All about glow plugs

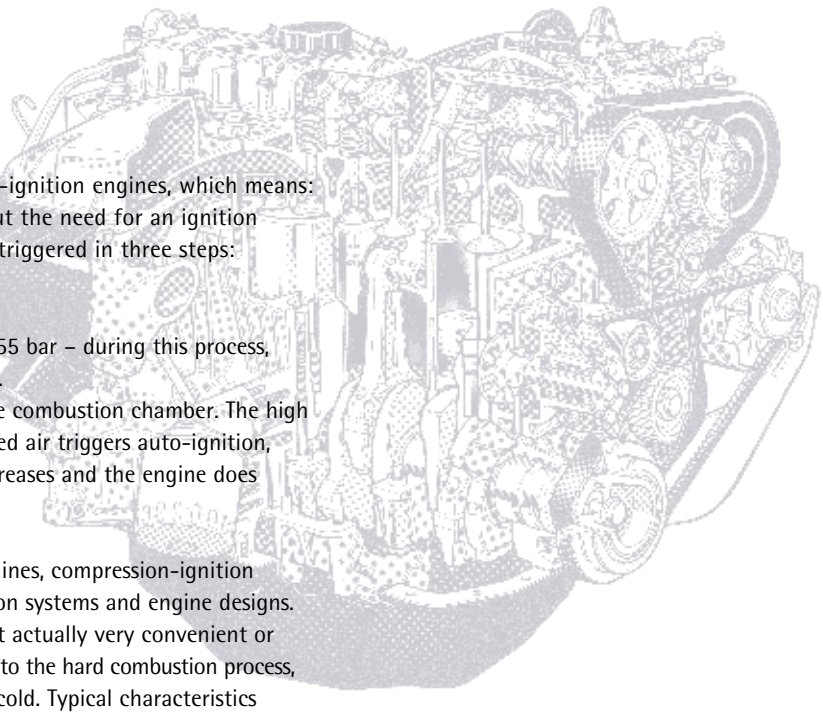
Technical Information No. 04

FEDERAL-MOGUL MOTORPARTS

Perfection built in BERU®

Contents

The diesel engine



Function

Diesel engines are compression-ignition engines, which means: the injected fuel ignites without the need for an ignition spark. The combustion cycle is triggered in three steps:

1. First, clean air is taken in.
2. This air is compressed to 30–55 bar – during this process, it will heat up to 700–900 °C.
3. Diesel fuel is injected into the combustion chamber. The high temperature of the compressed air triggers auto-ignition, internal pressure strongly increases and the engine does its work.

Compared to spark-ignition engines, compression-ignition engines require complex injection systems and engine designs. The first diesel engines were not actually very convenient or smooth-running drive units. Due to the hard combustion process, they made a lot of noise when cold. Typical characteristics included a lower power-to-weight ratio, a low output per liter displacement as well as a lower acceleration performance. Through continuous development of the injection technology and the glow plugs, it was possible to eliminate all these disadvantages. Today, the diesel engine is considered an equivalent or even better power source.

Cold start

The term „cold start" describes all start processes occurring while the engine and the media involved have not reached operating temperature. The lower the temperature, the less favorable are the conditions for a quick ignition and complete, environmentally friendly combustion. Certain suppporting measures are used to assist during the cold start and so that starting will not be unacceptably long or even impossible. These compensate for the poorer start conditions while initiating a well-timed and even ignition to ensure stable combustion.

The glow plug is one component that assists during cold start. It creates ideal ignition conditions for the injected fuel through electrically generated thermal energy that is brought into the combustion chamber. It is indispensable as as cold start aid for engines with a divided combustion chamber, in order to ensure that these can start even in the frequently occurring temperature range of 10–30 °C. Since the start quality deteriorates considerably at below freezing point, the glow plug is also used as cold start aid for direct-injection diesel engines.

The diesel engine

Injection systems

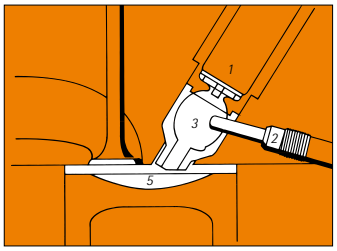
Depending on the design and arrangement of the combustion chamber, a distinction is made between the following three injection systems in diesel engines:

1. Antechamber system
2. Turbulence chamber process
3. Direct injection

Glow plugs are required for all systems – to ensure that the injected fuel can evaporate and the fuel-air mixture can ignite on the hot surface of the plug.

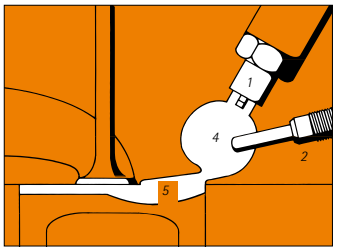
ANTECHAMBER SYSTEM

In this system, the combustion chamber is divided into two:
an antechamber and the main chamber. These are connected with one another by several bores (injection channels). During the compression stroke, a part of the compressed air is forced into the antechamber. Shortly before reaching the top dead centre, the fuel is injected through a nozzle directly into the antechamber of the respective piston. This is where the injected fuel is partially combusted. The high temperatures generated ensure a rapid increase in pressure. The entire contents of the antechamber are thus blown through the injection channels into the main combustion chamber, where the actual combustion takes place.



TURBULENCE CHAMBER PROCESS

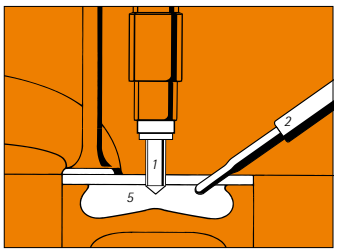
The spherical turbulence chamber is arranged in the cylinder head, separately from the main combustion chamber. Main combustion chamber and turbulence chamber are connected by a wide-diameter injection channel. During the compression stroke, the injection channel in the turbulence chamber causes intensive rotation of the intake air. The diesel fuel is injected into this air turbulence. Combustion starts in the turbulence chamber and then spreads through into the main combustion chamber



DIRECT INJECTION

In diesel direct injection (fuel-air introduction), the fuel is injected at high pressure through the multiple-hole nozzle into the highly compressed intake air for atomization; during this process, the special piston crown design helps with mixture formation. During start, the cold intake air is very quickly heated up due to the high compression pressure. The heating element projects into the main combustion chamber. In principle, the glow plug in direct injection engines has the same function as in the chamber engines: it helps with ignition during the start. The heating element of a modern glow plug reaches a temperature of over 1,000 °C within only a few seconds.

With cold starts, the situation is generally as follows: the cold air that is drawn in produces lower temperatures at the end of the compression stage. While driving, the temperature of the compressed air is adequate for self-ignition. However, it is not sufficient when starting, especially with low outside temperatures. But it is the low starting revs that have more serious consequences. Due to the long dwell time of the charge, the loss of temperature and pressure is much greater than, for example, when idling.



1 | Injection nozzle
2 | Glow plug
3 | Antechamber
4 | Turbulence chamber
5 | Combustion chamber

Self-regulating pencil type glow plugs

Requirements on a modern glow plug

SHORT HEAT-UP TIME

Glow plugs must provide a high temperature within as short a time as possible to assist with ignition – and they must maintain this temperature regardless of the ambient conditions, or even adjust the temperature depending on them.

SMALL SPACE REQUIREMENT

Passenger car diesel engines with antechamber or turbulence chamber injection and direct injection versions using 2-valve technology usually have enough space available for injection nozzles and glow plugs.
However, in modern diesel engines with common rail or pump-nozzle injection systems and 4-valve technology, the available space is very restricted. This means that the space required for the glow plug must be reduced to a minimum, resulting in a very thin and long shape. Today, BERU glow plugs with glow tube diameters reduced to <3 mm are already in operation.

PRECISE ADAPTATION TO THE COMBUSTION CHAMBER

Ideally, the glow rod should be situated precisely at the edge of the mixture vortex - however, it must still project sufficiently deep into the combustion chamber or the antechamber. Only then is it able to introduce the heat accurately. It may not protrude too far into the combustion chamber, as it would otherwise interfere with the preparation of the injected fuel and thus the preparation of the mixture for an ignitable fuel-air mixture. This would result in increased exhaust gas emissions.

SUFFICIENT GLOWING VOLUME

Apart from the glow plug, the injection system is of particular significance in the engine cold start. Only a system that has been optimized in terms of its injection point, quantity andmixture composition in conjunction with the correct position and thermal rating of the glow plug will ensure good cold start performance. Even after the engine has been started, the glow plug may not be „blown cold" by the increased air movement in the combustion chamber. Very high air speeds are in particular present in antechamber or turbulence chamber engines at the glow plug tip. In this environment, the plug will only work if it has sufficient reserves; i.e. if sufficient glowing volume is available so that heat can immediately be brought on into the cold-blown zone.

The glow plugs developed by BERU fulfill all these requirements in an optimal manner. BERU engineers work closely with the automotive industry especially during the engine development stage. The result: an environmentally-sound diesel quick start in 2-5 seconds (in conjunction with the Instant Start System ISS a maximum of 2 seconds), a reliable start up to –30 °C, a steady engine start-up that is gentle on the engine, with up to 40 % less carbon-particulate emissions in the warm-up phase for post-heating glow plugs (for more information see from page 7 onwards).

Self-regulating pencil type glow plugs

Design and function

The BERU glow plug basically comprises the plug body, heating rod with heating and regulating coil, as well as the connecting bolt. The corrosion resistant glow rod is pressed in the housing so that as to be gas-tight. The plug is additionally sealed by a sealing ring or a plastic component at the connector. A battery supplies the electrical energy for the glow plug. It is controlled by an electronic glow time control unit.

HEATING AND REGULATING COIL

The basic principle of a modern glow plug is the combination of a heating and a regulating coil into a single common resistor element. The heating coil is made of high-temperature resistant material the electrical resistance of which is largely temperature-independent. Together with the front part of the glow rod, it forms the heating zone. The regulating coil is attached to the live connecting bolt; its resistance has a large temperature coefficient.

The entire coil is firmly packed in a compressed, electrically insulating but highly heat-conductive ceramic powder. During mechanical compaction, the powder is compressed so much that the coil is fitted as if it was cast in cement. This makes it so stable that the thin wires of the heating and regulating coil can permanently resist all vibrations. Even though the individual windings are arranged only a few tenths of a millimeter apart, no winding short circuits can be produced – and certainly no short circuit to the glow tube, which would destroy the plug.

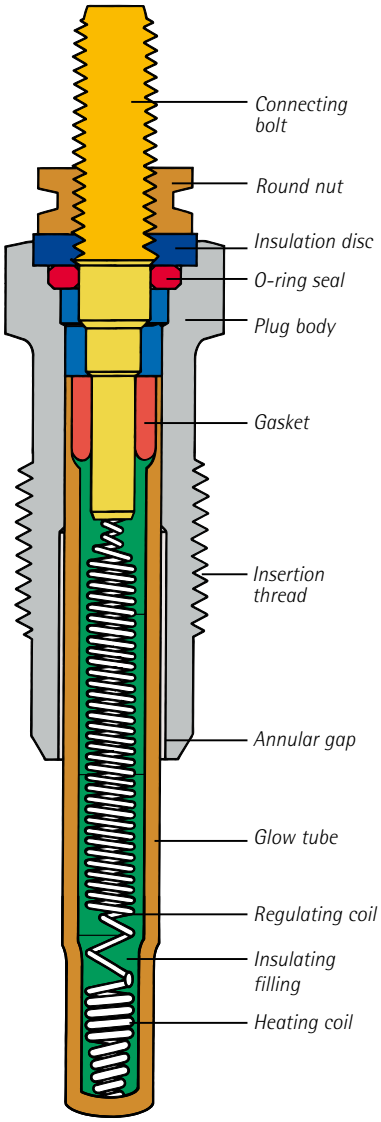
With the different materials, lengths and diameters, and different wire thicknesses for the heating and regulating coil, it is possible to change the heat-up times and glow temperatures of the plug in accordance with the respective requirements of the engine.

FUNCTION

During pre-heating, a high current initially flows via the connecting bolt and the regulating coil to the heating coil. The latter heats up quickly, causing the heating zone to glow. Glowing quickly expands – after 2-5 seconds, the heating rod glows up to near the plug body. This additionally increases the temperature of the regulating coil that has already been heated up by the current. Then, the electrical resistance increases and the current is reduced to a point where it cannot cause any damage to the glow rod. Overheating of the glow plug is thus not possible.

If the engine is not started, the glow plug will be switched off by the glow time control unit after a certain stand-by time.

The resistance of the alloy used on BERU glow plugs increases with the temperature. It is thus possible to design the regulating coil in such manner that it will initially let through a higher current to the heating coil than when it reaches the target temperature. The target temperature is thus reached quicker and is maintained within the permissible range by an increased regulating effect.



Design of a self-regulating, fast-heating.pencil type glow plug.

