward in the years that followed World War I. The Frenchman Auguste Rateau had already equipped an airplane with a turbocharger one year before the start of the war. His aim was to increase its performance and deal with a fundamental problem that airplanes had all experienced up to that point. The problem was that the higher airplanes flew, the poorer the performance of the piston engines that drove them. Turbocharging offered a real solution here, as it was possible to stabilize performance by varying the boost pressure. This allowed airplanes to fly higher, which offered two key advantages. Firstly, greater altitudes offered lower air resistance, meaning the planes required less energy. Secondly, exhaust gas turbines also worked more efficiently in the lower air pressure at these altitudes. This was demonstrated impressively in 1918 by Dr. Stanford Moss of General Electric, who tested an aircraft engine with exhaust gas turbocharger at 14,000 feet at the summit of Pikes Peak in Colorado, USA. At this altitude the power of the engine increased from 221 to 356 bhp.



Dr. Stanford Moss tested an aircraft engine with turbocharger in 1918 at Pikes Peak in Colorado



Auguste Rateau equipped an airplane with a turbocharger back in 1913

The passenger ship "Preußen" in 1923 with two ten-liter turbo diesel engines

1905
The Swiss engineer, Alfred Büchi, receives his patent for an "internal combustion engine, consisting of a compressor (impeller), a piston engine and downstream turbine": The turbocharger is born.

1914
The first working traffic light is put into operation in Cleveland, USA.

1918
Louis Schwitzer founds the Schwitzer Company in Indianapolis, USA.

Louis Schwitzer

1921
Albert Einstein receives the Nobel prize for physics.

1928
The BorgWarner Corporation is founded. Schwitzer builds the first turbocharger.

Louis Schwitzer

KK&K's trade fair stand in 1961

MTU fire engine from 1979

The famous Caterpillar became the industry standard – not only on construction sites, but also in sandboxes around the world!

Schwitzer and KK&K get in on the action

Aviation also provided the most productive field of application for turbocharging in the years after the war. Whether greater altitudes, lower consumption or improved range, turbocharging had a huge impact and even allowed the first non-stop Atlantic crossing by a passenger aircraft. The most important passenger aircraft of this age, Lockheed's Super Constellation, was equipped with an engine whose already impressive performance of 2,700 bhp was increased to 3,300 bhp with turbochargers.

In the automobile arena, development was initially limited to commercial vehicles. In 1938 the Swiss engineering works "Saurer" brought the first turbocharged commercial vehicle engine onto the market. This trend for turbocharged commercial vehicle engines continued and gained particular significance at the end of the 1980s, when stricter emissions legislation was introduced. Today, virtually all commercial vehicle engines are turbocharged.

But let us return to 1952. At this time the company "Kühnle, Kopp und Kausch (KK&K)" began developing and manufacturing turbochargers. And in the US, Schwitzer was in the process of fitting the first diesel racing car with a turbocharger in Indianapolis. At that point nobody could have realized that some 50 years later these two companies would come together to form BorgWarner Turbo Systems. Even back then, turbochargers for commercial vehicles were being produced on a large scale, and since 1954 Schwitzer has also been producing turbos for the commercial

Oldsmobile F85

Chevrolet Corvair Monza Turbo

The turbocharged engine in the Chevrolet Corvair Monza Turbo

vehicle manufacturer Caterpillar. In 1955 the D 9 by Caterpillar became the first turbo-diesel vehicle to go into series production in the United States.

However, it was not really until the 1960s that turbocharging started playing a more significant role in the automotive industry, following several unsuccessful attempts to integrate the technology into passenger cars at the start of 50s. The main reason for the lack of success had always been the turbo lag, which could not be overcome. Yet in 1962/63, despite the problems, General Motors launched two vehicles with turbocharged engines in the US: the Oldsmobile F85 and the Chevrolet Corvair Monza Turbo. The Oldsmobile was very tricky to look after. The complex system of its Jetfire engine, with more than 50 hoses and pipes in its oil and cooling system, made it prone to breaking down. It was taken out of production in 1964, although the Chevrolet hung on for another two years.

1940
Introduction of the automatic gearbox.

1952
The company "Kühnle, Kopp und Kausch" (founded in 1899) begins developing and manufacturing turbochargers.The first turbocharger by Schwitzer is fitted in a Cummins Diesel Racer.

