DENSO

SPARK PLUGS TRAINING MANUAL

WGP250 : LCR
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Formula1 : PANASONIC TOYOTA RACING
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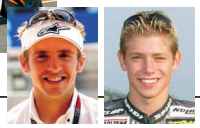
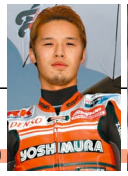
http://www.globaldenso.com/PLUG/ **http://www.denso.co.jp/PLUG/**

DENSO SUPPORT DRIVERS & RIDERS

DENSO RACE SUPPO

	1998	1999	2000	2001	20
Automobile					
F1			TOYOTA F1 Team Taking Malaysian GP Podium Position (TAKING PODIUM POSITION)	Supply TOYOTA F1 Racing Plugs	
WRC					
Super GT	IQ01-31	GT500 Champion	Castrol TOM'S GT500 CHAMPION	DENSO Racing Plug / GT500 Champion / au Supra GT500 CHAMPION	
Motorcycle					
WGP			WGP125 Noboru UEDA & Masao AZUMA IA01-34 / 3 Victories / Rd.1 Suzuka IRIDIUM POWER WGP Debut Win	WGP125 Noboru UEDA & Masao AZUMA IA01-32,34 / 1 Victory / WGP250 Naoki MATSUDO & Taro SEKIGUCHI	
WSB	DUCATI916 C.Fogarty DENSO Racing Plug / WORLD CHAMPION		AZUMA wins Suzuka GP / UEDA wins Italian GP	FOGGY PETRONAS DENSO Racing Plug	
AMA MX				PROCIRCUIT TEAM KAWASAKI M. BROWN & 3 riders IW01-27 / AMA EAST CHAMPION	
WMX				YAMAHA KURZ C. MELOTTE & 3 riders IW01-24,27	
Japan JGP (R2-1)		IA 125 CHAMPION		JSB(S-NK) CHAMPION	
Japan JMX			IA125 Champion	JSB (S-NK) Champion / KENZ Keiichi KITAGAWA	IB125 CHAMPION / IB250 Champion
Japan DRAG					Prostock Second Place

ORT HISTORY

02	2003	2004	2005
		Corporate sponsor	 TOYOTA F1 Team Taking Malaysian GP **Podium Position**
		Corporate sponsor 	 Supply WRC Plugs — Rd.3 Mexico IRIDIUM POWER WRC **Debut Win**
	GT500 Champion  Esso Supra GT500 CHAMPION		
	WGP125 Masao AZUMA & Yoichi UI — IA01-32,34 IAE01-32,34 — 7 Victories WGP250 Naoki MATSUDO & Team LCR	WGP125 Yoichi UI — IA01-32,34 IAE01-32,34 — 3 Victories WGP250 Naoki MATSUDO & Taro SEKIGUCHI & Team LCR	WGP125 Toshinaga KUZUHARA & Tomoyoshi KOYAMA  WGP250 Team LCR Robert Locatelli & Casey Stoner — 2 Victories
			 
	M. BROWN & 3 riders	IVAN TEDESCO & 3 riders — AMA EAST CHAMPION  — IU01-27	
	C. MELOTTE & 3 riders	SUZUKI KURZ L. DOVES & 1 rider 	
	JSB 1000 CHAMPION  KENZ Keiichi KITAGAWA — JSB 1000 Champion	IB125 CHAMPION  — IB125 Champion	   YOSHIMURA WATANABE KENZ NASHIMOTO Team Wheelie KIKUCHI
	 PROSTOCK CHAMPION — Prostock Champion	PROSTOCK CHAMPION — Prostock Champion	 IA250 TAJIMA NAYA  NOTO1 DRAG ONISHI NAKAMURA

WRC:SUBARU WORLD RALLY TEAM
Petter Solberg

WGP125 : AJO MOTORSPORTS
Tomoyoshi Koyama

WGP250 : TEAM LCR
Roberto Locatelli

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Chapter 2 Spark plugs

Chapter 3 Basics of Ignition

Chapter 1
Outline

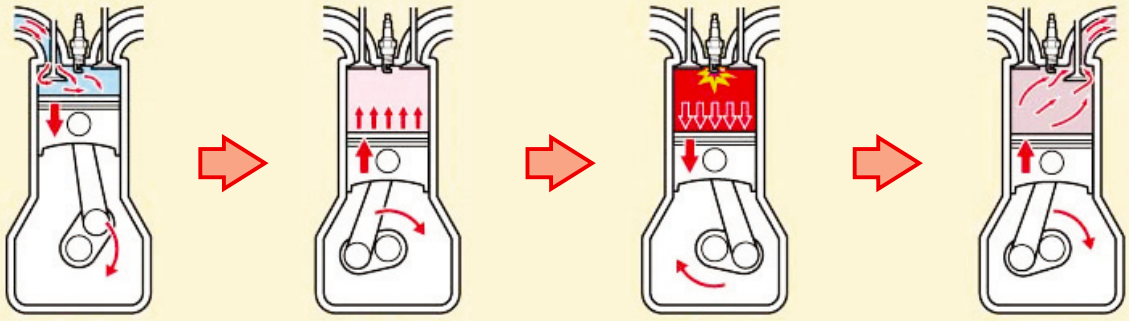
Study Tips
Let us study about the role of the ignition system, its components parts, and its different types.

1 4-Stroke Engines

Operation of 4-stroke engines

The 4-stroke engine was first invented by N. Otto in 1876. So it is also known as the Otto Cycle.
The spark plugs ignite and the gasoline burns driving the piston downwards, creating power.

Intake → Compression → Combustion → Exhaust
These four strokes rotate the crankshaft twice and complete one cycle.



1 Intake stroke
Takes the air-fuel mixture into the cylinder.

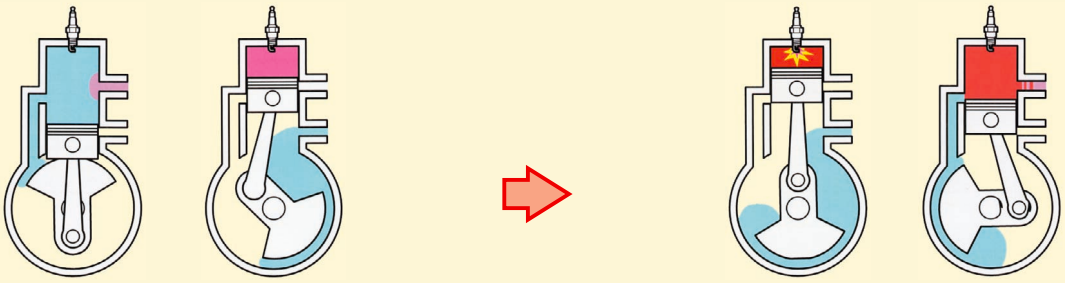
2 Compression stroke
Compresses the air-fuel mixture to high temperature and high pressure.

3 Combustion stroke
Ignites and combusts the gas mixture and uses the resulting high pressure to rotate the crankshaft.

4 Exhaust stroke
Exhausts the exhaust gas.

REFERENCE **2-stroke engines**

These two strokes complete one cycle during one motion of the piston (one crankshaft rotation).



1 Intake and compression stroke
When the piston rises and the cylinder side compresses, the crank case side is a vacuum and takes in the air-fuel mixture.

2 Combustion and exhaust stroke
When the piston is pushed down by the combustion, the air-fuel mixture on the crank case side is sent to the cylinder side where it pushes out the exhaust gas.

2-stroke engines do not require moving valves and have a simpler structure, but the compression ratio is low and they are only appropriate for small displacements.

2 Role of the Ignition System

The ignition system applies several thousand volts across the gap between the electrodes of the spark plug to generate spark to discharge and ignites and combusts the air-fuel mixture in the cylinder with this spark energy.
Igniting at the optimum time for the varying engine speed, load, etc. is also an important condition.

Three conditions for attaining the performance of gasoline engines

REFERENCE **Diesel engine ignition system**

Diesel engines directly inject fuel into high-temperature, high-pressure air and have the fuel ignite on its own, so they do not require ignition system.

1 Good Air-Fuel Mixture

REFERENCE **Good Air-Fuel mixture means**

The mixture that makes the gasoline combust most readily
[1]Gasified and well mixed with air [2]Always the correct air-fuel ratio (mixture proportions)

Air-Fuel ratio (A/F)

The proportion by weight of gasoline and air in the air-fuel mixture; these proportions must be varied with the engine state.
·Stoichiometric air-fuel ratio (about 15:1) Stoichiometric value for complete combustion
·Output air-fuel ratio (about 12:1) The mixture ratio that provides the maximum torque
·Economy air-fuel ratio (about 16:1) The mixture ratio that provides the best fuel economy
·In lean burn engines, this can be as high as about 23:1.

2 Good Compression

REFERENCE **Compression ratio**

By compressing the air-fuel mixture, it is possible to obtain large power when the mixture is combusted.
The degree of compression of the air-fuel mixture is expressed by the following compression ratio.

$$\text{Compression ratio} = \frac{\text{Intake air volume}}{\text{Compressed air volume}}$$

Generally, raising the compression ratio provides larger combustion pressure, but if the pressure is too high, knocking occurs. General engines are designed for compression ratios of 9-10.

3 Good Spark

REFERENCE **"Good spark" is the field for which the ignition system is responsible.**

■ Strong spark

High voltage of several thousands of volts are applied between the electrodes of the spark plug for the spark to discharge to ignite and combust the gas mixture.

■ Correct ignition timing

The ignition timing is adjusted to match the running state of the engine (speed and load) and obtain efficient combustion power.

Chapter 1
Outline

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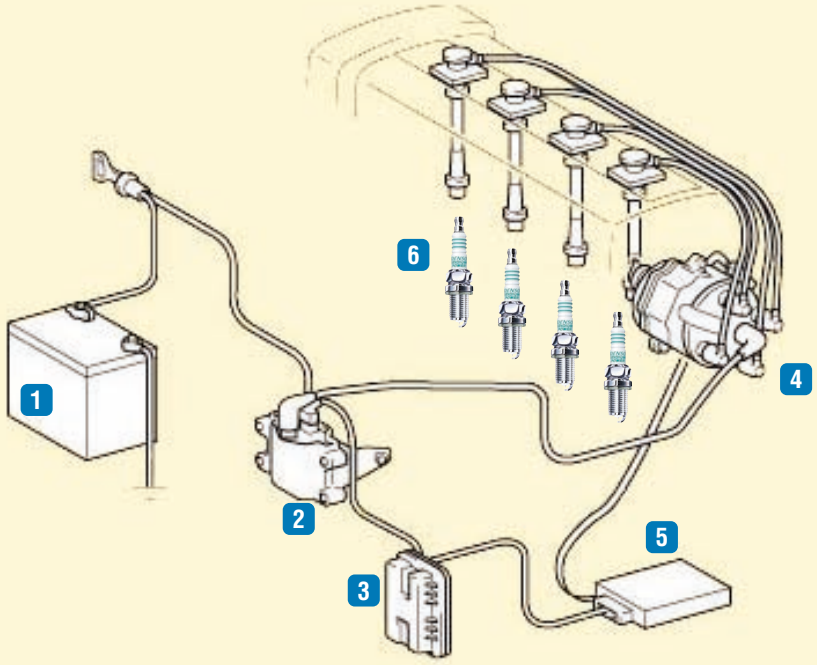
3 Ignition System Configuration

Ignition System Configuration

The ignition system comprises the following parts.



1 Battery
Supplies current to the primary coil

2 Ignition coil
The high voltage required for ignition is generated in the secondary coil through coil self-inductance and mutual inductance. The high voltage is generated when the primary current is cut off.

3 Igniter
In order to generate the high voltage required for ignition in the ignition coil, the current flowing through the primary coil is cut off.

4 Distributor
The high voltage generated by the ignition coil is distributed in the correct order to the spark plug for each cylinder.

5 Computer
Determines the ignition timing or the like

6 Spark plug
High voltage is applied to the gap between the electrodes to generate the spark and ignite the air-fuel mixture.

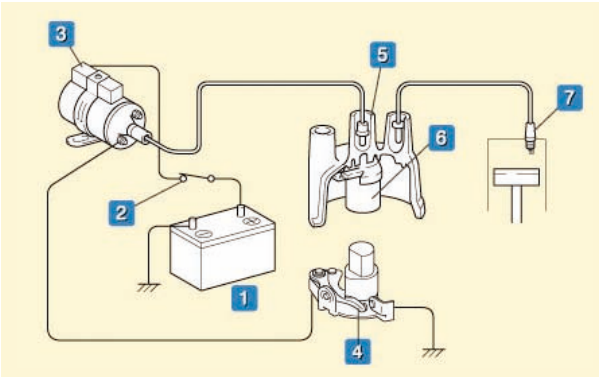
4 Types of Ignition System

Structurally, ignition system can be classified into the following three types.

Contact Ignition Type (Ordinary Ignition Type)

In this system, the current (primary current) flowing to the ignition coil from the battery is cut off at the mechanical contacts (breaker points) in the distributer to generate high voltage.

Demerit
Since these are mechanical contacts, sparks can fly between the contacts or the voltage drops at low speed. Also, sometimes current does not flow adequately due to soiling of the contact surface.

