

EXCLUSIVE IN THE
BERU
RETAIL PROGRAM

New glow plug technology from the world market leader

The BERU PSG pressure sensor glow plug: developed by BERU, the first and only manufacturer to supply in series production.

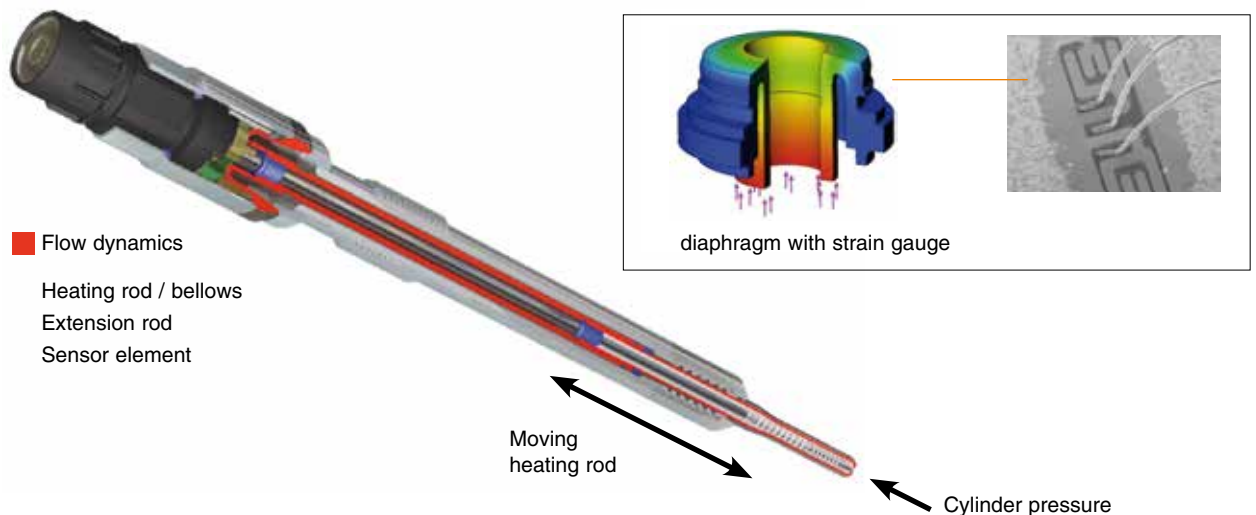
Innovative pressure sensor glow plug from the technology leader.

With the world's first glow plug to enable the regulation of the combustion processes inside a closed loop system now on the market, BERU once again highlights its technological lead. By installing pressure sensor glow plugs higher peak pressures can be implemented in today's smaller engines, standard and future combustion processes can be pushed even further to their limits, and constantly stable emissions control can be obtained throughout the engine's entire service life. In each cylinder, the pressure sensor glow plug measures the rapidly changing pressure in the combustion chamber during each combustion cycle and transmits this information continuously to the engine control electronics. BERU pressure sensor glow plugs are thus extremely important for accurate control of the combustion processes.

How it works.

The measurement principle is based on a moving heating rod which also serves as the transfer element to the piezo-resistive recorder at the rear of the glow plug. Here, the deformation on the measuring diaphragm is determined with the aid of the strain gauges providing accurate information about the real-time

pressure in the combustion chamber. The data is determined with the aid of an application-specific integrated circuit on the ECU, which then correspondingly adapts the circuit (ASIC). In this way the BERU pressure sensor glow plug creates a closed loop regulation in real time.



View PSG working inside a see-through combustion chamber: visit www.beru.federalmogul.com/de

The benefits at a glance.