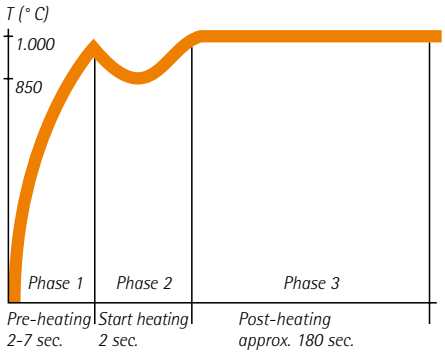
Self-regulating pencil type glow plugs

Post-heating pencil type glow plugs (GN)

Older vehicle models are normally equipped with glow plugs that only glow before and during the start phase. They can be recognized from the abbreviation GV. Modern Diesel passenger cars normally leave the assembly line with fitted GN glow plugs. They are equipped with the innovative 3-phase glow system. This means that they glow

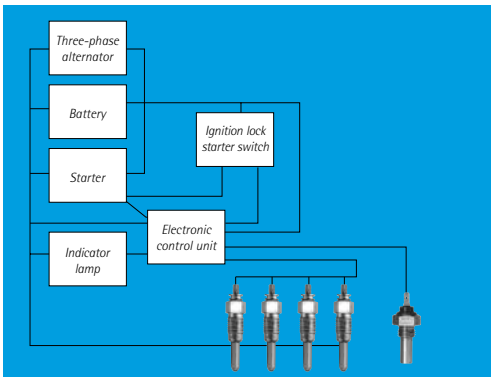
- before the start,
- during the start phase,
- after the start, and
- during engine operation (in coasting mode).

The 3-phase glow technology.



FUNCTION

The electronically controlled pre-heating starts when the ignition lock starter switch is operated and lasts for approx. 2-5 seconds at normal outside temperatures until the engine is ready to start. The post-heating time is up to 3 minutes after starting the engine to reduce pollutant and noise emissions to a minimum.
The engine operating state is registered e.g. by measurement of the coolant temperature. The post-heating process is continued until the coolant has reached a temperature of 70 °C, or it will be switched off after a certain time which is set in the performance map. No post-heating will normally take place if the coolant temperature was already higher than that before starting.



Circuit design principle for a post-heating glow system with four fast-heating glow plugs connected in parallel and a temperature sensor.

PROTECTION AGAINST OVERHEATING

Self-regulating glow plugs restrict the current flowing from the battery to the plug with increasing temperature to prevent overheating. However, when the engine is running, the voltage will increase to a point where glow plugs that do not comply with the newest technology will blow. Besides, the plugs that are supplied with current are exposed to high combustion temperatures after the start, and are thus heated up from the inside and the outside. The post-heating BERU glow plugs are functional at full generator voltage. Their temperature increases very quickly, but will then be limited by the new regulating coil to a saturation temperature that is lower than that of non post-heating plugs.

Important: Only GN glow plugs may be installed in a glow system designed for GN glow plugs – GV glow plugs could be damaged very quickly.

Self-regulating pencil type glow plugs

QUICK START IN 2 SECONDS

With the post-heating BERU GN glow plug, it is possible to reduce the glow time to 2-5 seconds. To achieve this, the designers reduced the diameter at the front end of the heating rod. The heating rod thus starts glowing quicker in this zone. At a temperature of 0 °C, this takes just 2 seconds until start. When temperatures are lower, the system is accordingly adapted to the requirements by the glow-time control, and glow time will respectively increase: at –5 °C approx. 5 and at –10 °C approx. 7 seconds.

REDUCTION OF WHITE/BLUE SMOKE

So-called white or blue smoke is emitted from the exhaust until the ideal ignition temperature has been reached. These types of smoke produced are the result of incomplete combustion of the fuel, resulting from too low an ignition temperature. Post-heating causes the diesel fuel to burn more completely and with less noise during the warm-up phase. Smoke opacity is thus reduced by up to 40 %.

Carbon deposits in the filter paper three minutes after the cold start. With post-heating (on the right), carbon deposits are approx. 40% less than without post-heating.

ELIMINATION OF COLD-START KNOCKING

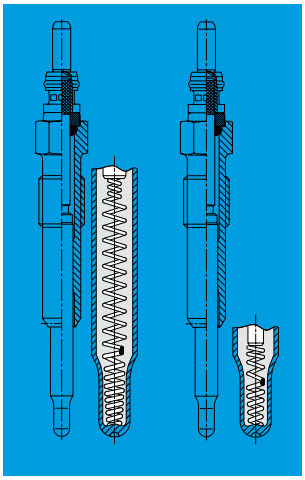
Knocking during cold-start of a diesel engine is caused by an increased ignition delay when the engine is cold. The fuel ignites abruptly, and the engine knocks. Pre-heating and post-heating of GN glow plugs ensure that the engine reaches the operating temperature quicker. This preserves the engine, results in quieter engine running and prevents knocking. The fuel will then be burnt more evenly and more completely. More energy is thus released and the combustion chamber temperature will increase faster.

Technical features of the GN glow plug

- Quick-start glow plug in slim design
- Short pre-heating time: only approx. 2 - 7 seconds
- Reliable start (even at -30 °C)
- Environmentally friendly: approx. 40 % less pollutant emission during the warm-up phase
- No knocking
- Quieter engine running
- Start is gentle on the engine
- For vehicles with operating voltages up to 14.5 V

The BERU Instant Start System (ISS)

To make a key-turn start possible for diesel fuelled vehicles resembling that for a spark ignition engine – that was the great challenge. The solution from the BERU engineers: the Instant Start System ISS.



Interior structure of the self-regulating standard glow plug SR (left) and the power-optimized ISS glow plug (right).

System concept

The BERU ISS comprises an electronic glow plug control unit and performance-optimized glow plugs with a reduced heat-up time of maximum 2 seconds – compared to approx. 5 seconds for a standard glow plug (SR). Both in the heating-up and in the saturation phase, they require significantly less energy. Power semi-conductors are used in the control unit as switches to control the glow plugs, replacing the electro-mechanical relay used in the past. Compared to the conventional self-regulating glow plugs, the winding combination of the power-optimized glow plug of the ISS is considerably shorter and the glowing area is reduced to approximately one third. In direct-injection engines, this corresponds to the part of the heating rod that protrudes into the combustion chamber.

Electronic control

When the engine is running, the glow plug is cooled by the change in the charge and air movement in the compression phase. The temperature of the glow plug will decrease with increased speed for a constant glow plug voltage and injection quantity, and will increase for an increasing injection quantity and constant glow plug voltage and speed. The electronic control unit can compensate for these effects: the glow plugs are always supplied with the optimal effective voltage for the respective operation point. The glow plug temperature can thus be controlled depending on the operating state. In addition, the combination of the low-voltage glow plug and the electronic control unit is used for heating up the glow plug extremely quickly. This is done by feeding the full on-board voltage to the glow plug for a pre-defined period, and only then operating with the necessary effective voltage during synchronized operation. The normal pre-heating period is thus reduced to a maximum of 2 seconds even at low temperatures. The efficiency of the system is so high that not much more than the power required by the glow plug is taken from the on-board power supply. As each glow plug can be controlled by a separate power semiconductor in the ISS, the current can be monitored separately in each glow current circuit. Individual diagnostics at each plug is thus possible.

Electronically controlled glow system ISS: Control unit and glow plugs.

The BERU Instant Start System enables key-turn start for compression-ignition engines just like that for a spark ignition engine.

Technical features of the ISS

- Reliable start even at temperatures of -30 °C
- Extremely fast heat-up time: 1,000 °C are reached in 1- 2 seconds
- Low power requirement (in particular important for engines with 6 or more cylinders)
- Higher functional reliability
- Controllable temperature for pre-, intermediate and post-heating
- Numerous diagnostics functions
- immediate stable idling and well-controlled load take-up
- Minimised pollutant emissions
- Specifically designed for diesel engines with direct injection
- On-board diagnostics-enabled

BERU – Lead innovator for the use of PSG pressure sensor glow plugs

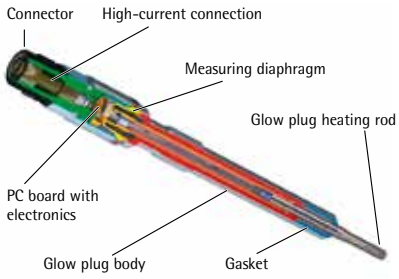
INTELLIGENT PRESSURE-SENSOR GLOW PLUG

New emission laws in Europe and in the US will further reduce the permissible exhaust gas emissions of diesel engines. The thresholds for NOx and particulate emissions, which are relevant for the diesel engine, will in future be up to 90 % lower than the present value. It will not be possible to comply with these emission standards with conventional solutions alone.

BERU developers have integrated a piezoresistive pressure sensor into the plug. In view of the extremely high temperatures, vibrations and pressure conditions in the cylinder head, the mechanical design of the glow plug is an important success factor. The heating rod is not pressed in the glow plug body, as was the standard in the past, but is supported elastically as mobile component, and it transmits the pressure to a diaphragm located in the rear area of the glow plug. The actual pressure sensor is thus positioned far away from the com-bustion chamber in an area with significantly more favorable ambient conditions. Thermal load on the seal remains controllable due to the use of a heating rod from the BERU Diesel ISS quick-start system, which only glows at its tip.

The intelligent PSG (pressure sensor glow plug) is already being tested as original equipment by Volkswagen group and GM/Opel, and is soon to be used in the latest diesel engine designs.

For more information about BERU PSG – pressure sensor glow plugs read BERU PSG brochure.



The intelligent PSG (pressure sensor glow plug).

BERU – Ceramic glow plug (CGP)

STRONG INNER VALUES

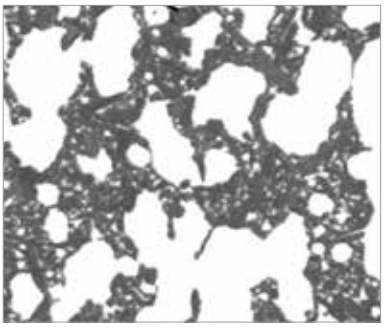
The composition of the materials is crucial to the performance of BERU ceramic glow plugs. High strength silicon nitride ceramic to enclose the electrically conductive Molybdenum disilicide inside an interpenetrating structure. This material withstands pressures up to 200 bar and temperatures up to 1,300°C - all in the various gaseous atmospheres encountered in the combustion chamber (ambient air, diesel, oxygen, water).

PERFORMANCE DRIVEN TO THE TIP

Besides short heat-up times, the externally positioned heating rod design, of course patented, also provides optimized regulation. Moreover the plug's heating capacity concentrated at the tip of the ceramic element requires less energy to generate the temperature required to start the engine - and thus uses less fuel compared with conventional plugs. Besides increasing the operating reliability, the resistance within the regulation system, ensures the BERU ceramic glow plug has the best possible energy balance at every engine operating point. This also contributes to a reduction in consumption and emissions.

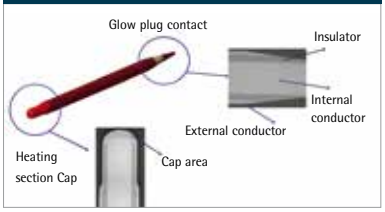
AN EXCLUSIVE PROCESS

BERU ceramic glow plugs are manufactured on patented series production facilities. The ceramic heating element is produced in an extrusion and injection molding process. This is followed by processes to relieve, sinter and harden them to produce the tight tolerances required before they can be fitted into the metal bodies. This requires several grinding procedures, and due to the extreme hardness and strength of the materials, the grinding must be performed with diamond tools. The ceramic heating rod contact is produced in special high-temperature procedures over the full surface. This achieves high resistance capacity against oscillations and temperature changes. With the combination of high-strength material, innovative construction and the latest production processes, BERU ceramic glow plugs offer outstanding features.



The microstructure of the BERU glow plug ceramic with strengthening small silicon nitride rods and white Molybdenum disilicide grains, which form the electrically conductive, three-dimensional structure.

The structure of the ceramic heating rod on the BERU glow plug



The heating element consists of electrically conductive solid ceramic. Because this has a higher specific resistance at the surface than the supply and return conductor material, the glow rod only glows at the tip (the cap) thus reaching high temperatures faster. The glow plug contact consists of an internal and external conductor with an insulator positioned between them.

BERU glow plugs: Fivefold safety for maximum quality

1. DESIGNED IN CLOSE COOPERATION WITH CAR MANUFACTURERS

As diesel cold-start specialist and development partner of the automotive industry, BERU has not only been involved in the glow plug design from the beginning, but was already present and involved during the development of new engines. It was therefore possible precisely to coordinate the installation position of the glow plug within the engine - and BERU engineers know exactly what parameters are particularly important or what performance reserves must be possessed by the glow plug under development.

2. MANUFACTURED ACCORDING TO ISO STANDARDS

BERU glow plugs are designed in compliance with ISO Standard 7578 and 6550. These specify the dimensions and tolerances of the geometry, the sealing angle, the wrench size, the heating rod diameter, etc.

3. DEVELOPED ACCORDING TO THE PRODUCT SPECIFICATIONS OF THE AUTOMOTIVE INDUSTRY

BERU glow plugs fulfil the product specifications of automotive industry, which vary from one vehicle manufacturer to the next. Thus, for instance, between 10,000 and 25,000 cycles are required for continuous operation.

Furthermore, BERU glow plugs must survive test runs in the cold chamber. In addition, tests are made on resistance to environmental influences, contact media, additives and engine cleaners.

4. SUBJECTED TO SPECIAL BERU TESTS

BERU glow plugs undergo special test runs that have been adapted to the practical requirements for everyday operation and for the workshop, for instance through simulation of connector pull-off forces or quick overload tests. The test personnel are unrelenting in these quick overload tests: Every test specimen must still be fully functional even after 3,000 cycles.

5. MANUFACTURED ACCORDING TO THE LATEST PRODUCTION METHODS

The manufacture of the extremely long and slim modern glow plugs for direct injection diesel engines brings particular challenges. The diameter of the glow tube must be exactly adapted to the combustion chamber. A precisely dimensioned length of the glow tube must project into the combustion chamber – only then can it be ensured that the turbulence will not generate any additional harmful emissions. The temperature properties of the glow plug must also be accurately suited to the combustion chamber design – and the current consumption of the glow plugs must be precisely adapted to the existing on-board power supply. Only the latest production facilities, such as those operating at BERU, provide the conditions for manufacturing these slim glow plugs to the desired quality.