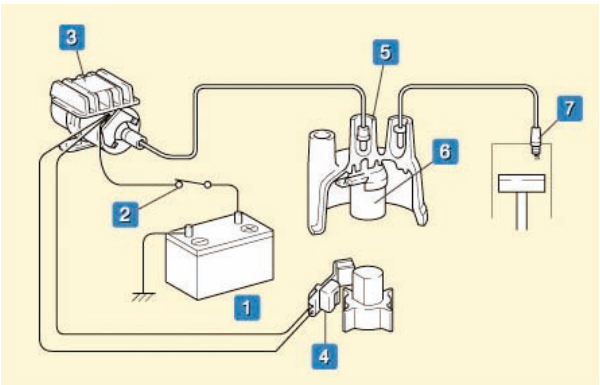


1 Battery
2 Ignition switch
3 Ignition coil
4 Breaker point
5 Distributor
6 Rotor
7 Spark plug

Transistor Ignition Type

This system generates high voltage by cutting off the current with transistors in the igniter. This system can provide stable high voltage.

Demerit
The ignition timing is controlled by the signal generator in the distributor, so there are limits to fine control.

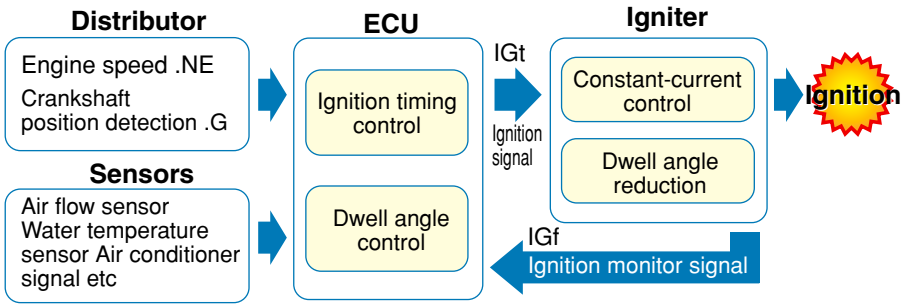


1 Battery
2 Ignition switch
3 Coil with an igniter
4 Signal generator
5 Distributor
6 Rotor
7 Spark plug

Electronic Spark Advance (ESA, DLI)

Electronic ignition type
(ESA:Electronic Spark Advance, DLI:Distributorless Ignition)

The ignition timing and dwell angle are controlled by microcomputer, which sends the ignition signals to the igniter, where the transistors inside the igniter cut off the current and generate high voltage. This makes more precise control possible and is the current mainstream ignition system.



5 Comprehensive Test

From the following statements about ignition system, select the incorrect one.

1 Both gasoline engines and diesel engines require spark plugs to ignite the air-fuel mixture.
2 The ignition timing is adjusted according to changes in the engine speed and load.
3 The air-fuel mixture for gasoline engines is the proportion of air and gasoline by weight and about 15:1 is called the stoichiometric air-fuel ratio.
4 The spark voltage for spark plugs is generated when the primary current through the igniter is cut off.
5 4-cycle engines ignite and combust each cylinder one time for two rotations for the engine crankshaft.

Answer on next page

Chapter 2
Spark Plugs

Study Tips
The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

1 Spark and Ignition

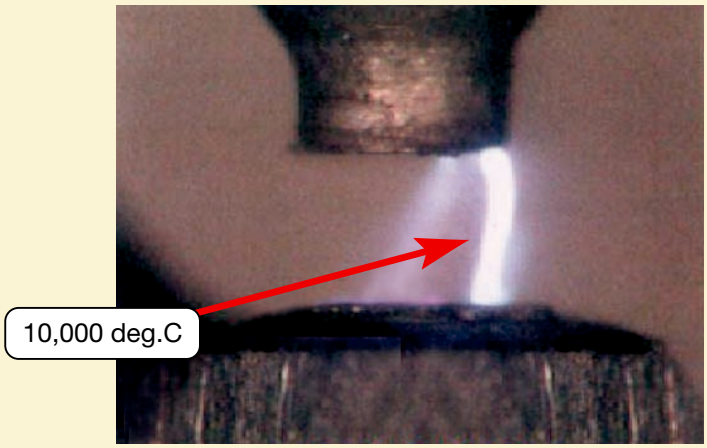
Spark

When the high voltage produced by the ignition system is applied between the center electrode and ground electrode of the spark plug, the insulation between the electrodes breaks down, current flows in the discharge phenomenon, and an electrical spark is generated.
This spark energy trigger ignition and combustion in the compressed air-fuel mixture.

This discharge is of extremely brief duration (about 1/1000 of a second) and is extraordinarily complex.

The role of the spark plug is to reliably generate a strong spark between the electrodes accurately at the specified time to create the trigger for combustion of the gas mixture.

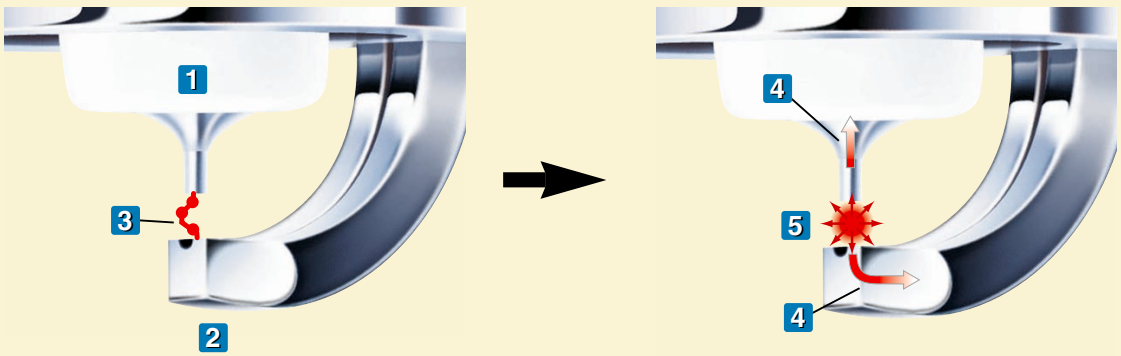
Sparking wear



High melting point

Ignition

Ignition by electrical spark occurs because the fuel particles between the electrodes are activated by the spark to discharge, a chemical reaction (oxidation) is triggered, the heat of reaction is generated, and the flame core is formed. This heat activates the surrounding air-fuel mixture, eventually a flame core is formed that spreads the combustion to the surroundings itself.
However, if the quenching effect between the electrodes (the work of the electrodes absorbing the heat and extinguishing the flame) is greater than the flame core heat generation action, the flame core is extingushed and the combustion stops.
If the plug gap is wide, the flame core is larger and the quenching effect is smaller, so reliable ignition can be expected, but if the gap is too wide, a large discharge voltage becomes necessary, the limits of the coil performance are exceeded, and discharge becomes impossible.



Formation of the flame core

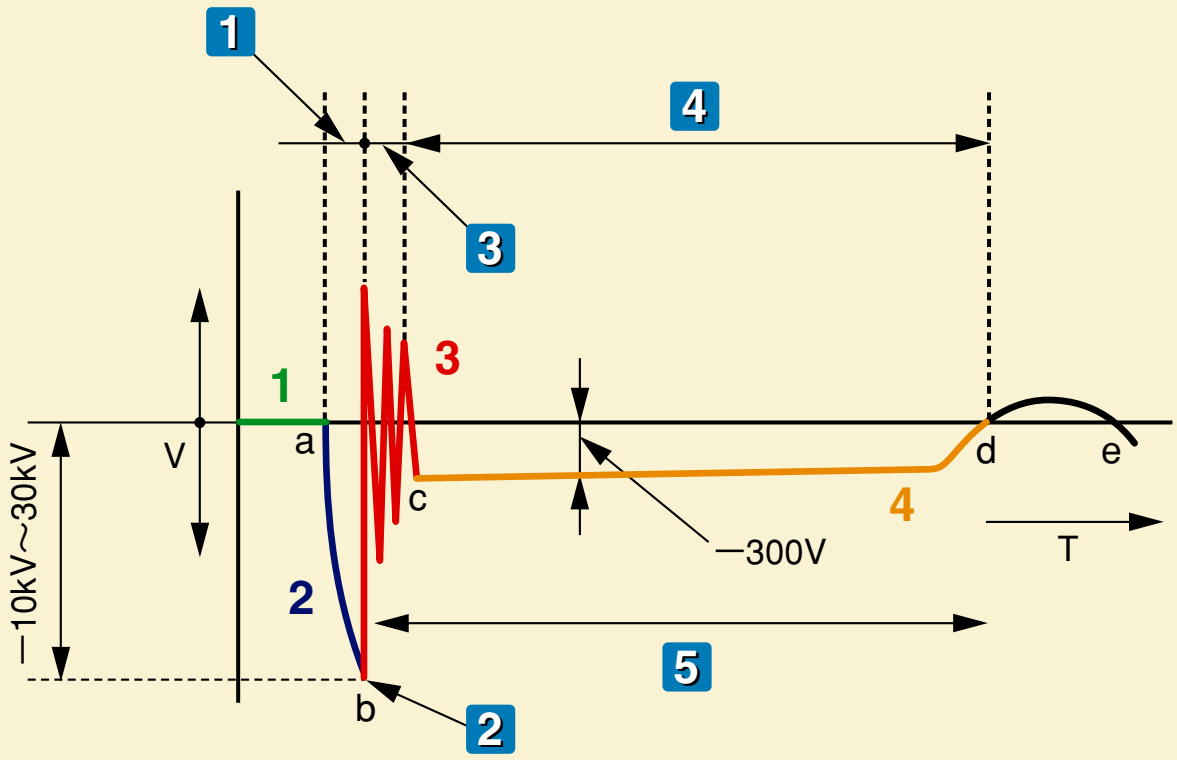
Quenching effect

1 Center electrode 2 Ground electrode 3 Flame core 4 Heat absorption 5 Flame propagation

Answer: 1

Change in the required voltage

The ignition system normally generates 10-30 kV secondary voltage.



1. When the primary current is cut off at the 'a' point, the secondary voltage rises.

2. At the 'b' point, partway through the rise in voltage, the spark plug reaches the required voltage and a spark is generated between the electrodes.

3. Between 'b' and 'c' is called the capacitance spark. At the start of the discharge, the spark is generated by the electrical energy stored in the secondary circuit. The current is large but the duration is short.

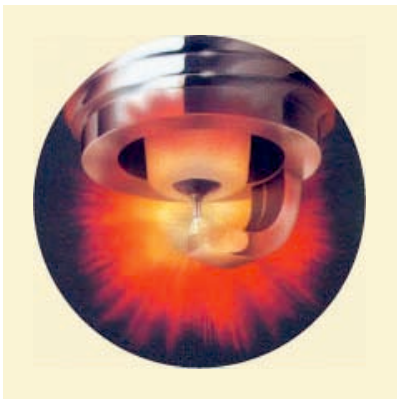
4. Between 'c' and 'd' is called the inductance spark. The spark is generated by the electromagnetic energy of the coil. The current is small but the duration is long. From the 'c' point, the discharge is continued for about 1 millisecond and at the 'd' point, the discharge ends.

Chapter 2
Spark Plugs

Study Tips
The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

The required voltage changes drastically with various conditions.

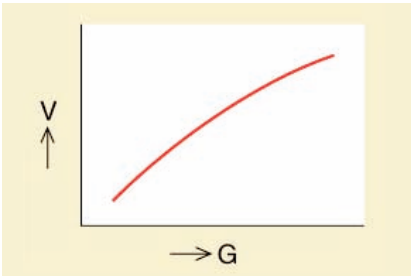
The three factors with particularly large impact are the spark plug gap, the compression pressure, and the air-fuel mixture temperature.



● Conditions that affect the required voltage

1 Spark Plug Gap

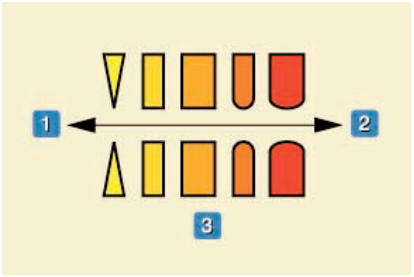
The required voltage rises in proportion to the spark plug gap.
The spark plug gap widens bit by bit as the electrode wears, so high required voltage becomes necessary and misfire occurs more easily.



G: Spark plug gap V: Required voltage

2 Electrode shape

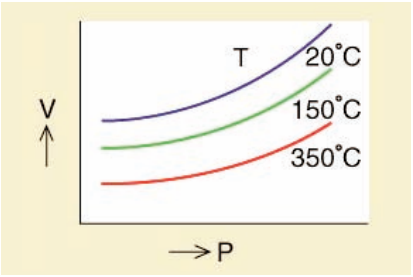
Even for the same spark plug gap, if there are edges on the electrode, discharge occurs more easily.
Older spark plugs have electrodes that have rounded, so discharge becomes more difficult and misfire more likely.



1 Easy discharge 2 Difficult spark
3 Electrode shape

3 Compression pressure

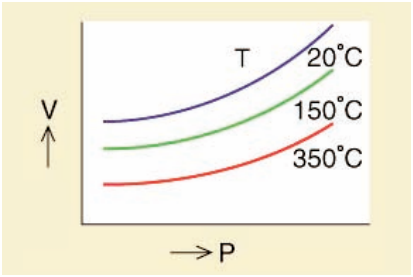
The required voltage rises in proportion to the compression pressure.
The compression pressure is higher for low speed and high load. Sudden acceleration for starting out fits these conditions, so higher voltage is required then and misfire occurs more easily.



P: Compression pressure T: Air-Fuel mixture temperature V: Required voltage

4 Air-Fuel mixture temperature

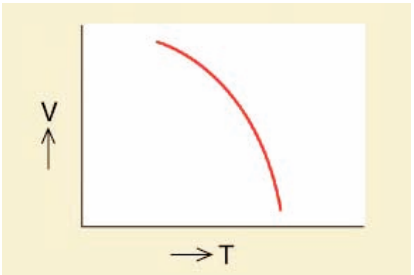
The required voltage drops as the air-fuel mixture temperature rises.
The lower the engine temperature, the higher the required voltage, so misfire occurs more easily at low temperature.



