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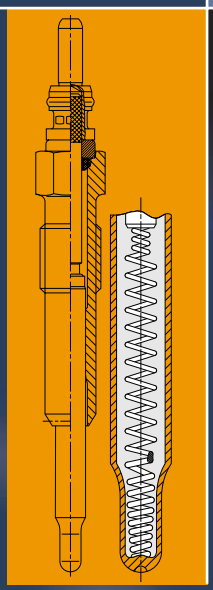

All about glow plugs

Technical
Information
No. 04

Perfektion
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BERU

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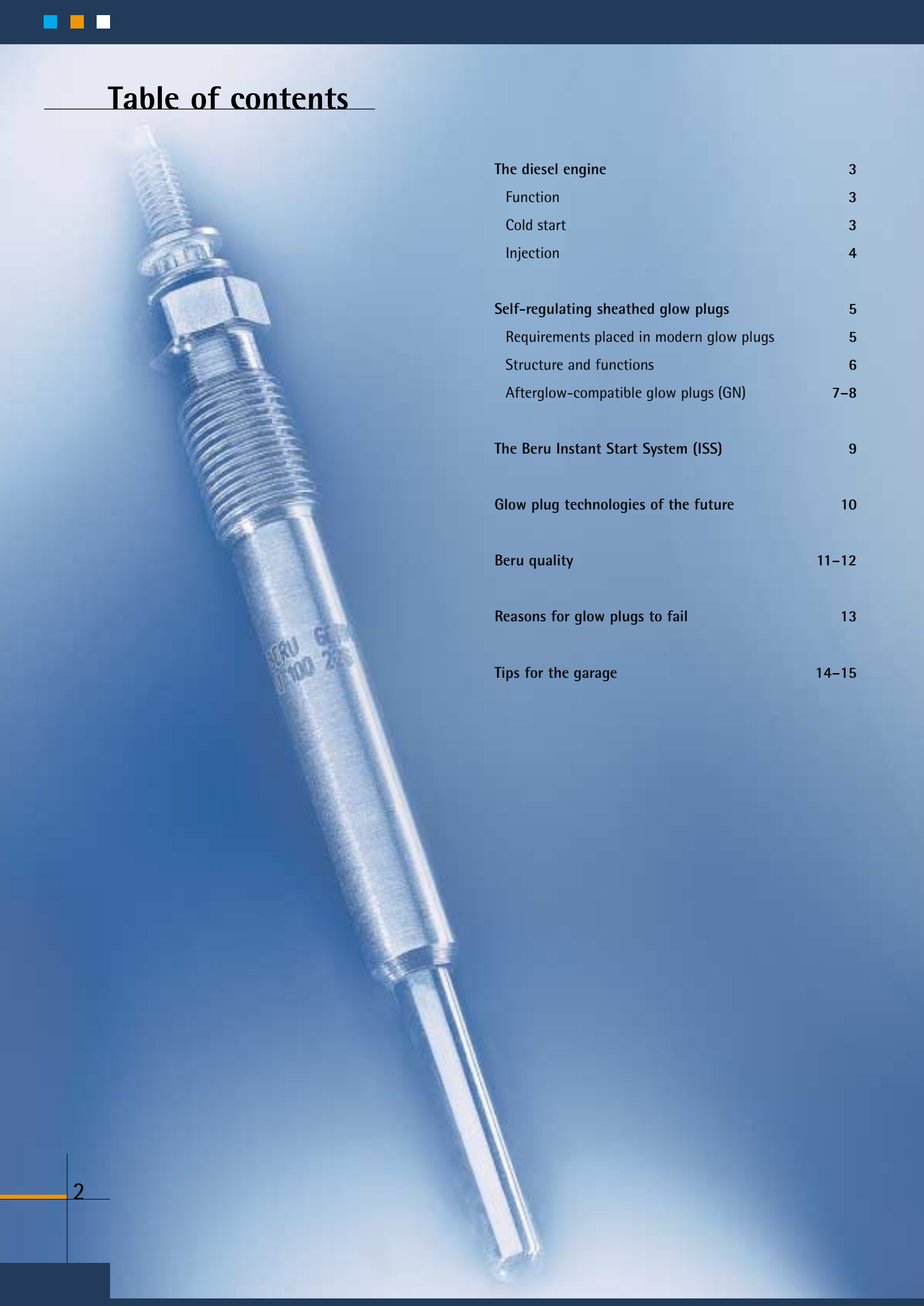
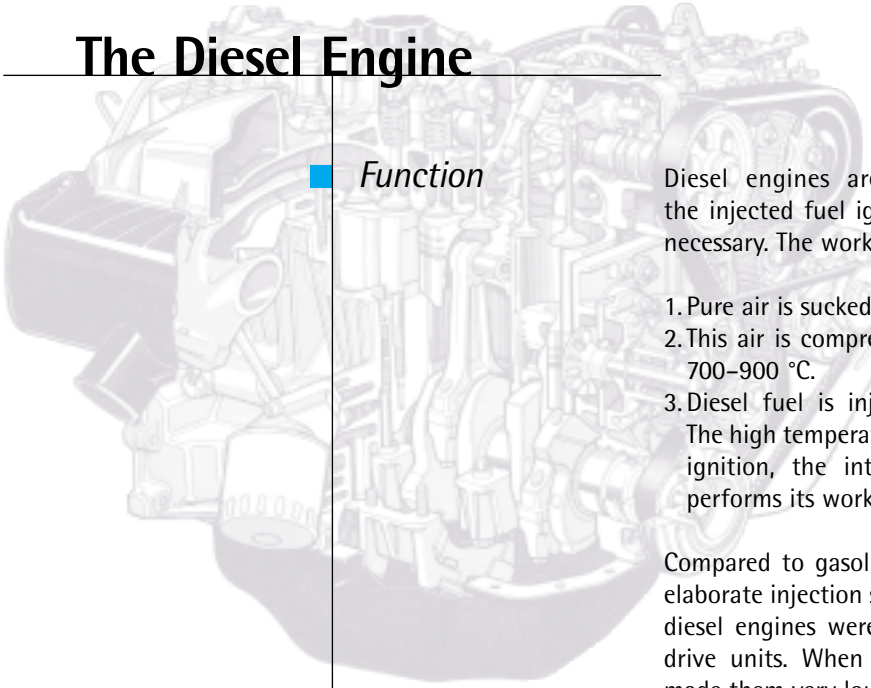