Cheap designs – something you should do without

2-COIL OPTICS, BUT ONLY 1-COIL TECHNOLOGY

Only a 2-coil glow plug achieves the short heat-up time and temperature resistance demanded by car manufacturers. However, as the second coil is not immediately visible from the outside, some manufacturers spare themselves the so-called regulating coil. The lack of limitation of the glow current puts excessive stress on the battery during start – and since the required heating is not achieved within the prescribed time, the vehicle will not start, or only with difficultly.
(See Figure 3)

HEATING ROD FILLING USING LOW-QUALITY INSULATING POWDER

Instead of the magnesite powder that is used by BERU, which is compressed and dried before filling, cheap glow plugs normally employ loose, in some cases contaminated, insulating powder that is put in without drying.

Fatal consequence: During first glow process, the powder expands significantly, and the glow tube inflates. The glow plugs can then only be removed by disassembling the cylinder head!
(See Figure 9)

HEATING COIL NOT CENTERED AND CRIMPED AT THE CONNECTION PIN

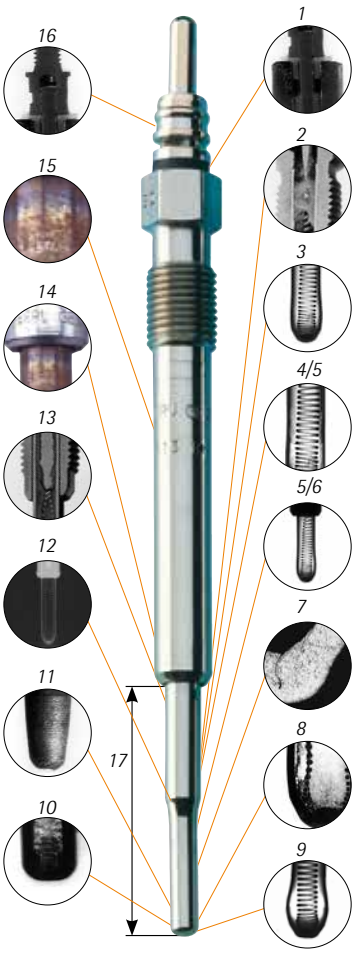
Production quality shows here as well: only the latest production machines can accurately center and crimp the connection pin. Dubious manufacturers manage by simply push fitting the heating coil onto the connection pin. However, the required protection against short-circuiting cannot be guaranteed in this manner. (For this, please see Figures 5 and 13)

DEFECTIVE CONTACT

In low quality glow plugs, the position of the electrical connection lugs does not comply with the OE specifications. Even though the connection looks similar to that of the original glow plugs, the contact will not be completed correctly. The electrical connection to the glow plug is thus not guaranteed. Some of these manufacturers also save on the material for the connecting components – at the cost of the electrical contact. (See Figure 16)

GLOW TUBE NOT ACCURATELY WELDED

Many cheap manufacturers do not have the production technology to accurately weld a glow tube. The result: Hairline cracks in the glow tubes – and thus leaks, which again could result in short-circuits.



How to recognize low-quality glow plugs

	Symptom	Risk
1	Single sealing	Not waterproof
2/9	Filling the glow tube with grade magnesium powder	Bad insulation, swelling of the Low glow tube
3	2-coil technology required, but only one coil installed	Profile of characteristics does not comply with the manufacturer's specification
4	Wall thickness not continuous	Glow plug blows
5	Coil in an inclined position in the glow tube	Short circuit
6	Glow tube not centered, thus no concentricity: The glow plug is in an inclined position in the antechamber or turbulence chamber	The glow plug is destroyed by the injection jet and burns
7	Heating rod with hairline cracks	Blowing
8/9	Heating rod tip is filled with not compressed and/or moist magnesium powder	Short circuit, inflation of the glow rod, reduced service life
10	Round end drilled on, not correctly welded through	Blowing

	Symptom	Risk
11	Glow tube tip twisted off, heating rod too thin	Scale deposits, reduced service life
12	Glow spiral not properly designed	Battery overload due to excessive current consumption, consequently risk of burning of the glow time control unit contacts: This reduces the service life or impairs the function
5/13	Glow coil mounted in inclined position	Short circuit
14	Cone does not correct fit for the cylinder head	Sealing problems, destruction of the cylinder head
15	Surface without surface coating	Seizing in the bore
16	Sleeve is only pushed	Loosening and interruption of current supply, loose contact
17	Pencil length not according to manufacturer's specifications	If pencil length is too long: glow plug is destroyed by the injection jet. If it is too short: start problems

Causes of failure in pencil type glow plugs

In warm and dry weather, a diesel engine will start even if one glow plug is defective and only the other plugs preheat. In such an event, there will usually be increased pollutant emission and possibly also knocking during start, however, the driver will not consciously notice these signs, or will not know how to interpret them. There will be a unpleasant surprise once the weather becomes cold and clammy, and the first night frost sets in: the „heating contribution" to the diesel engine fails to function, and the engine will at best start with difficultly and produce smoke– most probably, however, nothing will work at all. Below is a list of typical damage and the related causes. In most cases, it will be possible to correct a fault using this diagnostics aid.

HEATING ROD WITH FOLDS AND DENTS

Causes:
Coil interruption due to
a) operation at too high voltage, e.g. jump start
b) too long power supply due to a stuck relay
c) impermissible post-heating when engine is running
d) use of a non post-heating glow plug

Corrective action:
a) Jump start only at the voltage oft he on-board power supply.
b)/c) Check preheating system, replace glow time relay.
d) Install post-heating glow plugs.

HEATING ROD PARTIALLY OR FULLY MOLTEN OR BROKEN OFF

Causes:
Overheating of the heating rod due to
a) beginning of atomization too early
b) coked or worn nozzles
c) engine failure, e.g. because of piston jamming, valve breakage, etc.
d) dripping nozzles
e) seized piston ring

Corrective action:
a) Set injection timing point accurately.
b) Clean or replace injection nozzles
c) Check fuel jet profile.
d) Overhaul or replace injection nozzle
e) Ensure piston rings can move freely

HEATING ROD TIP DAMAGED

Causes:
Overheating of the heating rod due to
a) Atomization begins too early, and heating rod and heating coil are overheated during this; the heating coil becomes brittle and breaks.
b) closed annular gap between plug housing and heating rod; as a consequence, too much heat is deflected from the heating rod, the regulating

Corrective action:
a) Check injection system, set injection point accurately.
b) When screwing in a glow plug, always comply with the tightening torque specified by the vehicle manufacturer.

CONNECTING BOLT TORN OFF, HEXAGON DAMAGED

Causes:
a) Torn off connecting bolt: The current connecting nut was tightened with excessive torque.
b) Damaged hexagon: Use of incorrect tool; the plug is deformed and causes a short circuit from the housing to the round nut.

Corrective action:
a) Tighten current connecting nut with torque wrench. Always observe specified tightening torque. Do not lubricate or grease the thread.
b) Tighten plug with suitable torque socket wrench. Strictly comply with the specified torque (refer to specifications of the car manufacturers). Do not oil or grease the thread

Workshop tips

Glow plug test device: Testing without removing the plugs

Now, with the new BERU glow plug tester, you can test steel and ceramic glow plugs on vehicles with 12 volt on-board voltage, easily, quickly, and reliably - individually, and with no need to dismantle them or start the engine.

The new BERU glow plug quick tester offers many advantages for practice in the workshop:

- Reliable, fast and economical testing, because it is not necessary to remove the plugs or start the engine
- It is not necessary to pre-select the glow plug type (steel or ceramics)
- Automatic reconition of the glow plug voltage rating (from 3.3 – 15 volts)
- Testing under the actual conditions
- Easy to operate
- Possibility for testing each individual glow plug
- Analogue display for heating and current regulation (possibility for comparing individual glow plugs for current consumption and regulation performance)
- Protection against short circuits and polarity errors
- Protection against overload (monitoring of glow plug in addition via independent circuit)
- Test procedure controlled by characteristics curves as in electronics control equipment.
- Detection of loose contacts by processor, then a second check.
- Special microcontroller software integrated into the tester

There should be a BERU glow plug test device in every workshop.

Our tip:
Check the glow plugs with the BERU glow plug quick tester. Ideally, you should replace the entire glow plug set in the event of any defects or impaired function.

Experience shows that glow plugs mostly reach their wear limit shortly after one another – and once the connector leads and the conductor rails have been removed, it is cheaper to change the whole set than to have to replace further plugs only a short time later.

How to start a diesel engine quickly and reliably

The problem	The cause	BERU's solution
Fume during start, Smoke production	Glow plug with only one coil, too low temperature	Use BERU 2-coil technology glow plug (heating and regulating coil ensure that a higher temperature is reached during a shorter heat-up time)
Knocking during start phase	Glow plug without limiting effect and without heat reserve	Install BERU post-heating glow plugs for a better and quicker heat supply
Battery-depleting long start phase	Glow plug only heats up slowly, heat-up time too long	Install BERU GN glow plug that has accurately been adapted to the engine and the 3-phase glow system (pre-heating – start heating – post-heating)
Difficult and irregular running of engine	End temperature of glow plug too low	
Engine only starts running after several starting attempts	Glow plug defective	
Engine only starts running with production of unpleasant smells	The electrical values of the glow plugs have not been set appropriately	
The glow rod is slightly molten or scaled	The wall thickness of the heating rod is too small (this is often the case with cheap glow plugs)	
The glow rod is entirely melted	The injection nozzle is defective	Replace nozzle holder with BERU replacement nozzle holder assembly

Workshop tips

Torques

Important when replacing glow plugs: Keep to the torques!

Glow plug thread	Tightening torque
M 8	20 Nm
M 9	22 Nm
M 10	35 Nm
M 12	45 Nm

TIGHTENING TORQUE

Observe tightening torque when disassembling glow plugs.

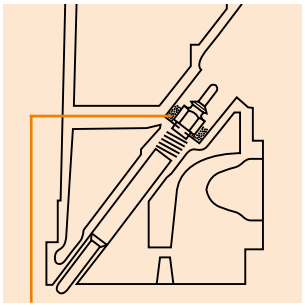
WHAT MUST I DO WHEN THE TIGHTENING TORQUE HAS BEEN REACHED?

Under no circumstances should you continue turning – the glow plug might otherwise break off. Instead, proceed according to the 3-point program: „Slightly loosen – Warm up – Unscrew“:

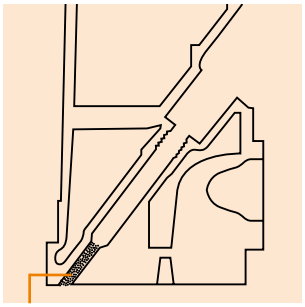
1. Slightly loosen: Apply a generous amount of synthetic oil to the glow plug thread and leave to act, if possible over night, or longer.
2. Warming up: Run engine until it is warm or use a separate cable to supply current to the functional glow plugs for 4-5 minutes (only possible for glow plugs with 11 – 12 V operating voltage) - the glow plug will heat up and burn loose.

3. Unscrew: Then try to unscrew it once again and carefully loosen the glow plug out of the cylinder head with a suitable tool. (Do not exceed the maximum loosening torque – see table above. Always stop before reaching the tightening torque, if necessary try once again by heating up.)

After the old glow plugs have been removed, always clean the thread, the conical seat and the glow plug channel in the cylinder head with suitable tools. (see below).



Now inject synthetic oil here.



These combustion residues can be removed with the BERU reamer.

Glow plug thread	Tightening torque
M 8	10 Nm
M 9	12 Nm
M 10	15 Nm
M 12	22 Nm

TIGHTENING TORQUE

When screwing in new glow plugs, the tightening torque stated by the vehicle manufacturer must be observed.

Note: The tightening torque of the connecting nut must also be observed for glow plugs with screwed connection.
In particular after baking (coking) between the glow rod and the cylinder head, the cylinder head bore is often soiled by residues from burning or dirt particles. Such coking can easily and safely be removed from cylinder heads with 10-mm threads – with the BERU reamer (RA003 - 0 890 100 003).

ONLY remove and fit glow plugs using a torque wrench.

Connecting nut thread	Tightening torque
M 4	2 Nm
M 5	3 Nm

BERU reamer: for a quick and reliable cleaning of the cylinder head bore

The BERU reamer – (RA003 – 0 890 100 003) loosens coking that might occur after „baking-on„ between glow plug and cylinder head.

AND THIS IS HOW IT'S DONE:

- Provisionally clean the glow plug bore with a cloth.
- Apply grease to cutting area of BERU reamer and screw it in the cylinder head: The combustion residues will stick to the grease and will be removed when unscrewing the tool.
- The new glow plug can then be mounted without any problem (please observe tightening torque again!).
- Before installing the glow plugs, grease the shaft and thread areas with GK grease (GFK01 – 0 890 300 034)

GKF01 - 0 890 300 034

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.