P: Compression pressure T: Air-Fuel mixture temperature V: Required voltage

5 Electrode temperature

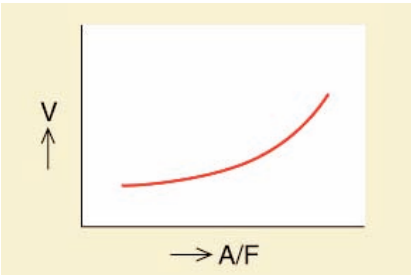
The required voltage drops as the electrode temperature rises.
The electrode temperature rises in proportion to the engine speed, so misfire occurs more easily at low speed.



T: Electrode temperature V: Required voltage

6 Air-Fuel ratio

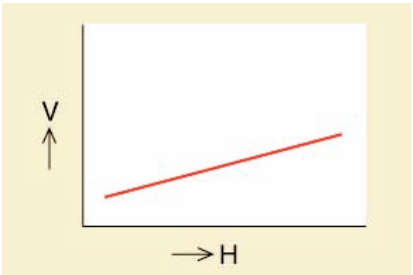
There is a tendency for the required voltage to be higher the leaner the air-fuel mixture (the larger the air-fuel ratio).
If the air-fuel mixture becomes leaner due to fuel system trouble misfire occurs more easily.



A/F: Air-fuel ratio V: Required voltage

7 Humidity

As the humidity rises, the electrode temperature decreases, so the required voltage becomes slightly higher.



H: Relative humidity V: Required voltage

The effect on the spark plugs of ignition and combustion of the running engine is severe and various aspects of performance for withstanding this are required.

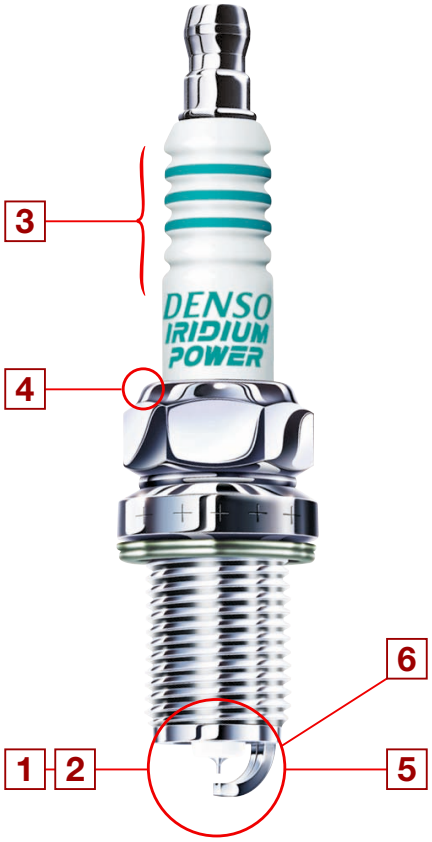
● Performance required of spark plugs

1 Can withstand sudden heat and sudden cold

The temperature received by the inside surface of the spark plug reaches as high as 3000˚C during combustion of the air-fuel mixture and during the intake stroke, the spark plug is subject to sudden cooling by low-temperature gas. In 4-cycle engines, this sudden heating and sudden cooling is repeated every other rotation as long as the engine is running.
As the same time that it must provide such capacity to withstand heat, the spark plug must also give off enough heat to avoid becoming a starting point for pre ignition.

2 Can withstand severe pressure changes.

In the intake stroke, the pressure is less than 1atm, but in the combustion stroke it reaches 50 atm or higher. The mechanical strength to withstand this severe pressure change is required.



3 Has insulation at high voltage

In an environment in which the temperature and pressure are constantly changing drastically, spark plugs must have adequate insulation to withstand high voltages that reach about 10-30 kV.

4 Maintains an airtight seal in a harsh environment

Spark plugs must maintain an airtight seal between the housing and the insulator under conditions of drastic temperature and pressure change and high voltage.
DENSO's heat staking process provides stable air tightness.

5 Minimizes electrode wear

Spark plugs must have the wear-proof resistance to minimize electrode wear in a severe usage environment.
DENSO's patented iridium alloy is effective against wear.

6 Minimizes fouling from combustion

It is required that under severe usage conditions, spark plugs minimize fouling of electrodes by the combustion of the air-fuel mixture and have self-cleaning that burns away carbon deposits with heat.
Therefore, it is desirable that the spark plug temperature rise quickly even when the vehicle is moving at low speed and that the insulator section reach the self-cleaning temperature (about 500˚C).

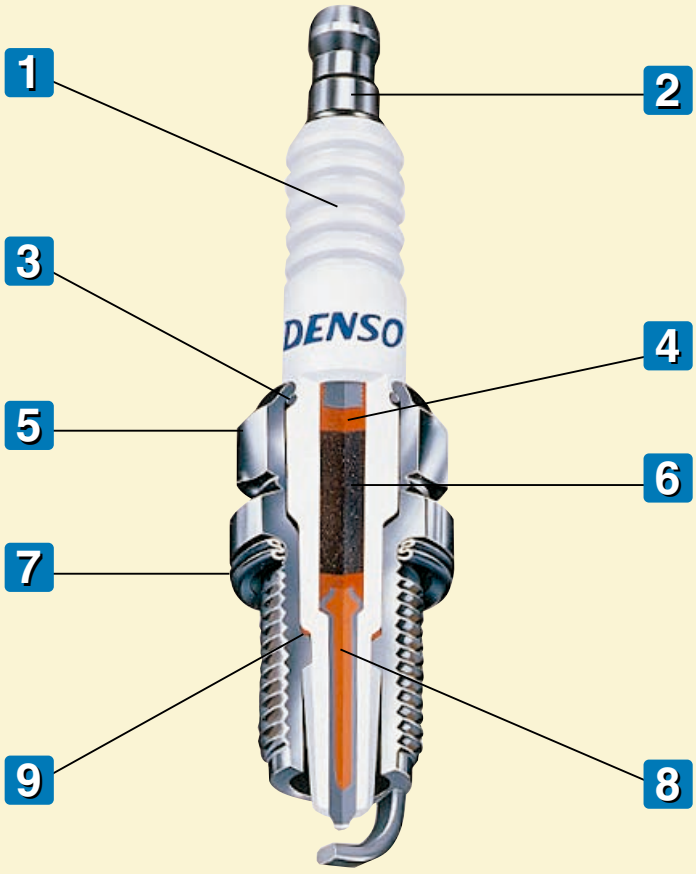
Chapter 2
Spark Plugs

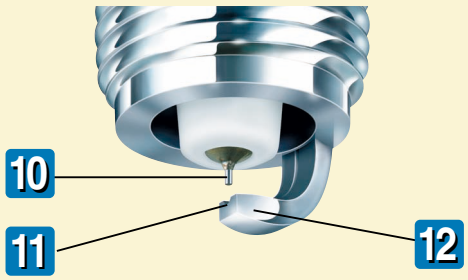
Study Tips
The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

2 Structure

A spark plug consists of three main parts, the housing, the insulator, and the electrodes.

Let us take a look at the figure, which shows an IRIDIUM POWER spark plug as an example, and look at the features of each part.





1 Insulator
2 Terminal
3 Ring
4 Center shaft (stem)
5 Housing
6 Glass seal
7 Gasket
8 Electrode with copper
9 Packing washer
10 0.4-mm iridium center electrode
11 U-groove ground electrode
12 Taper cut ground electrode

1 Insulator

Insulates the terminal, center shaft and center electrode from the housing, preventing escape of high voltage from the electrodes.
Since the bottom of the insulator projects into the combustion chamber, high purity alumina with superior heat-proof characteristic, mechanical strength, excellent insulation and thermal conductivity at high temperature, etc. is used.

2 Terminal

The terminal is connected to a high-tension cord through which high-voltage current from the ignition system flows.
A terminal nut is installed so this type can support almost any high-tension cord in the world. For vehicles not requiring a terminal nut, the terminal can be removed.

3 9 Ring, Packing washer

Makes the insulator and the housing fit tightly to each other and maintains the airtightness.

4 Center shaft (stem)

Center shaft connecting the terminal and the center electrode.
This shaft is made of steel and has the role of allowing high-voltage current to flow from the terminal to the center electrode without loss.

5 Housing

The housing forms an outer shell that surrounds the insulator, supports the insulator, and installs the spark plug in the engine.
At the bottom the ground electrode is located, so current can flow through the engine itself to the center electrode over the gap.

6 Glass seal

Mounted between the center shaft and insulator to maintain the airtightness.
DENSO uses the glass seal method.
A special mixture of glass powder and copper powder is charged in the installation section for the insulator and center shaft and center electrode and melted at high temperature. This bonds the center shaft and the center electrode and fuses the insulator and the metal.
The sealing for both is good and the thermal ratio of expansion is appropriate, so even under harsh conditions gaps do not occur and good airtightness can be secured.

7 Gasket

Makes the housing and the engine fit tightly to each other and maintains the airtightness of the combustion chamber.
There is a procedure for tightening and the appropriate tightening margin must be secured.

Standard tightening torque

Thread diameter (mm)	Tightening torque (Nm)
8	8 ～10
10	10～15
12	15～20
14	20～30
18	30～40

8 Electrode with copper

Special nickel alloy is used for the center electrode to reduce electrode wear.
Copper is sealed into the center section to improve thermal conductivity.

10 0.4-mm iridium center electrode

A new iridium alloy tip with a diameter of 0.4 mm is laser welded to the tip of the center electrode to make the center electrode ultra-fine.
This lowers the required voltage, secure reliable spark, reduces the quenching effect, and improves ignition performance.
Iridium, like platinum, is a precious metal and has extraordinarily superior properties for a spark plug electrode, for example high-temperature withstand, high strength, and low resistance. In order to further improve oxidation resistance at high temperatures, DENSO developed a unique new iridium alloy containing Rhodium.

11 U-groove ground electrode

Nickel chrome material is used for the ground electrode and various measures are taken with the shape to improve ignition performance.
One of these measures is the U- groove.
[1] The surface contacted by the air-fuel mixture is large,
[2] There is much edge section, and sparks occur easily.
[3] The flame core (flame size) widens easily.
There are many other feaures as well and large ignition energy can be obtained.
DENSO obtained patents for spark plug U-grooves from 1975 to 1992.

12 Taper cut ground electrode

The ground electrode has a shape in which the electrode tip is cut to a finely tapered shape.
This reduces the quenching effect, so it improves ignition performance.

Chapter 2

Spark Plugs

Study Tips

The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

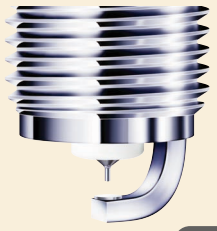
3 Types

Main types of spark plugs

1 IRIDIUM POWER

P.16

2 IRIDIUM TOUGH



P.17

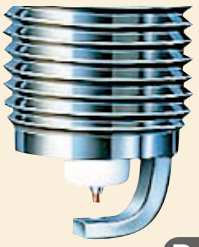
3 IRIDIUM RACING

P.18

4 Needle to needle Iridium Plug

P.18

5 Genuine iridium



P.19

6 Resistor

P.19

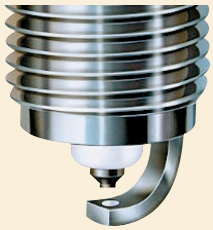
7 U-groove

P.20

8 Platinum ZU

P.20

9 Platinum



P.21

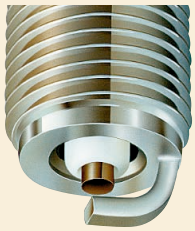
10 For rotary use

P.21

11 Extended

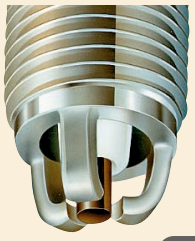
P.22

12 Semi-surface discharge



P.22

13 3 electrodes



P.23

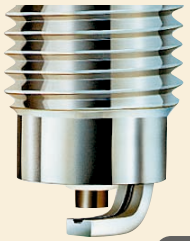
14 Compact type

P.23

15 Taper seat

P.23

16 For motorcycle



P.24

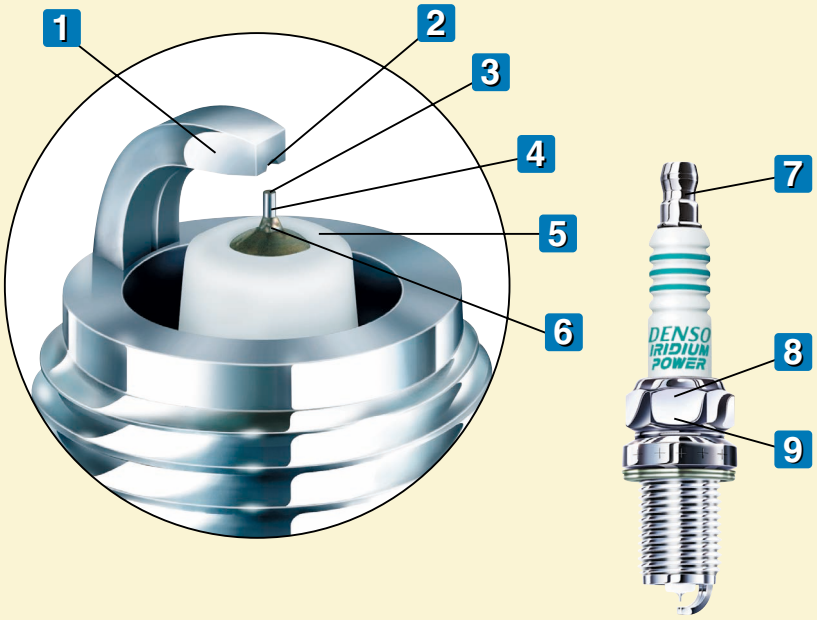
1 IRIDIUM POWER® (1)

● Uses the world's first and the world's smallest ultra-fine 0.4-mm diameter iridium tip for the center electrode. This lowers the required voltage and greatly improves ignitability.

