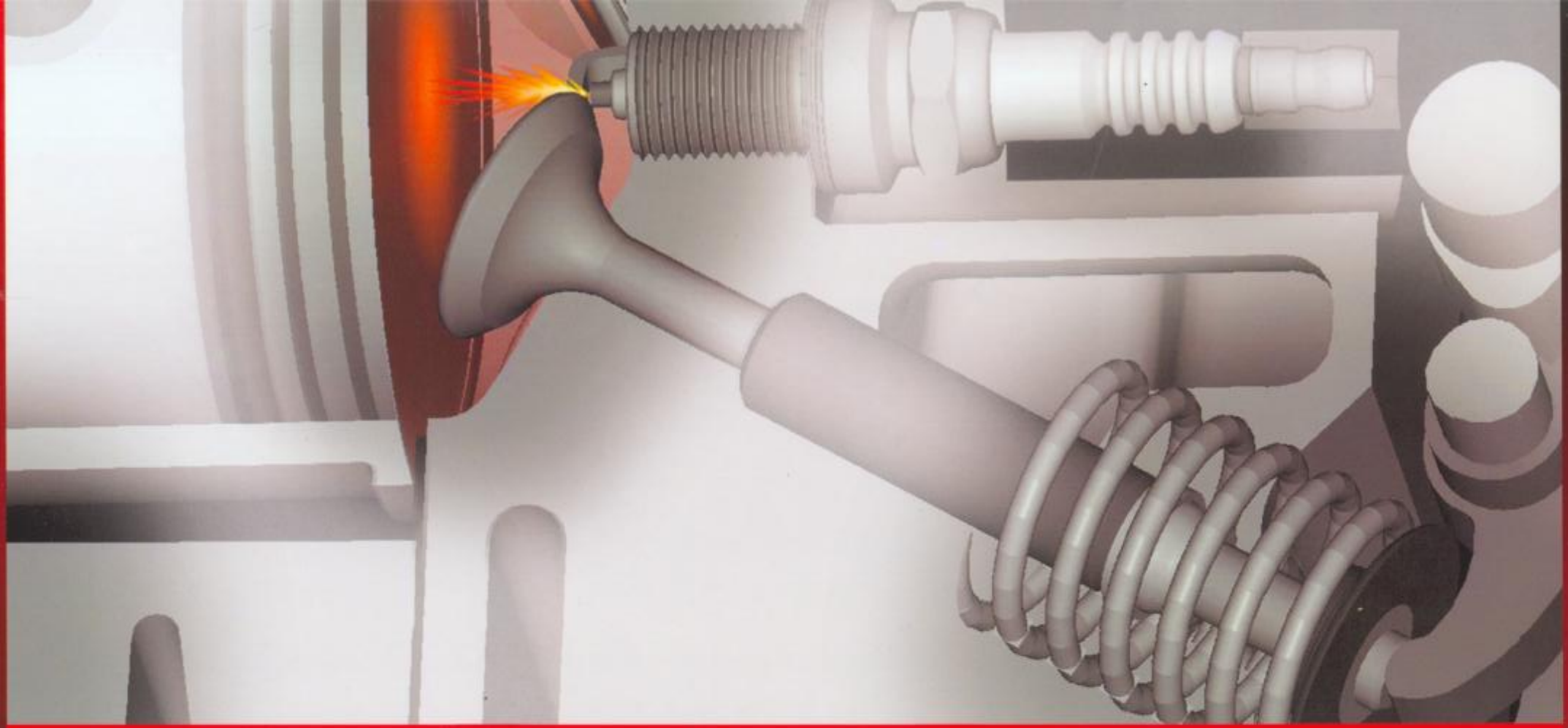

Spark plugs

TECHNICAL MANUAL

BRISK®

BRISK Tábor akciová společnost

This Technical manual is used by technicians and sellers of spark plugs produced by BRISK Tábor a.s. Its aim is to explain principles of basic relations between the individual effects influencing spark plug operation performance.

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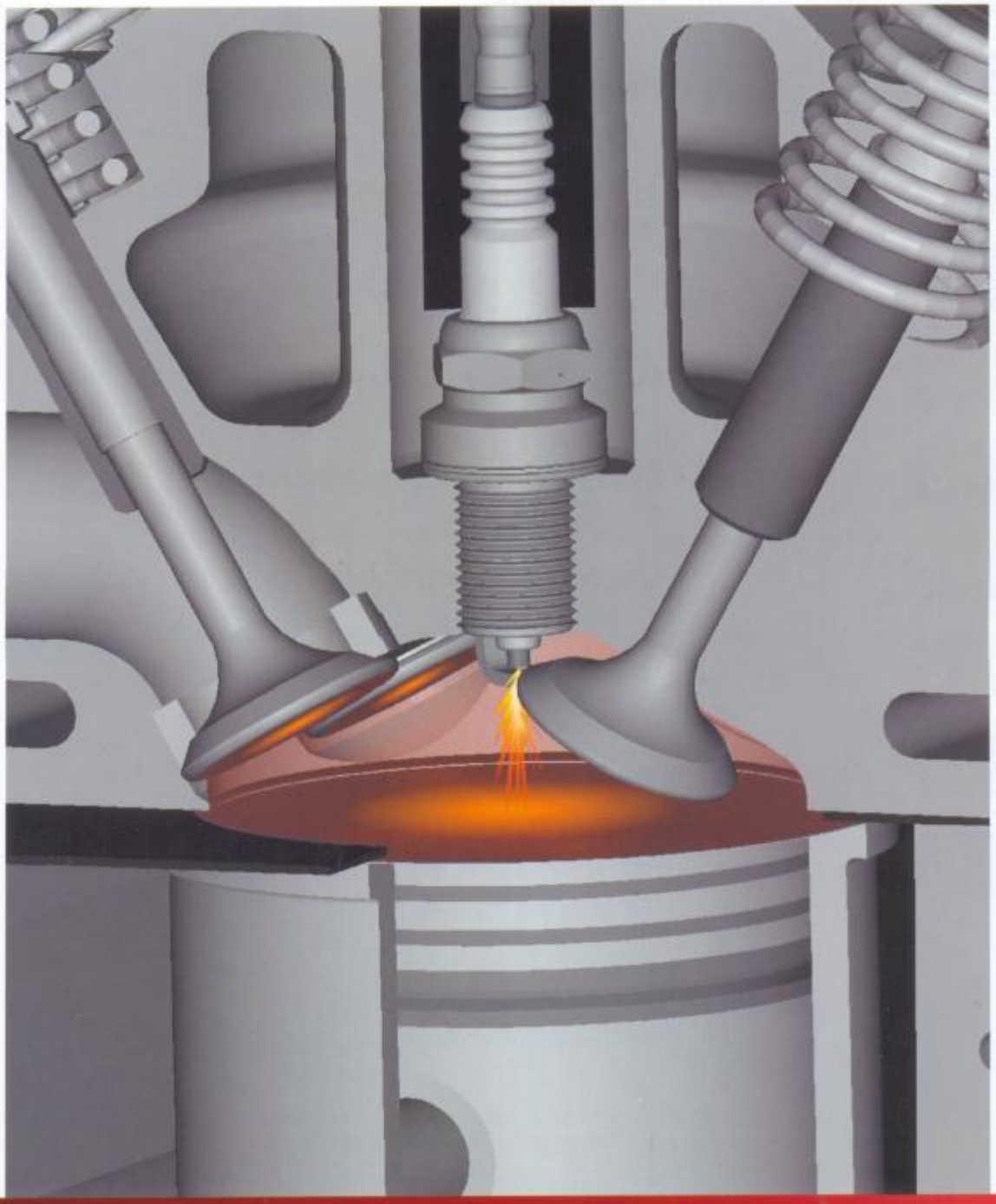
Spark plug
Functions