- Cylinder pressure can be recorded up to 200 bar, accurate to +/- 2% and with a resolution up to 700 steps per combustion cycle.
- The ECU is able to constantly adapt the fuel injection, the charge pressure and the exhaust gas recycling rate.
- Ignition can be optimised to each cylinder.
- The engine can be operated within the optimum window between maximum power and minimum exhaust gases.
- Combustion noise can be reduced.
- Enables constant stability of the combustion process.
- Effective compensation for injector ageing.
- Improves cold starts and cold running quality.
- Enables optimum torque control.
- Compensates for component tolerances, inaccuracies in fuel measurement as well as different operating conditions and fuel qualities (such as the wide cetane number range in the USA).
- No need for costly NO_x untreated emissions sensors at OEM stage. A development objective of dispensing with the air flow meter also appears to be realistic.
- Exhaust gas treatment can be minimised.

Award-winning

The BERU PSG has won internationally renowned prizes.

Automotive News PACE Award 2009.

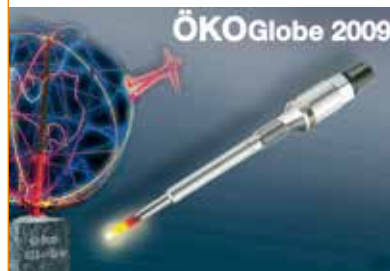


The BERU PSG won the renowned Automotive News PACE Award in the “European Products” category. BERU was selected from several hundred entrants as the winner of the competition sponsored by Automotive News, Ernst & Young and the Transportation Research Center Inc. The PACE Awards – PACE stands for Premier Automotive Suppliers’ Contribution to Excellence – have been awarded for the past 15 years for outstanding innovations by automotive suppliers.

Automotive News PACE Award 2009.

ÖkoGlobe 2009.

The BERU PSG took second place in the “Supplier Innovation” category at the coveted ÖkoGlobe environmental awards 2009 - the only awards in the automotive and mobility industry to consider exclusively ecological criteria. ÖkoGlobe 2009 was the third



occasion on which prizes for pioneering new products have been awarded in the mobility sector.

Lillehammer Award 2008.

The BERU PSG won the EUREKA Lillehammer Award 2008. This prize from the European initiative EUREKA for market-oriented research and development is awarded to projects that make a



EUREKA Lillehammer Award 2008.

major contribution to the sustainable protection of the environment.

Green Directory – Automechanika 2008.

The “green visitor guidelines” Green Directory launched for the first time at Automechanika 2008 in Frankfurt was used at the



fair as a signpost to selected exhibitors who offer particularly sustainable and emission-reducing technologies, products and services. The BERU PSG was listed in this guide - for BERU a special acknowledgement and an incentive: only 25 products

of approx. 4,600 eligible exhibitors at Automechanika satisfied the strict criteria to be listed in this Green Guide.

Automechanika Innovation Award 2006.

In the run-up to the Automechanika 2006 show in Frankfurt, the BERU PSG was awarded the outstanding innovation prize in the

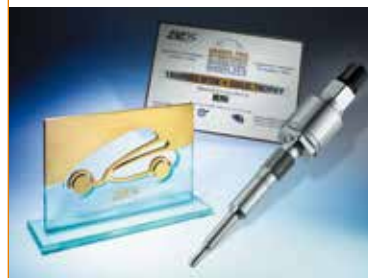


Automechanika Innovation Award 2006.

“Parts” category by a jury consisting of representatives from the fields of science, the media and industry associations.

Grands Prix Internationaux – Equip Auto 2005.

BERU was awarded the Gold Trophy at the Grands Prix Internationaux at Equipe Auto 2005 for its PSG in the “Engineering