● The inside of the ground electrode has a U-shaped groove to secure the large space required for flame core formation. This provides superior ignition performance with low spark voltage without enlarging the plug gap.

● The ground electrode tip is cut to a shape with a tapered tip. This reduces the quenching effect and greatly improves ignitability.

1 (1)

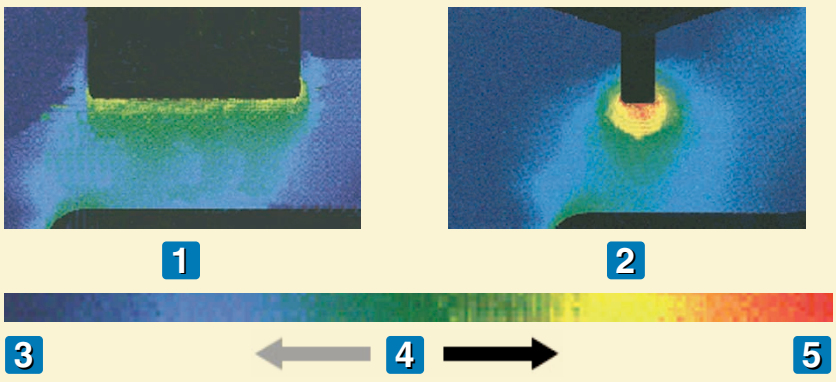


1 Taper cut ground electrode
2 U-groove ground electrode
3 Ultra-fine 0.4-mm diameter iridium alloy center electrode
4 Increased center electrode projection
5 Insulator projection
6 All-round laser welding
7 Terminal Nut
8 Built-in high-reliability resistor
9 Plated with highly corrosion resistant nickel

1 IRIDIUM POWER® (2)

● The finer the electrodes, the more the potential concent-rates at the electrode tip and the stronger the electrical field, so the lower the required voltage. Therefore, reliable combusion is obtained over a wide range and engine starting and acceleration are improved.

1 (2)



1 Normal spark plugs
2 IRIDIUM POWER®
3 Weak
4 Electrical field strength
5 Strong

Electrical field strength shown using FEM analysis

Chapter 2

Spark Plugs

Study Tips

The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

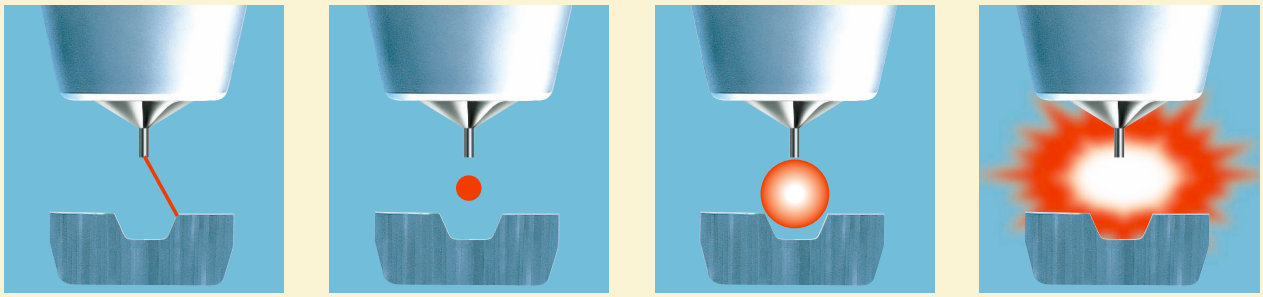
1 IRIDIUM POWER® (3)

- The electrodes have been taken to the limit of fineness, so the contact area with the flame core is small, the quenching effect is reduced, and the ignition performance is improved.

- IRIDIUM POWER can replace almost all normal spark plugs in Japan and overseas. When replacing normal spark plugs with IRIDIUM POWER check in the application table.

- For normal engines, replace with the same heat range as the spark plugs being replaced; for a tuned engine, select spark plugs that match the tuning level.

1 (3)



1 Sparks
Sparks discharge on the part of the electrode where they can spark most easily.

2 Formation of the flame core
The spark energy activates part of the air-fuel mixture and a small flame is produced.

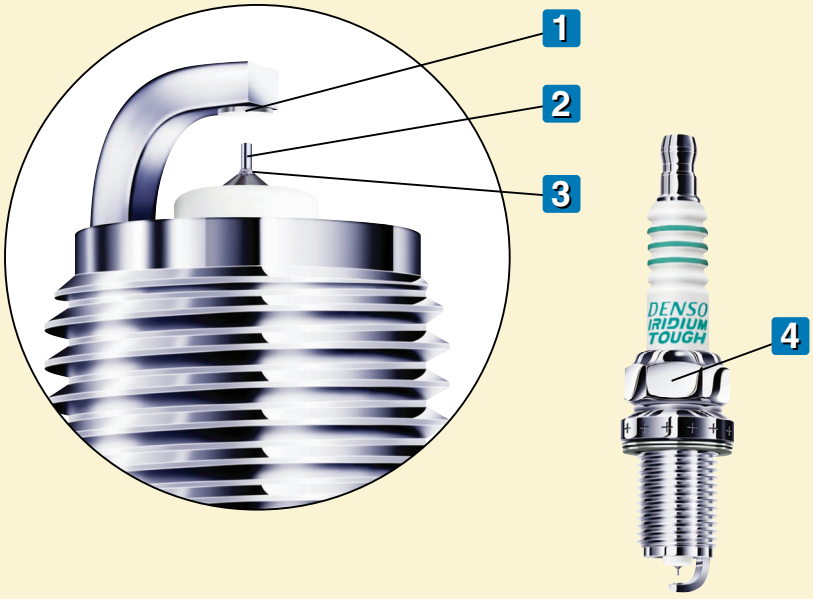
3 Growth of the flame core
The flame grows even though energy is absorbed in the center and ground electrodes.

4 Ignition
Growth of the live coal accelerates and finally, the flame spreads as explosive combustion.

2 IRIDIUM TOUGH®

- The center electrode uses the world's first ultra-fine 0.4-mm diameter iridium alloy for high performance and a platinum tip is used for the ground electrode to secure service life equal to platinum spark plugs.

2



1 Ground electrode with platinum tip

2 Ultra-fine 0.4-mm diameter iridium alloy center electrode

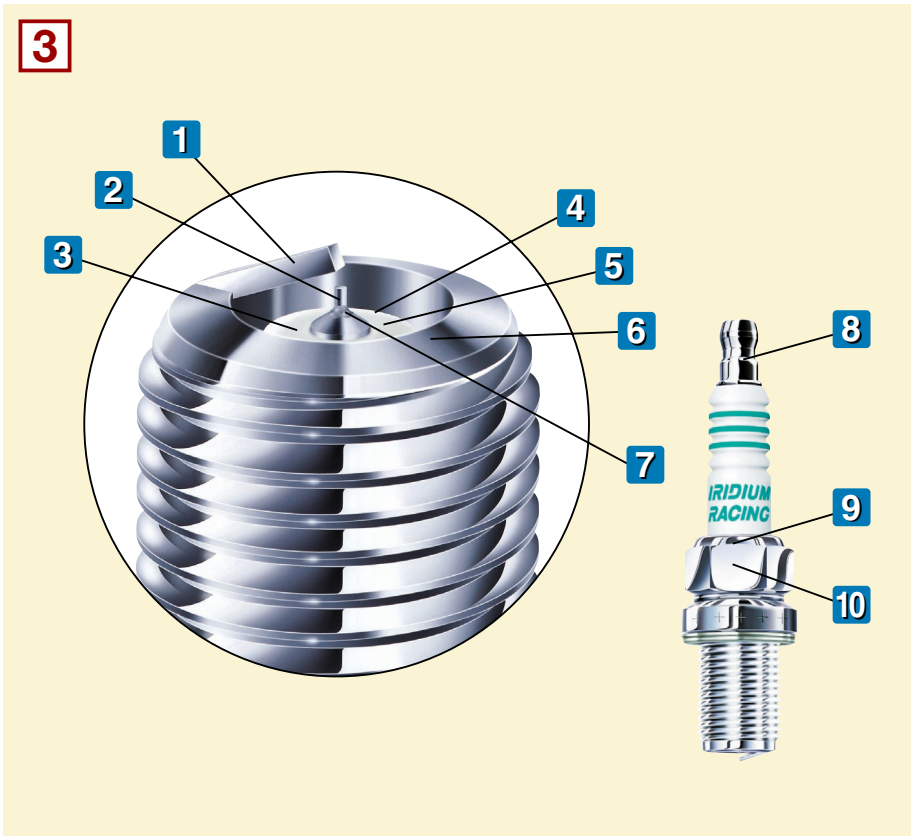
3 All-round laser welding

4 Housing plated with highly corrosion-resistant, lustrous nickel

3 IRIDIUM RACING

● Combining the ultra-fine 0.4-mm diameter iridium alloy center electrode with the 0.8-mm square all-platinum ground electrode, spark cleaning pocket, housing end chamfer, silicon oil application, racing insulator, etc. greatly improves ignition performance and extends durability.

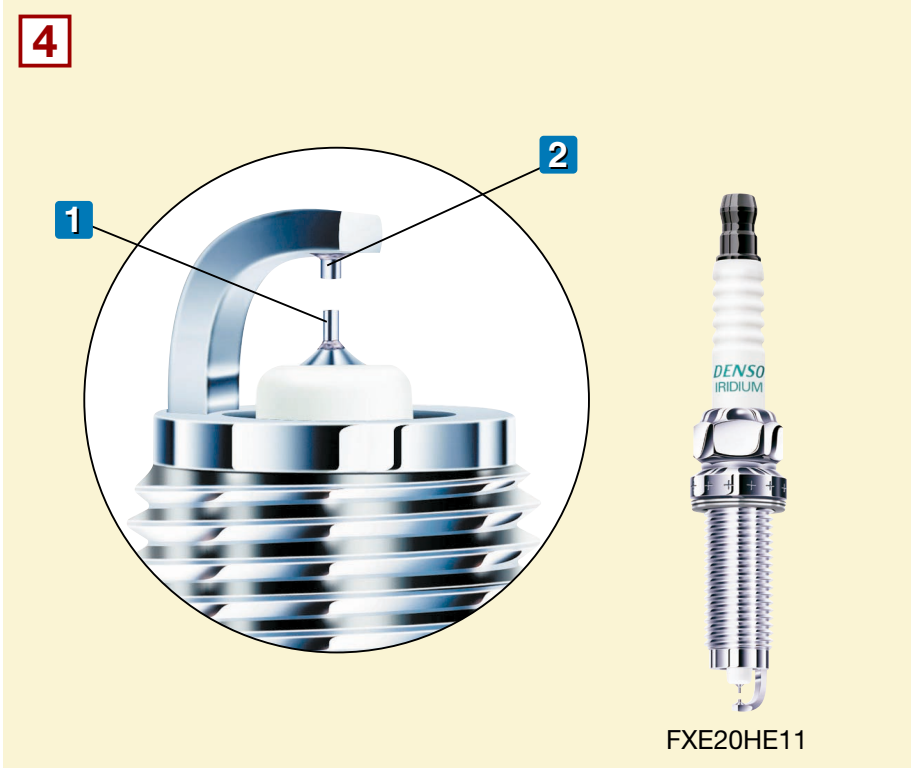
1. 0.8 mm square all-platinum ground electrode
2. Ultra-fine 0.4-mm diameter iridium alloy center electrode
3. Racing insulator
4. Spark cleaning pocket
5. Silicon oil application
6. Housing end chamfer
7. All-round laser welding
8. Terminal
9. Built-in high-reliability resistor
10. Plated with highly corrosion resistant nickel



4 Needle to needle Iridium Plug

● The ground electrode of this revolutionary iridium plug features DENSO's very own technology and is needle-shaped, resulting in an unparalleled reduction in quenching action.

1. 0.55mm diameter. Iridium
2. 0.7mm diameter. Platinum



FXE20HE11

Chapter 2
Spark Plugs

Study Tips
The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

5 Vehicle manufacturer's genuine iridium spark plugs

- Compared to IRIDIUM POWER, IRIDIUM TOUGH, and IRIDIUM RACING, which emphasize performance, this type emphasizes maintenance (service life).
- The replacement interval is 100,000 km.
- The center electrode is 0.7-mm iridium alloy and a platinum tip is used for the ground electrode.

- Iridium plug
Example : SK16R-P11
SK20R11

- Denso developed the world's first ultra-fine 0.7-mm diameter iridium alloy spark plugs to greatly improve ignition performance and service life.

The SK16R-P11 is used as the genuine spark plugs for the Toyota Century.

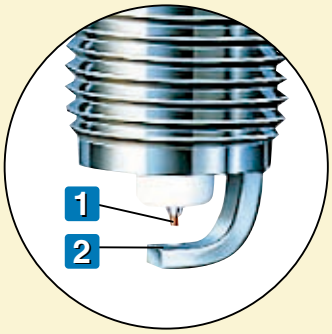
- New 3-electrode iridium spark plugs
Example: SK20BR11

- The design of these spark plugs is optimized for direct injection burning off carbon. The spark is at the main electrode normally and at the side electrode when the main electrode is sooty.