The Diesel Engine



Function

Diesel engines are self-igniting, or in other words: the injected fuel ignites without an ignition spark being necessary. The work cycle is triggered in three stages:

1. Pure air is sucked in first.
2. This air is compressed to 30–55 bar – heating it up to 700–900 °C.
3. Diesel fuel is injected into the combustion chamber. The high temperature of the compressed air triggers self-ignition, the interior pressure rises and the engine performs its work.

Compared to gasoline engines, self-igniters require more elaborate injection systems and engine structures. The first diesel engines were not particularly comfortable or fast drive units. When cold, the hard combustion sequence made them very loud. They were characterised by a higher performance weight, a lower performance per litre of capacity and poorer acceleration behaviour. All of these disadvantages have been eradicated by continual development of the injection technology and the glow plugs. Diesel is now regarded as an equal or better drive source.

Cold start

Cold starts are all starting procedures in which the engine and the medium are not at operating temperature. The lower the temperature, the worse the conditions for fast ignition and complete, eco-friendly combustion. In order to ensure that the start does not take an inordinate period of time or may indeed be impossible at lower temperatures, aids are used to support the cold start. They compensate the poorer starting conditions and initiate the punctual and even ignition for stable combustion.

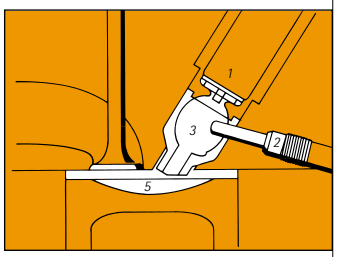
One component of the cold start support is the glow plug. Thermal energy, generated by electricity, flows into the combustion chamber to create the ideal ignition conditions for the injected fuel. If an engine has a divided combustion chamber, it is indispensable as a cold start aid in order to ensure starts in frequent temperature ranges of 10-30 °C. Due to the considerable deterioration of the start quality at temperatures below freezing point, the glow plug is also used for diesel engines with direct injection.

Injection systems

Diesel engines have the following injection systems, depending on the structure and arrangement of the combustion chamber:

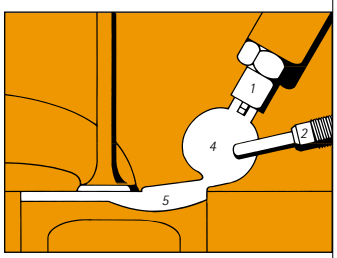
1. Pre-chamber systems
2. Turbulence chamber method
3. Direct injection

Glow plugs are required in all systems - so that the injected fuel can evaporate and ignite in the fuel-air mixture on the hot surface of the plug.



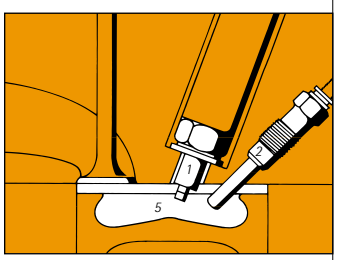
Pre-chamber system

In this system the combustion chamber has two parts: the pre-chamber and the main combustion chamber. They are connected by several drill holes (shot channels). A part of the compressed air is pressed into the pre-chamber during the compression cycle. Just before the upper dead centre is reached, fuel is injected through a nozzle directly into the pre-chamber of the corresponding piston. The injected fuel combusts partially there. The high temperature this generates ensures a speedy rise in pressure. The entire contents of the pre-chamber are therefore blown through the shot channels into the main combustion chamber, where actual combustion takes place.



Turbulence chamber method

The ball-shaped turbulence chamber is arranged in the cylinder head separate from the main combustion chamber. A shot channel with a large diameter connects the main combustion chamber and the turbulence chamber with each other. During the compression cycle, the shot channel in the turbulence chamber causes the incoming air to rotate heavily. The diesel fuel is injected into this rotating air. Combustion starts in the turbulence chamber and then spreads to the main combustion chamber. While driving, the temperature of the compressed air is sufficiently high for self-ignition. However, this is insufficient to start the engine, specifically if the outside temperatures are low.