Spark plug is a device placed in cylinder head of an internal combustion engine operating on the principle of firing ignition of air/fuel mixture.

Spark plug is connected to cylinder head with a thread. The active part projects into the engine combustion chamber. The upper part is designed for assurance of high voltage inlet from the ignition system to the spark gap of the spark plug.

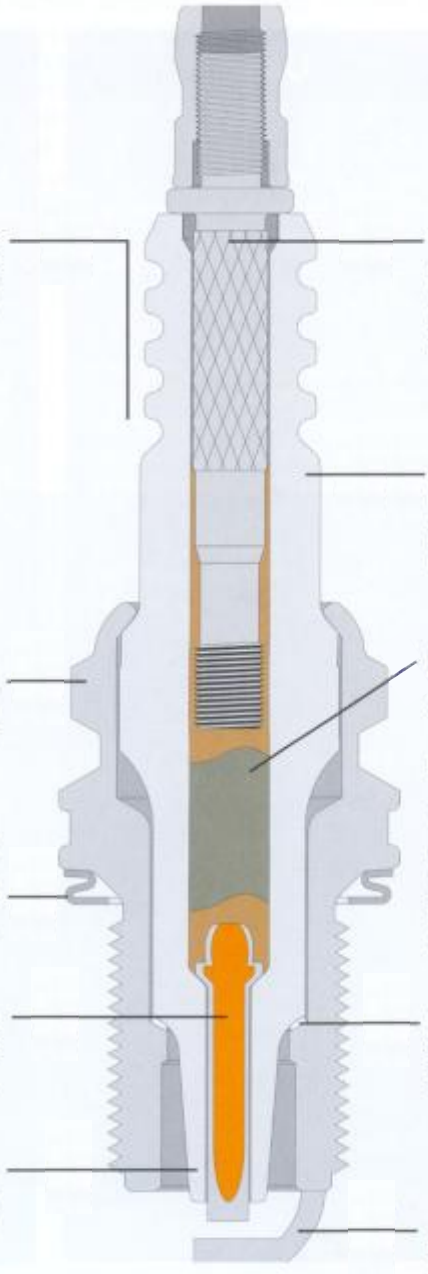
The basic function of a spark plug is the ignition of a air/fuel mixture in the engine combustion chamber at an exactly given moment.



Spark plug
Requirements

Spark plug must be designed in such a manner that it can be reliably resistant to:

- **high heat stress**
- **electrical voltage**
- **mechanical stress**
- **vibrations**
- **sudden temperature variation**
- **chemical influences in the combustion area**
- **erosion at high temperatures**
- **deposits from combustion**
- **atmospheric humidity**



Ribs
on insulator surface extend the surface trajectory for eliminating any surface discharges.

Terminal pin
Made of a steel wire resistant to vibrations. Its lower part is designed for connection with the seal, the upper part is used for the attachment of high voltage inlet.

Insulator
High content of aluminium oxide Al_2O_3 ensures a high insulation resistance, good thermal conductivity and mechanical strength.

Shell
features a high mechanical strenght and surface protection from corrosion.

Resistive seal
Basic functions of the seal are:
a) mechanical connection of insulator, terminal pin and centre electrode
b) electrical connection of terminal pin and centre electrode
c) gas tightness of the combustion area.
For spark plugs with radio interference elimination it provides suppression of electromagnetic radiation. There are two contact layers and one resistance layer.

Sealing washer
ensures gas tightness of the combustion chamber and a proper heat transfer from the spark plug to cylinder head.

Centre electrode
features high resistance to burn-off and optimum thermal conductivity.

Internal sealing washer ensures gas tightness of the combustion chamber and a perfect heat transfer from the combustion chamber to the shell.

Insulator tip
With its shape it facilitates regulation of heat removal from the combustion area.

Ground electrode
features high resistance to burn-off and optimum thermal conductivity.

Spark plug
Conditions
for proper performance

The following conditions must be ensured for an optimum performance of a spark plug:

Spark plug

- Sufficient electrical insulation between the positive and the negative electrodes of the spark plug. There must not be any short circuits, brake-through or leakage of electrical energy.
- Heat transfer from the active part of the spark plug into cylinder head must ensure a sufficient electrical insulation of the insulator tip and prevention from pre-ignitions.
- Perfect connection of the spark plug and cylinder head. Combustion area tightness, heat transfer from the combustion chamber and a possibility of spark plug replacement.
- Appropriate electrode gap corresponding with the energy supplied by the ignition system, compression of the mixture in cylinder and burn-off of electrodes.
- Proper location of the spark gap of the spark plug in combustion area in such a manner that the flame face can be fast enough on the one hand, but on the other hand, it shall not cause detonation combustion or imperfect ignition of the mixture of air and fuel.

User

- To use the vehicle in an ordinary manner. For example: not to leave the vehicle running at idle speed of the engine for several minutes uselessly, etc.

- To equip vehicle engines with a proper type of spark plugs. The important parameters are construction arrangement dimensions, thermal value, electrode gap, location of spark gap in the combustion chamber and interference elimination.

- Timely replacement of spark plugs after the achievement of a pre-specified mileage.

Engine - vehicle

- Supply of sufficient energy from the ignition system to the spark plug at all operation modes of the engine.
- Preparation, before ignition, of a suitably mixed mixture of air and fuel in a ratio as optimum as possible with regard to the operation conditions in question.
- Good technical condition of the engine, in particular:

a) sufficient compression pressure
b) exact timing
c) exact adjustment of ignition and fuel system
d) zero leakage of lubrication oil into the combustion chamber
e) sufficient insulation of high voltage inlet
f) good thermal balance of the engine cooling system
g) undamaged system for air and fuel mixture enrichment at start and acceleration
h) properly operating sensors, connected with timing of ignition and creation of air and fuel mixture.