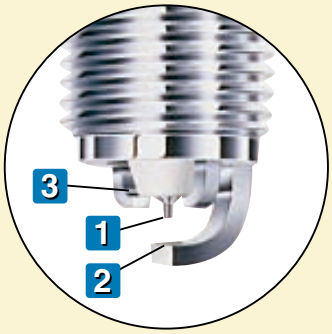
Used as the genuine spark plugs for the Toyota Crown 3-liter direct injection engine.

5

SK16R-P11, SK20R11



SK20BR11



SK20R11

1 Iridium ϕ 0.7 tip
2 Platinum tip
3 Side electrode

6 Resistor plug

- In order to prevent the generation of electromagnetic noise, the spark plug has resistor (5 kilo-ohms) built into the glass seal section.
- This resistance suppresses the capacitance dischage power during discharge and can greatly reduce the electromagnetic noise.
- Recently, with the increased use of electronic products in vehicles, the majority of spark plugs installed in new vehicles have resistors.

1 Resistor

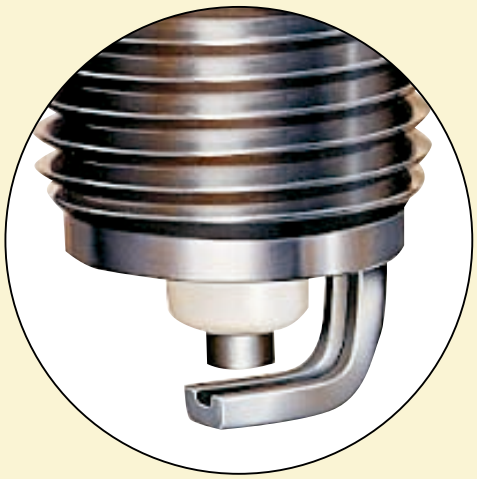
6

K16R-U11

7 U-groove

- Making a U-shaped groove on the inside of the ground electrode secures the large volume required for flame core formation and growth and makes it possible to obtain large ignition energy.
- Since it is possible to reduce the spark voltage without enlarging the spark plug gap, superior ignition performance is attained.

7



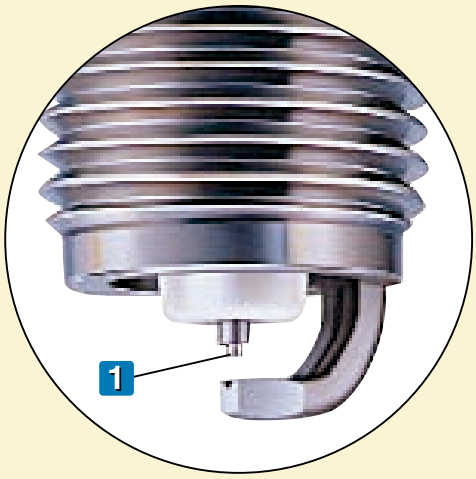
K16R-U11

8 Platinum ZU

- This spark plug uses 0.7-mm diameter ultra-fine special platinum alloy for the center electrode to improve sparking and uses a U-groove and taper cut for the ground electrode to improve ignition.

1 Platinum

8



W31ES-ZU

Chapter 2

Spark Plugs

Study Tips

The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

9 Platinum spark plugs

Example : PK20R11

- These spark plugs have platinum tips welded to the center electrode and ground electrode.
- The tips of the center electrodes are finer than those of ordinary spark plugs.
- They greatly improve fuel consumption, driveability, and durability and support maintenance-free operation.

~ For DLI (+ - discharge) Platinum spark plugs

Example : PK20R-P11

- In order to prevent wear from + discharge, the volume of platinum for the ground electrodes has been increased.

- Extended platinum spark plugs

Example : PKJ20CR-L11

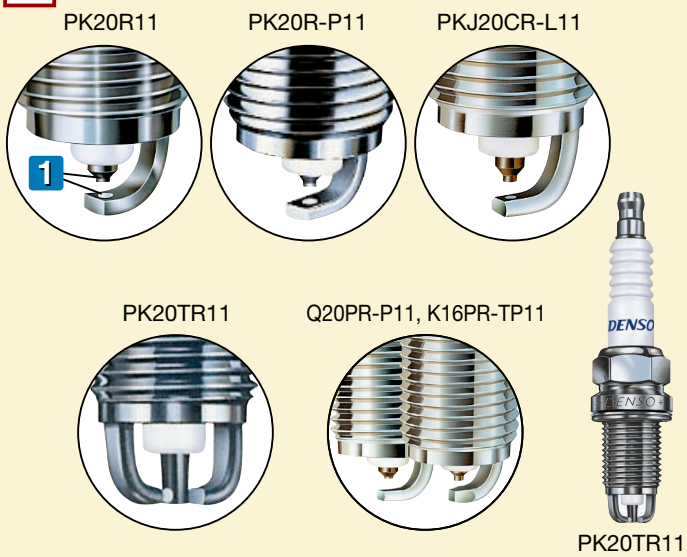
- Extended the spark position into the combustion chamber improves the combustion efficiency, fuel consumption, and driveability.

- 2-electrode platinum spark plugs

Example: PK20TR11

- Platinum tips are bonded to the center electrode facing to the ground electrode section.
- The 2-electrode structure reduces the voltage required for + discharge.

9



1 Platinum tip

- Single platinum spark plugs

Example : Q20PR-P11
K16PR-TP11

- These spark plugs use platinum only for the tip of the center electrode to improve fuel consumption, driveability, and durability by making the electrodes finer.
- The K16PR-TP11 has a tapered cut ground electrode to further improve ignition performance.

10 For rotary engines only

- These special spark plugs for rotary engines were designed taking into account the characteristics rotary engines give spark plugs.
- With rotary engines, heat remains in the ground electrodes and they melt, so to match the higher engine temperature, improvements have been made EA → EDR → semi-surface discharge → surface discharge.

1 EA spark plug (initial rotary engine spark plug)
This spark has two short facing ground electrodes.

2 EDR spark plug (transitional period)
This spark plug has four ground electrodes.
It has a built-in resistor to prevent the generation of electromagnetic interference.

3 Surface-discharge spark plugs
The surface-discharge action improves ignition, fouling-proof, and durability.

10

11 Extended

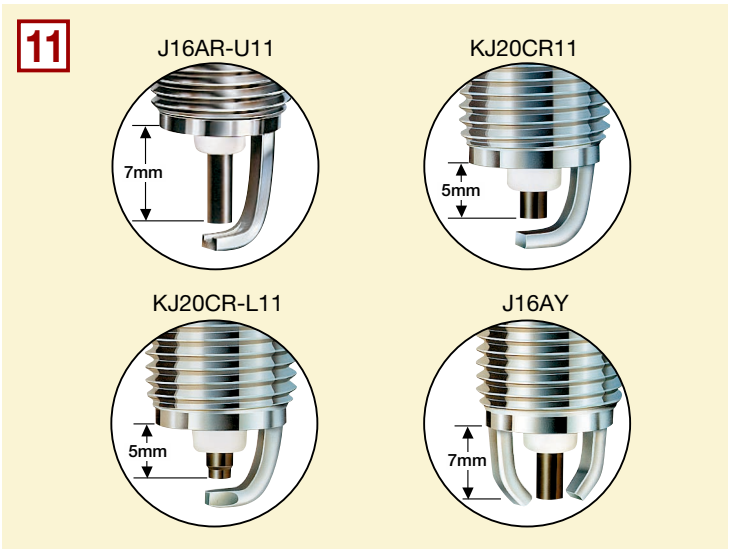
- This type of spark plug projects the center electrode and ground electrode far beyond the bottom section.
- Bringing the spark position closer to the center of the combustion chamber improves the combustion efficiency.
- Extended spark plugs can only be installed in the specified engines. If you use Extended spark plugs in place of ordinary spark plugs, there is a danger of interference with the valves or other parts.

Example : J16AR-U11

- The U-groove ground electrode obtains large ignition energy making it easy to ignite even lean air-fuel mixtures.
- Projecting the spark position into the combustion chamber improves the combustion efficiency, fuel consumption, and driveability.

Example : KJ20CR-11
KJ20CR-U11

- For Mazda and Mitsubishi.
- The KJ20CR11 has no U-groove.
The KJ20CR-U11 has a U-groove.



Example: KJ20CR-L11

- A taper cut is adopted for the ground electrode and a thin center electrode is adopted to improve ignitability.

Example : J16AY

- This spark plug is only for Daihatsu. It has two ground electrodes and provides durability.

12 Semi-surface discharge

- Semi-surface discharge spark plugs have surface discharge from the entire circumference of the ground electrode and normal discharge from the hook.
- Giving the semi-surface discharge structure to the ground electrode improves the ignition, fouling-proofing, and durability.

- Semi-surface discharge spark plugs

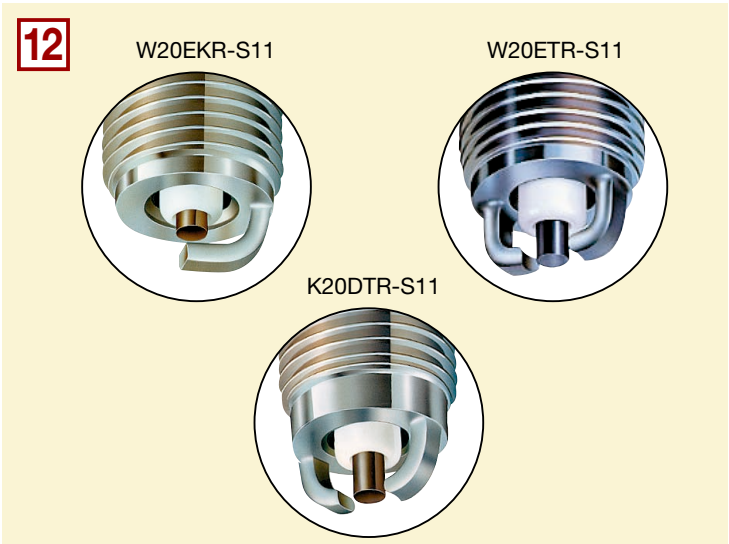
Example : W20EKR-S11
W20EPR-S11

- The use of semi-surface discharge improves ignition and fouling-proofing.
- The W20EKR-S11 is used in Honda and the W20EPR-S11 is used in Mitsubishi.

- semi-surface discharge 2-electrode spark plug

Example: W20ETR-S11

- 2 ground electrodes are adopted with the gap set to 1 mm.
- Superior durability is secured by using two short facing ground electrodes.
- The ignition is improved with full projection.
- The new auxiliary cap improves fouling-proofing.
- Used for Toyota and Daihatsu.



- 2-electrode half-surface discharge spark plug with shroud

Example : K20DTR-S11
W20DTR-S11

- In addition to the half-surface discharge structure, the thread tip is extended into the combustion chamber and a shroud formed to improve the fouling-proofing.
- Used for Daihatsu and Subaru.

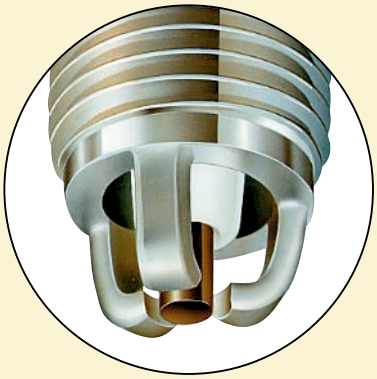
Chapter 2
Spark Plugs

Study Tips
The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

13 3 electrodes

- There are three ground electrodes for increased durability.
- For Audi, VW, Citroen, Fiat, Mercedes-Benz, and Renault.

13
K22PB, W20EPB



14 Compact type

- Compact and light weight (contributes to improved fuel consumption).

- Compact spark plugs
Example : Q16R-U11
Q16PR-U11

- By reducing the hexagonal width across flats (to 16 mm), lighter spark plugs were attained.

- ISO compact spark plugs
Example : K16R-U11
K16PR-U11

- Spark plugs that meet ISO standards.

* Be careful when installing these spark plugs. The height (H) is 2.5 mm shorter than for the Q type.

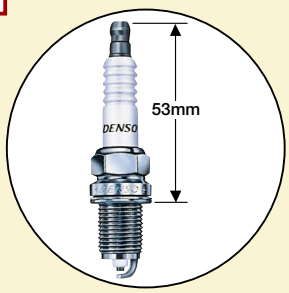
- Compact spark plugs for mini-sized cars
Example : XU22EPR-U

- By reducing the hexagonal width across flats (to 16 mm), these spark were made usable in mini-sized cars. The thread diameter is 12 mm.

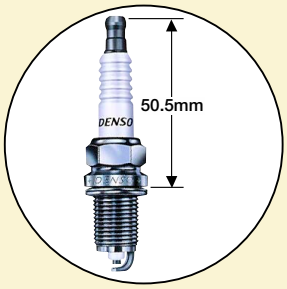
- Compact, long-torso spark plugs
Example : QL20PR-U
QL20TR-S

- The housing torso section is lengthened to secure the installation dimensions.
- Only for Daihatsu.
- The QL20TR-S has two ground electrodes and a semi-surface discharge, so it has improved fouling-proofing.