1 Injection nozzle
2 Glow plug
3 Pre-chamber
4 Turbulence chamber
5 Combustion camber

Direct injection

In diesel direct injection (fuel-air distribution), the fuel is injected at high pressure through a multi-hole nozzle and into the intake air and is therefore atomised, whereby the formation of a mixture is supported by a corresponding design of the piston floor. The cold intake air heats up very quickly during the start due to the high compression. The heating rod protrudes into the main combustion chamber. In principle, the glow plug in a direct injection engine has the same function as in combustion engines: It provides an ignition aid at the start. The heating rod in modern sheated glow plugs reaches a temperature in excess of 1,000 °C in only a few seconds.

The following applies to cold starts in general: Cold incoming air leads to lower temperatures at the end of compression. The lower starting revolutions are more serious, however. Due to the long dwell of the load, the pressure and temperature loss is much higher than in neutral revolutions, for example.

Self-Regulating sheathed Glow Plugs

Requirements placed in modern glow plugs

Short heating time

Glow plugs must ensure a high temperature to support ignition in as short a time as possible - and must maintain this temperature regardless of, or align it to suit, the ambient conditions.

Compact form

Up until now, diesel engines have worked mainly as direct injection engines with 2 valves and have therefore offered sufficient space for injection nozzles and glow plugs. Modern diesel engines with common rail or pump-nozzle injection systems and 4-valve technology can only offer limited space, however. This means: The space required by the glow plug must be minimised, which leads to a very thin and long form. Beru glow plugs are now in use that have the glow tube diameter reduced to 3 mm.

Exact alignment to suit the combustion chamber

Ideally, the tip of the glow plug is located right on the edge of the mixture turbulence - however, it must also protrude sufficiently into the combustion chamber or pre-chamber. This is the only way for it to provide the heat right where it is needed. It must not protrude too far into the combustion chamber, as this would otherwise disturb the preparation of the injected fuel and also the formation of a combustible mixture of air and fuel. This would lead to an increased emission of exhaust gas.

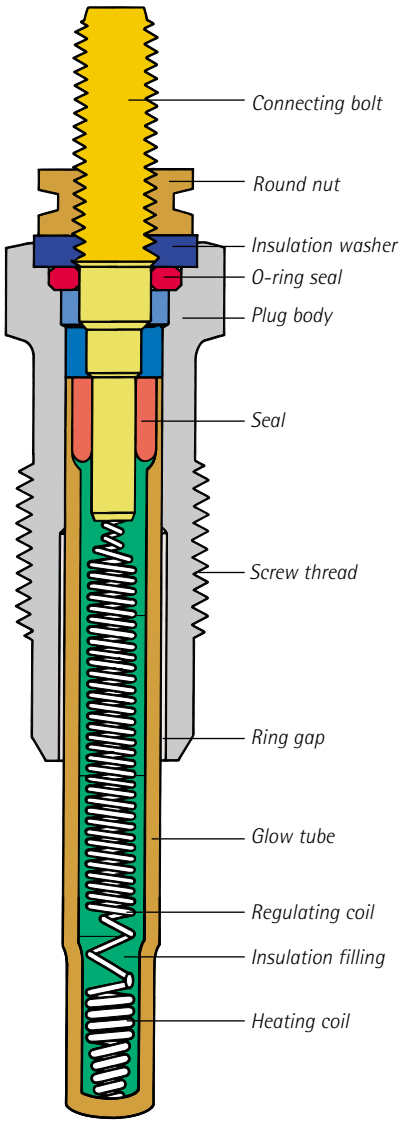
Sufficient glowing volume

In addition to the glow plug, the injection system also plays a significant role in cold starts. A system must be optimised for cold starts in terms of injection time, quantity and mixture formation, combined with the right position and temperature design of the glow plug, to ensure good cold start behaviour. Further, the glow plug must not be „blown cold" by the increased movement of air in the combustion chamber once the engine has started. There are very high wind speeds around the glow plug, especially in pre-chamber and turbulence chamber engines. In this environment, the glow plug can only function if it has sufficient reserves; i.e. if there is sufficient glowing volume in order to deliver immediate heat to the cold zone.

The glow plugs developed by Beru satisfy all these demands perfectly. Beru engineers cooperate closely with the automobile industry in the development of the engines. The results: eco-friendly, fast diesel start in 2-5 seconds (even shorter in connection with the Instant Start System ISS), secure start down to -30 °C, smooth and engine-friendly engine start, up to 40 % less carbon emission in the warm run phase with after-glow compatible plugs (more on this from page 7).

Structure and function

The Beru sheathed glow plug consists mainly of the plug body, the heating rod with the heating and regulating coil and the connection bolts. The non-corrosive glow tube is pressed into the housing gas tight. Additionally, the plug is sealed to the connecting point by an O-ring or a plastic part. The glow plugs take their electrical energy from the battery. An electronic glow time control device deals with the control.



Structure of a self regulating quickstart sheathed glow plug.

Heating and regulating coil

The basic principle of a modern glow plug is the combination of a heating and a regulating coil to create one single resistance element. The heating coil is made of highly temperature-resistant material whose electrical resistance is effectively independent of the temperature. It forms the heating zone together with the front part of glow tube. The regulating coil is attached to the conductive connection bolt; its resistance is characterised by a large temperature coefficient.

The entire coil is packaged tightly in a compressed, electrically insulating ceramic powder that conducts heat very well. During mechanical compression, the powder is pressed so tightly together that the coil rests as if it were cast in cement. This makes it so stable that the thin wires of the heating and regulating coil can permanently stand up to all oscillation. Although the individual coils are only several tenths of a millimetre from each other, they cannot join together - and most certainly cannot cause a short-circuit with the glow tube, which would destroy the plug.