Thermal characteristic

Two basic conditions for proper performance of a spark plug are given by sufficient electrical insulation between the centre and ground electrodes and heat transfer from the parts of the spark plug projected into the combustion chamber. Both conditions are directly related.

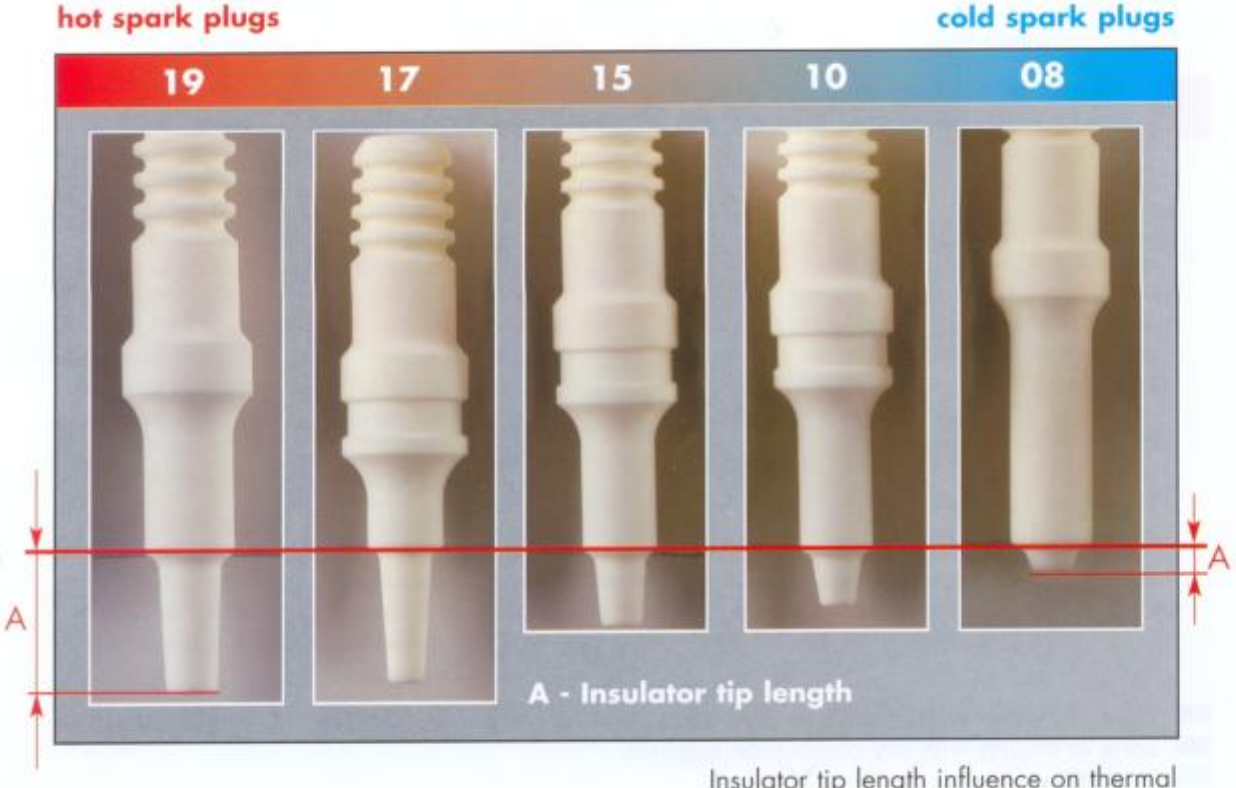
In order to ensure sufficient insulation between centre and ground electrodes it is necessary, during operation, to keep the insulator tip (the part of the insulator projecting into the engine area) within an optimum temperature range. If the insulator tip temperature drops into the so-called **deposit zone**, combustion deposits (carbon, non-combusted fuel, lubrication oil, impurities from the atmosphere) start to form on the insulator tip surface. A consequence of these combustion deposits on the insulator tip is reduction in electrical insulation resistance accompanied by failing ignitions and after a certain period of time even by a failure of the spark plug performance. Providing a higher temperature of the insulator tip, no further combustion deposits are formed, and those already existing will not be burnt. If the insulator tip temperature rises above 500 °C - the so-called **self-cleaning zone**, no new deposits are formed and those existing will be burnt. The spark plug operates in an optimum manner.

Too high temperature of the insulator tip is undesirable. High temperature results in pre-ignitions of the air-fuel mixture and further compression of the mixture already ignited leads to high temperature which can cause serious damage to the engine.

In order to achieve the correct temperature of the insulator tip for a given engine, the spark plugs are produced in various thermal values. The range of thermal values for BRISK spark plugs extends from the warmest to the coldest, namely 19, 18, 17, 15, 14, 12, 10 and 08.

"Hot" spark plugs remove heat from the combustion area relatively slowly. They have a longer insulator tip and they achieve a temperature higher than the deposition zone relatively fast.

"Cold" spark plugs feature a relatively short insulator tip and they remove heat from the combustion area quite fast, in order to avoid advanced ignitions. The choice of a proper heat range is very important. A specific spark plug with particular heat ranges is prescribed for each specific type of engine.