Photo: Velocity Auto Journal

1954
Schwitzer produces the first turbocharger for Caterpillar.

Photo: Technikmuseum Sinsheim

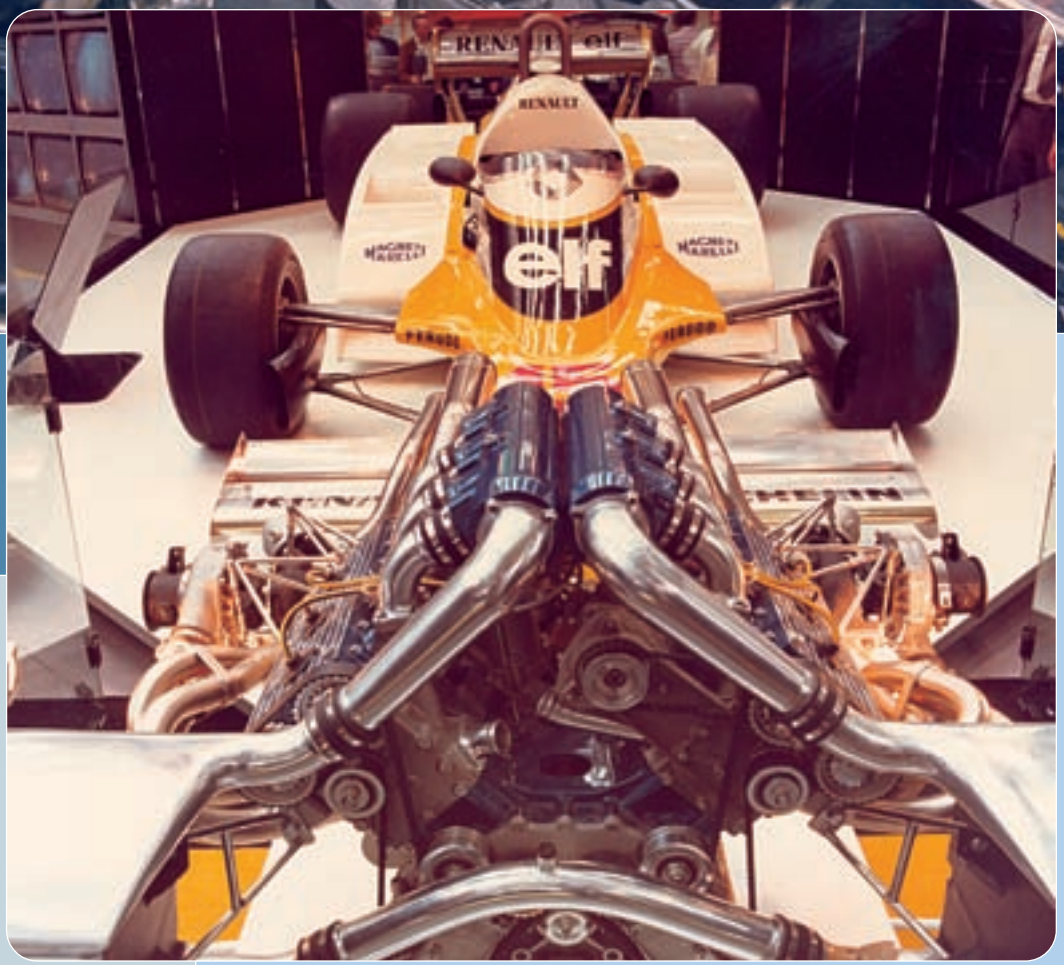
1960
Start of turbocharger production in Kirchheimbolanden.

1962
Cooperation between the turbocharger manufacturers Schwitzer, AG Kühnle, Kopp & Kausch, and Holset (UK).

1969
On 20 July, Neil Armstrong becomes the first man to walk on the moon.

A VW test vehicle with turbocharged engine from 1980 is shown on German television

BMW Formula 1 racing engine: 1,350 bhp impresses even the hardiest of motor racing fans



Renault racing engine from 1981 with K26 turbocharger: Over 1,000 bhp of fierce performance

Pure turbocharger power

In the years that followed, interest in turbocharging for passenger cars remained low, although it took off for motor racing applications. This was the first time that European engines were able to compete and even surpass their American counterparts. At the end of the 1960s, BMW was the first company to use turbocharged engines in touring car racing. In 1973, Porsche used a turbocharged engine in its 917/30 racing car to generate more than 1,100 bhp. This vehicle destroyed the competition and even led to the US racing series having to change its rules!

bhp, "was so powerful, it was almost impossible to drive". In 1989 the complex turbos in Formula 1 were banned, and the normally aspirated engine came back in focus.

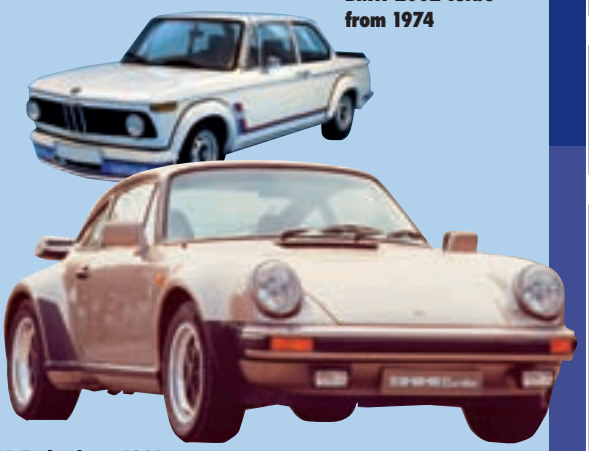
BMW and Porsche both brought out production cars with turbochargers in 1974. BMW built the 2002 Turbo, and Porsche the 911 Turbo. This was something of a surprise, given that the industry was suffering from the ongoing oil crisis. Their high consumption at this difficult time ultimately had an effect on sales. Indeed, BMW only produced