The heating times and glow temperatures of the plug can be changed using different materials, lengths, diameters and wire thickness of the heating and regulating coils, thus matching the requirements of the different engine types.

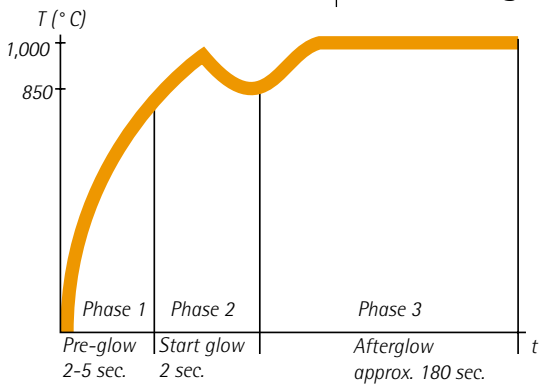
Function

Strong current flows through the connecting bolt and the regulating coil to the heating coil at the start of pre-heating. It heats up quickly and makes the heating zone glow. The glow spreads rapidly - the heating rod is glowing right up close to the plug body after 2-5 seconds. This raises the temperature of the regulating coil even more, which was already hot due to the electric current. Consequently, electrical resistance rises and the current is reduced to such an extent that the glow tube cannot be damaged. This means that the glow plug cannot overheat.

If no start takes place, the glow time control device switches the glow plug off after a certain period.

An alloy is used in Beru glow plugs; its resistance grows with the temperature. This means that the regulating coil can be designed in such a way that it permits greater current to pass into the heating coil at the start than it does once the target temperature has been reached. This means that the start temperature is reached faster, and remains safely within the permitted range due to the greater controls.

Afterglow-compatible sheathed glow plugs (GN)

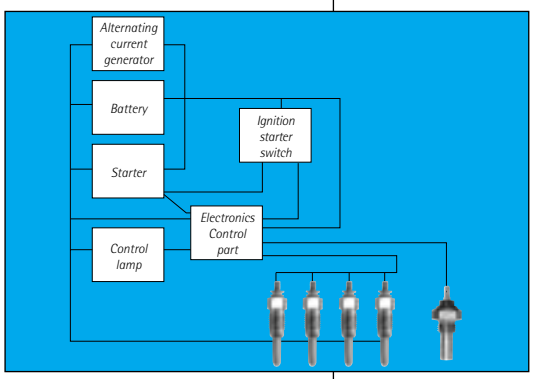


The 3-phase glow technology.

Older vehicles are generally equipped with glow plugs that only glow before and during the start phase. They are characterised by the abbreviation GV. Modern diesel cars generally run with GN glow plugs. They are fitted with the innovative 3-phase glow system. This means they glow

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

Function



Circuit principle of an afterglow-compatible glow plug with four parallel rapid heating sheathed glow plugs and a temperature sensor.

The electronically controlled pre-glow starts when the ignition key is turned on; if the outside temperatures are normal, it takes 2-5 seconds before the engine is ready to start. The afterglow phase lasts up to 3 minutes after the engine has started in order to minimise the pollutant and noise emission.

The engine operating state is recorded by measuring the cooling water temperature, for example. The afterglow process takes until the cooling water temperature reaches 70 °C, or it is deactivated after a period specified in the code field. Afterglow does not take place if the temperature of the cooling water is already over 70 °C at the start.

Protection against overheating

Self-controlling glow plugs protect themselves against overheating by restricting the flow of electricity from the battery to the plug as the temperature increases. However, when the engine is running, the voltage rises to such a level that glow plugs that are not designed for the latest technology burn out. In addition, the plugs carrying current are exposed to high combustion temperatures after the start and are therefore heated up from inside and outside. The afterglow-compatible Beru glow plugs remain functioning at full generator voltage. Although their temperature rises sharply, the new regulating coil keeps them at a steady, maintained temperature, which is below that of the non afterglow-compatible plugs.

Important: Only GN plugs must be installed in a glow system that was designed for GN glow plugs - GV glow plugs may be damaged in a very short time.

Fast start in 2 seconds

The afterglow-compatible Beru GN glow plug succeeds in cutting the glow time to 2-5 seconds. In order to achieve this, the constructors have reduced the diameter of the tip of the heating rod. This means that the heating rod starts to glow very quickly in this zone. It only takes 2 seconds to start at a temperature of 0 °C. If the temperature is lower, the glow time control of the system adjusts to suit the requirements and increases the glow time accordingly: approximately 5 seconds at -5 °C and roughly 7 seconds at -10 °C.

Reduction of white and blue smoke

So-called white or blue smoke is blown out of the exhaust until the ideal ignition temperature has been reached. This development of smoke is due to incomplete combustion of the fuel as a result of the ignition temperature being too low. The afterglow means that the diesel fuel is burnt more completely and at lower sound levels during the warm-up phase. This cuts the smoke gas opacity by up to 40 %.

Soot quantity in the filter paper three minutes after the cold start. Afterglow (right) cuts the soot quantity by approx. 40 %.

