INNOVATION DRIVEN

SOLUTIONS FOR SUSTAINABLE EMISSION REDUCTION AND EFFICIENT ELECTRIFICATION OF THE POWERTRAIN

RHEINMETALL AUTOMOTIVE

PIERBURG
Reducing CO₂ and other emissions while simultaneously optimizing performance as well as the electrification of the drivetrain: these are the great challenges of the automotive industry.

Whether conventional or alternative engines, what is needed are specialists who find optimal solutions for our customers. With a tradition stretching back over a hundred years, Pierburg is a unique brand that stands for reliable partnership and future-oriented technology. As a development partner of the automotive industry, Pierburg researches engine technology for the future, and develops innovative solutions that are ready for mass production. Whether EGR systems, valves, actuators, or pumps - Pierburg is a synonym for competency and innovation in the area of reduced emissions and consumption. Our partners trust in the know-how of our personnel and our passion for developing and manufacturing mechatronic components, modules, and systems for engines. We meet every challenge and, through creativity and innovative power, we enable the drive of tomorrow.

Rene Gansauge
Division Manager Mechatronics (Pierburg)
As a specialist in the reduction of CO₂ and other emissions, Pierburg is an important partner to the vehicle industry.

We are pioneers in this area and can look back upon a long history of success in the development and manufacturing of innovative system solutions in the area of engines. As far back as 1928, Pierburg was the market leader in carburetor production for vehicle and engine manufacturers. And with the invention of the secondary air system, we once again led the way. Today, Pierburg is the first point of contact when it comes to reducing the fuel consumption and emissions of conventional engines. The variety of high-quality components and systems is convincing all across the board. And for alternative drives, Pierburg is also excellently positioned. For instance, components such as electric coolant pumps, valves, and actuators are important components for the thermomanagement of electrical and hybrid engines.

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**KNOW-HOW FOR THE DRIVES OF THE FUTURE**

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**HISTORY**

1909 | Bernhard Pierburg founds the iron trading company Gebr. Pierburg OHG in Berlin
1928 | The first Solex carburetor of Gebr. Pierburg OHG is used in the motor of the Hanomag P 2/10
1969 | In Neuss, Pierburg constructs Europe’s most modern R&D center for the reduction of harmful emissions
1970 | Development of the first exhaust gas recirculation (EGR) valve by Pierburg
1989 | Start of oil and water pump production by Pierburg
1998 | The companies Kolbenschmidt and Pierburg are merged to form Rheinmetall’s automotive division as the company Kolbenschmidt Pierburg AG
2000 | Joint Venture with SMC (Hannover, PHP in China)
2012 | 75-millionth EGR valve produced in Spain
2014 | Production record 35-millionth water circulation pump produced in Hartha
2016 | Opening of the plant in Niederreichenau

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**LOCATIONS WORLDWIDE**

**NORTH AMERICA**

4 locations in Mexico and USA

**EUROPE**

10 locations in Germany, France, Italy, Spain and Czech Republic

**SOUTH AMERICA**

1 location in Brazil

**ASIA**

6 locations in China, India and Japan

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*as of 30th of June, 2017

Rheinmetall Automotive is represented at all locations around the world.
EMISSION REDUCTION AND EFFICIENT ELECTRIFICATION OF THE POWERTRAIN

BUSINESS UNITS

The Pierburg brand represents a long tradition of competency in exhaust gas recirculation, actuator technology, thermal- and fluid management, as well as components for boosting.

Our five business units Actuators, Automotive Emission Systems, Commercial Diesel Systems, Pump Technology, and Solenoid Valves develop solutions for the great challenges of the industry, such as downsizing and emission reduction with simultaneous optimization of performance. The comprehensive product portfolio encompasses a variety of EGR systems, electric motor throttle bodies, control valves, and exhaust gas flaps, solenoid valves, actuators, and valve train systems, as well as oil, water, and vacuum pumps for passenger cars, commercial vehicles, and off-road applications from light to heavy-duty.

The business unit ACTUATORS produces high-quality throttle bodies and control valves, as well as various actuators for the global automotive industry.

The business unit AUTOMOTIVE EMISSION SYSTEMS (reduction of harmful emissions) offers innovative technologies for exhaust gas recirculation, such as EGR radiator modules, compact EGR valves, electric exhaust gas flaps, and secondary air pumps.

The business unit COMMERCIAL DIESEL SYSTEMS (reduction of harmful emissions for commercial vehicles) develops and produces high-quality EGR valves, EGR mixer modules, EGR radiators, and EGR poppet valves for commercial vehicles.

The business unit PUMP TECHNOLOGY (pumps) offers great system competency and a broad range of pumps in the areas of oil, vacuum, and cooling systems for all motor and cooling applications.

The business unit SOLENOID VALVES is the worldwide market and innovation leader in the area of electric turbo recirculation valves and also offers high-quality hydraulic valves, coolant valves, and vacuum valves.