Racing car legend of the 70s: The Porsche 917

In Europe, Renault introduced turbocharged engines for Formula 1 racing cars in 1977, with their first victory coming two years later in 1979. The technology, with which they were able to generate more than 1,000 bhp from the small 1.5 liter 4-cylinder engine in training, soon established itself among the other manufacturers. From 1983 on, turbocharged engines then dominated the scene. However, top speeds did not increase as much as the twofold or even threefold increase in power had suggested. As the fuel tanks were of limited size, the teams were keen to keep consumption as low as possible. Boost pressure limiters were therefore introduced to cap the top performance. The Austrian, Gerhard Berger, drove the most powerful Formula 1 car of all time in 1986. He later reported that the Benetton-BMW, which generated 1,350

1,672 vehicles of this type in total. However, Porsche's 911 Turbo was always targeted at a somewhat more exclusive clientele, seeking a no-compromise sports car for the road. The 911 took off, and the name has now become legend, supporting Porsche's image as manufacturer of high-grade luxury sports cars.

BMW 2002 Turbo from 1974



Porsche 911 Turbo from 1981

Illustrations: www.porsche917.com

1984
The first vehicles with anti-lock brakes (ABS) come onto the market. Bosch was the first company to offer an ABS system for motor vehicles in 1982.

1999
BorgWarner takes over Schwitzer. 3K Warner Turbo Systems and Schwitzer join forces to become "BorgWarner Turbo Systems".

BorgWarner Turbo Systems

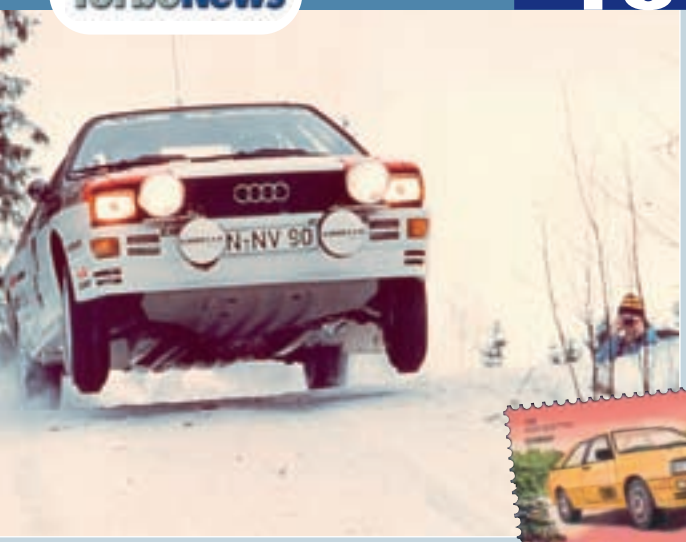
2000
BorgWarner Turbo Systems moves its HQ to Kirchheimbolanden.

Emblem of Kirchheimbolanden

Market launch of the smallest turbocharger for passenger car diesel engines: The KP31.

Start of production for passenger car turbochargers with variable turbine geometry.

2000
The American biologist Craig Venter makes the sensational announcement that his company has decoded 99 % of the human genome. Pioneering medical advances are predicted from this knowledge of the genome with its 100,000 genes.



A true legend, thanks mainly to its success on the rally circuit: The Audi Quattro

Champion on all fours

Six years after the oil crisis, things had already started looking up for the automobile manufacturing industry. In March 1980, Audi presented its "quattro" to the public at the Geneva Motor Show. It was the first mass-production car to use permanent all-wheel drive, and was fitted with a straight five-cylinder engine block using a turbocharger. It raced from 0-60 in just under 7 seconds and achieved a top speed of 138 mph. Although the trade press celebrated the Audi quattro as a sensation, only 11,452 units were built in its ten year lifespan, not least due to its high purchase price. But it was on the racetrack that the Audi quattro demonstrated its true potential. While the competition's cars were still using two-wheel drive, Audi was committed to its four-wheel drive technology – winning two constructor's and driver's world championships from 1981 to 1985.

Turbochargers take to the streets

The triumphant advancement enjoyed by turbocharging technology in passenger cars started in Europe in 1982 with the Golf Turbodiesel. Diesel engines had previously been considered somewhat slow and ponderous, and better suited to commercial vehicles, yet the Golf ushered in the dawn of powerful diesel engines in small cars. More and more new inventions have helped optimize the engines, allowing diesel-powered cars to combine sporty performance with their traditional virtue of low consumption. Important milestones include the direct injection turbo diesel, variable turbine geometry of turbochargers, and most recently the combination of turbocharger and supercharger in the TSI. Almost every diesel engine sold in Europe today is fitted with a turbocharger. And developers of gasoline engines are also concentrating more and more on turbocharging. In light of increasing energy prices, thoughts of increased performance have long since given way to a desire for reduced consumption. Reducing exhaust emissions is another important goal of engine and turbocharger developers. In 2004, some 62 % of all new passenger cars sold in Western Europe were fitted with a turbocharger. This is the highest level worldwide. The trend seems to be toward ever smaller turbocharged engines that offer the same performance as their larger counterparts but with lower weight and reduced consumption.

