

Technical  
Information



# All about glow plugs

Diesel Cold Start Technology



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# 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:

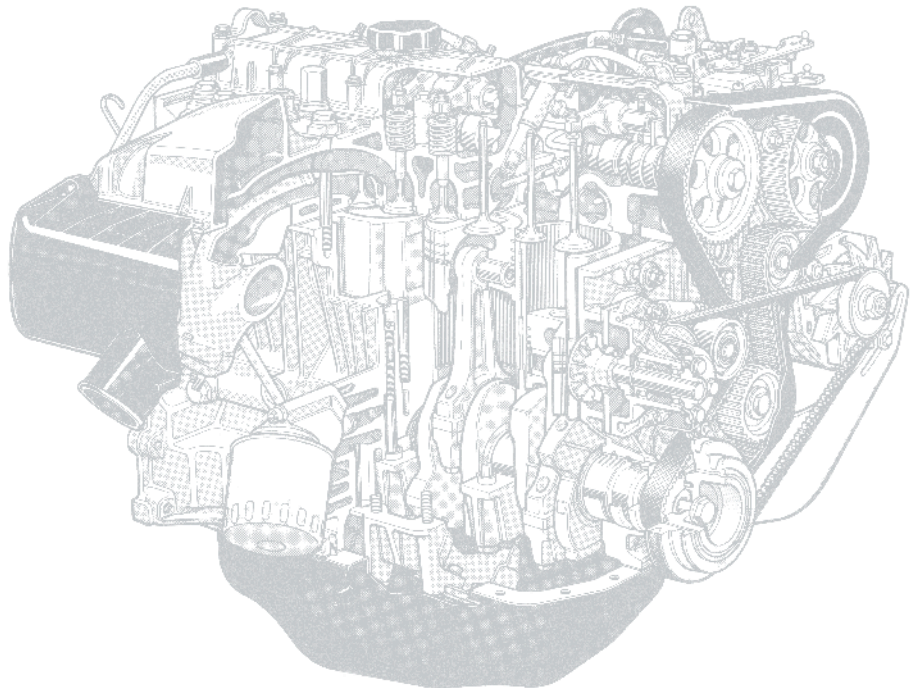
1. First, clean air is taken in.
2. This air is compressed to 30–55 bar – during this process, it will heat up to 700–900 °C.
3. Diesel fuel is injected into the combustion chamber. The high temperature of the compressed air triggers auto-ignition, internal pressure strongly increases and the engine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

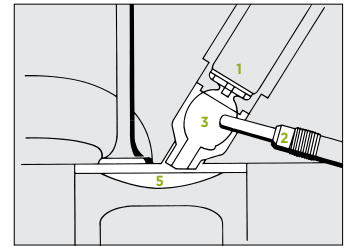
1. Antechamber system
2. Turbulence chamber process
3. Direct injection

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

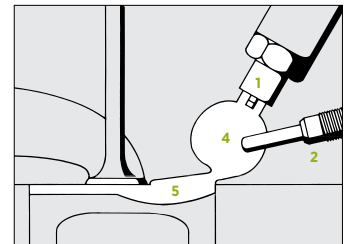
**In this system, the combustion chamber is divided into two:**

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.



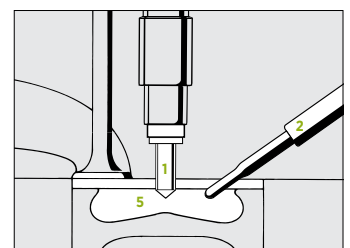
### TURBULENCE CHAMBER PROCESS

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.



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

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.

# 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

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, BorgWarner 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 and mixture 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 BorgWarner fulfill all these requirements in an optimal manner. BorgWarner 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).

However, even after a cold start and warm-up phase, glow plugs are still active in modern diesel engines. With the so-called intermediate glow, the innovative glow plugs from BorgWarner ensure that the exhaust gas temperatures do not drop too far, even in stop/start and overrun operation. This ensures low-noise and low-emission combustion in every engine operating condition. At the same time, soot deposits in the diesel particulate filter and the exhaust gas recirculation valve are reduced. The ISS glow plugs from BorgWarner, for example, offer long glow times of 5-8 minutes in conjunction with high temperature resistance and long service life.



# Self-regulating pencil type glow plugs

## Design and function

The BorgWarner 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.