Perfection built in BERU®

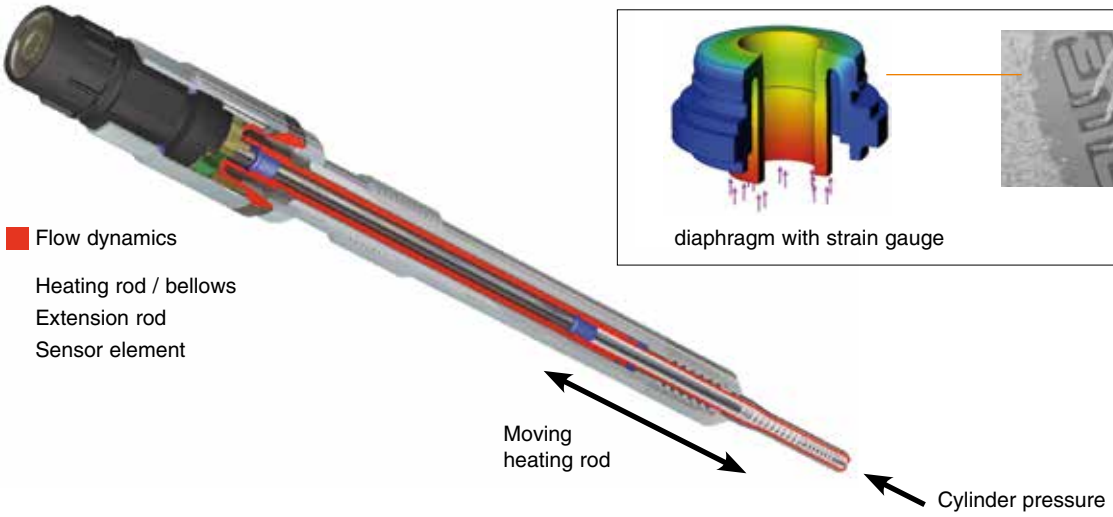
FEDERAL-MOGUL MOTORPARTS

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 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.



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 hund-red 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 major contribution to the sustainable protection of the environment.

EUREKA Lillehammer Award 2008.

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

Automechanika Innovation Award 2006.

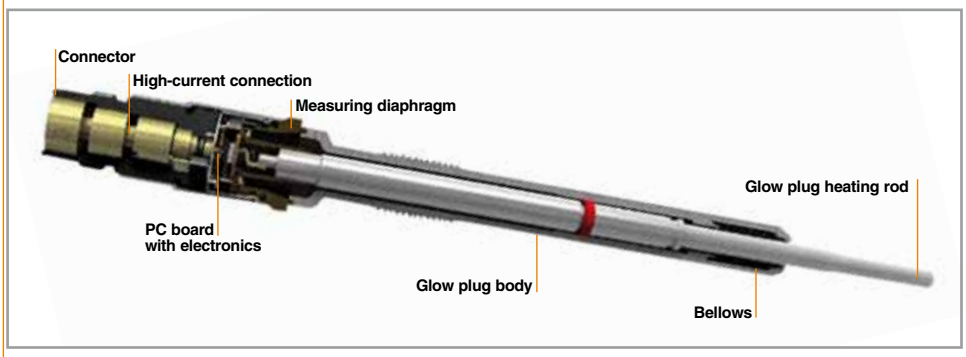
Grands Prix Internationaux – Equip Auto 2005.

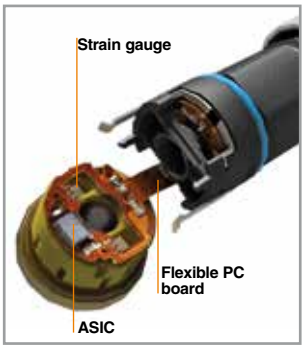
BERU was awarded the Gold Trophy at the Grands Prix Internationaux at Equipe Auto 2005 for its PSG in the "Engineering and Advanced Technologies" category - an accolade awarded only once every two years for special technical innovations.

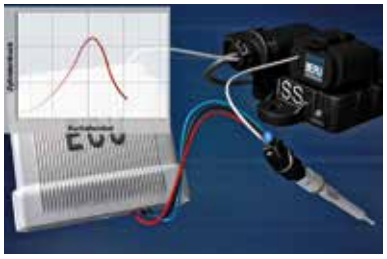
Gold Trophy– Equip Auto 2005.

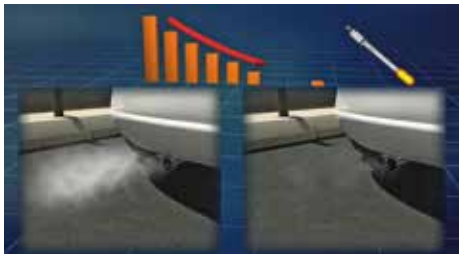
Design and function of the BERU PSG

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.



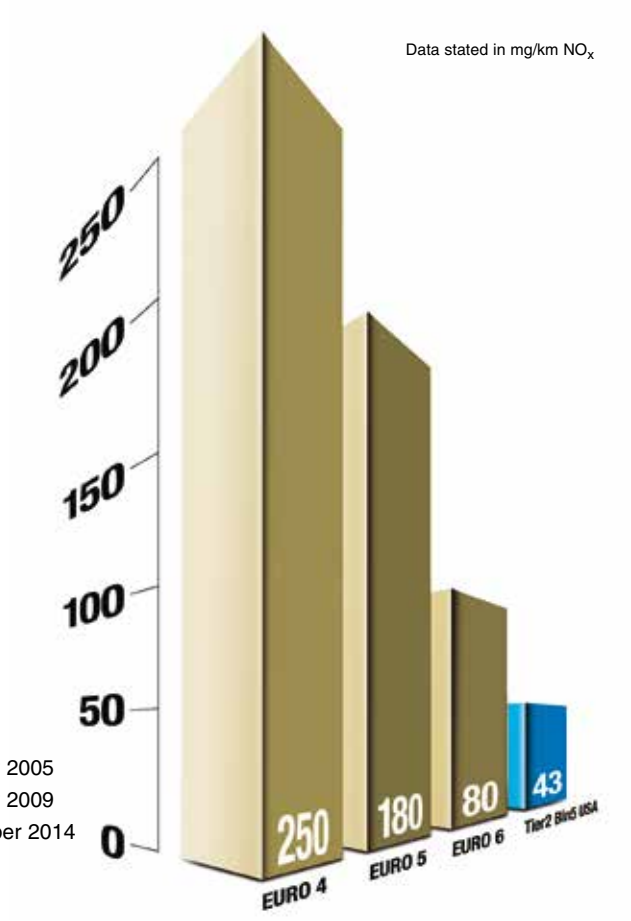






Technical features

- 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.

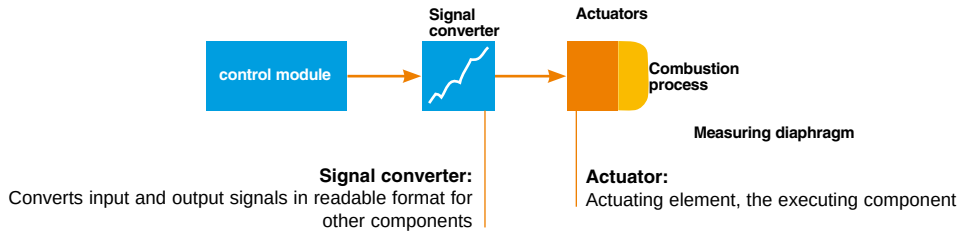
EURO 4: since 1st January 2005
EURO 5: since 1st January 2009
EURO 6: from 1st September 2014

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.

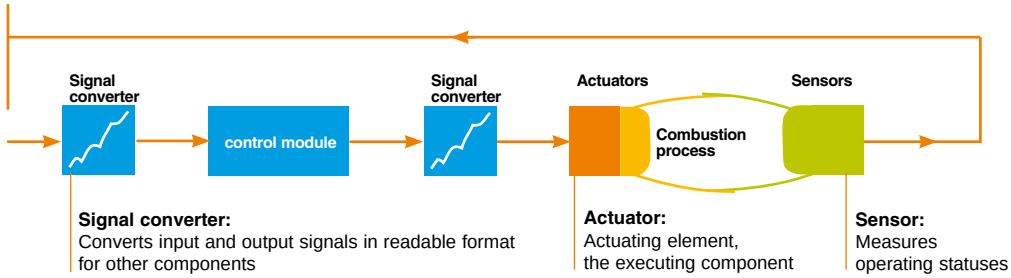
The Controller in the Open Loop System

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 variables 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 CO_2 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 and 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.

8

9

10

11

12

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.

1

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

2

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

3

... which is visible here in detail.

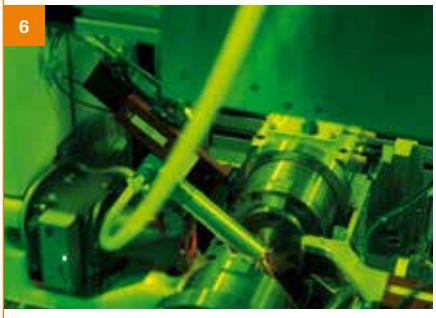
4

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

5

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

6



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

7

This manufacturing step is monitored by an imaging system.

8

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

9

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

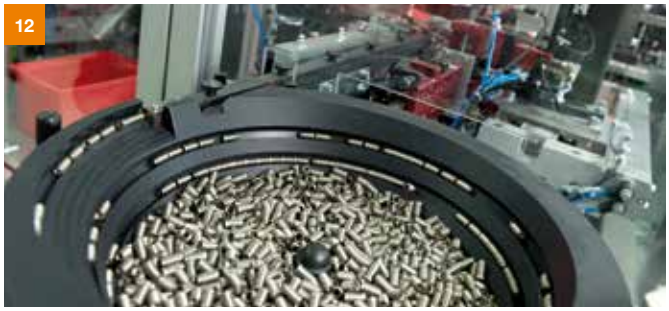
10

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.

11

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

12



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.

13

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

14

Then leak testing is performed.

15

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

16

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

17

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

BERU NEWSLETTER #6
CERAMIC GLOW PLUGS

BERU extends its Ceramic Glow Plug range

BERU Ceramic Glow Plugs for VW, Opel, Renault-Nissan now also available in our range for the aftermarket.

BERU is a trusted development partner to all leading automobile manufacturers. Wherever the cars of the future are being created, BERU is in demand as an expert in ignition technology.

Perfection built in BERU®

FEDERAL-MOGUL MOTORPARTS

BERU Ceramic Glow Plugs

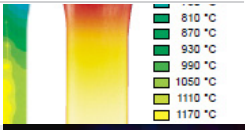
Modern engine designers are looking for solutions that make heat energy available when the engine would otherwise generate higher emissions due to excess cooling.

High requirements linked to refinement, low emissions and performance can result in poorer starting characteristics, something which the BERU ceramic glow plug can offer a solution for.

The forward looking BERU Ceramic Glow Plugs (CGP) fulfill these requirements – from rapid temperature rise to a high maximum temperature. At the same time they are characterized by high-durability and long life.

Technical features

- **Glow temperatures up to 1300°C**



- **Extremely rapid heat-up time in under 3 seconds to 1300°C**

- **Extended life time**

- **Exact measurement of the glow plug resistance**
- **Optimized close-loop control for pre-, intermediate and post-heating**
- **Reducing pollutant emissions due to improved combustion**

What makes BERU Ceramic Glow Plugs special?

Shorter heat up times than conventional ceramic glow plugs.

Particular design of the ceramic treating rod:

The heating element consists entirely of electrically conductive ceramic. Because its surface has a higher specific resistance than the material of the supply and return conductors, the glow rod only glows at the tip (cap) and thus reaches high temperatures more rapidly. The glow pin contact consists of an internal and external conductor separated by an insulator.

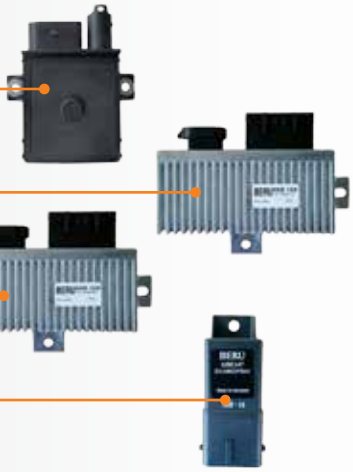
1 Heating section cap
2 Glow pin contact
3 Cap area
4 External conductor
5 Insulator
6 Internal conductor