In the US, diesel engines only really started to appear in passenger cars in the 70s. The US had been hard hit by the oil crisis in 1971, causing an increase in demand for diesel vehicles, which were cheaper and more economical. With the end of the oil crisis, however, American drivers went back to their gasoline engines. The higher compression in diesel combustion caused blocks to crack and crankshafts to wear out prematurely. Consumers were also looking for powerful engines, an area where diesels suffered. But back to today. Diminishing global oil resources, and the increase in fuel prices that accompanies this, have led to diesel vehicles once again gaining in popularity. And modern turbo diesel engines have long since shrugged off the image of being underpowered, loud and smoky.

The story is totally different in Japan. Turbocharged diesel engines have been in use there since the 1960s, originally being introduced to reduce consumption and improve the performance of commercial vehicles. However, the high

Emotion versus Efficiency

Admittedly, a somewhat unfair comparison between the dream car Cadillac Eldorado de Ville and the brand new Golf TSI.

	Cadillac Eldorado de Ville	VW Golf GT 1.4 TSI
Built in:	1960	2005
Length:	19.5 ft. (6 meters)	13.5 ft. (4.2 meters)
Displacement:	500 cu. in. (8.2 liter) 8-cylinder	85 cu. in. (1.4 liter) 4-cylinder
Power output:	340 bhp	170 bhp
Top speed:	115 mph	135 mph
Average consumption:	8 mpg US / 9.5 mpg UK	30 mpg US / 38 mpg UK

power offered by turbocharged gasoline engines in passenger cars has often been viewed critically, with many believing this encourages people to drive too fast. This was one of the reasons why turbocharged gasoline engines gained little acceptance in the 1970s. This all changed in the early 80s with the introduction of the Nissan Cedric – the first Japanese car with turbocharger. Turbos then started to become more popular due to their lower consumption. In 1981 Honda introduced the CX500T, the world's first motorbike with turbocharger. In the same year Hitachi produced the turbocharger for the world's first boosted Wankel engine. This was developed by Mazda and celebrated its premiere in the Mazda Cosmo RE Turbo. With the launch of its "Mark II" (in Europe "Supra") in 1985, Toyota brought the first vehicle with bi-turbo engine to the market.

So-called "minicars" have traditionally always had large market shares in Japan due to a road tax that is based on the size and weight of vehicles. These minicars must be no more than 3.395 meters long (just over 11 feet) and 1.475 meters wide (just under 5 feet). They generally use tiny, turbocharged gasoline engines with a displacement of 0.66 liters.

The diesel engine also had a tough time gaining acceptance in passenger cars at first. A lack of appropriate legislation on the part of the government and the delay in introducing catalytic converters had led to a situation where Japan was suffering from severe air pollution, which was predominantly attributed to the diesel engines. All this even caused the authorities in Tokyo to launch a "say no to diesel vehicles" campaign in the year 2000. Although the Japanese government initially only introduced very few useful measures to reduce exhaust emissions, the country now has the strictest regulations for both gasoline and diesel engines. These are set to be enforced from 2010 onward. The Japanese manufacturers are currently working on a whole range of concepts for minimizing consumption and emissions. Alongside diesel and bio-diesel engines, hybrid drive technologies are currently among the most popular solutions.

Honda CX500T, the first motorbike with turbocharged engine

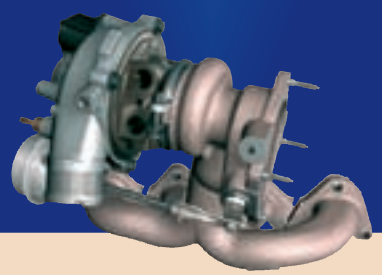
Mazda RE

A Toyota Supra rally car

2002
Start of series production of VTG turbochargers.

2004
Introduction of the world's first passenger car diesel engine with regulated 2-stage turbocharging.

2005
BorgWarner supplies the turbocharger for the world's first twin-charged FSI engine.



And that was just the beginning ...

100 years of the turbocharger – and experts are still predicting potential consumption savings of up to ten percent from one model to the next. The turbo technology boom seems to be far from over, and the worldwide demand for turbochargers has more than tripled in the last 10 years. The sharp increase in the use of turbochargers in diesel passenger cars has clearly been the main driving factor behind this, and experts are predicting this will spread beyond Europe's borders. But we should not forget the future potential of turbocharged gasoline engines. Many manufacturers and consumers are starting to realize the advantages of such drive concepts. We can summarize this in plain English: In future the only good engines will be turbocharged engines.

Alfred Büchi, who made all this possible with his invention, died back in 1959 and never witnessed the breakthrough of his idea in the automotive industry. Yet the force and ingenuity behind his original idea remains as strong today as it ever was.