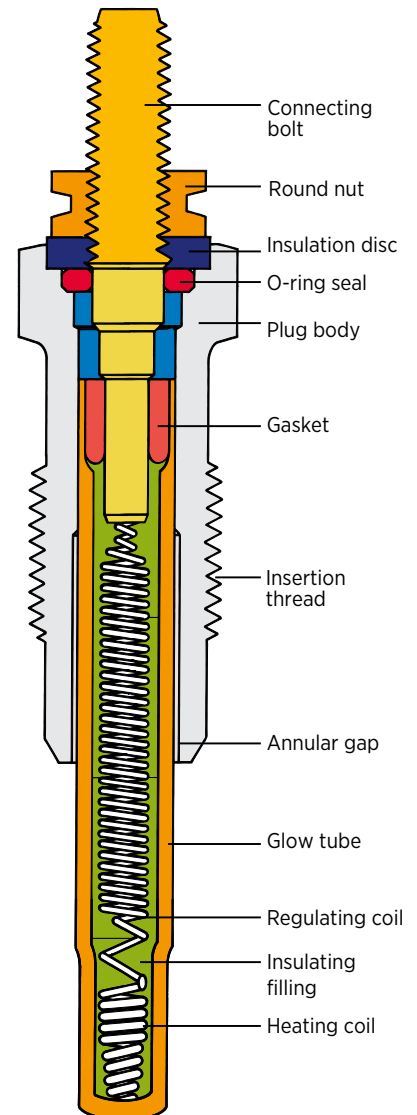
With the different materials, lengths and diameters, and different wire thicknesses for the heating and regulating coil, it is possible to change the heat-up times and glow temperatures of the plug in accordance with the respective requirements of the engine.

### 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 BorgWarner 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).

### 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.

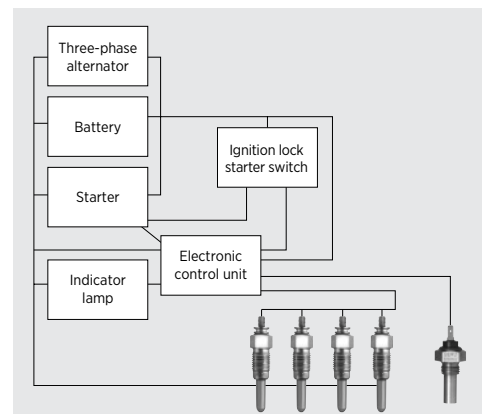
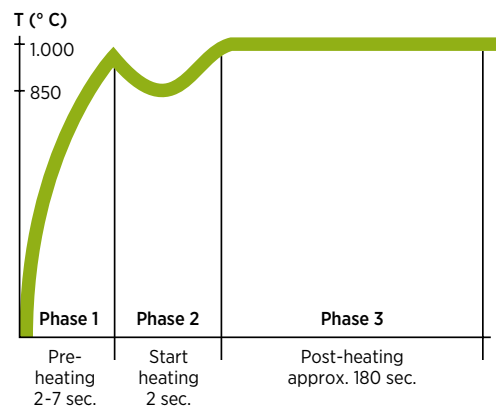
The engine operating state is registered e.g. by measurement of the coolant temperature. The post-heating process is continued until the coolant has reached a temperature of 70 °C, or it will be switched off after a certain time which is set in the performance map. No post-heating will normally take place if the coolant temperature was already higher than that before starting.

### 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 BorgWarner 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.**

### The 3-phase glow technology.



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

# Self-regulating pencil type glow plugs

## QUICK START IN 2 SECONDS

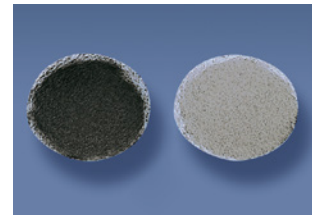
With the post-heating BorgWarner GN glow plug, it is possible to reduce the glow time to 2–5 seconds. To achieve this, the designers reduced the diameter at the front end of the heating rod. The heating rod thus starts glowing quicker in this zone. At a temperature of 0 °C, this takes just 2 seconds 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 %.