Ready to order: 15 NPI's from BERU

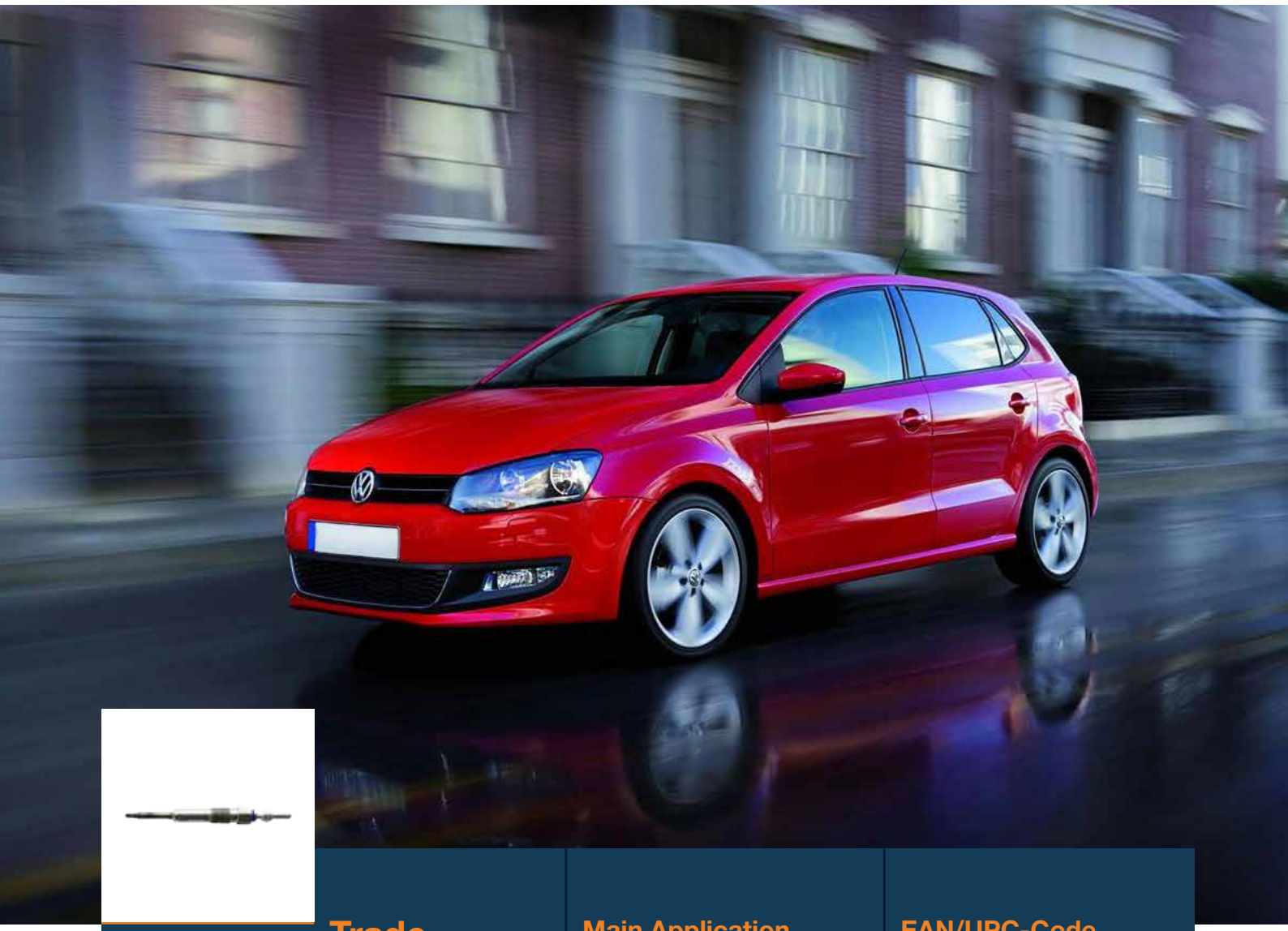
Ceramic Glow Plugs

Ignition coils

Glow Plug timer relay



Perfection built in BERU®



Trade Number
CGP002

Product group
Ceramic Glow Plug

OE Reference
N 105 916 04
N 105 916 08

Main Application
Audi: A3, A4

Seat: Alhambra, Altea, Cordoba, Ibiza, Leon, Toledo

Skoda: Fabia, Octavia, Roomster, Superb

Volkswagen: Crafter, Jetta, New Beetle, Passat, Polo, Sharan, Touareg, Transporter

Year
2004

EAN/UPC-Code
4044197848225

Dimension (mm)
97 x 12 x 9

Gross Weight (kg)
0,027

Net Weight (kg)
0,025

Trade Number
CGP003

Product group
Ceramic Glow Plug

OE Reference
N 105 798 03
N 105 798 05

Main Application
Audi: A3, A4, A6
Seat: Altea, Leon, Toledo
Skoda: Octavia
Volkswagen: Golf, Jetta, Passat, Touran

Year
2004

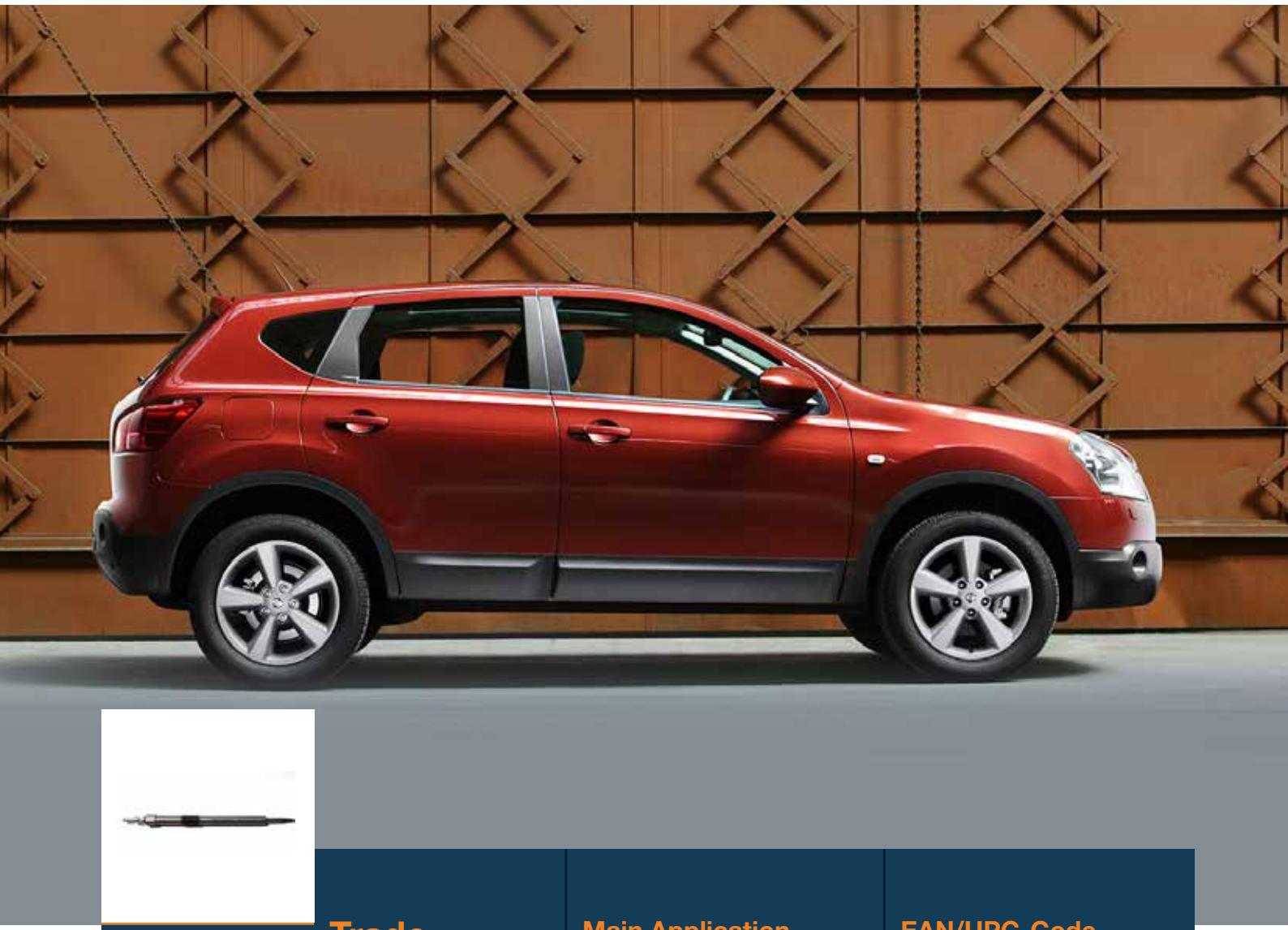
EAN/UPC-Code
4044197848249

Dimension (mm)
117 x 8 x 6

Gross Weight (kg)
0,022

Net Weight (kg)
0,019

Perfection built in BERU®



Trade Number
CGP007

Product group
Ceramic Glow Plug

OE Reference
Opel: 93198468
Nissan: 11065 5X00A
Renault: 82 00 561 251

Main Application
Opel: Movano Bus, Vivaro F7 CDTI

Nissan: Murano, Navara, Pathfinder, Qashqai, X-Trail CDI

Renault: Espace IV, Koleos, Trafic II Bus

Year
2007

EAN/UPC-Code
4044197848263

Dimension (mm)
163 x 11 x 9,5

Gross Weight (kg)
0,023

Net Weight (kg)
0,021

Trade Number
GSE104

Product group
Glow Plug timer relay

OE Reference
A 034 545 64 32

Main Application
Mercedes Benz: C-Class (W203) C30CDI AMG

Year
2002-2008

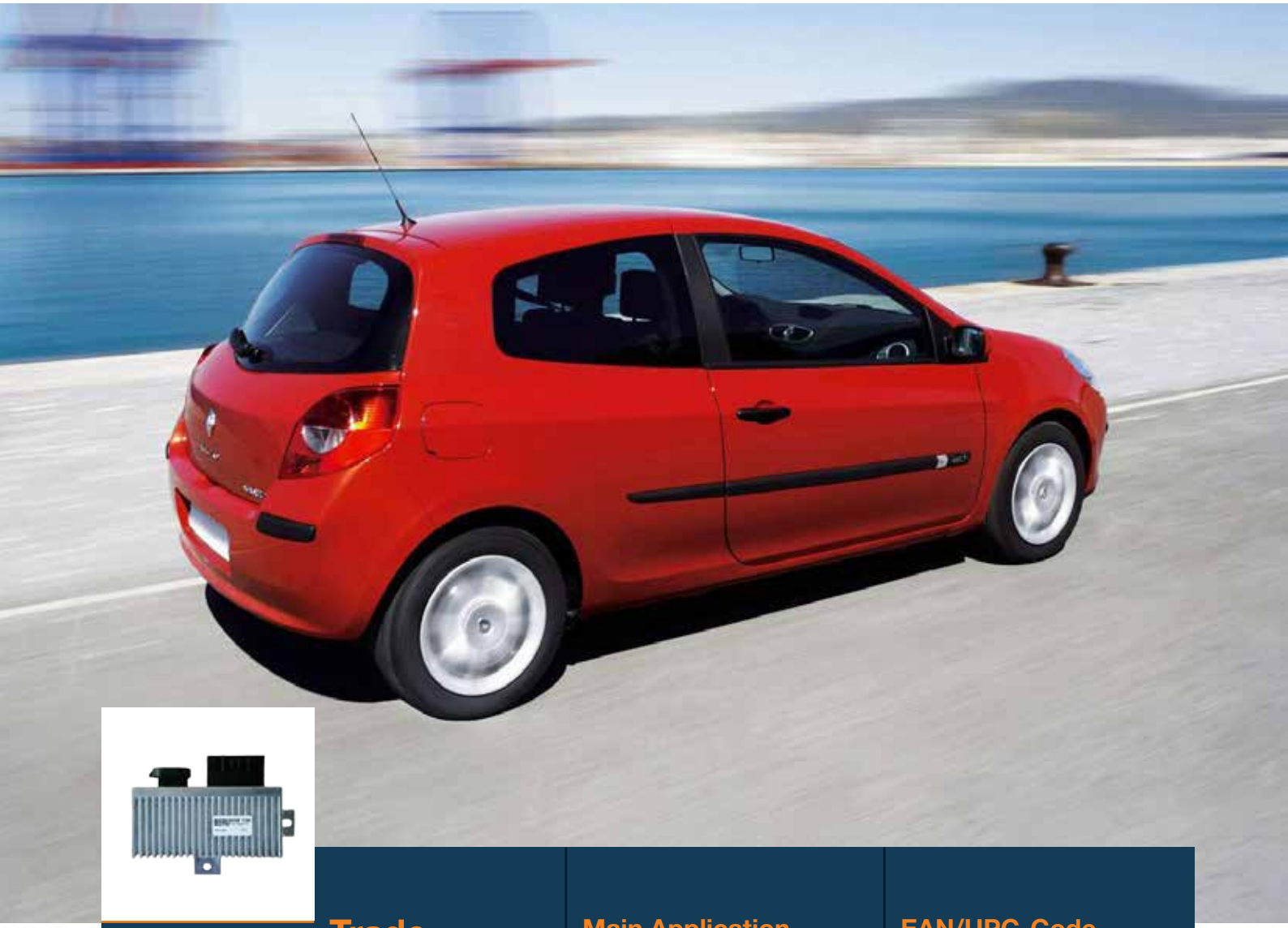
EAN/UPC-Code
4044197844142

Dimension (mm)
190 x 130 x 8

Gross Weight (kg)
0,336

Net Weight (kg)
0,250

Perfection built in BERU®



Trade Number
GSE128

Product group
Glow Plug timer relay

OE Reference
77 00 109 860

Main Application
Renault: Clio II, Kangoo

Year
1998-2005

EAN/UPC-Code
4044197844289

Dimension (mm)
210 x 100 x 70

Gross Weight (kg)
0,210

Net Weight (kg)
0,158

Trade Number
GSE129

Product group
Glow Plug timer relay

OE Reference
77 00 111 525

Main Application
Renault: Clio II, Laguna I

Year
1997-2005

EAN/UPC-Code
4044197844302

Dimension (mm)
210 x 100 x 70

Gross Weight (kg)
0,212

Net Weight (kg)
0,160

Perfection built in BERU®

Trade Number
GSE147

Product group
Glow Plug timer relay

OE Reference
9640469680

Main Application
Citroën: Berlingo
Ford: Focus II, Fiesta V
Mazda: Mazda 2
Opel: Movano, Vivaro
Renault: Trafic II Bus

Year
2001

EAN/UPC-Code
4044197844166

Dimension (mm)
105 x 100 x 40

Gross Weight (kg)
0,105

Net Weight (kg)
0,076

Trade Number
GSE148

Product group
Glow Plug timer relay

OE Reference
598120

Main Application
Citroën: XM

Peugeot: 605

Year
1989-2000

EAN/UPC-Code
4044197844180

Dimension (mm)
210 x 100 x 70

Gross Weight (kg)
0,216

Net Weight (kg)
0,154

Perfection built in BERU®

Trade Number
GSE149

Product group
Glow Plug timer relay

OE Reference
598131

Main Application
Citroën: Berlingo, C2, C3, C5I, Evasion, Jumper, SAXO, XANTIA, XSARA Break, Picasso