PIERBURG CORE COMPETENCIES

- ELECTRIFICATION
- INNOVATE POWER
- FLEXIBILITY
- DEVELOPMENT COMPETENCY
- PRODUCTION PROCESSES
- REDUCTION OF EMISSIONS
- REDUCTION OF CONSUMPTION
- OPTIMIZED PERFORMANCE
- INTERNATIONAL FOOTPRINT
- PROXIMITY TO THE CUSTOMER
- MECHATRONICS

All systems go: tests in the Pierburg test lab

Valuable sample: prototype of an EGR valve

Requires comprehensive know-how and many years of experience: prototyping and small-batch production

BUSINESS UNITS
Our **set screws** for lower consumption, **reduced emissions**, and optimized performance

Pierburg offers highly advanced technological system solutions that help produce an economically and ecologically balanced automobile. The product portfolio of Pierburg encompasses components for the following areas of the drive train.
Lawgivers are passing increasingly strict laws and exhaust standards, and customers are demanding low-noise yet powerful automobiles.

As a result, modern gasoline and diesel engines must increase performance while using less fuel and reducing emissions. At the same time, there is increasing pressure to develop alternative propulsion systems to achieve the breakthrough to the mass market. At the same time, the purchase price must drop, the range rise, and the charging times shorten. In order to advance development in all areas, the specialists at Pierburg are working hand in hand with the automobile manufacturers to develop the automotive power plants of the future.

The automotive industry faces great challenges. Manufacturers must walk a tightrope between reduction of emissions, economic efficiency, and driving enjoyment.
Acting as a single source for manufacturers who need to depend on a development partner that can supply complete systems. Even now, we are making a decisive contribution to the electrification of internal combustion engines and are designing new components, modules, and systems, such as electric coolant pumps, electro-motor EGR valves, and solenoid valves. And we are working intensively on the optimization of alternative drives, for instance in the area of thermal management. Furthermore, our rapid prototyping competency offers you the ability at an early stage of projects to test prototypes nearing production maturity.

Whether maximum performance, minimum emissions, or a balanced overall package – Pierburg is applying its comprehensive know-how and rich inventive capacity to develop customer-specific drives for today and tomorrow.

EGR MODE OF ACTION

<table>
<thead>
<tr>
<th>O₂ PERCENTAGE</th>
<th>COMBUSTION SPEED</th>
<th>COMBUSTION TEMPERATURE</th>
<th>NOₓ EMISSION</th>
<th>AIR POLLUTION CONTROL</th>
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SETTING A LIMIT ON EMISSIONS

Both in gasoline and diesel engines, exhaust gas recirculation is extremely effective in reducing nitrogen oxide emissions by reducing the burning temperature. Depending on the concept, it is possible to achieve sometimes immense savings. In addition to internal exhaust gas recirculation and external high-pressure exhaust gas recirculation, a low-pressure variant for reducing nitrogen oxide has also found a place in diesel engines in recent years. Currently, however, gasoline engines with high charging and very high compression ratios are being developed. However, the high efficiency also leads to a knocking tendency, and there is a danger of self-ignition. This can be prevented through low-pressure exhaust gas recirculation. In addition, five to six per cent less gasoline is used.

No matter which EGR concept manufacturers use, with Pierburg as a development partner, they have concentrated competency on their side and always get the right solution. For faster and more precise functioning, modern EGR valves use electro-motor control almost exclusively. However, Pierburg offers not just individual valves, but also installation-space-optimized modules and systems with a cooler and bypass line. The exhaust valves from Pierburg are also an important element in reducing emissions, sound shaping, and NVH optimization for the engine. They utilize electro-motor control and offer infinitely variable adjustment. Depending on the customer’s wishes, the exhaust valve can be adapted to the required function and installation space.
INNOVATIVE ASSISTANT FOR GREATER EFFICIENCY AND MORE DRIVING ENJOYMENT

IDEAL GAS EXCHANGE AND MIXTURE FORMATION PROCESSES OF THE INTERNAL COMBUSTION ENGINE ARE DECISIVE IN ACHIEVING LOWER VEHICLE CONSUMPTION AND IN MINIMIZING HARMFUL EMISSIONS. IN ADDITION, IT IS ALSO POSSIBLE TO ATTAIN GOOD RESPONSE BEHAVIOR AND DRIVING DYNAMICS THAT DRIVERS CAN FEEL; HELPING INCREASE ACCEPTANCE OF DOWNSIZING CONCEPTS IN PARTICULAR.

In this context, Pierburg concentrates on two key technologies: the variable valve train and electric air charger (eAC). With a variable valve train, the adaptable valve lift and cylinder shutoff can reduce CO\(_2\) by up to 7%. This is mainly due to the reduction in intake losses and a more favorable friction level, which has a positive influence on charging movement. In combination with the possibility of cylinder shutoff, this has the potential to achieve great savings.