## ELIMINATION OF COLD-START KNOCKING

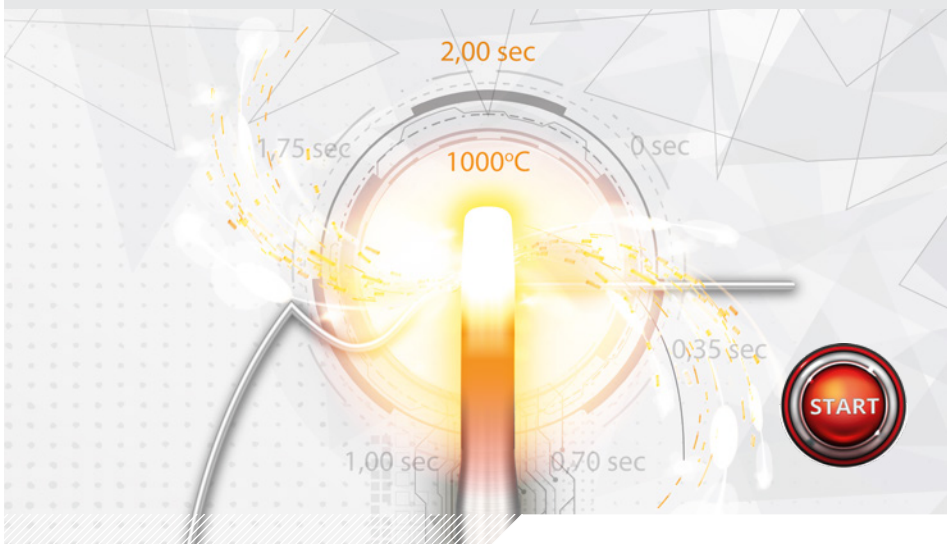
Knocking during cold-start of a diesel engine is caused by an increased ignition delay when the engine is cold. The fuel ignites abruptly, and the engine knocks. Pre-heating and post-heating of GN glow plugs ensure that the engine reaches the operating temperature quicker. This preserves the engine, 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.



**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.**

## 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 BorgWarner 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 BorgWarner engineers: the Instant Start System ISS.

## System concept

The BorgWarner 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 (GE-types) for a standard glow plug (SR). Both in the heating-up and in the saturation phase, they require significantly less energy.

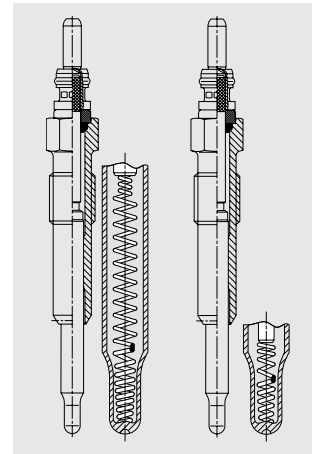
Power semi-conductors are used in the control unit as switches to control the glow plugs, replacing the electro-mechanical relay used in the past. Compared to the conventional self-regulating glow plugs, the winding combination of the power-optimized glow plug of the ISS is considerably shorter and the 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 adjusted 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.

When using the BorgWarner Closed Loop Control Module, the voltage is set by the microcontroller with a programmed controller so that the heating is always efficient and the requested temperature is maintained.



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



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



The BorgWarner 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  $-30^{\circ}\text{C}$
- Extremely fast heat-up time:
  - 1,000  $^{\circ}\text{C}$  are reached in max. 3 seconds (GE-types)
  - 850  $^{\circ}\text{C}$  are reached in 2 seconds (SR)
- Low power requirement (in particular important for engines with 6 or more cylinders)
- Higher functional reliability
- Numerous diagnostics functions
- Controllable temperature for pre-, intermediate and post-heating
- Immediate stable idling and well-controlled load take-up
- Minimised pollutant emissions
- Specifically designed for diesel engines with direct injection
- On-board diagnostics-enabled

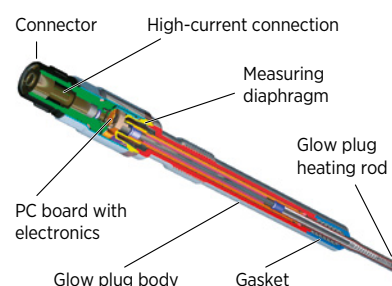
# BorgWarner – Lead innovator for the use of PSG pressure sensor glow plugs

## 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 significantly lower than before. It will not be possible to comply with these emission standards with conventional solutions alone.

BorgWarner 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 combustion 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 BorgWarner Diesel ISS quick-start system, which only glows at its tip.

The intelligent PSG (pressure sensor glow plug) is used in diesel engines made by Volkswagen, Audi, BMW/Mini, Opel and Renault.



**The intelligent PSG (pressure sensor glow plug).**

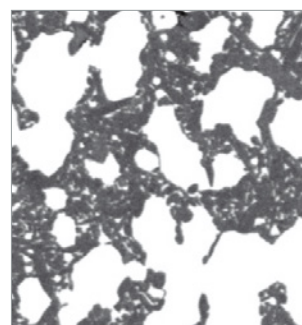
## BorgWarner – Ceramic glow plug (CGP)

### STRONG INNER VALUES

The composition of the materials is crucial to the performance of BorgWarner 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 and 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 BorgWarner ceramic glow plug has the best possible energy balance at every engine operating point. This also contributes to a reduction in consumption and emissions.