Peugeot: 106, 206, 306, 406, 605, 607, 806, 807, Boxer Box, Bus, EXPERT, Partner Box

Year
1994

EAN/UPC-Code
4044197844203

Dimension (mm)
210 x 100 x 70

Gross Weight (kg)
0,204

Net Weight (kg)
0,142

Trade Number
GSE151

Product group
Glow Plug timer relay

OE Reference
047L907282

Main Application
Audi: A3, A4 Avant, A5, A6 Avant, A8 4,2 TDI quattro, Q5 2,0 TDI quattro

Seat: Alhambra, Leon

Skoda: Octavia

Volkswagen: Beetle, Golf Sportsvan, Golf V, VII, Passat TDI , Sharan TDI, Transporter V Box

Year
2003-

EAN/UPC-Code
4044197844241

Dimension (mm)
105 x 100 x 40

Gross Weight (kg)
0,083

Net Weight (kg)
0,053

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Trade Number
GSE152

Product group
Glow Plug timer relay

OE Reference
038907281D

Main Application
Audi: A1, A3, Q3 TDI quattro

Seat: Alhambra TDI, Altea, Ibiza IV, V, Leon, Toledo III

Skoda: Fabia TDI, Fabia Combi, Octavia, Superb, Yeti,

VW: Amarok, Caddy III Box, EOS, Golf V, Passat, Polo, Scirocco, Tiguan, Touran

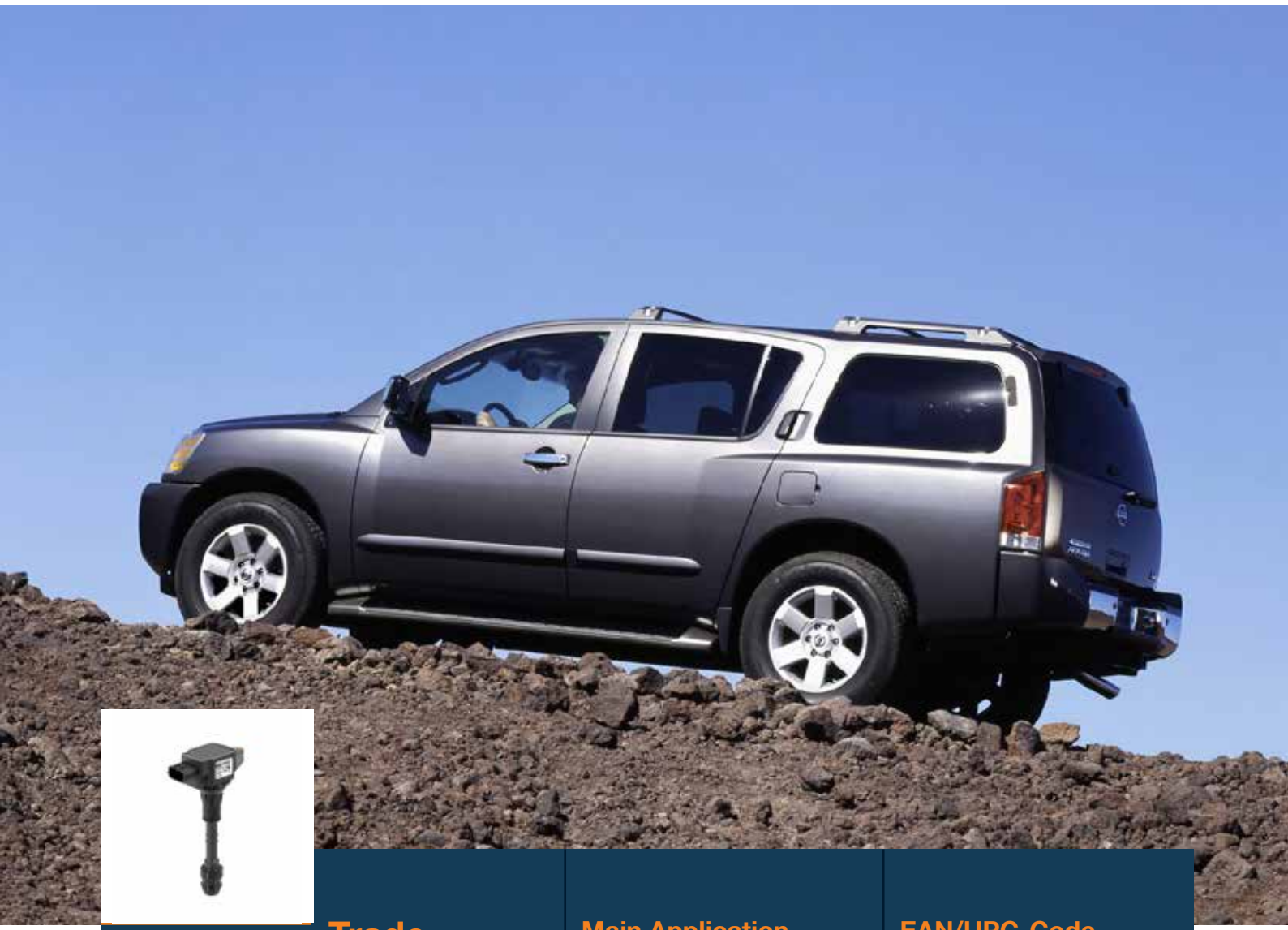
Year
2003

EAN/UPC-Code
4044197844265

Dimension (mm)
105 x 100 x 40

Gross Weight (kg)
0,097

Net Weight (kg)
0,067



Trade Number
ZSE156

Product group
Ignition Coils

OE Reference
22448-ZE00C

Main Application
Nissan: Armada, Titan

Year
2003

EAN/UPC-Code
4014427141501

Dimension (mm)
172 x 94 x 73

Gross Weight (kg)
0,230

Net Weight (kg)
0,190

Perfection built in BERU®

Trade Number
ZSE157

Product group
Ignition Coils

OE Reference
22448-AR215

Main Application
Infiniti: FX45, M45, Q45

Year
2003-2008

EAN/UPC-Code
4014427141518

Dimension (mm)
172 x 94 x 73

Gross Weight (kg)
0,220

Net Weight (kg)
0,180

Trade Number
ZSE158

Product group
Ignition Coils

OE Reference
22448-JA10C

Main Application
Infiniti: EX35, M35, Q50

Nissan: 350 Z, Roadster, Altma, Murano, Tena II

Renault: Laguna III, Latitude 2,5 V6

Year
2008

EAN/UPC-Code
4014427141525

Dimension (mm)
172 x 94 x 73

Gross Weight (kg)
0,230

Net Weight (kg)
0,190

Perfection built in BERU®

Trade Number
ZSE159

Product group
Ignition Coils

OE Reference
12570616

Main Application
Cadillac: CTS 5,7 V8, Escalade

Chevrolet: Avalanche, Camaro, Corvette, Silverado 1500, Trailblazer

Year
2009

EAN/UPC-Code
4014427141532

Dimension (mm)
172 x 94 x 73

Gross Weight (kg)
0,310

Net Weight (kg)
0,270

In this BERU Newsletter

Ignition Technology

Spark Plugs

- Ultra
- Ultra X Titan
- Platin

Ignition Coils

- Distributor Ignition Coils
- Pencil Coils/Plug Top Coils
- Block Ignition Coils
- Ignition Coil Rails

Ignition Leads & Components

Diesel Cold Start Technology

Glow Plugs

- Post heating (GN)
- Post heating electrical (GE)
- Ceramic Glow Plugs

Pressure Sensor Glow Plugs (PSG)

Instant Start System (ISS)

Also available from BERU

Cooling

- Fan wheels
- Fan Clutches
- Elelctrical Fans

Sensors

- Oxygen
- High-temperature
- Speed, Oil and Temperature

Perfection built in BERU®

BERU NEWSLETTER #7
PRESSURE SENSOR GLOW PLUGS

New BERU Pressure Sensor Glow Plug 007 for the VW AG group

BERU, the first and only manufacturer to supply PSG in series production.

Discover also **18** new Ignition Coils for more than **420** applications

BERU is a trusted development partner to all leading automobile manufacturers. Wherever the cars of the future are being created, BERU is in demand as an expert in ignition technology.

Perfection built in BERU®

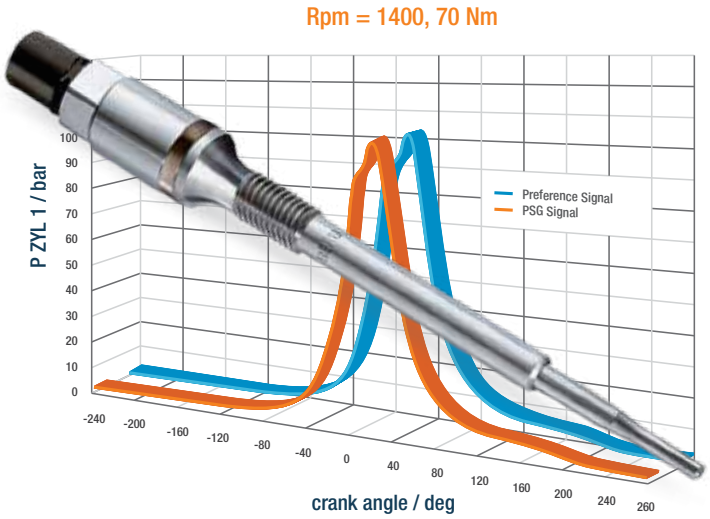
FEDERAL-MOGUL MOTORPARTS

Innovative pressure sensor glow plug

With the world's first glow plug to enable the regulation of the combustion processes inside a closed loop system 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.

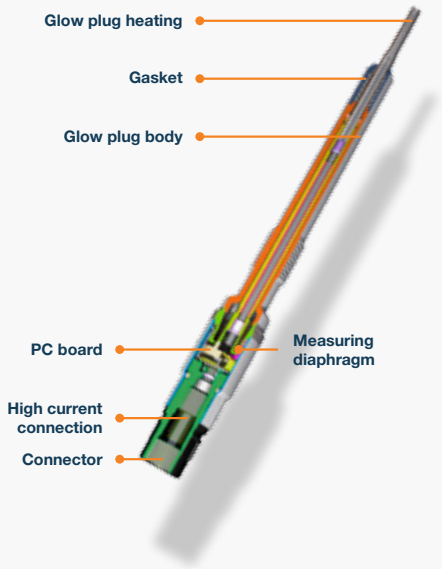
Future of cold start technology

The BERU PSG is an intelligent glow plug with integrated combustion chamber pressure sensor which reports data to the engine control electronics. Injection is adjusted to the actual combustion in real time.



Technical features

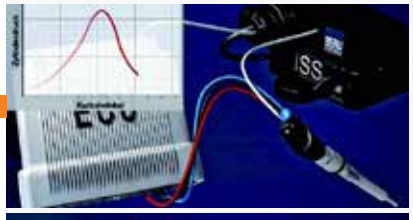
- **Sensor principle: piezo-resistive**
- **Moving heating rod to transfer the pressure**
- **Robust sealing element between body and heating rod**
- **Miniaturised electronics integrated into top part of the glow plug**
- **Calibrated and programmed to customer specifications**
- **Integral concentric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



Benefits at a glance

1. Cylinder pressure can be recorded up to 200 bar, accurate to +/- 2% and with a resolution up to 700 steps per combustion cycle.
2. The ECU is able to constantly adapt the fuel injection, the charge pressure and the exhaust gas recycling rate.
3. Ignition can be optimised to each cylinder
4. Improves cold starts and cold running quality.
5. Enables optimum torque control
6. Higher engine performance with limited emission of pollutants, soot particles and nitrogren oxides
7. "Closed loop" method introduced into the Diesel Engines

1



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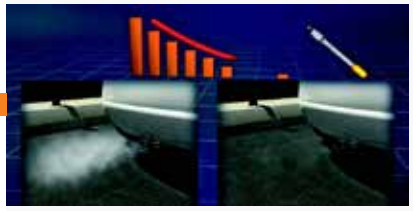