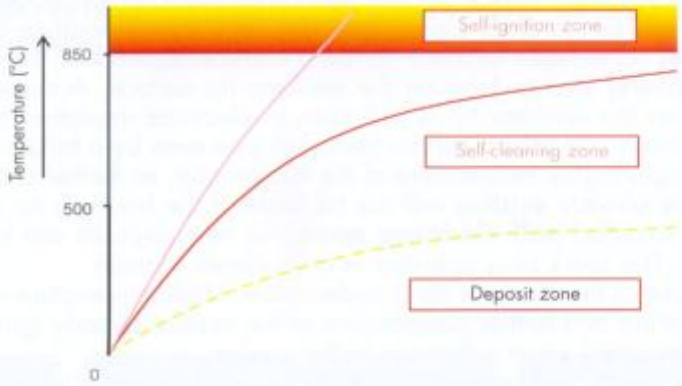


Insulator tip length influence on thermal value of a spark plug

Thermal characteristic

Thermal characteristic

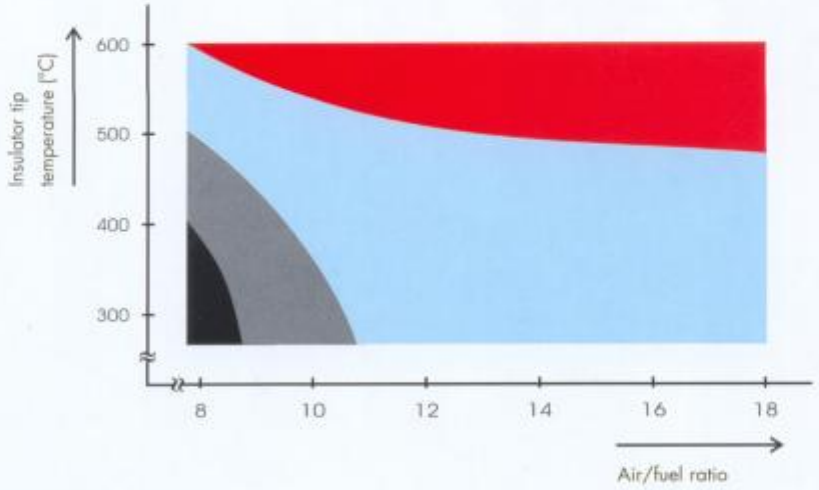
Insulator tip temperature influence on the proper choice of spark plug heat range



---- A. Too cold spark plug for a given engine
— B Suitable spark plug for a given engine
— C. Too hot spark plug for a given engine

Even a spark plug featuring a properly selected heat range is influenced by the processes of fouling and self-cleaning of the insulator tip. The setting of combustion deposits on the insulator tip is caused by an imperfect combustion due to a "rich" air/fuel mixture. On the other hand, the combustion deposits previously set will burn if the insulator tip temperature rises above 500 °C.

Zones of fouling and self-cleaning zone depending on the air/fuel ratio and on the insulator tip temperature



Zone of fouling with non-evaporated fuel
Zone of fouling with dry combustion deposits
Inert zone
Self-cleaning zone

Thermal characteristic

Zone of fouling with non-evaporated fuel – this is the zone of the highest degree of fouling for spark plugs. The mixing ratio of fuel and air is very low in this case (rich mixture). Diffusion (atomisation) of fuel is low and the fuel burns in its liquid state. Level of creation of combustion deposits is significant. In addition, the insulator tip is wet from the non-evaporated fuel. The decreasing insulation resistance of the insulator tip results in an occasional failure of ignition. Cold starts and frequent moving off from rest in cold weather will accelerate the fouling of the insulator tip.

Zone of fouling with soft deposits – vehicle engine run at idling speed or its low load can result in the setting of soft (dry) combustion deposits on the insulator tip, even if the fuel does not burn in liquid state.

Inert zone – in this zone, there does not occur any setting of combustion deposits on the insulator tip and there does not occur any self-cleaning either. No deposits set on the insulator tip surface even if the spark plug temperature drops below 500 ^{0}C. The new spark plug does not feature any fouling and if a spark plug is fouled, it does not get cleaned.

Self-cleaning zone – The combustion deposits set in this zone on the insulator tip will burn and the insulation strength of the insulator tip will return to a common value. The shift into the self-cleaning zone generally takes place during acceleration and at higher speeds of the vehicle.

Fouling with non-evaporated fuel

Fouling with dry combustion deposits

Self-cleaning

Determination of thermal value of a spark plug

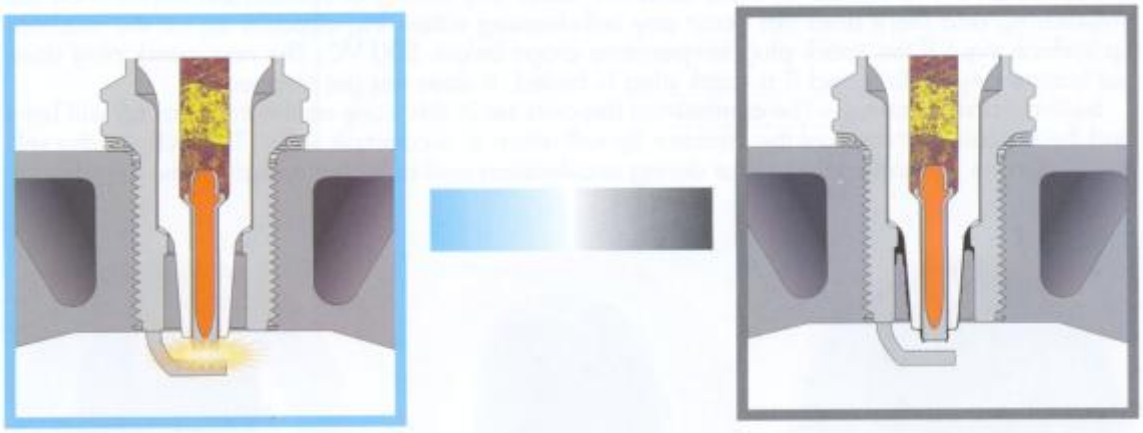
While the engine is running, the spark plug is being heated to a certain temperature. The highest temperature can be detected at the insulator tip end. Thermal balance between the input and output of heat from the spark plug is determined by the value known as the spark plug heat range. An important parameter of this heat range is given by the so-called self-ignition value. It is measured by a special measuring engine by means of a gradual increase in the super-charging pressure up to the initiation of self-ignitions of the spark plug. The self-ignitions are indicated with the help of the ionisation method, then they are processed by the control system with a feedback to the engine control. Thermal load is expressed by the IMEP (Indicated Mean Effective Pressure lb/in^2) units.