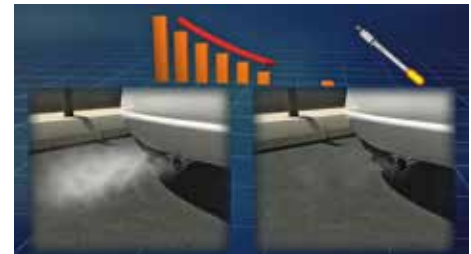
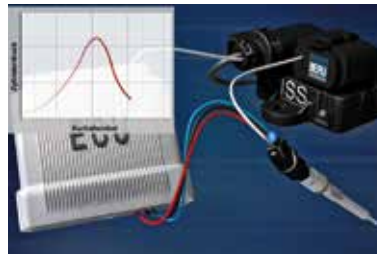
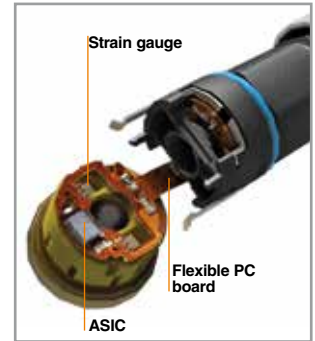
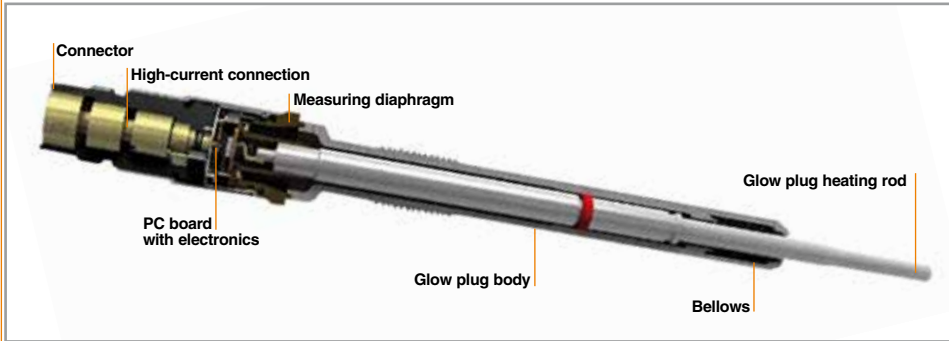


Gold Trophy– Equip Auto 2005.

and Advanced Technologies” category - an accolade awarded only once every two years for special technical innovations.

Design and function of the BERU PSG

The BERU PSG pressure sensor glow plug consists of a robust moving heating rod and a sensor which determines, for each cylinder, the precise and constantly stable pressure signals from the combustion chamber for a closed-loop regulation system. These are processed in the analysis electronics and then transmitted to the ECU. The fuel injection is thus constantly adjusted to the actual combustion in real time.

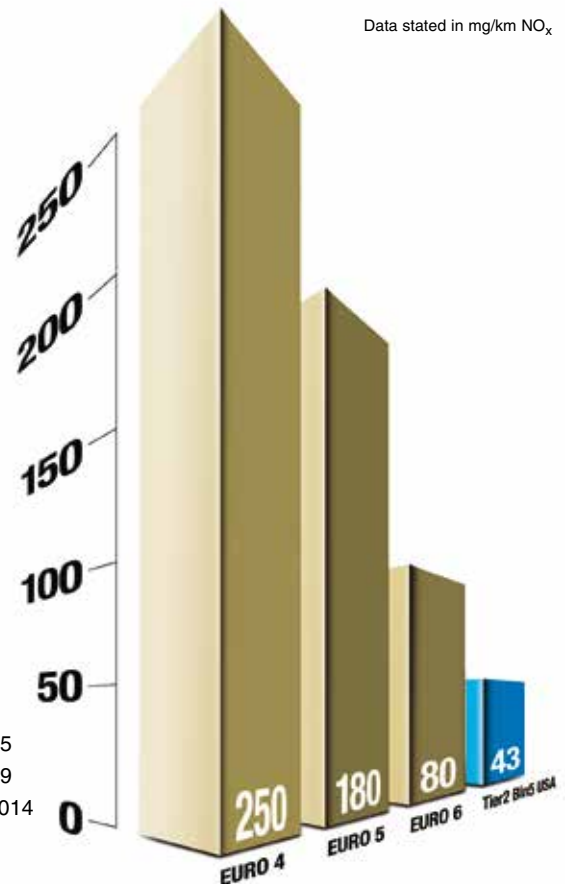


Technical features

- Sensor principle: piezo-resistive
- Moving heating rod to transfer the pressure
- Robust sealing element between body and heating rod
- Miniaturised electronics integrated into top part of the glow plug
- Calibrated and programmed to customer specifications
- Integral concentric automotive connector

In order to comply with ever stricter statutory directives, engines must operate at their optimum operating conditions. This is achieved by means of precision combustion regulation.