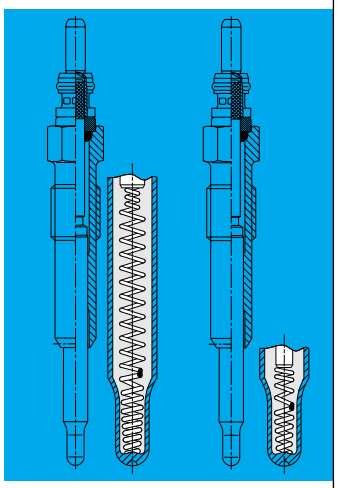
Eradication of cold start shuddering

The cold start shuddering when dealing with diesel is due to a greater ignition delay when the engine is cold. The fuel ignites suddenly and the engine shudders. The pre-glow and afterglow in the GN glow plug brings the engine faster to operating temperature. This is gentle on the engine, makes it run more smoothly and prevents shuddering. The fuel burns more evenly and completely. This releases more energy and the combustion chamber temperature rises faster.

Technical characteristics of the GN glow plug

- Fast start glow plug in a lean form
- Short pre-glow time: only about 2-5 seconds
- Safe start (even at -30 °C)
- Eco-friendly: 40 % less pollutant emission in the warm-up phase
- No shuddering
- Smooth engine running
- Gentle engine start
- For vehicles with up to 14.5 V operating voltage

The Beru Instant Start System (ISS)



Inner structure of the self-controlling standard glow plug SR (left) and the performance-optimised glow plug of the ISS (right).

System concept

The biggest challenge was to enable a key start for diesel vehicles just like for gasoline engines. The solution for the Beru engineers: the Instant Start System ISS.

The Beru ISS consists of an electronic glow plug control device and performance-optimised glow plugs with a reduced heating time of no more than 2 seconds - compared to 5 seconds in standard glow plugs. They require considerably less energy in the heating and in the balancing phase. Performance semiconductors are used in the control device as switches to control the glow plugs; they replace the previously used electromechanical relays.

Compared to the traditional self-controlling glow plug, the coil combination of the performance-optimised glow plug of the ISS is much shorter and the glowing part is reduced to roughly a third. This corresponds with the part of the heating rod that protrudes into the combustion chamber in engines with direct injection.

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

Electronic control

During the compression phase while the engine is running, the glow plug is cooled by load change and the flow of air. The temperature of the glow plug falls with increasing speed and constant glow plug voltage and injection volume. With increasing injection volume and constant voltage and speed the temperature of the glow plug rises.

These effects can be compensated using the electronic control device: the optimum effective voltage for the current operating point is fed to the glow plugs. This means that the glow plug temperature can be controlled in dependence on the operating mode. In addition, the combination of the low voltage glow plug and the electronic control device is used to heat up the glow plug extremely quickly. This takes place by applying the entire on-board network voltage to the glow plug for a predefined period before the cycle then switches to the required effective voltage. This means that the previously standard pre-glow period is reduced to a maximum of 2 seconds, even during the lowest temperatures.

The system is so effective that the glow plug takes hardly any more voltage from the on-board network than it requires. As each glow plug in the ISS is controlled by a separate performance semiconductor, the current can be monitored individually in each glow circuit. This enables individual diagnosis of each plug.

The Beru Instant Start System enables „gasoline engine key start" of the self-ignition.

Technical characteristics of the ISS

- Secure start, even at temperatures of -30 °C
- Extremely fast warm-up time: 1,000 °C reached inside of 2 seconds
- Low power requirements (important particularly in engines with 8 cylinders or more)
- High function security
- Controllable temperature for pre, after and intermediate glow
- Numerous diagnosis functions
- Immediate stable neutral and clean load acceptance
- Minimised pollutant emission (satisfies EURO-IV standard)
- Designed specifically for diesel engines with direct injection
- On-board diagnosis-compatible

Glow plug technologies of the future

Combined systems

Glow plugs are the right starting aid to guarantee a fast start of the diesel engine with the lowest possible strain on the on-board network. In addition, the electrical heating flanges that are used mainly in heavy commercial vehicles also have potential for personal vehicle use:

- to avoid warm-up emission
- to increase smooth engine running
- to improve the load acceptance

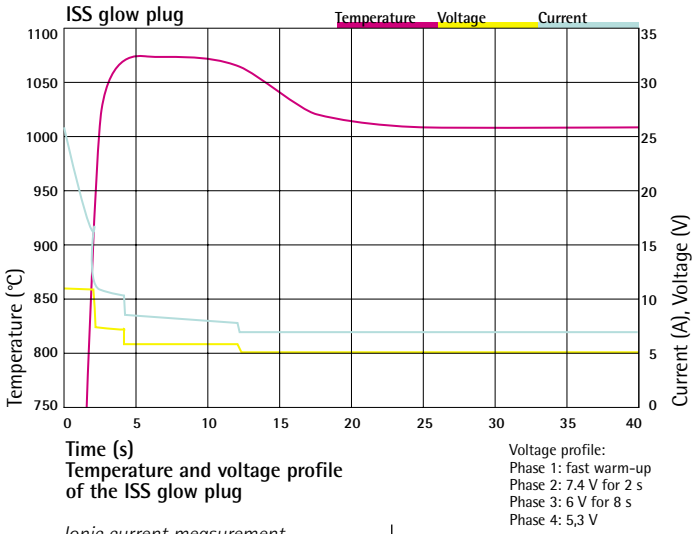
A combination of both systems is conceivable - for a fast start with minimal emissions and maximum smooth running - especially with a view to the fact that the statutory regulations on emission values are being tightened continually.