Determination of engine equipment with spark plugs

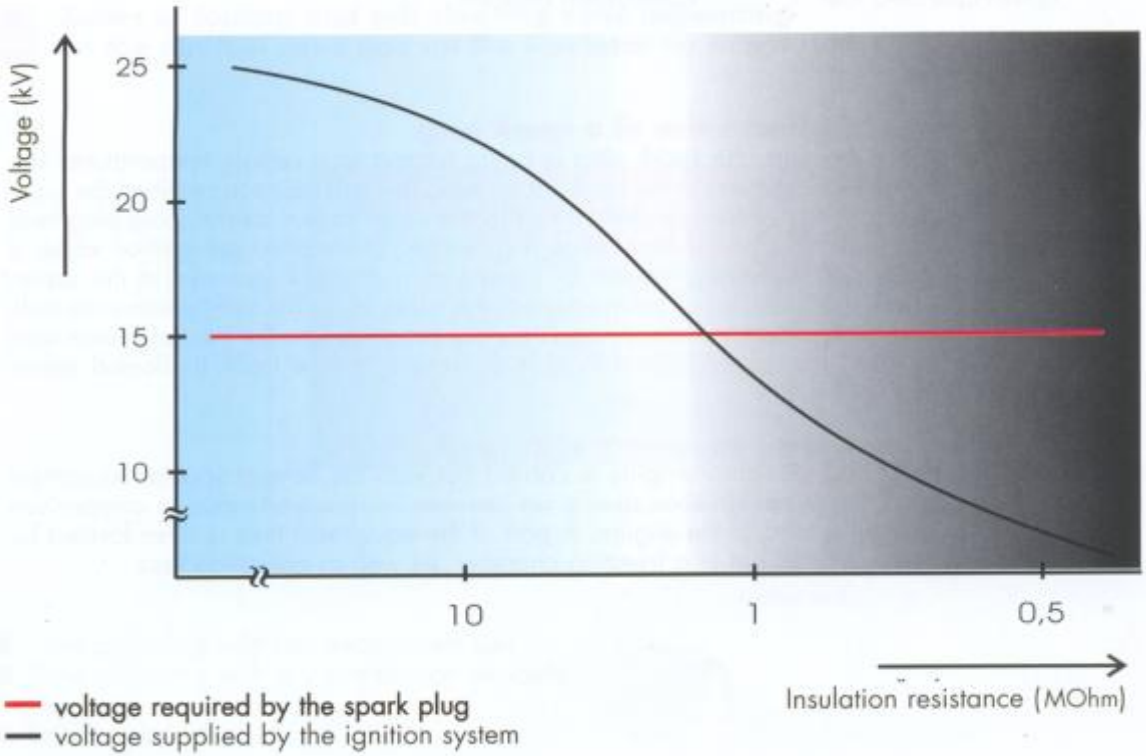
The equipment test of a particular engine is carried out with the help of special equipment making it possible to detect self-ignitions during an increase in spark advance in comparison with the original one, at a load of the engine. A part of the equipment tests is often formed by a starting capacity test carried out in a freezing chamber, as well as operation tests.

Electrical characteristic

The fouling of insulator tip surface with combustion deposits reduces electrical **insulation resistance.** If the insulation resistance drops, there also occurs a drop in electrical voltage supplied to the spark plug from the ignition system. If, as a result of heavy fouling of the insulator tip, the insulation resistance decreases down to the value when the electrical voltage supplied from the ignition system is lower than the voltage required by the spark plug, there will be misfire of spark between the spark plug electrodes and a failure of the engine function.



Reduction of the insulation resistance from electric energy leakage on the insulator tip surface



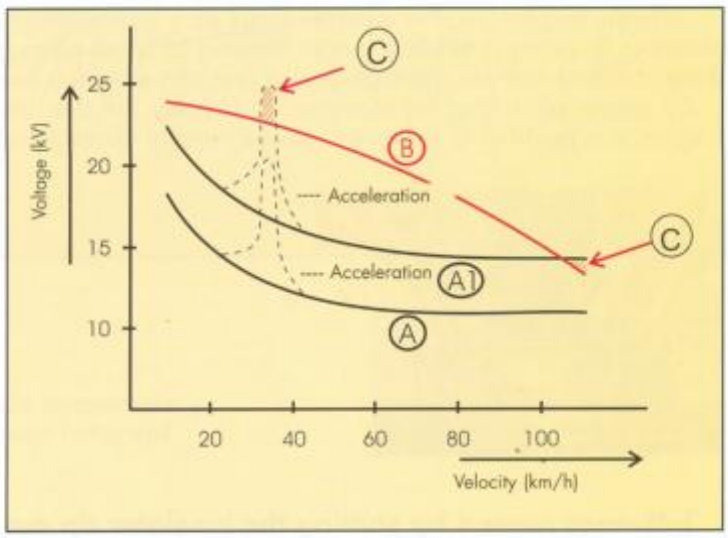
Electrical characteristic

Voltage required by the spark plug and voltage supplied by the ignition system. In order that a discharge can occur between the spark plug electrodes, it is necessary that the ignition system can supply voltage of a certain value.

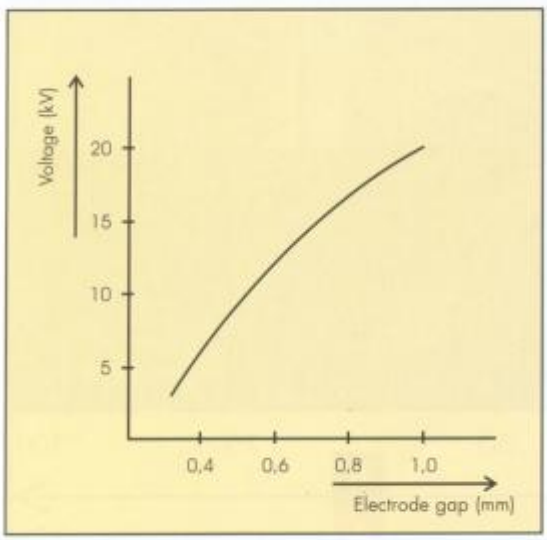
If the spark plug requirement concerning the voltage supplied by the ignition system exceeds its possibilities, there will not occur any spark jump across the spark gap. It generally applies that the spark plug voltage requirement increases if the electrode gap rises and during acceleration. The voltage supplied by the ignition system decreases at starting, low ambient temperatures and at a high speed of the engine.

Relation between voltage supplied by the ignition system and the spark plug requirement

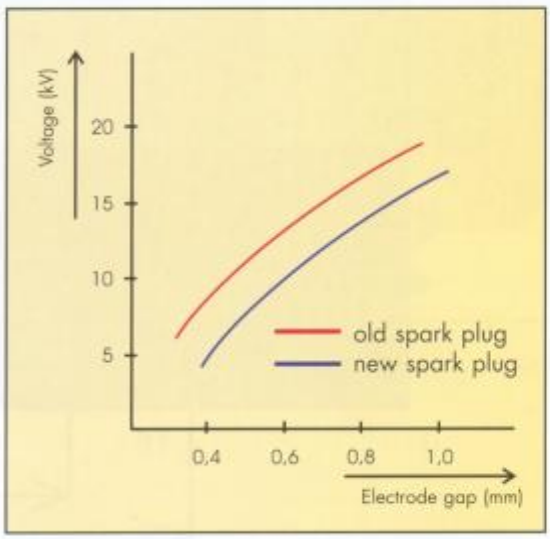
A voltage required by the spark plug (new)
A1 voltage required by the spark plug (used)
B voltage supplied by the ignition system
C insufficient voltage supplied by the ignition system



Relation between electrode gap and voltage requirement of the spark plug



Relation between the spark plug wear and spark plug voltage requirement



Spark plug design

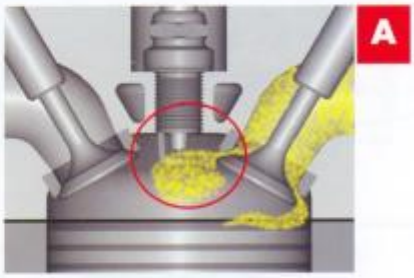
For the purpose of a perfect use of the fuel energy and in order to ensure that the harmful exhaust gas emission does not exceed a minimum level, it is necessary to optimise the spark plug construction with regard to the requirements of particular engines.