EURO 4: since 1st January 2005
EURO 5: since 1st January 2009
EURO 6: from 1st September 2014



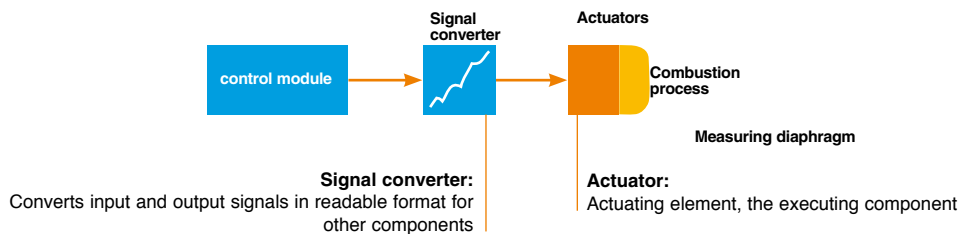
Precision combustion regulation and smaller engines to comply with current and future exhaust gas standards.

In order to meet the ever stricter statutorily prescribed exhaust gas values for new vehicles, and to further exploit the savings potential in combustion engines, it is necessary to reduce the amount of untreated exhaust emissions in the combustion chamber. Specifically this means changing from a process that simply controls the combustion to an active combustion regulation system that adjusts to the operating situation. This extends the range of the glow plug's tasks.

The Controller in the Open Loop System

In diesel engines, combustion has to date been almost exclusively open loop controlled rather than closed loop controlled. This means - taking a common-rail system as an example - that the input values are obtained using different sensors. Based on these inputs and the characteristic maps stored on the ECU the pertinent output variables/actuation variables are computed. These outputs are transmitted to the actuators (such as injectors, etc.) and implemented by them. The combustion initiated in this way takes place without further monitoring. As a consequence,

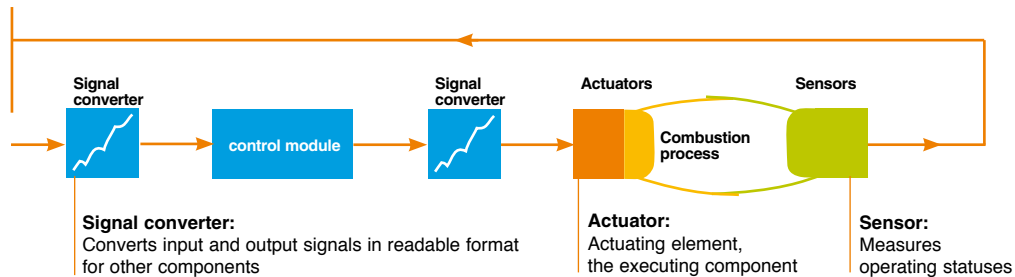
the options for optimising raw emissions are very limited; in particular the aging-related drift of component properties cannot be adequately considered. For example, it is impossible to check whether the initial value computed by the control unit as the setpoint actually matches the actual value. Therefore, the actual value as the current output value has no direct influence on the important inputs for the control unit. This means that interference (e.g., air leaks, maximum design tolerances, or fuel tolerances) cannot be compensated for.



Super-efficient: Regulation inside the closed loop system

In order to comply with the stricter exhaust emission limits arriving soon, the diesel engine also had to operate as a closed loop system. In order to construct a regulation system of this type, it is essential that information received from the combustion chamber is reliable. Such information ensures that the output variables determined by the control unit in turn affect the ECU's calculations in the form of input variables. Since the system detects any deviations from nominal values, it is also possible to compensate disturbance vari-

ables such as leak air, design-dependent component and fuel tolerances etc. This makes it possible to achieve stable emissions values throughout the entire life cycle, and thus comply with strict statutory specifications. The PSG pressure sensor glow plug developed by BERU plays a crucial role in a regulation system of this nature. It measures the cylinder pressure and transmits the relevant signals in order to ensure super-efficient combustion.