7

Ready to order: 19 NPI's from BERU

Glow Plugs
Pressure Sensor Glow Plugs

PSG007
Page 04

Ignition coils

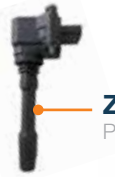
Distributor Ignition Coils

ZSE177
Page 05

ZS445
Page 06

Plug Top Coils

ZSE160
Page 07



ZSE163
Page 08

ZS446
Page 09

ZS453
Page 10

ZS473
Page 11

ZSE093
Page 12

ZSE094
Page 13

Block Ignition Coils

ZSE025
Page 14

ZSE162
Page 15

ZS447A
Page 16

ZS454
Page 17

ZS455
Page 18

ZS456
Page 19

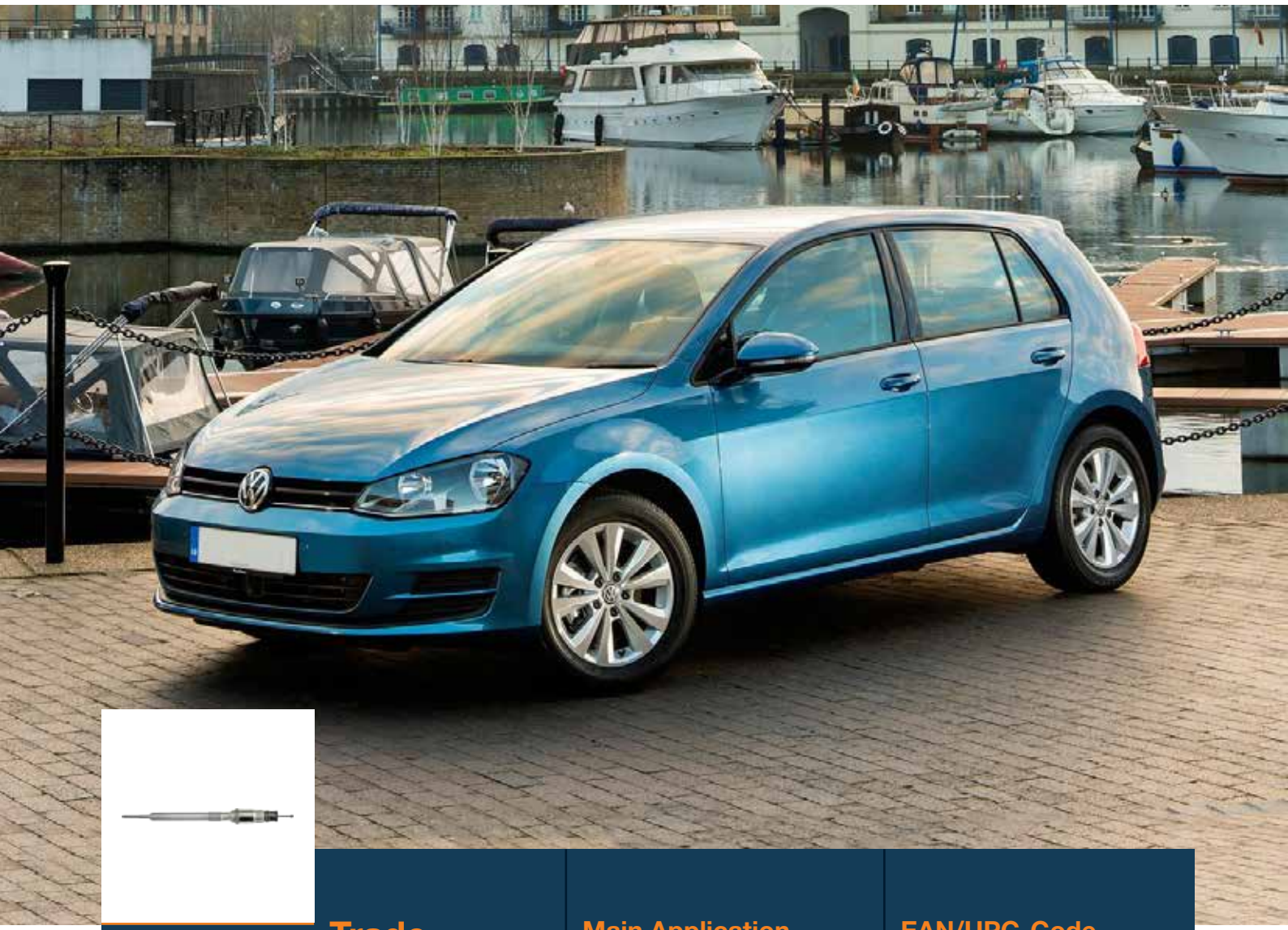
ZS469
Page 20

ZS470
Page 21

Ignition Coil Rails

ZS452
Page 22

Perfection built in BERU®



Trade Number

PSG007

replaces PSG002

Product group

Pressure Sensor Glow Plugs

OE Reference

03L905061G
03L905061F
03L905061E
03L905061D

Main Application

Audi: A1, A3
(Audi A1 2015→)
(Audi A3 2013→)

Seat: Ibiza
(2016→)

Skoda: Octavia
(2013→)

Volkswagen: Golf, Sharan, Tiguan
(Golf 2014→)
(Sharan 2016→)
(Tiguan 2012→)

EAN/UPC-Code

4044197858545

Dimension (mm)

260 × 34 × 37

Gross Weight (kg)

0,079

Net Weight (kg)

0,055

Trade Number
ZSE177

Product group
Distributor Ignition Coils

OE Reference
12 558 693

Main Application
Chevrolet:
Silverado 2500 6,0 AWD,
TAHOE 4,8 V8-6,0 V8
(1999→2006)

Hummer: H2 SUT
(1999→2006)

EAN/UPC-Code
4044197844128

Dimension (mm)
82 × 75 × 80

Gross Weight (kg)
0,275

Net Weight (kg)
0,250

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Trade Number
ZS445

Product group
Distributor Ignition Coils

OE Reference
9091902197

Main Application
Lexus: GS, LS (1993→2000)

Toyota: 4 Runner, MR2 II (1989→1995)

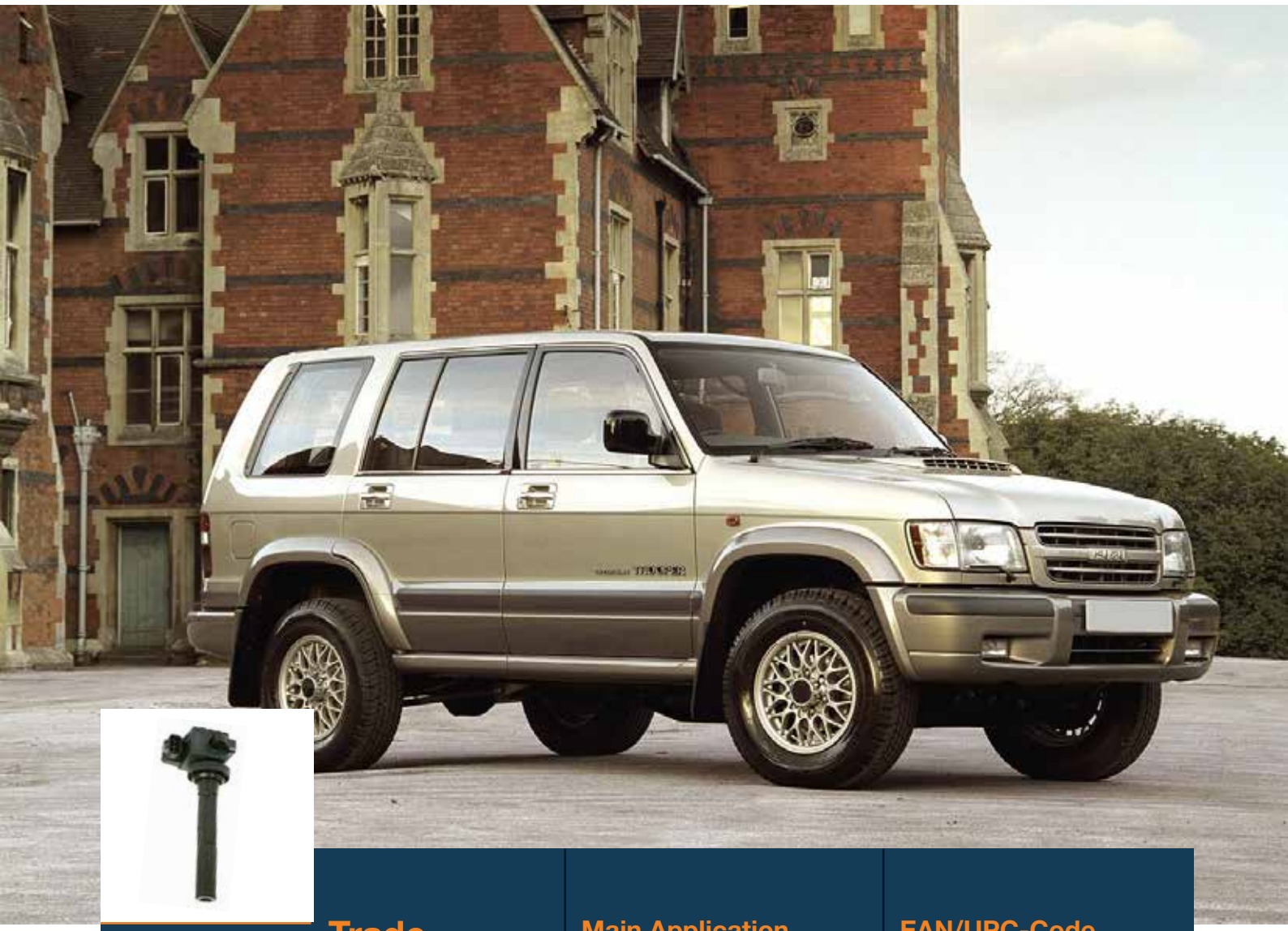
Volkswagen: Taro 2,4i 4x4 (1989→1997)

EAN/UPC-Code
4014427139805

Dimension (mm)
83 × 72 × 127

Gross Weight (kg)
0,494

Net Weight (kg)
0,448



Trade Number
ZSE160

Product group
Plug Top Coils

OE Reference
8971363250

Main Application
Honda: Acura SLX V6, Passport V6 (1998→1999)

Isuzu: Amigo, Rodeo, Trooper V6 (1998→2001)

ONLY FOR EXPORT USA

EAN/UPC-Code
4014427141549

Dimension (mm)
222 × 80 × 73

Gross Weight (kg)
0,280

Net Weight (kg)
0,240

Perfection built in BERU®

Trade Number
ZSE163

Product group
Plug Top Coils

OE Reference
946 602 104 00

Main Application
Porsche:
Macan 3,0S;
Macan 3,6 Turbo
(2014→)

EAN/UPC-Code
4044197771752

Dimension (mm)
53 × 34 × 23

Gross Weight (kg)
0,320

Net Weight (kg)
0,260

Trade Number
ZS446

Product group
Plug Top Coils

OE Reference
1275971

Main Application
Volvo: 940 (944) 2,0 Turbo, 960 II, C70I Convertible, S40 I+II, S90, V90 Estate (1990→)

EAN/UPC-Code
4014427139829

Dimension (mm)
98 × 200 × 90

Gross Weight (kg)
0,258

Net Weight (kg)
0,196

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Trade Number
ZS453

Product group
Plug Top Coils

OE Reference
04606869AB
04606869AC

Main Application
Chrysler: 300 C (2003→2012)

Dodge: Avenger, Journey (2007→)

Fiat: Freemont (2011→)

Volkswagen: Routan (2008→2010)

EAN/UPC-Code
4014427141143

Dimension (mm)
84 × 64 × 196

Gross Weight (kg)
0,281

Net Weight (kg)
0,182

Trade Number
ZS473

Product group
Plug Top Coils

OE Reference
90919-02212

Main Application
Toyota: Land Cruiser 90, 4 Runner 3,4i (1995→)

EAN/UPC-Code
4014427142140

Dimension (mm)
188 × 110 × 92

Gross Weight (kg)
0,384

Net Weight (kg)
0,295

Perfection built in BERU®

Trade Number
ZSE093

Product group
Plug Top Coils

OE Reference
(A)2769060260
(A)2721500280
(A)2761500080
(A)2769060160

Main Application
Mercedes: C-Class (W204), E-Class (W212), G-Class (W463) M-Class (W166), S-Class (W222) (2011→)

EAN/UPC-Code
4044197749348

Dimension (mm)
210 × 100 × 90

Gross Weight (kg)
0,326

Net Weight (kg)
0,250

Trade Number
ZSE094

Product group
Plug Top Coils

OE Reference
(A)2769065100
(A)2769064500

Main Application
Mercedes:
GL-Class (X166) GL 400 4-matic,
M-Class (W166) ML400 4-matic
(2011→)
ONLY FOR ETHANOL-FUEL (E85)

EAN/UPC-Code
4044197749355

Dimension (mm)
210 × 100 × 90

Gross Weight (kg)
0,328

Net Weight (kg)
0,252

Perfection built in BERU®

Trade Number
ZSE025

Product group
Block Ignition Coils

OE Reference
96350585
10450424
10490192
1104038
8-01104-038-0
1208051

Main Application
Opel: Frontera 2,2i (1998→)

Daewoo: Lanos, Lengaza, Nubira 1,4i-2,0i (1997→)

EAN/UPC-Code
4014427077404

Dimension (mm)
210 × 120 × 90

Gross Weight (kg)
1,060

Net Weight (kg)
0,979

Trade Number
ZSE162

Product group
Block Ignition Coils

OE Reference
058905101A

Main Application
Audi: A4, A6, A6 Avant (1995→2001)

Volkswagen: Passat, Passat Variant (1996→2005)

EAN/UPC-Code
4014427141914

Dimension (mm)
228 × 160 × 113

Gross Weight (kg)
1,290

Net Weight (kg)
1,170

Perfection built in BERU®

Trade Number
ZS447A

Product group
Block Ignition Coils

OE Reference
96253555
25182496
96253555

Main Application
Chevrolet:
Aveo Hatchback, Captiva, Kalos, Lacetti, Matiz, Nubira Estate (2005→)

Daewoo: Evanda, Kalos, Lacetti, Lanos Saloon, Matiz, Nubira, Rezzo (1997→)