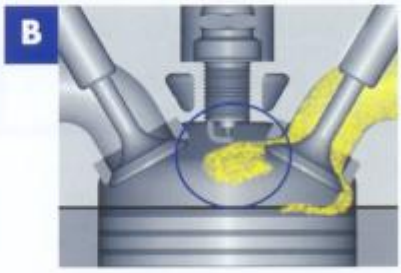
The following parameters will influence the quality of the ignited air/fuel mixture in the combustion area:

- location of spark gap in the combustion chamber
- change in the electrode gap in course of the spark plug replacement interval.
- change in properties in the electrode material in course of the spark plug replacement interval
- free access of the flame face in its initial phase of propagation
- possibility of discharge location selection according to the instantaneous concentration of fuel molecules in the air/fuel mixture in the immediate surroundings of the spark gap area

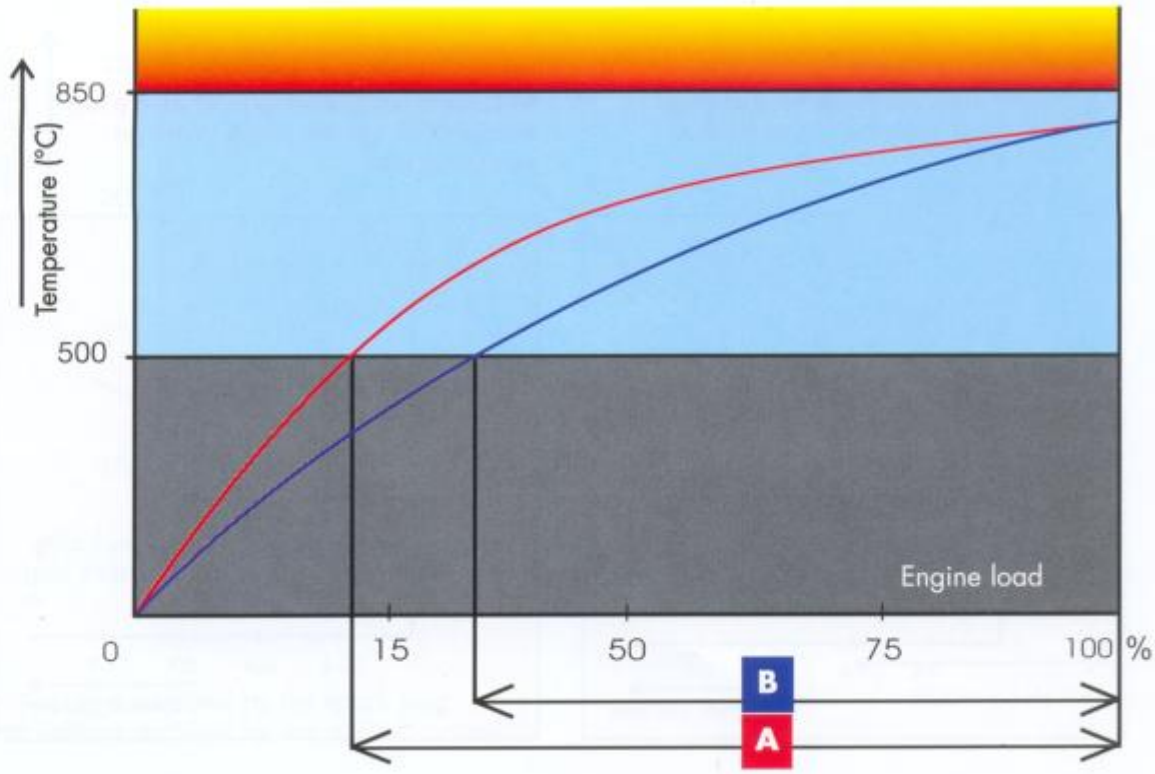
Different engines require different spark plug arrangement and its location in the combustion chamber. In order to achieve longer lifetimes of spark plugs required by the engine producers, there are used multiple spark plugs and precious materials (such as platinum, silver, tungsten...).

By means of shifting the insulator tip suitably out, i.e. into the combustion chamber of the engine, it is possible to achieve required thermal characteristics.