With a two-stage or multi-stage charging strategy, the improvement of response behavior and performance dynamics constitute an essential factor in the success of an engine: the electric charger from Pierburg offers a conversion ratio of applied electrical output to the effective motor performance achieved of between 5 and 15. This makes it possible not only to substantially increase the available low-end torque but also to decrease harmful emissions through reduced raw emissions and more effective after-treatment of exhaust gases.

USE ONLY WHAT YOU REALLY NEED

Hardly any technology is in such demand these days as demand-oriented systems, because they make a substantial contribution to increased engine efficiency. For instance, the use of electrically driven coolant and oil pumps, which pump the coolant or lubricant without rigid belt drives, is on the march. In comparison to mechanical coolant pumps, electrically driven units are so efficient that they allow a distinct reduction in fuel consumption. Likewise, they permit sophisticated thermal management of the engine through the demand-based flow of the coolant. Eliminating the belt drive means that the pumps can be positioned freely on the engine or chassis. In the thermal management of hybrid and electric vehicles, electric coolant pumps are likewise significant in stabilizing the thermal economy of batteries, converters, power electronics, and electrical drive motors. Another example of demand-based function is provided by continuously variable valve trains, which adapt the lift and control times of the valves to the current performance requirements of the vehicle. With UniValve for gasoline and FlexValve for diesel engines, it is also possible, in addition to variable valve lift and control times, to implement cylinder shutoff. This not only reduces consumption and emissions; it also relieves the load on other drive components and increases the reliability and service life of the engine. Whether for use in three-cylinder car engines or in large-volume units for heavy-duty trucks, FlexValve is the custom-tailored solution for all diesel engines. With continuously variable valve trains, it is possible to achieve optimum control of process and exhaust management. Engine braking performance increases, the control of charging volume and temperature is optimized, and torque builds up faster.
With ever stricter exhaust standards, legislators are putting pressure on the manufacturers of large-volume diesel engines. Trucks and other commercial vehicles must achieve a distinct reduction in emissions in order to avoid possible penalties.

The primary challenge is to reduce fuel consumption without sacrificing performance and efficiency. An important factor for the industry is reliability. After all, the failure of an engine is not just annoying; it can also cost a lot of money. Customers must be able to rely on the quality and performance of their engines.

In Pierburg, manufacturers have a partner with comprehensive know-how and great development competency.

Long distances, heavy loads – commercial vehicles need power, because they are the backbone of industry.
Rheinmetall Automotive AG is the parent company of Rheinmetall Group’s mobility sector and is represented worldwide at more than 40 locations.

As an automotive supplier, Rheinmetall Automotive develops, produces and markets components and systems for the automotive industry. The core competencies of the operating units cover the following areas related to the internal combustion engine: reduction of emissions, pollutants, and consumption; cooling and thermal management, downsizing, and the reduction of weight and friction. Furthermore, Rheinmetall Automotive deals with the drives of the future for electric and hybrid vehicles, and has aligned its development and production accordingly. With the brands KS Kolbenschmidt and Pierburg, Rheinmetall Automotive looks back upon more than a hundred years of automotive competency – and its Motorservice is a strong brand in the automotive aftermarket. This combination results in unique system competency that enables all current and future mobility topics to be covered in a comprehensive fashion.

Looking beyond 2020, I therefore see a clear need for Rheinmetall Automotive to orient development activities toward an ever-growing electro-mobility in its various facets. We assume that our markets are continuously changing and that electric drives will take on a growing importance in this process. We need to meet this challenge. That is why we are already in the process of forging a new path in aligning its activities in research and development. On the product side, for example, this includes areas like thermal management and fuel cell components which are also featured in our current development portfolio.

The electric motor will gain importance at latest from 2025 onwards. The diversity of the types of drives that will then be available will supply us with further potential for new business areas. For this reason, I am betting on a strategy that allows the company to get the best from both worlds: in addition to our vast expertise in conventional drives, we will strengthen our competence in relation to the upcoming changes in the automotive market. In principle, our goal is the same as it has been for more than 100 years: then as now, we want to help advance the revolution in mobility over the long term through novel solutions and innovative products.

HORST BINNIG, CEO, ON TECHNOLOGICAL DEVELOPMENTS IN THE AUTOMOBILE SECTOR AND THE FUTURE ORIENTATION OF THE COMPANY.

Are we on the brink of a continuous future trend toward hybridisation and a gradual transition toward more diverse forms of electric drive in the years to come? Or do we merely expect a short bold leap in the age of electric vehicles? And what role will be played by the overarching factors such as urbanization, demographic change and lawmaking?

As automotive suppliers, classifying and projecting the market development in as detailed and accurate a way as possible is essential if we are to align our portfolio for the future. In the coming five years, we will first see clear growth in plug-in hybrids for petrol and diesel engines. They are the current market drivers. And we also continue to be well positioned for this development, given our specialisation in emission and consumption reduction as well as downsizing. At the same time development cycles in the automotive industry make it necessary to set a course for any core areas at an early stage to be able to keep pace with the competition and – even better – dash at the head of the pack in the race for customer orders.
OUR HEART BEATS FOR YOUR ENGINE.