NEW FORD FOCUS ST WITH POWERFUL ENGINE AND BORGWARNER TURBOCHARGER

Focus gets new lease

Racing from 0-60 in less than 8 seconds and top speeds of over 125 mph used to be the domain of the sports car. Not anymore. Now anybody on a modest budget looking for a family-friendly compact car can also get that genuine sports car feeling.

Launched in November, the new Ford Focus ST offers the perfect balance of practicality and performance. It uses the same 2.5 liter 5-cylinder turbocharged engine available in the Volvo S40/V50 since late 2003. This offers truly exhilarating performance and makes the Focus ST a direct competitor to the Golf GTI and Opel Astra OPC – both of which also rely on turbocharged gas engines with BorgWarner technology.

Like the Volvo S40, the top model in the Focus line is based on the so-called P1 platform. This allowed Ford to offer excellent all-round performance without the need to make any drastic changes to either the engine or the turbocharger. The engine produces 225 bhp and offers its exemplary 235 lb-ft of torque over an amazing range from 1,600 to 4,000 rpm – ensuring more than enough pickup for any situation.

The Focus ST accelerates from 0-60 in just over 6.5 seconds and reaches a top speed of 149 mph. Yet it is not just its performance that impresses. This really is a car you can use every day. It offers 26 miles to the gallon (US), which is truly economical in this class of vehicle. And of course the high-tech engine also meets the strict Euro4 standard.

A key factor to this performance is the innovative K04 turbocharger by BorgWarner. This is the first ever series production turbocharger that can withstand exhaust gas temperatures of up to 1050 °C (1920 °F). Alongside this, the turbocharger is equipped with an integrated cast steel turbine housing, an integrated recirculation valve and integrated waste gate. The engine and turbocharger were developed in intensive cooperation between the engineers at Volvo and BorgWarner Turbo Systems, who were not prepared to accept any compromises – a philosophy that holds true for the whole Ford Focus ST concept.

While the 5-cylinder turbo engine provides impressive performance, the developers can also be proud of the Focus ST's appearance. The special

# of life

A glance at the exterior of the new Ford Focus ST gives an indication of what lies beneath

The first series production turbo-charger for exhaust temperatures of up to 1,050 °C (1,920 °F)

Integrated turbine housing made of high-strength cast steel

"Electric Orange" paint finish really makes the car stand out. The ST also distinguishes itself from the family Focus through several design elements, such as the new front and rear bumper, 18-inch alloys, a discreet rear spoiler and the side blinkers integrated into the wing mirrors. The sporty feeling continues with the interior. The Recaro seats are striking, and the instruments on the dashboard show booster pressure, oil temperature and oil pressure.

One particular highlight is the sound system, designed by Ford's motor racing department, which allows the intake sound from the engine to be forwarded directly to the interior. This allows passengers to enjoy the sporty sound of the turbocharged engine and contributes to the sports car feeling.

Specifications of the Ford Focus ST

Engine:	5 cylinder, in-line
Displacement:	2,522 cm^3
Power output:	225 bhp at 6,000 rpm
Max. torque:	236 lb-ft at 1,600 rpm
Top speed:	149 mph
0 to 60 mph:	6.5 seconds
Gearbox:	6-speed manual
Consumption (mixed):	25 MPG (US), 30 MPG (UK)

Shaping the fut

THE ROLE OF THE ENGINE SYSTEMS GROUP AS AN INTERDISCIPLINARY TEAM OF EXPERTS

In the BorgWarner Powertrain Technology Center in Auburn Hills, Michigan, a small team of BorgWarner experts is working on tomorrow's drive solutions. The Engine Systems Group has the task of investigating and assessing system solutions for the future. The results from these investigations should help the individual business units such as Turbo Systems to develop innovative products for the future.

Efficient cooperation

The Engine Systems Group operates as a catalyst between the development teams of the individual business units, offering them insight into product properties that customers are likely to demand in future. The team also promotes communication within the BorgWarner group, so that the individual business units are able to offer customers solutions that are perfectly matched to one another. It is then the task of the individual business units to perform the necessary development work so that new products can be provided to satisfy changing customer needs and wishes.

New innovative EGR concepts

As the Engine Systems Group coordinates many different projects, it can also offer a valuable contribution to product development in the various business lines. One good example of this is the EGR Boost System: High-pressure exhaust gas recirculation is one of the most effective ways of reducing nitrogen oxide emissions. This technology is widespread in modern engines, including in many diesel engines with turbochargers. However, above a certain exhaust gas level, the dynamics of the turbocharger are compromised. Within the BorgWarner group, various business units are working together on new concepts to solve this problem – a cooperation coordinated by the Engine Systems Group.