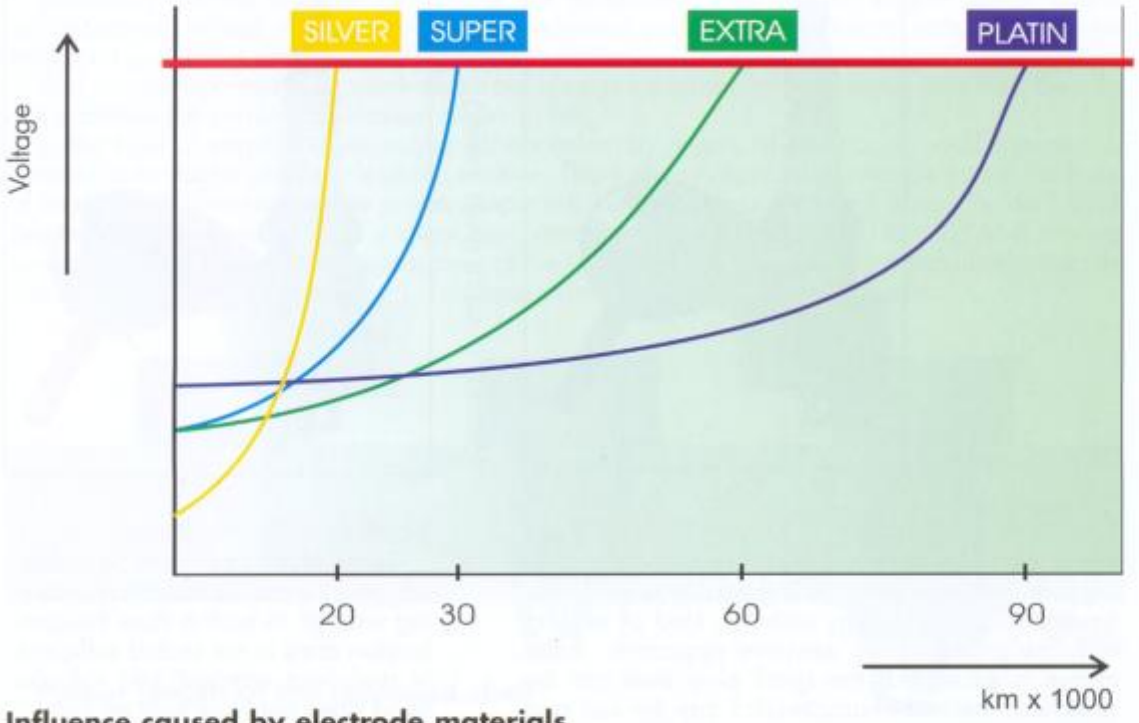




Influence caused by shifting the insulator tip out on thermal range extension



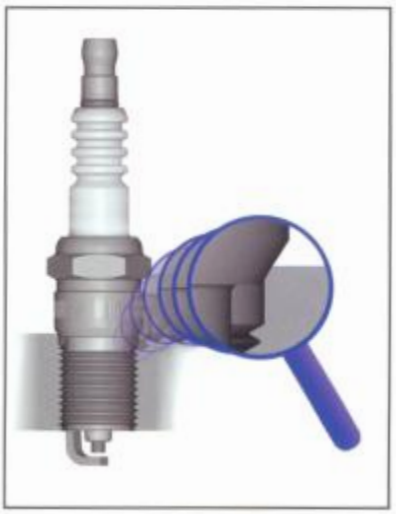
Spark plug
Spark plug design



Influence caused by electrode materials on the spark plug replacement interval

Spark plug **Assembly**

Spark plugs are constructed by using two different manners of sealing in cylinder head.



Methods of spark plugs sealing

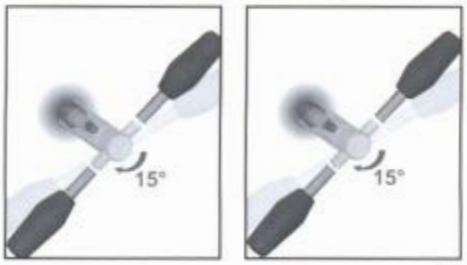
Conical seat

Spark plug is sealed in cylinder head with a conical seat. In this case no sealing washer is used. The assembly of spark plugs with this kind of sealing requires an especially sensitive approach. If the torque is exceeded, the spark plug shell can be stretched, thermal characteristics can be lost and there may even occur a rupture of the spark plug during its assembly or dismantling in the engine.

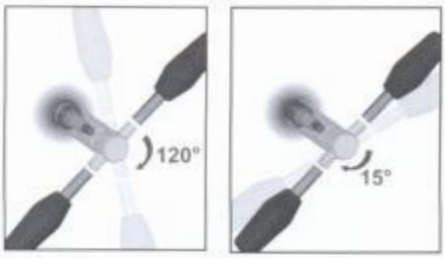
Sealing with a washer

Spark plugs can never be mounted into cylinder head without a sealing washer. In such a case the combustion area is not sealed sufficiently and heat removal into cylinder head does not work well enough.

Tightening of spark plugs without using a torque wrench



new old



new old

Torque table

Spark plug		Head of engine	
plug sizes	seals	cast - iron	aluminium
M 10 x 1	sealing ring	10 - 15 Nm	10 - 15 Nm
M 12 x 1,25	sealing ring	15 - 20 Nm	15 - 25 Nm
M 14 x 1,25	sealing ring	20 - 40 Nm	20 - 30 Nm
M 14 x 1,25	conical seat	10 - 20 Nm	10 - 20 Nm
M 18 x 1,5	conical seat	20 - 30 Nm	20 - 30 Nm

Spark plug
Assembly

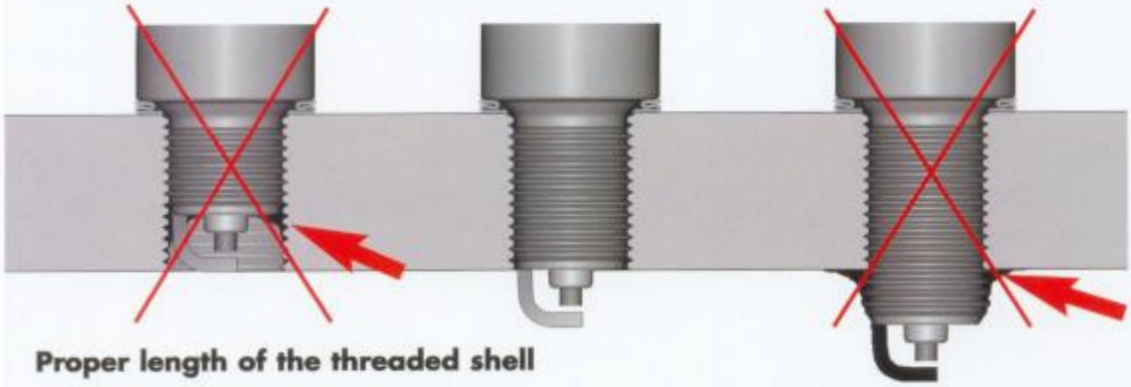
Selection of proper spark plugs

Heat range

Vehicles produced in series (which are not additionally modified for engine power output enhancement), whose engines are properly adjusted and in good technical condition, can be equipped according to the current application tables.

Any comparison charts of spark plugs are always for informative purposes only and they do not substitute the current application tables in full.

In the case of engine power output enhancement by means of additional modifications it is suitable to contact a producer's representative. There always applies a principle that in the case of medium modifications of the power output it is suitable to use the spark plugs "colder" by 2 degrees than those forming its original equipment (e.g. a change from 15 to 12). After driving several miles and subsequent assessment of the insulator tip appearance it is possible to decide about the most suitable equipment. This operation requires enough experience.