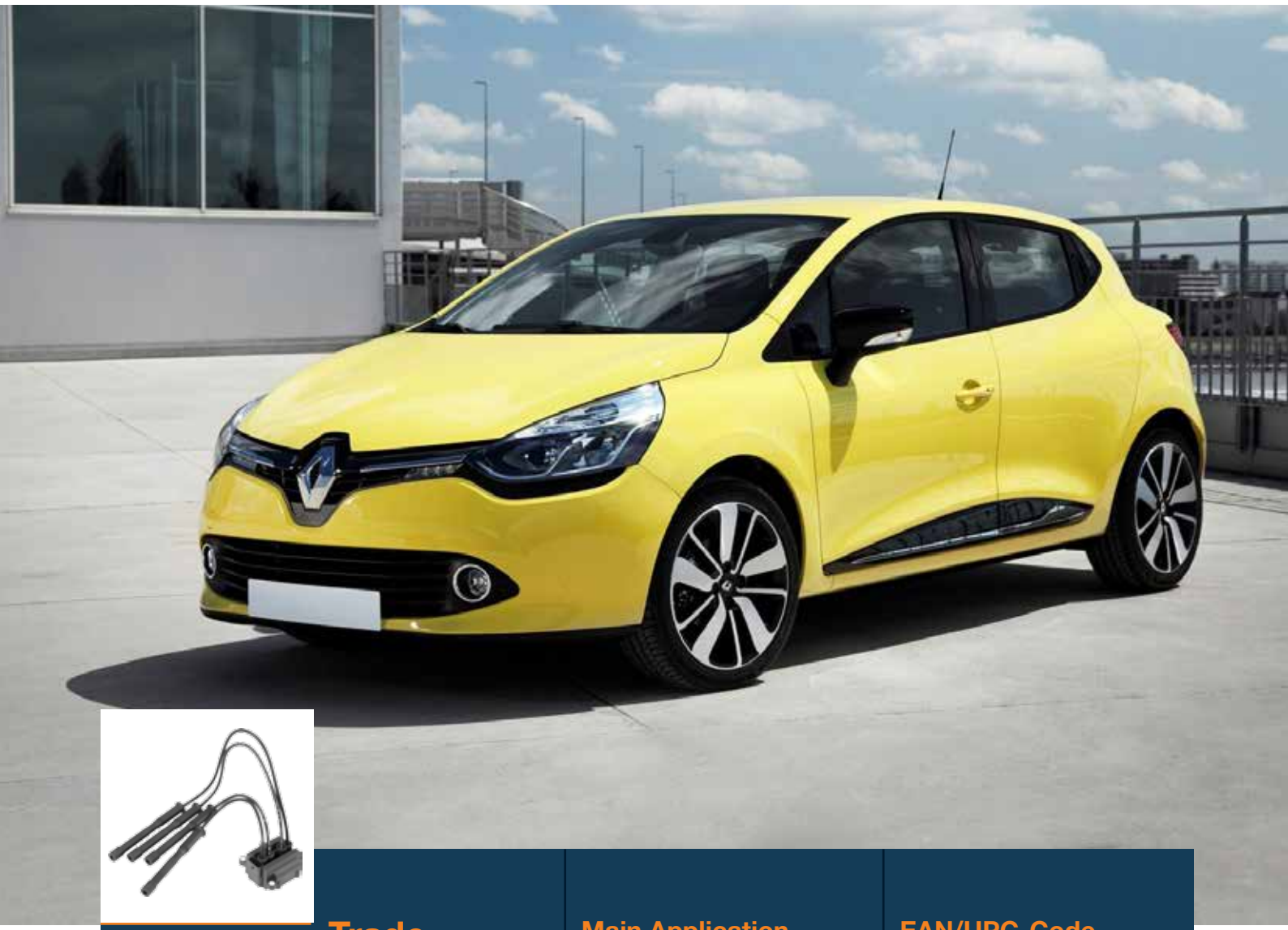
Opel: Antara 4x4 (2006→)

EAN/UPC-Code
4014427139836

Dimension (mm)
130 × 98 × 100

Gross Weight (kg)
0,841

Net Weight (kg)
0,783



Trade Number
ZS454

Product group
Block Ignition Coils

OE Reference
8200084401
8200051128

Main Application
Proton: Savvy (2005→)

Renault: Clio, Kangoo, Thalia, Twingo (2001→)

EAN/UPC-Code
4044197743285

Dimension (mm)
320 × 170 × 140

Gross Weight (kg)
1,025

Net Weight (kg)
0,942

Perfection built in BERU®

Trade Number
ZS455

Product group
Block Ignition Coils

OE Reference
56032520AB
56032520AC
56032520AE
56032520AF

Main Application
Chrysler: Grand Voyager, Town & Country, Voyager III/IV (2000→2008)

Dodge: Caravan (2000→2007)

Jeep: Wrangler II/III (2006→2007)

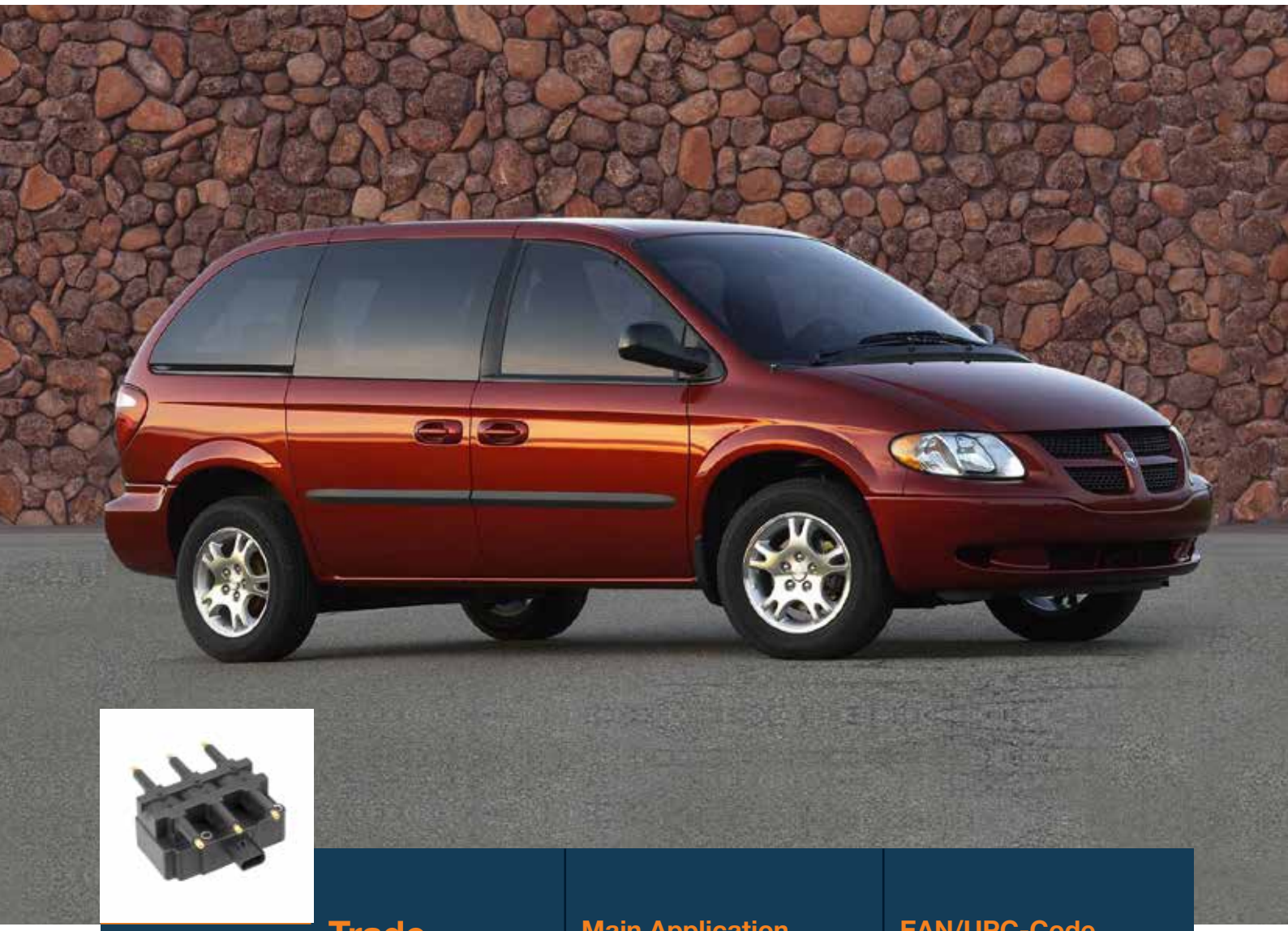
Volkswagen: Routan (2008→2010)

EAN/UPC-Code
4014427141150

Dimension (mm)
154 × 137 × 72

Gross Weight (kg)
1,542

Net Weight (kg)
1,404



Trade Number
ZS456

Product group
Block Ignition Coils

OE Reference
56029098AA
56029098AB

Main Application
Chrysler: Voyager IV (2000→2008)

Dodge: Caravan (2000→2007)

Jeep: Wrangler II/III (2006→)

EAN/UPC-Code
4014427141167

Dimension (mm)
154 × 137 × 72

Gross Weight (kg)
1,500

Net Weight (kg)
1,368

Perfection built in BERU®

Trade Number
ZS469

Product group
Block Ignition Coils

OE Reference
NEC 100630

Main Application
Land Rover: Freelander 4x4 (1998→2006)

Rover: 100/Metro, 200, 25, 400, Cabriolet, Coupe (1990→2005)

EAN/UPC-Code
4014427140955

Dimension (mm)
157 × 115 × 105

Gross Weight (kg)
0,921

Net Weight (kg)
0,822

Trade Number
ZS470

Product group
Block Ignition Coils

OE Reference
4609140AB
4609140

Main Application
Chrysler: Voyager III/IV (1999→2008)
Dodge: Caravan (1995→2007)

EAN/UPC-Code
4014427140962

Dimension (mm)
157 × 115 × 105

Gross Weight (kg)
1,407

Net Weight (kg)
1,306

Perfection built in BERU®

Trade Number
ZS452

Product group
Ignition Coil Rails

OE Reference
56041476AA
56041019
56041476AB

Main Application
Jeep: Cherokee 4,0 i, Grand Cherokee I+II 4,0i, Wrangler (1991→2006)

EAN/UPC-Code
4014427141136

Dimension (mm)
692 × 182 × 102

Gross Weight (kg)
2,115

Net Weight (kg)
1,810

Diesel Cold Start Technology

Glow Plugs

- Post heating (GN)
- Post heating electrical (GE)
- Ceramic Glow Plugs

Pressure Sensor Glow Plugs (PSG)

Instant Start System (ISS)

Ignition Technology

Spark Plugs

- Ultra
- Ultra X Titan
- Platin

Ignition Coils

- Distributor Ignition Coils
- Pencil Coils/Plug Top Coils
- Block Ignition Coils
- Ignition Coil Rails

Ignition Leads & Components

Also available from BERU

Cooling

- Fan wheels
- Fan Clutches
- Elelctrical Fans

Sensors

- Oxygen
- High-temperature
- Speed, Oil and Temperature

Perfection built in BERU®

High-tech BERU Glow Plugs, pre-, start and post-glowing (type GE, type GN)

Diesel starting is now quicker, more reliable and more environmentally friendly.

BERU Systems is one of the leading manufacturers of glow plugs in the world — and inventor of numerous innovations in Diesel cold start technology

The latest diesel car engines are equipped with the innovative three-phase glow technology (pre-heating — heating during starting — post-heating). This means: the glow plug not only heats prior to and during the starting phase, but also up to 180 seconds after starting. This protects the environment and the engine.

The BERU 3-phase glow plugs are available in both the GE and GN type.

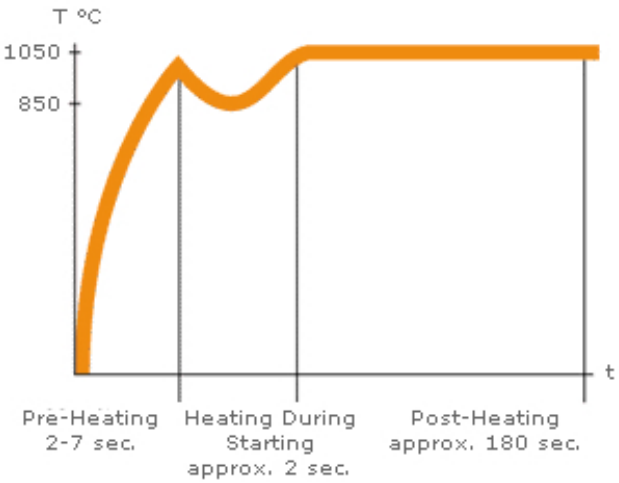
GE and GN glow plugs in 2-coil technology have not only a heating coil to maintain the optimal heating temperature, but also have a regulator coil that effectively protects the glow plug from overheating. In this way BERU glow plugs are extremely reliable and durable.

The GE glow plug is a performance-optimised, controlled glow plug used in engines of the latest generations. The fast heating of the glow plug and the controlled operation are provided by a programmable microcontroller in the glow time control unit.

BERU Slim Line — the slim, rapid high-tech glow plug that post-heats.

Technical Features

- Super quick start glow plugs in new, slim shape
- Extremely short pre-heating time: from 2 seconds
- Reliable starting (even at -30 °C!)
- Can be used for post-heating, as a result environmentally friendly: up to 40% less pollutant emissions during the warm up phase
- No more cold start knocking
- Quieter engine running
- Protects the engine during starting



The function

Pre-heating starts with the operation of the ignition switch and, at normal outdoor temperatures, continues until the engine is ready to start, 2-7 seconds. The difference to previous heating technology is that the glow plugs continue to be heated for approx. 3 minutes after the engine is started.

The advantages

Due to the post-heating, during the warm up phase the diesel fuel is burnt more fully and with less noise. In this way, clouding of the exhaust gas is reduced by up to 40%. The engine runs quieter from the beginning on, and the exhaust gas emissions are considerably reduced. Due to the quieter engine running during the starting phase, the life of the engine is improved.

Our Tip

Every 75,000 to 100,000 km (45,000 to 60,000 miles), the glow plugs should be tested with a glow plug quick tester (it is not necessary to remove the plugs for this test). This ensures reliable diesel starting also at low temperatures.