Smaller sizes

Smaller engines have lower consumption and CO₂ emissions due to their lower cubic capacity, yet they maintain engine output. The idea behind this is that engines with a lower cubic capacity are lighter, have a lower absolute friction loss, and lower gas exchange cycle losses under partial load. They operate at a higher load and thus achieve a better efficiency level.

Here too, the BERU PSG plays an important role: By accurately measuring the combustion chamber pressure, higher peak pressures can be implemented, so standard combustion processes can be brought closer to their limits. The result - higher engine output, combined with greater efficiency - in other words minimum consumption and exhaust values.

New Volkswagen Euro 6 engine: Cleaner than the air that we breathe - with BERU PSG!

September 1, 2014 – deadline for the EU 6 standard. To meet the more stringent emission limits, automobile and engine manufacturers are working on new, fuel consumption- and emissions-optimised power units. For example, Volkswagen has developed a 2-litre engine with 135 kW/184 HP and a standard consumption of 4.2 l diesel.

The significant new feature here is the adjustable camshaft. This can alter the compression on demand: a high compression ratio is required for the cold start and warm-up phase, it is then lowered after warming up. At the same time, the injector pressure has been increased to 2000 bar using new injection systems. This helps to reduce emissions by up to 40%.

A special challenge for engine developers is also exhaust gas aftertreatment for diesel: in contrast to the spark ignition engine, the diesel engine produces „cold“ exhaust gases. All systems for exhaust gas treatment, however, depend on relatively high temperatures. To achieve them, dual exhaust gas recirculation is used in EU 6 engines. For these systems, newly-designed control units are necessary due to greater monitoring and control overhead. A storage catalytic converter, which is installed downstream of the particulate filter, reduces NOx emissions from 180 to 80 milligrams per kilometre.

The BERU pressure sensor glow plug (PSG) is used to manage these complex processes in a targeted way: It monitors the cylinder pressure and regulates the supply of the correct volume of air.

Equipped in this way, the diesel becomes an air freshener: the mixture leaving the new EU 6 diesel's exhaust is cleaner than the intake air – also thanks to BERU PSG.

PSG001



Opel Insignia

PSG002



VW Golf VI



VW Touareg

PSG003



Opel/Vauxhall Meriva B



Opel/Vauxhall Corsa D

PSG004



Opel/Vauxhall Mokka



Opel/Vauxhall Astra J

PSG005



Opel/Vauxhall Zafira

Now also available for retailers and workshops.

PSG001

BERU Order no. PSG001 –0 103 010 903
GM no. 55 564 163 / Opel/Vauxhall no. 18 26 354
GM no. 55 579 436 / Opel/Vauxhall no. 12 14 087

PSG002

BERU Order no. PSG002 –0 103 111 104
Volkswagen Group no. 03L 905 061 D, E, F

PSG003

BERU Order no. PSG003 –0 103 110 904
GM no. 55 577 419 / Opel/Vauxhall no. 12 14 061
GM no. 55 580 403 / Opel/Vauxhall no. 12 14 086
GM no. 55 565 634 / Opel/Vauxhall no. 12 14 057

PSG004

BERU Order no. PSG004 –0 103 010 104
GM no. 55 568 366 / Opel/Vauxhall no. 12 14 088
GM no. 55 590 466 / Opel/Vauxhall no. 12 14 104

PSG005

BERU Order no. PSG005 –0 103 010 107
GM no. 55 571 600 / Opel/Vauxhall no. 12 14 099

PSG006

BERU Order no. PSG006 –0 103 010 907
GM no. 55 590 467 / Opel/Vauxhall no. 12 14 101



BERU the world's market leader in Diesel Cold-Start Technology.

BERU developed the first diesel engine glow plug back in 1929 – and continues to shape the market today with countless patented innovations: from self-regulation post-heating glow plugs, covering the ISS Instant Start System, through to the intelligent PSG pressure sensor glow plug.