14
Q16R-U11



K16R-U11



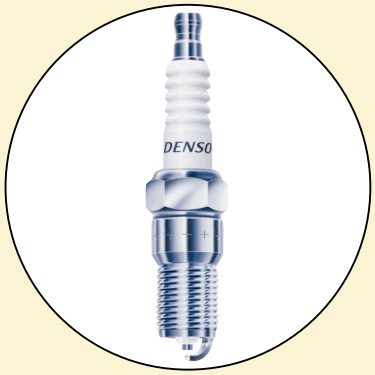
XU22EPR-U

QL20PR-U/QL20TR-S

15 Taper seat

- A special type of spark plug for foreign vehicles only; this type has no gasket.

15
T16EPR-U



16 For motorcycle

- There are various types for different manufacturers and models.
- Because spark plugs must be used in specific engines, it is difficult to make a general (common) spark plug.

Example : X24GPR-U

- There is a 3 mm shroud at the thread tip and the thread length is 22 mm, so this spark plug can only be used in the specified vehicles.
- Only for Honda.

Example : X24EPR-U9

- ϕ 12 mm × L 19 mm

Example : W27EMR-C

- Spark plug with compact insulator head section.
- Only for Suzuki and Honda.

Example : U27FER9

- ϕ 10 mm × L 19 mm half threads.
- Ignition is improved by widening the gap from 0.6-0.7 mm for previous models to 0.9 mm.
- Only for Honda.

Example : U31ETR

- The heat-proofing is improved by having two ground electrodes.
- For Kawasaki and Suzuki.

Example : U27ESR-N

- ϕ 10 mm × L 19 mm all threads.
- The fouling-proofing is improved with the 0.5-mm projection.
- For Kawasaki, Suzuki, and Yamaha.

Example : U20FSR-U

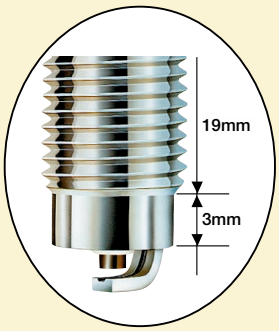
- ϕ 10 mm × L 12.7 mm

Example : Y27FER

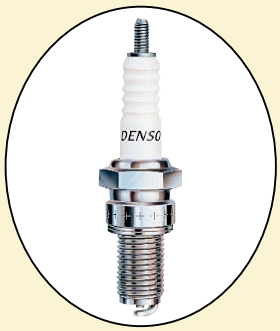
- Ultra-compact spark plugs ϕ 8 mm x L 19 mm half threads.
- Can only be installed in the specified vehicles.
- Only for Honda.

16

X24GPR-U

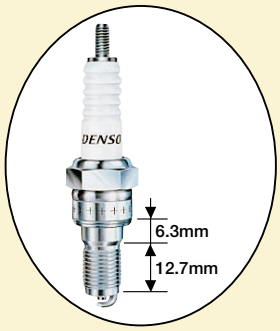


X24EPR-U9

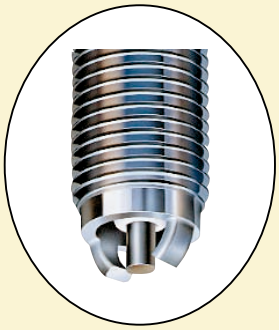


W27EMR-C

U27FER9



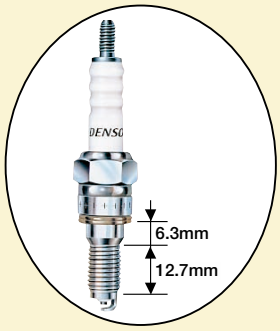
U31ETR



U27ESR-N

U20FSR-U

Y27FER



Chapter 2
Spark Plugs

Study Tips
The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

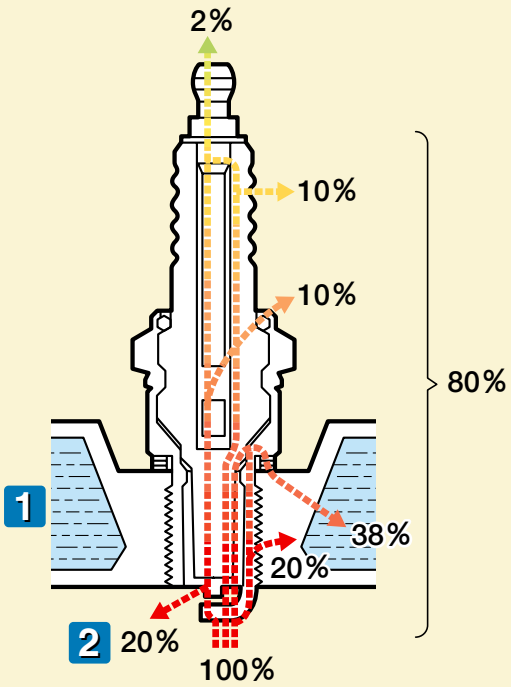
4 Heat Range

Spark plug heat dispersion

The heat that the electrode section of the spark plug receives due to combustion is dispersed through the path in the figure.

The degree to which a spark plug disperses the heat it receives is called its "heat range". Spark plugs with a high degree of heat dispersion are called high heat range (cold type) and those with a low degree of heat dispersion are called low heat range (hot type).

This is largely determined by the temperature of the gas inside the combustion chamber and the spark plug design.

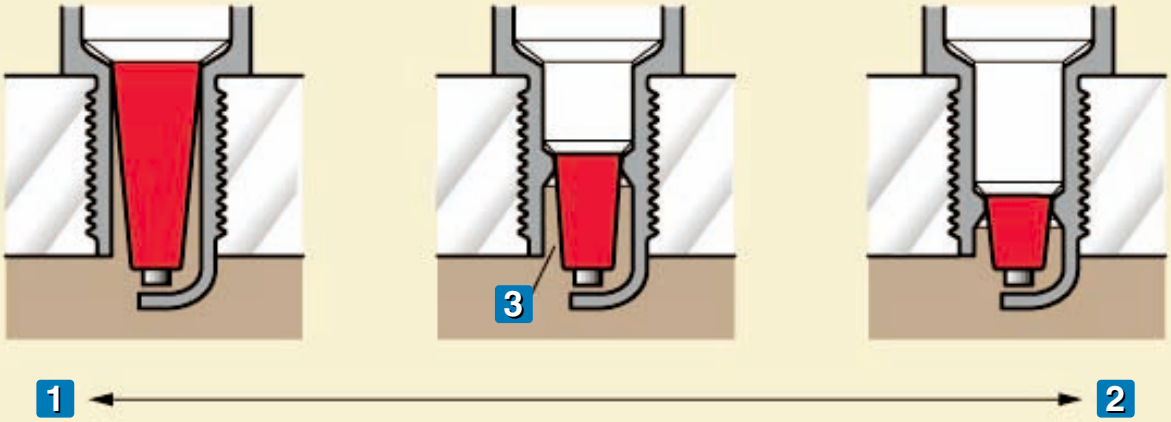


1 Water
2 Cooled by intake air-fuel mixture

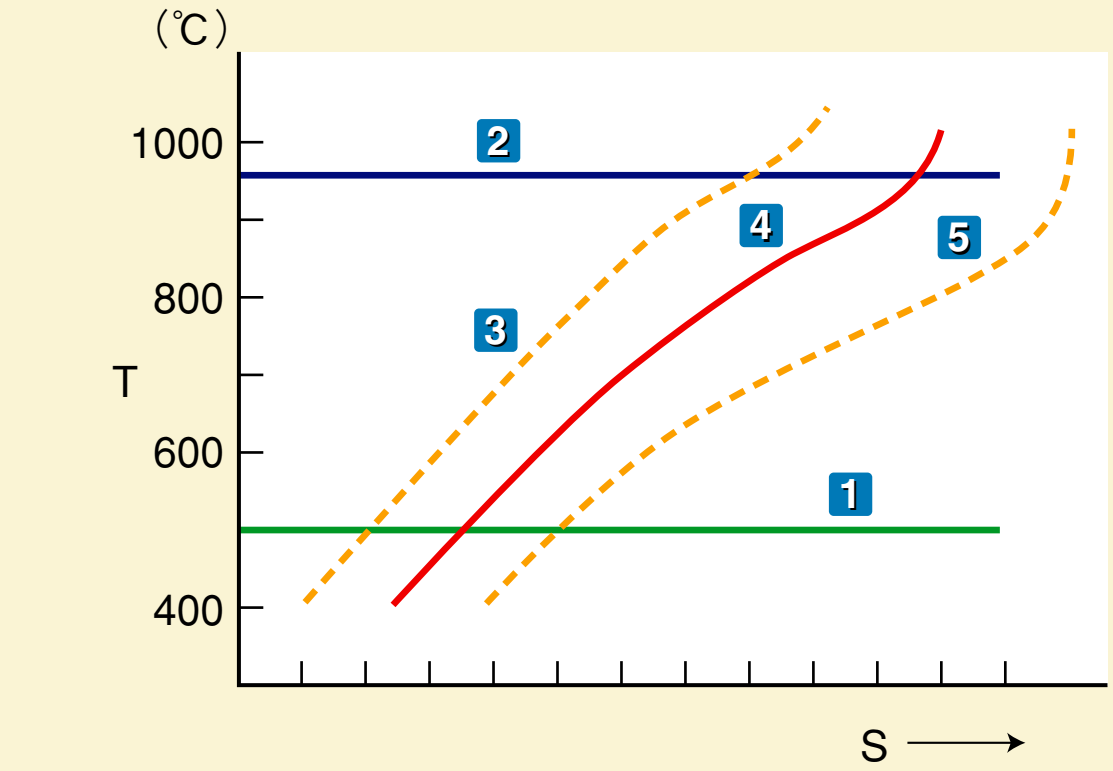
Low heat range and high heat range

Low heat range plugs have long insulator leg sections and the surface area affected by the flame and the gas pocket capacity are large. Also, since the heat release path from the insulator nose to the housing is long, heat dispersion is low and the temperature of the center electrode rises easily.

On the other hand, high heat range plugs have short insulator nose and the surface area affected by the flame and the gas pocket capacity are small.
Also since the heat release path from the insulator nose to the housing is short, heat dispersal is high and the temperature of the center electrode does not rise easily.



1 Low heat range (hot type) spark plugs
2 High heat range (cold type) spark plugs
3 Gas pocket



1 Self-cleaning temperature
2 Pre-ignition temperature
3 Low heat range (hot type) spark plugs
4 Standard spark plugs
5 High heat range (cold type) spark plugs
S: Vehicle speed
T: Spark plug temperature (℃)

Spark plug temperature and vehicle speed (1)

The relationship between the spark plug temperature and vehicle speed and heat range is expressed with a graph like that in the figure.

There are restrictions on the temperatures at which spark plugs can be used: the lower limit is the self-cleaning temperature and the upper limit is the pre-ignition temperature.A spark plug only functions completely when its center electrode temperature is between these temperatures of about 500˚C and 950˚C.

Spark plug temperature and vehicle speed (2)

- self-cleaning temperature

When the center electrode temperature is 500˚C or lower, free carbon generated when the fuel does not combust completely is deposited on the surface of the insulator. Therefore, the insulation between the insulator and the housing falls, electricity leaks occurs, the spark across the gap is incomplete, causes ignition failures.
This temperature of 500˚C is called the self-cleaning temperature because above this temperature the carbon is naturally burnt away completely by combustion.

Spark plug temperature and vehicle speed (3)

- pre-ignition temperature

When the center electrode reaches 950˚C or higher, pre-ignition (early ignition) occurs, meaning that the electrode serves as a heat source and ignition occurs without a spark.
Therefore, output falls and this can reach the level of electrode wear and insulator damage.

Spark plug temperature and vehicle speed (4)

Low heat range spark plugs have center electrode tem-peratures that rise easily and even at low-speed, they easily reach the self-cleaning temperature, so carbon is not deposited easily on the insulator section.

On the other hand, **high heat range spark plugs** have center electrode temperatures that do not rise easily, so they are unlikely to reach the pre-ignition temperature even at high speed.
Therefore, this type of spark plug is generally used for high speed, high output engines.

That is why it is necessary to select spark plugs with the appropriate heat range for the engine characteristics, run-ning conditions, etc.

Chapter 2
Spark Plugs

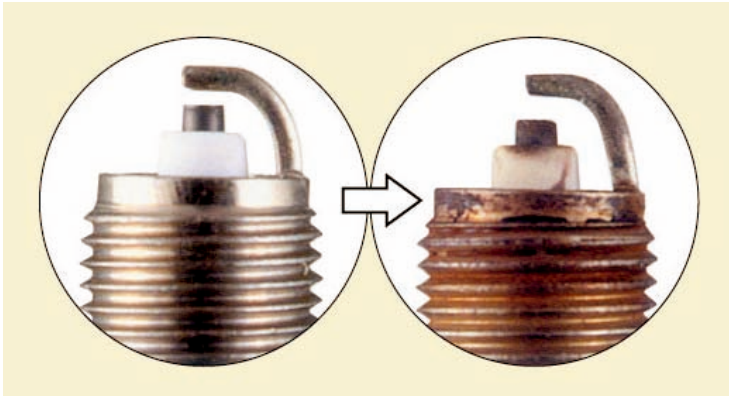
Study Tips
The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

5 Service Life

Electrode wear

The electrode wears from the locations that discharge easily with spark discharge.
In particular, since the center electrode reaches high temperatures, it oxidizes and wears.