Ionic current measurement

The glow plug can be used to measure the ionic current in diesel engines due to its good position. Accordingly, it is not necessary to introduce an additional probe into the combustion chamber. If the heating rod of the glow plug body is insulated and voltage is applied, an electric field forms around the tip of the glow plug in the combustion chamber. The charge of the particles in this field leaks out of the electrodes. With a suitable circuit, this current can be measured, amplified and finally transferred to the engine control device in a treated form.

Possible areas of application:

- Identification of combustion interruption
- Equation of cylinders in terms of the start of combustion and the balancing of tolerances in the injection and suction system
- Satisfaction of OBD requirements through direct feedback from the combustion chamber
- Compensation of differing fuel qualities



Ionic current measurement in the diesel engine.

Controlled glow systems

Electronically controlled systems will gradually replace the self-regulating glow plugs. Intensive research is being carried out on the development of suitable systems that do not require any complex calculation of the control output in dependence on the engine parameters. In the future, the upstream engine control device will only communicate the glow requirements to the glow control device in the form of a target value; the glow control device then applies the required voltage to the glow plug. Special glow plugs will be developed for this purpose, which are able to report back to the glow time control device a stable temperature signal than can be analysed easily.

Beru Glow Plugs: 5-fold security for top quality

1. **Created in close cooperation with automobile manufacturers**

   Beru is not only included in the design of the glow plugs right from the start as a specialist for cold starting diesel engines and as a development partner of the automobile industry, it is also onsite in the development of new engines. This enables exact coordination of the installment situation of the glow plug in the engines - and the Beru engineers have precise information about which parameters are particularly important or which performance reserves the new glow plug must have.

2. **Manufactured according to ISO standards**

   Beru glow plugs are designed according to ISO standards 7578 and 6550. These standards regulate the dimensions and tolerances of the geometry, the sealing angle, the key width and the heating rod diameter, etc.

3. **Developed according to the tender specifications of the vehicle industry**

   Beru glow plugs meet the tender specifications of the vehicle industry, which are different depending on the vehicle manufacturer. For example, between 10,000 and 25,000 cycles are demanded as permanent run.

   In addition, Beru glow plugs undergo test cycles in the cold chamber. In addition, there are tests of resistance to environmental influences, contact substances, additives and engine detergents.

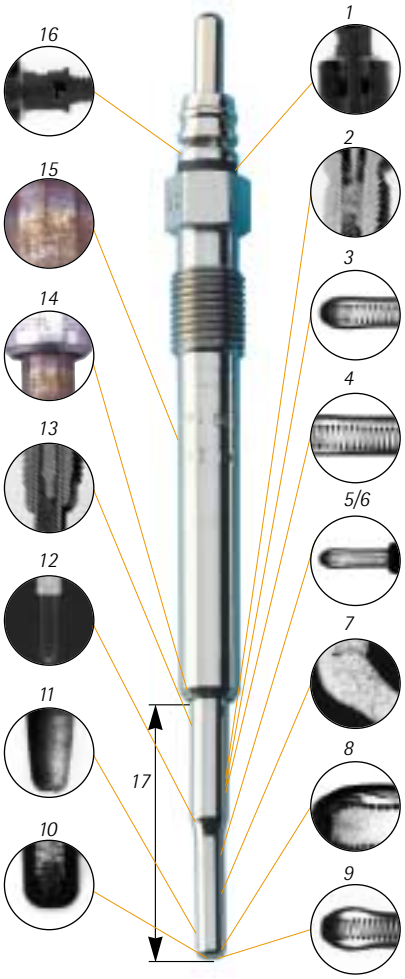
4. **Subjected to special Beru tests**

   Beru glow plugs are subjected to special test cycles that are designed especially to suit the practical demands of daily running and garage repair, for example in the simulation of plug-in termination and disconnect forces or fast overload tests. The testers show no mercy in these fast overload tests: Every test subject must still function perfectly, even after 3,000 cycles.

5. **Manufactured according to state of the art production methods**

   There are special demands linked to the production of the modern glow plugs for diesel engines with direct injection, as they are extremely long and slim. The diameter of the glow tube must suit the combustion chamber precisely. The glow tip must protrude into the combustion chamber to the exact, specified length - the only way to ensure that no additional, harmful exhaust gases form due to the turbulence. The temperature behaviour of the glow plug must also be aligned precisely to suit the structure of the combustion chamber - and the power consumption of the glow plugs must be tailor-made to suit the installed on-board network. These slim glow plugs can only be manufactured in the demanded quality on production systems such as those used by Beru.

Stay away from the cheap constructions



2-coil look, but only 1-coil technology

Only a 2-coil glow plug can satisfy the demands of automobile manufacturers for short warm-up times and temperature resistance. Since the second coil is not easily visible from the outside, some manufacture safe the so called regulating-coil. The lack of control of the glow current, the start puts inordinate load on the battery - and as the warm-up is not achieved in the prescribed time, the vehicle starts with difficulty or not at all. (See figure 3.)

Heating rod filling with low-quality insulating powder

Instead of the magnesium oxide powder that Beru uses and that compresses firmly and is dried before being filled, cheap glow plugs use loose insulation powder that in some cases is contaminated and is filled without drying. The fatal consequence: The powder expands strongly the first time it glows and the glow tube balloons. The glow plug can then only be removed if the whole cylinder head is dismantled! (See figure 9.)