Lower emissions with improved dynamics

The group of experts is currently concentrating on integrating exhaust gas recirculation systems and turbochargers in a single solution, which will help BorgWarner's customers meet the strict legal emission values to be introduced in 2007 for diesel engines. Particular focus is placed on the so-called low pressure exhaust gas recirculation here. In contrast to common high pressure exhaust gas recirculation systems, the low pressure system introduces cooled exhaust gas that has been cleaned by a diesel particulate filter into the incoming air stream of the engine's turbocharger to achieve significant NOx reductions. Alongside lower emissions, the new technology also offers improved charging system dynamics.

ure

However, the low pressure exhaust gas recirculation places new demands on the system components, in particular the turbocharger. The recirculated gas now flows through the compressor side of the turbocharger and hits it with significantly higher temperatures than before. There are also residual particles in the exhaust gas which can stick to the compressor wheel or even attack the material of the wheel. Designing the compressor side of a turbocharger system to operate under these conditions is therefore the challenge now being taken up by the Turbo Systems Division as their part of the group-wide collaborative effort. Other elements include advanced EGR valves, a thermal management system, and a comprehensive control system to manage the EGR-Boost technology.

Keeping one step ahead of the competition

Having the right products ready before customers need them is one of the strategies BorgWarner Turbo Systems are using to meet company goals. Collaborative efforts, such as the EGR-Boost project and the forward-looking work of the Engine Systems Group, help guide product development and facilitate systems-based solutions that allow the company to maintain its unique competitive advantage.

BORGWARNER SHOWS AT THE SAE CONGRESS 2005 IN BRAZIL

New markets – New technologies

The BorgWarner Team was able to welcome almost all important customers to its stand, offering insights into the latest technologies

Since 1992 the Society of Automotive Engineering has been organizing the largest international congress for technology and mobility in South America. The SAE Congress takes place every year in São Paulo, Brazil, and attracts thousands of visitors.

The motto of this year's event was "New markets – New technologies: Challenges in automotive development". The main items presented were GPS tracking and navigation systems, vehicles made of aluminum, new diesel technologies which reduce fuel consumption and emissions, and several development projects from 100 % Brazilian companies.

More than 80 companies presented their products, services and technologies – including vehicle manufacturers and suppliers that offer parts for passenger, commercial and off-road vehicles. The exhibition was extended to include a three-day program with exciting conventions, lectures and events focusing on new technologies. Some 10,000 visitors – predominantly engineers and technicians – took advantage of this interesting event.

BorgWarner took part in the SAE Congress 2005 with the two business units of Turbo Systems and Thermal Systems. With DaimlerChrysler, MWM-International, Cummins, Ford, Caterpillar, Volkswagen, Iveco and Valtra, several of BorgWarner's most important customers took the opportunity to learn about the company's latest technologies and products and make new contacts.

Performance Truck

INTERNATIONAL LAUNCHES PRODUCTION OF LIGHT COMMERCIAL VEHICLES WITH R2S™ CHARGING SYSTEM

Many Americans associate the name "International Truck and Engine Corporation (ITEC)" with medium-sized and heavy trucks. Yet with the new CF series (Cab Forward), available since mid 2005, International now also offers smaller commercial vehicles, which are particularly well suited to urban deliveries. The trucks in the CF product range are powered by the new International VT 275. This is an advanced 4.5 liter V6 turbo diesel engine, which uses the regulated two-stage turbocharging system R2S™ by BorgWarner Turbo Systems. This is the first time a 2-stage regulated charging system has ever been used in this class of vehicle in the US.

New horizons

BorgWarner Turbo Systems employees, including Eric Parlow, Robert Lebold, and Dave Shrader, began working on a turbocharger application for International's 4.5L V6 engine platform back in 2001. The V6 range was originally conceived for North American pick-up trucks, but was then also incorporated for use in light commercial vehicles. Its use in commercial vehicles, with their higher payloads, made the engine subject to the strict heavy-duty vehicle emissions legislation. For the turbocharging system, this meant high levels of EGR and correspondingly high levels of boost pressure to maintain power density and an acceptable air/fuel ratio for combustion. The designers took all this into consideration, and managed to develop a unit that meets these strict requirements without sacrificing the engine's dynamic response. The application release was led by Dylan Foglesong from Asheville and was completed in late 2004 in time for the 2005 model year.

The R2S™ system by BorgWarner offers an almost sporty feeling in the new CF range

More performance for commercial vehicles

International enjoys an enviable reputation of offering its customers truly high performance trucks – a reputation it was keen to maintain with the new CF range by offering class-leading response and torque. International's aim was therefore to exceed the expectations of those who have owned and driven similar trucks – offering real improvements in drivability and performance. The two-stage technology offered by BorgWarner allowed them to achieve performance objectives previously considered impossible with more conventional turbochargers.

The newly developed R2S™ system for the V6 by ITEC employs a K16 high-pressure stage and a K27.2 low pressure stage. The high pressure turbine has a bypass valve which is opened by a pneumatic actuator. The engine management system commands the bypass to maintain valve closure up to approximately 2,000 rpm for maximum use of the small turbo's low inertia and quick response. As the rpm increases, it then opens the valve to regulate system boost pressure and to keep exhaust manifold pressures within limits.