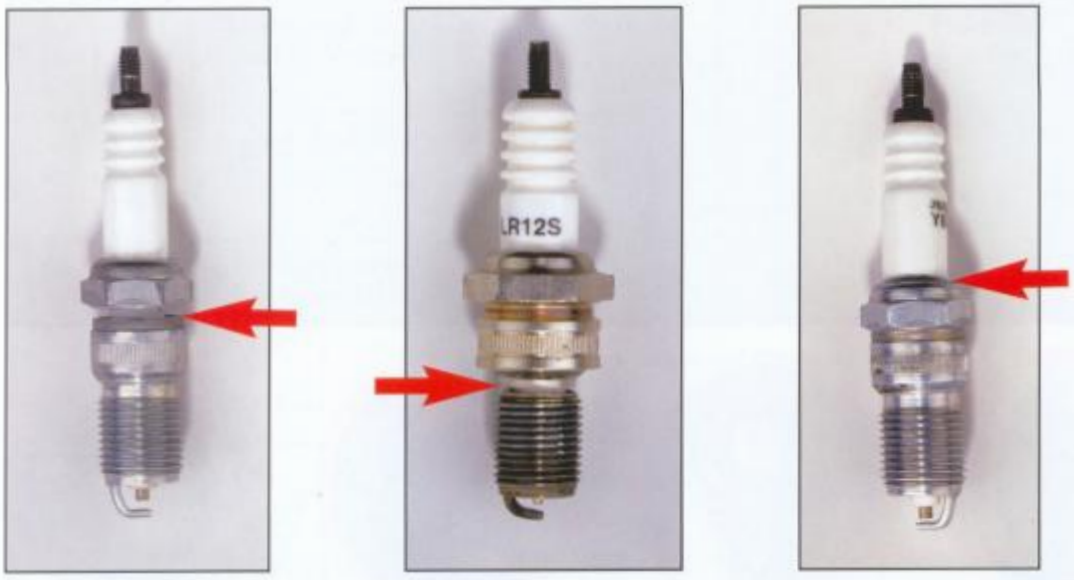


Proper length of the threaded shell

Dimensions

It is necessary to use, on principle, the spark plugs recommended in current equipment tables. An exception can be allowed only in the case of changes among the Super, Extra, Silver and Platin series, if the prescribed replacement intervals for the series in question are complied with.

Electrode gap is an important parameter of the spark plug. It basically influences the engine performance and cannot be changed arbitrarily.



Assembly fauls

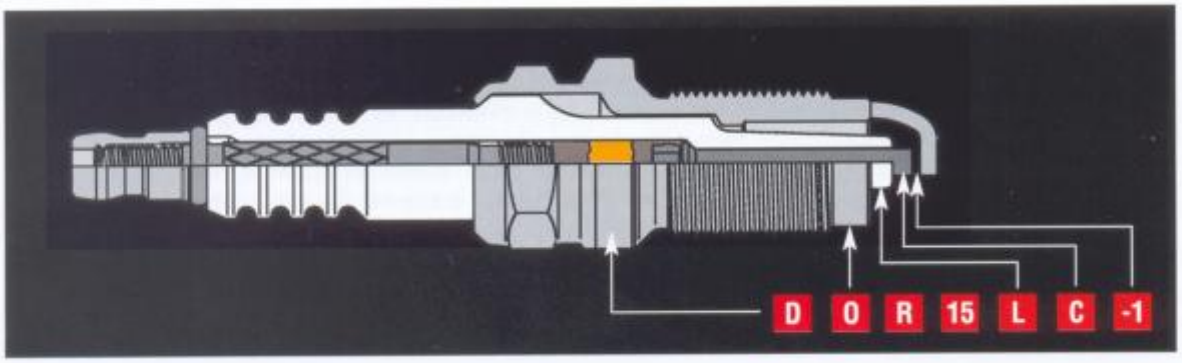
Diagnostic of failure

Diagnostic of failure

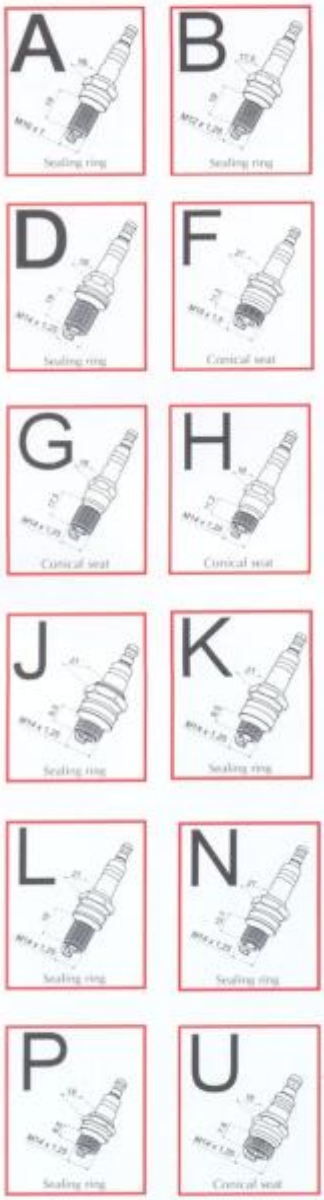
Failure	Cause	Consequences	Fig.
Improperly adjusted ignition system	Spark advance (from a proper moment)	Pre - ignitions Detonation burning	2
	Spark delay (from a proper moment)	Excessive formation of combustion deposits	1
Improper air/fuel ratio	Rich mixture	Excessive formation of combustion deposits	1
	Lean mixture	Pre - ignitions Detonation burning	2
Low or no performance of the air filter	Dust penetration into the combustion area	Excessive deposits	3
	Filter impassability	Excessive formation of combustion deposits	1
Compression pressure	Low	Excessive formation of combustion deposits	1
Improperly selected spark plug	Too hot	Pre - ignitions Detonation burning	2
	Too cold	Excessive formation of combustion deposits	1
None		Perfect performance of the spark plug	4

Diagnostic of failure

Spark plug
Identification system



Shell dimensions



D — **Shell dimensions**

O — **Metal shell projected into combustion chamber**

- Complies with relevant ISO standard
- O Does not comply with relevant ISO standard

R — **Interference suppression**

- No interference suppression
- R Interference suppression
- X Resistor reducing electrode burn-off

15 — **Heat range**

Hot ⟷ Cold

19 18 17 16 15 14 12 10 08

L — **Spark gap design**

- Not projected insulator tip
- Y Projected insulator tip
- L Extremely projected insulator tip
- T Projected insulator tip and three ground electrodes EXTRA
- LG Extremely projected insulator tip and ring-shaped spark gap PREMIUM
- Z Two auxiliary electrodes on the insulator tip and ring-shaped electrode gap PREMIUM
- TX One auxiliary electrode on the insulator tip and three ground electrodes PREMIUM
- LT Extremely projected insulator tip and three ground electrodes EXTRA

C — **Elektrode material**

- Nickel-alloy centre electrode
- C Copper cored centre electrode SUPER
- S Silver centre electrode SILVER
- P Centre electrode with platinum contact PLATIN
- PP Centre and ground electrode with platinum contact PLATIN

-1 — **Spark gap**

- 0,4 - 0,9 mm
- -05 0,5 mm
- -1 1,0 - 1,1 mm
- -3 1,3 mm
- -X Special design

Maintenance

Spark plugs do not require any maintenance during the replacement interval. Certain level of maintenance is, however, required by the vehicle whose part the spark plugs are. All deficiencies caused by an insufficient vehicle maintenance can be reflected on the spark plug. That is why we recommend, within the framework of prevention, to check the spark plugs at least once a year. Their appearance reflects technical conditions of your vehicle.

Spark plugs replacement intervals are specified for a maximum mileage performance of the engine in a good technical condition. Therefore **never exceed** the replacement intervals prescribed for a given type of spark plugs! Possible spark plug replacement before the interval prescribed will not cause any problem.

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