The history of Innovations.

2013 More than 3 million PSGs have been sold (as of January 2013)

2012 100 years of the BERU brand and a fully-automated production line for pressure sensor glow plugs (PSGs) is launched in Ludwigsburg

2010 BERU PSG added to the BERU portfolio. BERU ceramic glow plugs with new technology enter series production

2008 The BERU PSG goes into series production in Europe too



2007 World premier: BERU supplies the first intelligent PSG (pressure sensor glow plug) to OEM vehicles in the USA

2006 Launch of the 2nd generation BERU ISS, with new control unit and additional heater flange



2001 Launch of the first electronically controlled diesel instant start system (ISS)

1991 3 heating stages (pre-heating - start heating - post-heating) provided by the post-heating enabled, self-regulating instant start glow plugs



1978 First self-regulating quick start glow plug with a pre-heating period of just 5-7 seconds

1975 First quick heating glow plug reduces pre-heating period to 20 seconds

1931 The first 2-pole wire glow plugs invented and patented - during the 1960s the wire glow plug developed into the rod glow plug



1929 The first glow plug for Diesel Cold-Start Technology developed and manufactured

A delicate exchange

The list of PSG applications is long: and it is getting longer all the time – after all, BERU is the sole supplier of the pressure sensor glow plug to all automobile manufacturers who use this advanced technology, a key technology for meeting current and future exhaust gas limits.

In case of plug changes, special care is required in order to prevent damage to the highly sensitive sensor and to ensure the full functionality:

- A drop from just 2 cm height can damage the PSG.
- Only pull off the connector manually, to avoid the risk of plug damage.
- Installation and removal only with the BERU custom tool. Push the tool onto the PSG so that the glow plug's hexagon head is completely covered; note the torque.
- Only remove the protection cap after the installing the glow plug.

The right approach to removal:

- Remove the engine cover and the other components, that impair access to the glow plugs (1).
- Manually disconnect the electrical connector (2) on each glow plug.
- To ensure that no foreign bodies enter the combustion chambers, clean the area around the glow plug in question (3). If the fuel system has been opened, also pay attention to cleanliness and seal the cables with a cap, if possible.
- Exclusively use the BERU socket bit to loosen the PSG; this avoids damage to the connector block. Important: Complete coverage of the PSG hexagon head (4) + (5) Please use a torque wrench and note the permissible breaking torque (6).
- Remove the glow plug (7).



Glow plug-friendly installation




- Before installing, coat the thread and shaft of the new PSG with BERU glow plug installation grease GKF01 (Article no. 0 890 300 034), to avoid „caking“ later on (8).
- Clean the glow plug channel and the thread in the cylinder head to remove oil and combustion products.
Important: Make sure that no dirt enters the combustion chamber.
- First screw in the glow plug by hand (9), then tighten afterwards with a torque wrench (observe the installation torque!) fitted with a BERU socket insert (10). Important: Complete coverage of the PSG hexagon head (4) + (5)
- Now remove (and not before now!) the protective cap from the PSG to avoid damage to the connector and mating connector.

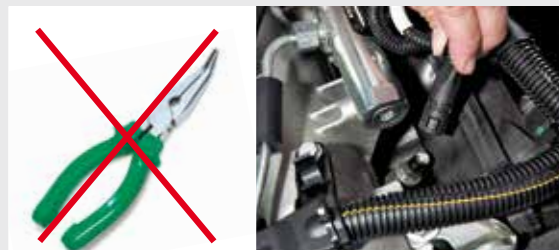
- Push the wiring harness connector until it snaps onto the PSG (11).
- Install the engine cover and all other previously disassembled parts (12).
- At the end check the memory of the engine control unit for error code entries and delete them.