The heating coil is not centred and crimped on the connection pin

This is also a sign of product quality: The connection pin can only be centred and crimped precisely using state of the art production machines. Dubious manufacturers are satisfied simply inserting the heating coil on the connection pin. However, this cannot satisfy the demand for absolute protection against short circuits. (See figures 5 and 13.)

Insufficient contacting

In low-quality glow plugs, the position of the catch tappets does not satisfy the OE requirements. Although the connection seems similar to that of original glow plugs, the contact does not catch properly. This cannot guarantee an electrical connection to the glow plug. Sometimes costs are even cut on the material of the connecting parts - and the contacting loses out. (See figure 16.)

Glow tube is not welded precisely

Many cheap producers do not have the technology to weld a glow tube precisely. The consequence: Hairline cracks in the glow tube - which leads to insufficient insulation, which again may cause short circuits.

How to recognise low quality glow plugs

Symptom	*Danger*	*Symptom*	*Danger*
1 Simple insulation	*Not waterproof*	*11 Tip of glow tube bent, heating rod too thin*	*Ageing, shorter service life*
2 Filling with low-quality magnesium powder	*Poor insulation, expansion of the glow tube*	*12 Heating coil not designed correctly*	*Battery overload due to excessive power consumption, which leads to a threat of the glow time control device contacts burning out: This cuts service life or prevents proper functions*
3 2-coil technology required, but only one coil is installed	*Characteristic profile does not conform to manufacturer's instructions*		
4 Wall thickness is not even	*The glow burns out*		
5 The coil is slanted in the glow pipe	*Short circuit*	*13 Heating coil is installed at a slant*	*Short circuit*
6 Glow tube is not centred and cannot run smoothly. The glow plug is slanted in the pre- or turbulence chamber	*The glow plug is „shot down" by the injection jet and burns out*	*14 Cone does not suit cylinder head*	*Insulation problem, destroyed cylinder head*
7 Heating rod with hairline cracks	*Burns out*	*15 Surface without surface protection*	*Rusting in the drill hole*
8/9 Heating rod tip filled with uncompressed and/or moist magnesium powder	*Short circuit, expansion of the glow tube, shorter service life*	*16 Threaded sheath is only inserted*	*Loosening and interruption of the flow of current, loose contact*
10 Point drilled, not properly welded	*Burns out*	*17 Protrusion does not meet manufacturer's instructions*	*If protrusion is too long: The glow plug is „shot down" by the injection jet and burns out. If it is too short: Problems starting*

Failure causes for sheathed glow plugs

A diesel engine will start in warm and dry weather even if a glow plug is defective and only the other plugs pre-glow. Although the start is usually accompanied by an increased emission of pollutants and sometimes shuddering, the driver will not consciously notice these signs or may be unable to interpret them correctly. The nasty surprise then comes when it is cold or damp and the first night's frost arrives: The „source of heat" in the diesel engine no longer functions and at best it will start poorly and smoke - although it is more probable that nothing will start. The following indicates typical damage and lists the various causes. This diagnostic aid guarantees a speedy remedy in most cases.

Beru guarantee: If none of the causes of failure listed here are possible, please send the defective plug to Beru AG, Ludwigsburg, for testing. Naturally, we will replace the plug if it is a material or manufacturing fault.

Heating rod with folds and dents

Causes:

Break in the spiral caused by

a) Operation with excessive voltage, e.g. with a starter aid
b) Current applied too long by suspended relay
c) Forbidden afterglow while engine is running
d) Use of a non-afterglow-compatible glow plug

Possible remedies:

a) Use starter aid with 12-Volt on-board network.
b)/c) Check pre-glow system, replace glow time relay.
d) Install afterglow-compatible glow plug.

Heating rod melted, melted through or broken

Causes:

Overheating of the heating rod due to

a) Premature start of injection
b) Nozzles blocked or clogged with soot
c) Engine damage, e.g. due to piston corrosion or valve breakage, etc.
d) Dripping nozzles
e) Piston rings blocked or stuck

Possible remedies:

a) Set injection time precisely.
b) Clean injection nozzles.
c) Check jet profile.

Tip of heating rod damaged

Causes:

Overheating of the heating rod due to

a) Premature start of injection, which overheats the heating rod and heating coil; the heating coil becomes brittle and breaks.
b) Closed ring gap between the plug housing and the heating rod; too much heat dissipates out of the heating rod as a result,
c) The regulating coil remains cold and allows too much current pass into the heating coil, which overheats.

Possible remedies:

a) Check injection system, set the injection time precisely.
b) Adhere to the tightening torque specified by the manufacturer when screwing in the glow plug.

Connecting bolt broken, hexagonal bolt damaged

Causes:

a) Break in connecting bolt: The current connecting nut was tightened with excessive torque.
b) Damaged hexagonal bolt: Use of incorrect tools; the deformation of the plug creates a short-circuit between the housing and the round nut.

Possible remedies:

a) Tighten the current connecting nut with the torque spanner. Adhere to the tightening torque. Neither grease nor lubricate the thread.
b) Tighten the plug with a suitable torque socket spanner. Adhere exactly to the specified tightening torque (this can be seen in vehicle manufacturer regulations).

Tips for the garage

The Beru glow plug test device should be an integral part of every garage.

Our tip:
Test the glow plugs every 75,000-100,000 km with the glow plug fast tester. Replace the entire glow plug set if any one has a defect or only restricted functions.