Optimum response

The new 4.5 liter V6 engine is rated to 200 bhp at 2,700 rpm and 440 lb-ft of peak torque at 1,850 rpm. The small "high pressure" turbo is responsible for providing the vehicles in the CF range with excellent starting torque, but the system is also sized appropriately so that the system is still highly efficient even at full load and at higher speeds. The CF Truck gives drivers not used to commercial vehicles the feeling that they are actually driving a large passenger vehicle.

Made in Campinas

The new turbocharging system for ITEC is produced by BorgWarner Turbo Systems in Campinas, Brazil. The employees at Campinas were very eager to have the R2S™ system come to their manufacturing facility, as the project ultimately involves both a new customer and a new type of high performance product. Making all preparations and getting manufacturing up and running was a tough task, but one which the team in Campinas mastered perfectly, allowing the R2S™ turbocharger to be delivered on time for the planned product launch at International in Huntsville, Alabama and Escobedo, Mexico. International was pleased with the results of the cooperation.

The V6 project with ITEC underlines BorgWarner's leading technological position and is a perfect example of how the global organization works together seamlessly to ensure its customers' satisfaction.

The new Cab Forward Trucks are perfectly equipped for urban deliveries

Specifications of the International VT 275

Engine:	V6
Displacement:	4,500 cm^3
Power output:	200 bhp at 2,700 rpm
Max. torque:	440 lb-ft at 1,800 rpm

The R2S™ system with K16 high pressure turbocharger and K27.2 low pressure booster system

Twice the fun

BORGWARNER SUPPLIES TURBOCHARGER FOR WORLD'S FIRST TWIN-CHARGED FSI ENGINE

It was with the fitting name "Twin charger" that Volkswagen presented the world's first twin-charged direct injection gasoline engine (TSI) at this year's IAA in Frankfurt. This pioneering technology celebrated its debut in the new Golf GT. The innovative 1.4 liter TSI engine generates its impressive power from a belt-driven mechanical compressor, which has been combined with a K03 turbocharger by BorgWarner Turbo Systems.

More power with lower consumption

The turbocharger has been matched precisely to the high demands of the new high-performance unit and has an integrated exhaust manifold and recirculation valve. One of the main aims of the developers was to reduce consumption and emissions even further than previous generations of engines. Yet they also wanted to give the new unit a powerful and wide torque band and ensure a long service life despite the amazing performance on offer.

Best of both worlds

The concept of twin charging offers decisive advantages for small gas engines, as it completely eliminates the typically poor pickup they offer. So how does it work? In the lower rpm range the engine is supported by the mechanically driven compressor, which offers impressive response at low revs. As the revs then increase, the mechanical compressor is disengaged and the BorgWarner turbocharger with waste gate control takes over the charging of the unit. The K03 exhaust gas turbocharger is particularly efficient in the upper rev band. In fact, it performs so well that from 3,500 rpm upward, no more support is needed from the compressor. The turbocharger then does all the work itself.

Fun at all speeds

So what does the package offer? An extremely agile engine, which unites high performance, smooth running, low consumption and low emissions. With its tiny 1.4 liter displacement the new TSI in the Golf GT offers an amazing 170 bhp and maximum torque of 177 lb-ft, which is available over a massive rev band from 1,750 to 4,500 rpm. This high torque gives drivers the impression they are driving a much larger normally aspirated engine. And as if that wasn't enough, 32 mpg (US) makes it even sweeter.

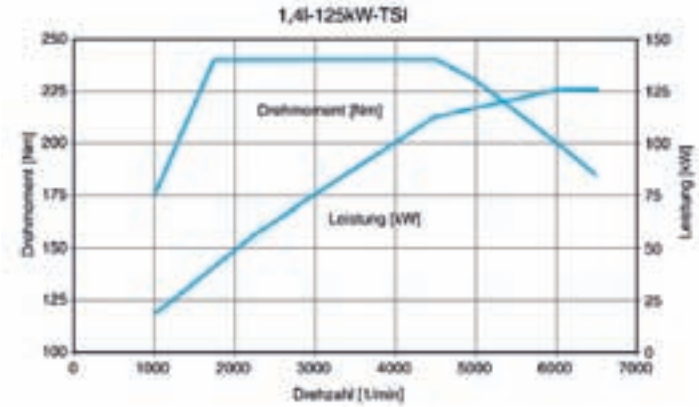
The 1.4 liter TSI with 170 bhp has been available since November 2005. Another version with 140 bhp is also set to be launched in early 2006 in the VW Golf and VW Touran, again with a BorgWarner Turbo Systems turbocharger.

Pioneering engine concept

With the 2 liter direct injection turbo engine released earlier, the Volkswagen Group and BorgWarner Turbo Systems already succeeded in developing the world's first direct injection gas engine with turbocharging. This engine is already being used in several VW and

The new Golf GT 1.4 TSI offers impressive performance and extremely low consumption

The "twin charger", a mechanical charger in combination with a BorgWarner turbo-charger, offers 120 bhp per liter displacement – making it the king of four cylinder passenger car engines



The maximum torque of 177 lb-ft is available to the driver across the broad range from 1,750 to 4,500 rpm

Audi models, such as the new Audi A3 Sportback, Audi A4, Golf GTI and VW Passat. The new 1.4 liter TSI unit underlines BorgWarner Turbo Systems' leading position as a supplier of pioneering booster technology for gas engines.