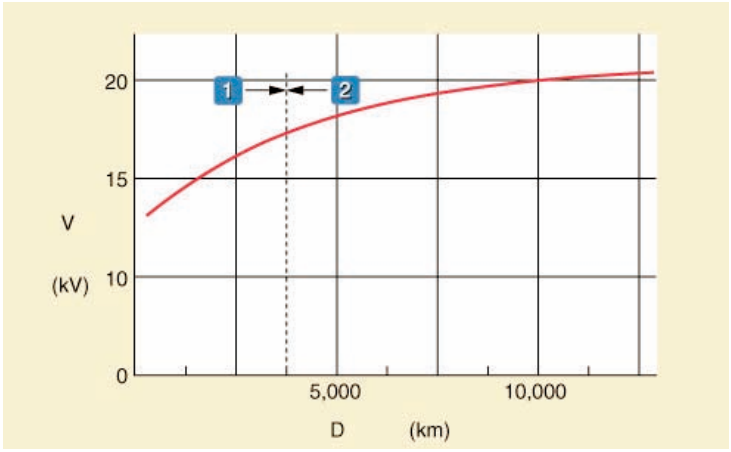
The amount of electrode wear varies with the electrode material melting point, strength, hardness, etc. In order to reduce the amount of this wear, nickel alloys, platinum, iridium, and other such materials are used for the electrodes and service lives are also extended with fine electrodes.
Also, the wear varies with the engine type and usage conditions, but for normal nickel alloy plugs, it is approximately in the range of 0.10-0.15 mm for each 10,000 km driven.



Electrode wear

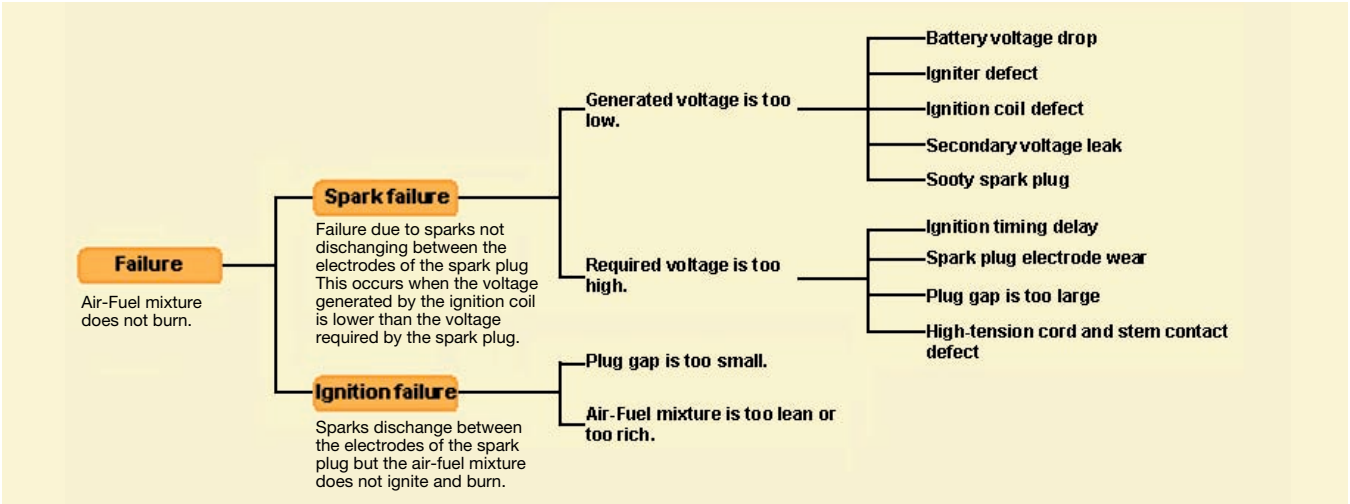
Rise in required voltage

The required voltage rises in proportion to the distance driven.
This rise in the required voltage is large until the sharp section at the end of the center electrode is worn round to some degree (about 4,000 km). After that, the main factor is the enlargement of the gap due to electrode wear and the rise in the required voltage is smaller.



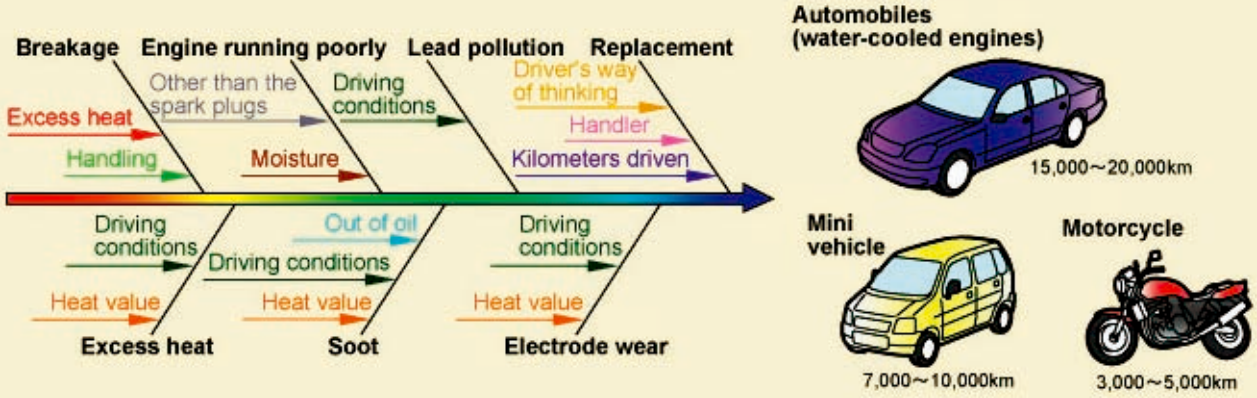
1 Shape change 2 Gap wear
D: Mileage driven (km) V: Required voltage (kV)

Misfiring and its cause



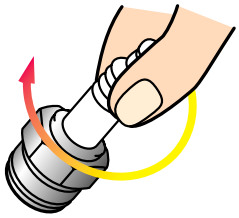
Economic service life

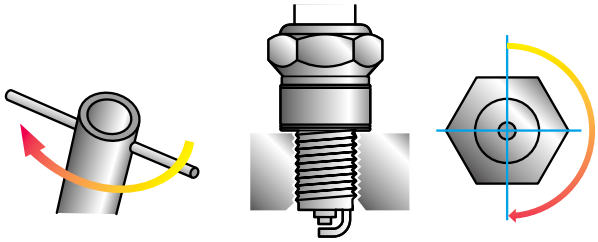
The physical service life for a spark plug can be thought of as the number of kilometers driven until the spark plug begins to misfire. Misfiring causes not only wastage of fuel, but also irregular engine vibration and output drop. In particular, for vehicles with emissions controls, misfiring can damage the catalytic converter, so using a spark plug all the way to the end of its physical service life is inexpedient economically.
Therefore, as the economical replacement interval, replacement after the number of kilometers in the figure above is recommended. (However, 100,000 km for platinum & iridium spark plugs.)



Recommended Torque and Tightening Angle for DENSO plugs.

1) Use the correct wrench for the hex on the plug, and be careful not to damage the insulator.
2) When changing, make sure that the oil, etc. on the outside of the plug does not enter the engine interior.
3) When putting the plugs in, clean the engine side of the flange, and put in the plugs after making sure the gasket is in the flange.
4) Make sure the plugs are vertical, and tighten them by hand until they cannot be tightened any further.
5) Then, use a plug wrench to tighten them accurately to the torque or rotation angle showed in the chart below.





If a thread lubricant such as grease is coated on the thread, tightening to the recommended torque is tightening too much; this has been linked to seal leakage. Do not use a thread lubricant.

Tightening more than the tightening angles and torques shown on the right could result in damage to the engine and furthermore could result in the plug coming off at the thread.

Thread Size	Applicable Models	Recommended Torque	Recommended Tightening Angle	
			New Plug	Previously Used
M8	All Types	8-10N・m	About 1 turn	About 1/12 turn
M10	Types other than the ones shown below	10-15N・m	About 1/3 turn	About 1/12 turn
M10	UFE, IUH, VUH, VNH Types	10-15N・m	About 2/3 turn	About 1/12 turn
M10	Stainless Gasket Type (※1)	10-15N・m	About 3/4 turn	About 1/12 turn
M12	All Types	15-20N・m	About 1/3 turn	About 1/12 turn
M14	Types other than the ones shown below	20-30N・m	About 1/2 turn	About 1/12 turn
M14	Stainless Gasket Type (※2)	20-30N・m	About 2/3 turn	About 1/12 turn
M18	All Types	30-40N・m	About 1/4 turn	About 1/12 turn
M14 Taper seat	All Types	20-30N・m	About 1/16 turn	About 1/16 turn

(※1) IUH27ES, U24FER9S (※2) PK22PR-L11S, SK22PR-M11S, IK16G, IK20G, IK22G, VK16G, VK20G, VK22G, K20PR-U9S, SK20PR-L9S SKJ20DR-M11S, KJ20DR-M11S, K20PR-L11S

Chapter 2
Spark Plugs

Study Tips
The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

6 How to read Spark Plugs

How to read types

DENSO spark plug type names are combinations of letters and numbers. The model names tell you the installation thread diameter, heat range, reach, and shape.
Car manufacturers select appropriate spark plugs for the engine and vehicle type, so use the specified spark plugs.

I : High-performance spark plugs
W : Thread Diameter and Hex Size
16 : Heat range
E : Reach
X : Shape (type, IRIDIUM POWER)
R : Internal Construction
U : Shape (type)
11 : Gap

High Performance Plug

IW16EXR-U11

Code	Center electrode	Ground electrode
F	φ0.55 iridium (Needle to needle Iridium Spark Plugs)	φ0.7 needle platinum
I	φ0.4 iridium (IRIDIUM POWER)	U-groove
P	φ1.1 platinum (Platinum Spark Plugs)	With platinum tips
S	φ0.7 iridium (Iridium Spark Plugs)	With platinum tips
SV	φ0.4 iridium (Iridium Spark Plugs)	With platinum tips
V	φ0.4 iridium (IRIDIUM TOUGH)	With platinum tips
Z	φ0.55 iridium (Iridium Spark Plugs)	With platinum tips

Thread Diameter and Hex Size

IW16EXR-U11

Code	Thread diameter	Hex size (mm)	Application
M	18mm	25.4	Thread length 12 mm
L	18mm	22.2	Thread length 12 mm
MW	18mm	20.6	Thread length 12 mm
MA	18mm	20.6	Taper sheet, thread length 12 mm
WF	14mm	20.6	IRIDIUM POWER (φ0.4), reach 12.7 mm
UF	10mm	16.0	IRIDIUM POWER (φ0.4), reach 12.7 mm
UH	10mm	16.0	IRIDIUM POWER (φ0.4), half threads
TF	14mm	16.0	IRIDIUM POWER (φ0.4), tapered sheet, reach 11.2mm
J*	14mm	20.6	Projection spark plugs
K*+	14mm	16.0	Small spark plugs
KJ*+	14mm	16.0	Small, projection spark plugs
LP*	14mm	20.6	LPG spark plugs
P*	14mm	20.6	Platinum spark plugs
Q*	14mm	16.0	Compact plugs

Code	Thread diameter	Hex size (mm)	Application
QJ*	14mm	16.0	Small, projection spark plugs
QL*	14mm	16.0	Small,long-torso housing plugs
S	14mm	20.6	Surface discharge spark plugs (for RE engines)
SF**	14mm	20.6	Surface discharge spark plugs
T	14mm	16.0	Taper seat
TR**	14mm	20.6	Only for Marine
W*	14mm	20.6	
		19.0	Compact types
X*	12mm	18.0	
XU*	12mm	16.0	
U*	10mm	16.0	
U	10mm	14.0	U20M-U only
Y*	8mm	13.0	
Z	1/2PF	23.8	

* Reach 19.0 + ISO type ** Reach 12.7

Heat Range

IW16EXR-U11

DENSO	9	14	16	20	22	24	27	29	31	32	34
NGK	2	4	5	6	7	8	9	9.5	10	10.5	11
CHAMPION	18	16	12,11	10,9	8,7	63,61	59	57	55	53	
BOSCH	10	9	8	7,6	5	4	3		2		

← Hot type Cold type →

Reach

IW16**E**XR-U11

Code	Thread diameter	Model examples
A	19.0mm	J16AR-U11
	Electrode position 7 mm	
	21.5mm	S29A
B	19.0mm	J16BR-U
	Electrode position 9.5mm	
C	19.0mm	KJ20CR11
	Electrode position 5.0mm	
D	19.0 mm shroud 2	K20DTR-S11
E (with gasket)	19.0mm	W16EXR-U
	20.0mm	W25EBR

Code	Thread diameter	Model examples
E (Taper seat)	17.5mm	T16EPR-U
F	12.7mm	W20FP-U
FE	19.00 mm half threads	U24FER9
G	19.0 mm shroud 2.8	X27GPR-U
	19.0 mm shroud 3.0	PK20GR8
H	19.0mm	QJ16HR-U
	Electrode position 8.5mm	
	26.5mm	K16HPR-U11
L	11.2mm	W14L
M	8.6mm	U20M-U

Code	Thread diameter	Model examples
N (Taper seat)	17.5mm	T20NR-U11
V (Taper seat)	25.0mm	PT16VR13
None	9.5mm	W14M-U, W20S-U
	11.2mm	L14-U, M24S
	19.0mm	P16R, K16R-U
	19.0mm	PK20PR11, SK20R11
	21.5mm	S27
None (Taper seat)	8.3mm	T20M-U
	11.2mm	T16PR-U
	11.2mm	MA16PR-U

Shape (Type)

IW16E**X**R-U11

Code	Thread diameter	Model examples
A	Double ground electrodes	W22EA
A	Slanted ground electrode (for racing)	K29A-Z
AY	Double ground electrodes and special curved shape	J16AY
B	Triple ground electrodes	W22EB
D	Four ground electrodes	W27EDR
K	Insulator projection 1 mm	W16EKR-S11
LM	Compact type (20.6 mm hex)	W14LM-U
M	Type with shorter insulator head length	W27EMR-C
M	Compact type (19.0mm hex)	W20M-U
N	Racing type (nickel electrodes)	W27EN
Pt	Racing type (platinum electrodes)	W31EPt
P	Projection (Projection 1.5 mm)	W16EP-U
S	No projection (Projection 0 mm)	W24ES-U
T	Double ground electrodes	W20ET-S
TM	Double ground electrodes	K22TM
TN	Double ground electrodes	K22TNR-S
V	Slanted ground electrode	QL22VR-ZU
X	Full projection (Projection 2.5 mm)	W16EX-U

Shape (IRIDIUM POWER)

IU27**A**

Code	Thread diameter
A	Slant electrode, No U-Groove, No taper cut
B	Projected insulator (1.5mm)
C	No U-Groove
D	No U-Groove, Inconel ground electrode
ES	Stainless steel gasket
F	Special
G	Stainless steel gasket
J	Projected insulator (2.5mm)
K	Special
L	Projected insulator (2.5mm)
T	For LPG applications, strengthened insulator
X	0.8mm gap
Y	0.8mm gap
Z	Taper cut

Internal Construction

IW16EX**R**-U11

Code	Shape
R	With register
None	No register

<Exception>
S27A, S29A, S31A, and IRIDIUM POWER spark plugs have register.