TIGHTENING AND BREAKING TORQUE FOR BERU PSG GLOW PLUGS

Installation values for PSG glow plugs

		
PSG 001 (M9x1)	11 Nm	22 Nm
PSG 002 (M10x1)	12 Nm	35 Nm
PSG 003 (M9x1)	11 Nm	22 Nm
PSG 004 (M10x1)	13 Nm	35 Nm
PSG 005 (M10x1)	13 Nm	35 Nm
PSG 006 (M9x1)	11 Nm	22 Nm



Important when loosening the connector on the BERU PSG: do this manually, and do not use tools like pliers or similar!



Safe removal and installation of PSG glow plugs with the BERU socket set, size 12 width-across-flats (BERU Article no. 0890000006).

New modular PSG production line at the Ludwigsburg location

The future of the diesel engine requires intelligent and resource-efficient solutions such as the PSG. To meet the growing demand for this innovative glow plug in the medium to long-term demand, BorgWarner has invested in a highly sophisticated production line.

The fully automatic concept consists of 16 individual modules in which the entire process takes place – from the delivery of the first individual part to the finally assembled PSG. The significant feature of the new line is the strict separation of assembly and welding processes with a high level of process reliability and efficiency. The latest laser technology is used for welding; welding operations are optimised by the precisely controlled supply and extraction of shielding gas – and monitored by state-of-the-art camera systems. A PC-based control concept allows traceability up to the individual component. Numerous test instruments integrated into the process chain ensures the high quality level of each individual pressure sensor glow plug by BERU.



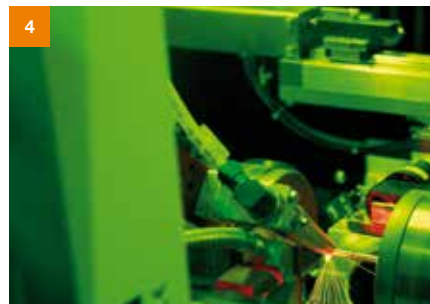
A look at the modular production line for PSG pressure sensor glow plugs.



Start of the fully automated production process: The installation of the heating element and its extension...



... which is visible here in detail.



The heating element and extension are laser welded in the 2nd module.



The O-ring is mounted in the extension here to centre the heating element.



Then the glow power connector is mounted and welded on the inner terminal.



This manufacturing step is monitored by an imaging system.



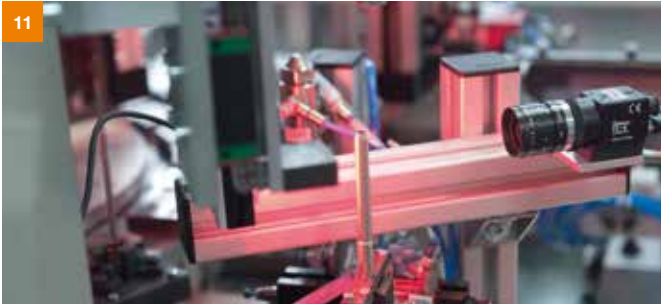
The glow current connector is fed through the duct inside the sensor module.



In the 6th module the sensor is laser welded onto the extension.



In the logistics module, the parts are moved from the first to the second production train, where pre-assembly of the end cap initially takes place.



Feeding of the glow plug upper part is monitored and documented by a camera.



To achieve flexible bearing of the heating rod, the glow tube is surrounded by a boot. The figure shows the boot feeding via a conveyor rail.



100% functional testing of the PSG: The glow test proves that the plug reaches the required temperature in the allotted time.



Then leak testing is performed.



This is now followed by geometry testing of the plug: The final dimensions and precise concentricity are documented by a camera system.



Only plugs that have passed all the tests, are transported on to the next step, laser marking.



Here the tested pressure sensor glow plugs are packed for shipment.

BERU® is a Registered Trademark of BorgWarner Ludwigsburg GmbH
PRMBU1736-EN

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0%

-10%

-20%

-30%

-40%

-50%

-60%

-70%

-80%

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Global Aftermarket EMEA
Prins Boudewijnlaan 5
2550 Kontich • Belgium

www.federalmogul.com
www.beru.federalmogul.com

beru@federalmogul.com

 www.fmecat.eu

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