Glow plug test device: Testing without removing the plugs

The glow plug fast tester can be used to test 12 V sheathed glow plugs **(not ISS glow plugs, as they are designed for less than 11 Volt)** simply, reliably and quickly - individually, when installed and without starting the engine. The device measures the power consumption and the control.

Test conditions

- Cooling during the glow process: The installed plug is cooled sufficiently by the cylinder head. If a dismantled glow plug is to be tested, it must be screwed into a cooling block or a dismantled cylinder head. Alternatively, the candle can be clamped lightly in a vice with the hexagon head.
- Source of voltage: 12-Volt battery or voltage constant

Test procedure

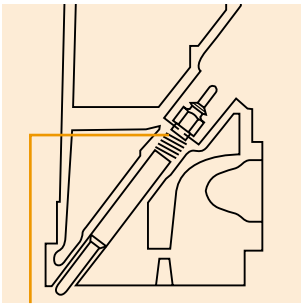
1. Unscrew the glow plug connections (power supply bar).
2. Attach the test device to the battery with the red clamp on the positive and the black clamp to the negative pole (or to the poles of the voltage constant accordingly). Attach the crocodile clip to the connecting bolt of the plug you wish to test.
3. Press button to start plug test. The glow plug is defect if the pointer remains in the red field; the plug is in full working order if it moves into the green field. Replace the defect plug. Test last approx. 14 seconds.
4. Test power supply. After the plug test, the working plug must also be tested for an interruption of power supply, a loose contact or a short circuit. It is only certain hat the plug functions fully if the full voltage is applied.

The power consumption of an intact sheathed glow plug is between 15 and 8 amperes after 20 seconds.

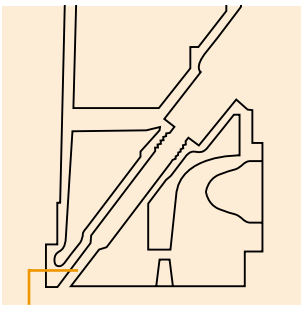
How to get the diesel to start up quickly again

The problem	*The cause*	*The Beru solution*
Smoking start, smoke development	*The glow plug is too cold as it has only one coil*	*Use a glow plug in 2-coil technology (the heating and regulating coils guarantee a higher temperature with a shorter warm-up time)*
Shuddering start phase	*The glow plug has no control effect or heat reserve*	*Install Beru afterglow-compatible glow plugs for a better and faster supply of heat*
Battery-wearing, long start	*The glow plug takes too long to heat up, warm-up time too long*	*Install a Beru GN glow plug that is aligned precisely to suit the engine and the 3-phase glow system (pre-glow - start glow - afterglow)*
Engine starts difficulty and not smoothly	*The glow plug end temperature is too low*	
Engine takes several attempts to start	*The glow plug is defect*	
Engine only starts very loudly and stinks	*The electrical values of the glow plug are not set correctly*	
The glow tube is melted or aged	*The wall thickness of the heating rod is insufficient (often the case in cheap glow plugs)*	
The glow tube has melted down	*The injection nozzle is defect*	*Replace the nozzle holder with a Beru replaceable nozzle holder*

Important when replacing glow plugs: Observe torques!



Inject multi-function oil here.



You can remove this combustion residue with the Beru reamer.

Breakage torque

Observe the breakage torque when dismantling glow plugs.

Glow plug thread	*Breakage torque*
8 mm	*20 Nm*
10 mm	*35 Nm*
12 mm	*45 Nm*

What should you do when the breakage torque has been reached?

On no account carry on turning - the glow plug could otherwise break. Instead, proceed according to the 3-point programme: heat up - release -unscrew:

1. Heat up: Run the engine until it is warm or apply current to the intact glow plug through a separate cable for 4-5 minutes - this heats up the glow plug and burns it free.
2. Release: Apply a generous quantity of anti-rust agent or multi-functional oil to the base of the thread and leave to work in for approx. 5 minutes.
3. Unscrew: Then start a new attempt to unscrew the plug and use suitable tools to release the glow plug from the cylinder head. (Do not exceed the maximum release torque - see table above. Make sure you stop before you reach the breakage torque, if necessary start a new attempt by applying heat.)

After the old glow plugs have been removed, make sure you clean the thread, the pin seat and the glow plug channel with a suitable tool (see below).

Tightening torque

Observe the torque specified by the manufacturer when screwing in a new glow plug:

Glow plug thread	*Tightening torque*
M 8	*10 Nm*
M 10	*12–18 Nm*
M 12	*22–25 Nm*

Note: The tightening torque of the connecting nut must be taken into account when dealing with glow plugs with screw connection:

Glow plug thread	*Tightening torque*
M 4	*2 Nm*
M 5	*3 Nm*

The Beru ring-ratchet-spanner (order no. 0 890 100 002): ideal to dismantle and assemble glow plugs, even in very tricky spots.

New: the Beru reamer - removes coking that may occur after „baking" between the glow plug and the cylinder head.

The Beru reamer: for fast and secure cylinder head drilling

The cylinder head drill holes often have combustion residue or dirt particles, in particular after coking between the glow tube and the cylinder head. This coking can be removed simply and securely in cylinder head with 10 mm thread - with the Beru reamer (order no. 0 890 100 003).

This is how it works:

- Wipe the glow plug drill holes with a cloth.
- Grease the cutting edge of the reamer and screw into the cylinder head: The combustion residue sticks to the grease and is carried out when the tool is unscrewed.
- The new glow plug can then be installed without difficulty (please observe tightening torque!).

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