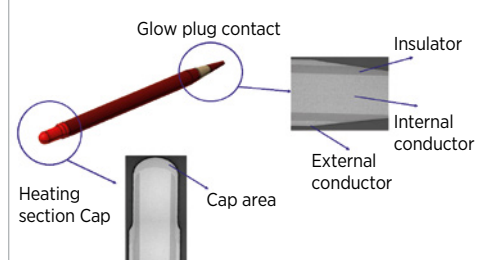


**The microstructure of the BorgWarner glow plug ceramic with strengthening small silicon nitride rods and white Molybdenum disilicide grains, which form the electrically conductive, three-dimensional structure.**

### AN EXCLUSIVE PROCESS

BorgWarner 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, BorgWarner ceramic glow plugs offer outstanding features.

### The structure of the ceramic heating rod on the BorgWarner 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 than other ceramic blow plug technologies (BorgWarner patent). The glow plug contact consists of an internal and external conductor with an insulator positioned between them.**

## BorgWarner 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, BorgWarner 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 BorgWarner 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

BorgWarner glow plugs are designed in compliance with ISO Standards. 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

BorgWarner 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, BorgWarner 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 BORGWARNER TESTS

BorgWarner 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 BorgWarner, 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 difficulty. (See Figure 3)

## HEATING ROD FILLING USING LOW-QUALITY INSULATING POWDER

Instead of the magnesite powder that is used by BorgWarner, 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.

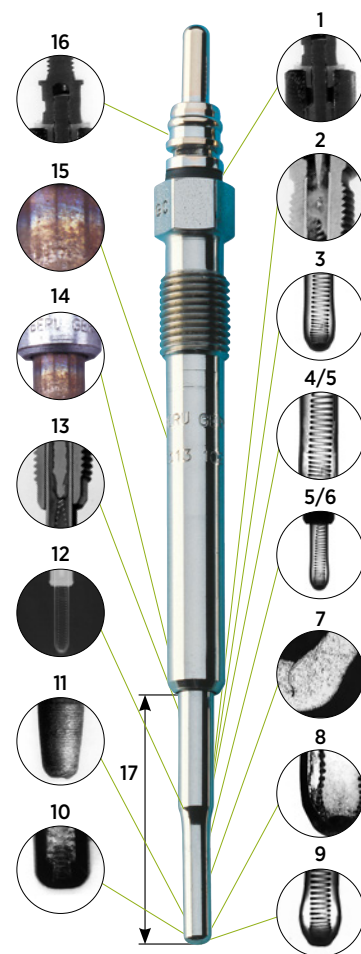
(For this, please see Figures 5 and 13)

## 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 difficulty 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 of the 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

## How to start a diesel engine quickly and reliably

THE PROBLEM	THE CAUSE	BORGWARNER'S SOLUTION
Fume during start, Smoke production	Glow plug with only one coil, too low temperature	Use BorgWarner 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 BorgWarner 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 BorgWarner 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 BorgWarner replacement nozzle holder assembly



# Torques

## 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).

## 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.

## Special tooling (reamer): for a quick and reliable cleaning of the cylinder head bore



The reamer loosens coking that might occur after “baking-on” between glow plug and cylinder head.

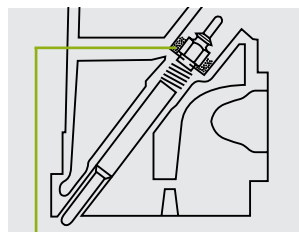
### AND THIS IS HOW IT’S DONE:

- Provisionally clean the glow plug bore with a cloth.
- Apply grease to cutting area of the 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).

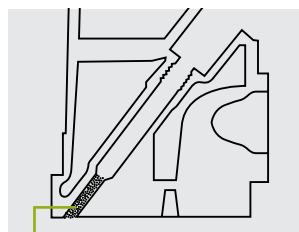
Important when replacing glow plugs: Keep to the torques!

### TORQUES FOR DISMANTELING

GLOW PLUG THREAD	TIGHTENING TORQUE
M 8	20 Nm
M 9	22 Nm
M 10	35 Nm
M 12	45 Nm



Now inject synthetic oil here.



These combustion residues can be removed with special toolings – like reamers.

### TORQUES FOR SCREWING IN

GLOW PLUG THREAD	TIGHTENING TORQUE
M 8	8–10 Nm
M 9	8–10 Nm
M 10	15–20 Nm
M 12	15–25 Nm

CONNECTING NUT THREAD	TIGHTENING TORQUE
M 4	2 Nm
M 5	3 Nm



ONLY remove and fit glow plugs using a torque wrench.



GKF01 –  
0 890 300 034

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