Award for standardized saving

TURBO SYSTEMS WINS
"BEST PRACTICE" DIN AWARD 2005

BorgWarner Turbo Systems doesn't want to achieve greater efficiency through newly developed turbochargers alone. In the organizational field too, the company is doing everything it can to tap the full potential for improvement in efficiency across the globe. As a result, Turbo Systems was honored with the "Best Practice" DIN award, which was awarded by the German Institute for Standardization for the second time this year.

Lower costs through fewer materials

The merger of the two turbocharger manufacturers Schwitzer and 3K-Warner to form BorgWarner Turbo Systems in 1999 doubled the amount of materials used in the company. There were 200 different materials for the turbine casings alone, which were reduced to just 20 by updating the master data. A concept therefore needed to be developed to enable a further reduction in the amount of material, thereby cutting the costs for administration, warehousing and inspection.

The management of BorgWarner decided to label the special materials for high-tech turbochargers in accordance with DIN EN 1560 in future. This is a material labeling system for cast iron materials that covers both standardized and non-standardized materials.

On the basis of DIN EN 1560, the materials were grouped, similar materials pooled together and the minimum deviations with regard to properties brought to a common denominator. This procedure enabled the number of materials used to be reduced by 60 percent cutting them from 20 to seven. Three of these materials are only used in special cases.

Significant saving

According to expert estimates, the costs for administration, warehousing, inspection, etc. that are involved in using just one special material amount to around € 75,000. Reducing the number of materials used therefore brings noticeable savings.

Worldwide standardized labeling

In addition to improved internal and external communication, the creation of a global material labeling system in accordance with DIN EN 1560 has a series of other advantages that also lead indirectly to further cost savings – such as avoiding redundancies in master data and shortening development times. The introduction of this outstanding labeling system will therefore also offer the turbocharger specialists' customers noticeable competitive advantages.

DIN

The award winners 2005

Viktor Narejkis received the "Best Practice" DIN award 2005 on behalf of BorgWarner Turbo Systems

BORGWARNER INVITES CUSTOMERS TO WORKSHOP TO LEARN ABOUT NEW TECHNOLOGIES

Technology Workshop

On 21 November 2005, BorgWarner Turbo Systems held a workshop for several of its customers and main suppliers in São Paulo, Brazil. The event was held by experts in new technologies and attended by some 70 guests. The experts on hand to offer insights into the new technologies included Ulli Fröhn, Vice President Sales & Marketing, Werner Bender, Director of R&D Commercial Diesel Product Development, and Werner Erlewein, Global Customer Program Manager.

Guests included representatives from DaimlerChrysler, Cummins, General Motors, Mitsubishi and MWM-International, as well as staff members from BorgWarner's most important suppliers.

During the workshop, the fourth of its kind and already a great success, those present gained a great insight into the BorgWarner organization, important new developments and the latest materials for components. The large number of engineers in the audience were able to gather lots of valuable technical information.

A lecture by Sergio C. Veinert, General Manager of BorgWarner in Brazil, then rounded off the event. He pointed out that the new exhaust emission legislation, which is set to be introduced in 2007, will force manufacturers to make various technical changes to turbochargers for diesel engines. BorgWarner Turbo Systems is keen to get to grips with this challenge early on together with its customers.

35 STAFF MEMBERS TAKE PART IN THE REFA TRAINING COURSE IN KICHHEIMBOLANDEN

Fit with REFA

In 2005 BorgWarner Turbo Systems in Kirchheimbolanden held two REFA seminars with 15 and 20 staff members respectively. The participants were production planners, members of the works council, center managers, center management assistants and staff members from Controlling. They each attended 48 hours of intensive training on the topic of rationalization with time management, and should now be able to apply in practice the knowledge successfully gained during the course.

Through the use of REFA methods, the management of Turbo Systems can gain precise information on throughput times, capacity utilization and a proportional breakdown of times – especially standstill times, set-up times and distribution times. The data gathered are needed to set reference times. In addition to this, the REFA methods for time management also offer a reliable basis for calculations.

Following the positive experiences from the first training sessions, a decision has already been taken to make the REFA courses mandatory for all production planners at BorgWarner Turbo Systems in future.

The REFA courses were organized by Günter Jung (Production planning manager), Uwe Schwarz (Production planning manager), Simone Stuppy (HR) and Werner Bachmann (REFA association).

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Editing and coordination
Günter Krämer, Global Marketing,
BorgWarner Turbo Systems

Authors
Sabine Bossert, Brock Fraser, Jacquie Fette,
Ulli Froehn, Viktor Narejkis, Nicole Raimer,
Uwe Schwarz, Shunsuke Osawa

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rai@turbos-bwauto.de

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