Shape (Type)

IW16EXR-**U**11

Code	Thread diameter	Model examples
-C	Ground cutback	W27EMR-C
-GL	Platinum center electrode	X22EPR-GL
-L	Retracted insulator only for CVCC	W20ESR-L11
	3.5 mm insulator projection for motorcycles	W14FP-UL
	Retracted insulator for motorcycles	W20FR-L
	Fine center electrode type for motorcycles	U20FS-L
	Heat-proof ground electrode type	K20PR-L
-M	Ground electrode size increased	
-N	Spark plugs for Yamaha and Kawasaki	U24ESR-N
-P	Uses two layers of platinum for the ground electrode	PQ20R-P8
	Uses platinum for the center or ground electrode	Q20PR-P

Code	Thread diameter	Model examples
-S	Semi-surface discharge type	W20EPR-S
-SA	Half high heat range type with semi-surface discharge	W20DTR-SA
-TP	Platinum center electrode and ground electrode taper cut	K20PR-TP
-U	U-groove electrode	W16EX-U
-US	Uses star-shaped center electrode	W14-US
-V	Ultra-fine center electrode	W27ES-V
-Z	0.7-mm diameter platinum alloy center electrode	K29A-Z
-ZU	0.7-mm diameter platinum alloy center electrode and U groove ground electrode with taper cut	W27ES-ZU

Gap

IW16EXR-U**11**

Code	Shape
8	0.8mm (0.032")
9	0.9mm (0.035")
10	1.0mm (0.040")
11	1.1mm (0.044")
13	1.3mm (0.050")
14	1.4mm (0.055")
15	1.5mm (0.060")
20	2.0mm (0.080")

<Not shown>
Car 0.8 mm
Motorcycle 0.7 mm

<Exception>
P16R, PQ16R, PQ20R are 1.1mm

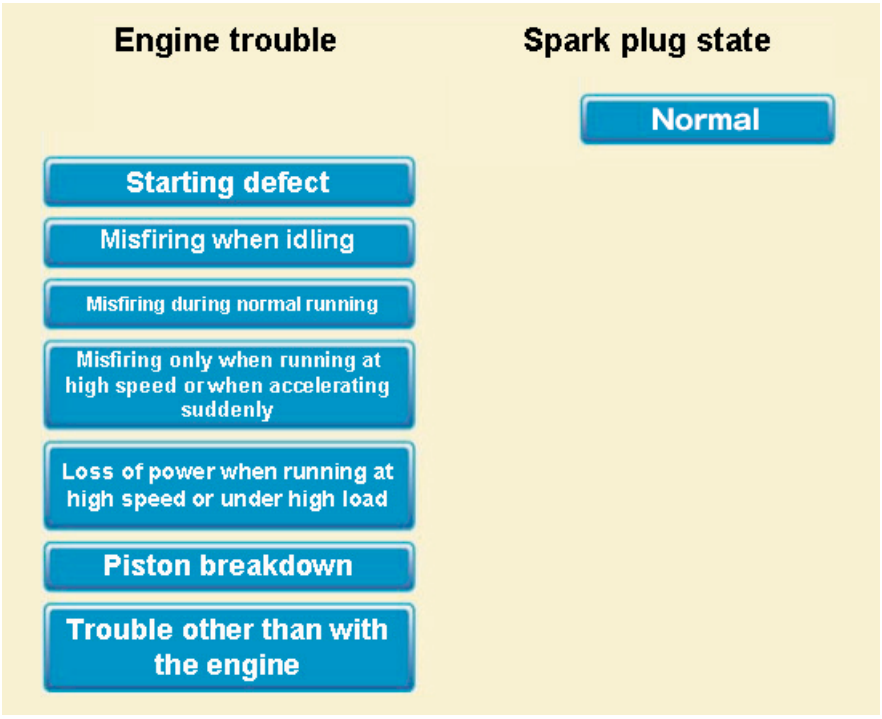
Chapter 2
Spark Plugs

Study Tips
The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.

7 Troubleshooting

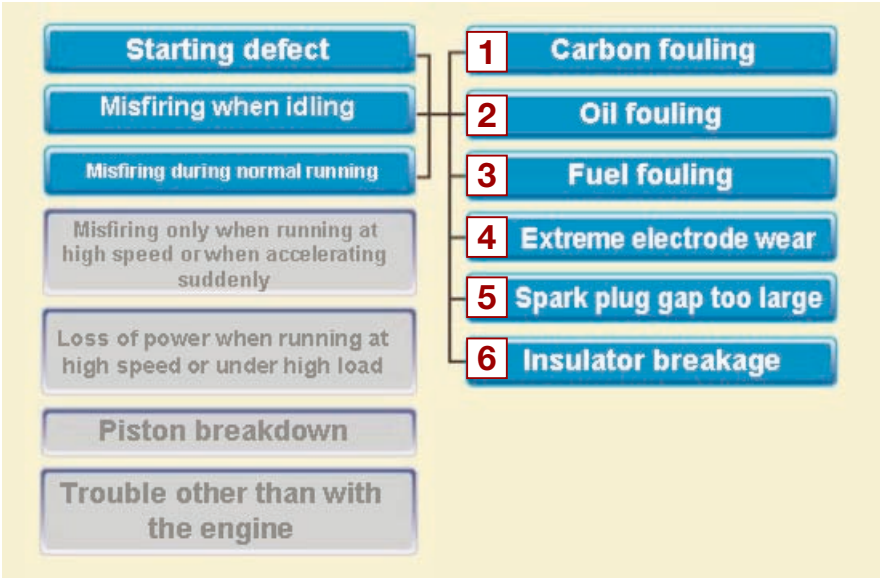
Troubleshooting

Diagnosing the state of the spark plugs is an effective method for elucidating the cause of engine troubles.



● **Normal**

The insulator leg section has light gray or tan deposits and slight electrode erosion.



1 Carbon fouling

[Appearance] The insulator foot section and electrode section are covered with dried, soft black carbon.

[Results] Poor starting, misfiring, acceleration defect.

[Cause] Repeated short-distance driving (driving with the engine cool), incorrect choking (overly rich air-fuel mixture), injection timing delay, plug heat range too high.

2 Oil fouling

[Appearance] The insulator section and electrode section is black and lustrous with wet oily deposits.

[Results] Poor starting and misfiring.

[Cause] Oil leaking due to piston ring, cylinder, or valve guide wear (occurs easily to new engines and engines that have just been overhauled), high oil content in air-fuel mixture (2-stroke engines).

3 Fuel fouling

[Appearance] The spark plug is wet with gasoline immediately after it is removed, but it soon dries off.

[Results] Poor starting and misfiring.

[Cause] The air-fuel ratio is too rich and is not igniting. (Among the ways this can happen is if the driver presses the accelerator over and over while starting the vehicle.)

[Handling] Remove all the spark plugs, crank the starter motor to bring fresh air into the cylinder and make the air-fuel ratio leaner.

4 Extreme electrode wear

[Appearance] The center and ground. electrodes are rounded and the gap has become too wide.

[Result] Poor starting and acceleration.

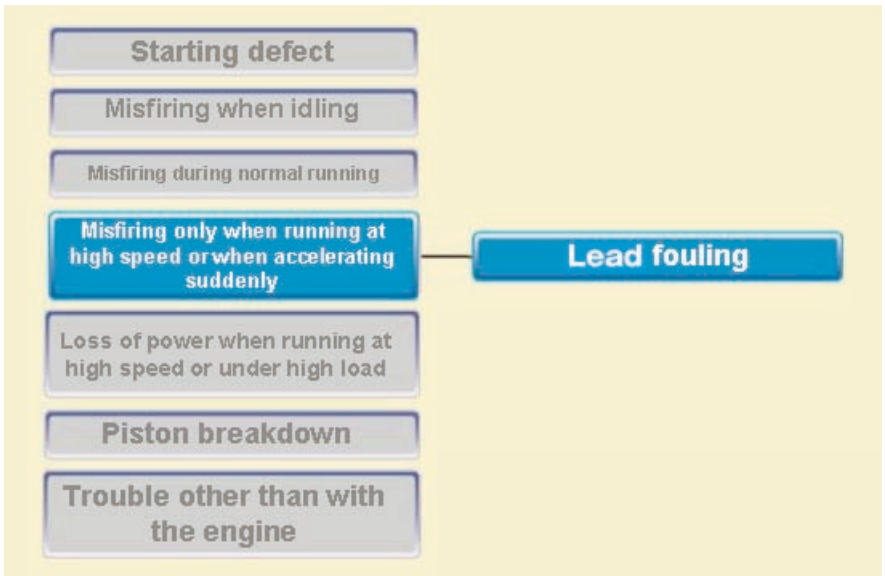
[Cause] Inadequate maintenance (spark plug has exceeded its service life).

5 Spark plug gap too large

[Appearance] The gap is wider than appropriate.

[Result] Poor starting and acceleration.

[Cause] The gap is inappropriate; the wrong spark plug was selected.



6 Insulator breakage

[Appearance] Insulator cracked.

[Result] Shorts due to insulation defect, causes poor idling and misfiring during acceleration.

[Cause] Spark plug removed/installed incorrectly (spark plug turned too far with spark plug wrench, excess tightening torque, or other inappropriate work).

● Lead fouling

[Appearance] The insulator leg section has yellow or yellowish-brown burnt on deposits or is covered with a glossy surface.

[Result] Misfiring during rapid acceleration or under high load, but no problem in normal running.

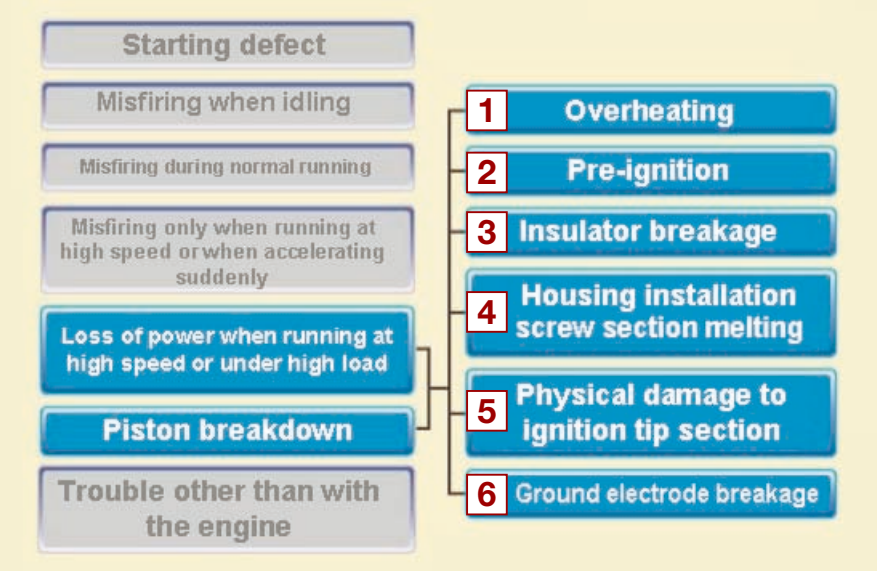
[Cause] Use of gasoline with much lead.

Chapter 2

Spark Plugs

Study Tips

The spark plugs are critical parts that dominate the engine combustion and bear a major responsibility for higher engine performance.



1 Overheating

[Appearance] The insulator nose section is scorched extremely white with small black deposits. Rapid electrode wear.

[Result] Loss of power when running at high speed or under high load.

[Cause] Spark plug incorrectly tightened, engine cooling problem, ignition timing too early, spark plug heat range too low, severely abnormal combustion.

2 Pre-ignition

[Appearance] The center electrode or ground electrode is melted or scorched. There are spots on the insulator nose section and deposits of aluminum or other metal powder.

[Result] Power loss due to engine damage.

[Cause] Often this is due to overheating; pre-ignition is a phenomenon in which combustion occurs before ignition.

The plug heat range is too low, the injection timing is too advanced, etc.

3 Insulator breakage

[Appearance] The insulator nose section is cracked or broken.

[Results] Misfiring

[Cause] Severely abnormal combustion, lack of attention to gap adjustment.

4 Housing installation screw section melting

[Appearance] Thread screw section melting.

[Result] Power loss due to engine damage.

[Cause] Incorrect spark plug tightening.

5 Physical damage to ignition tip section

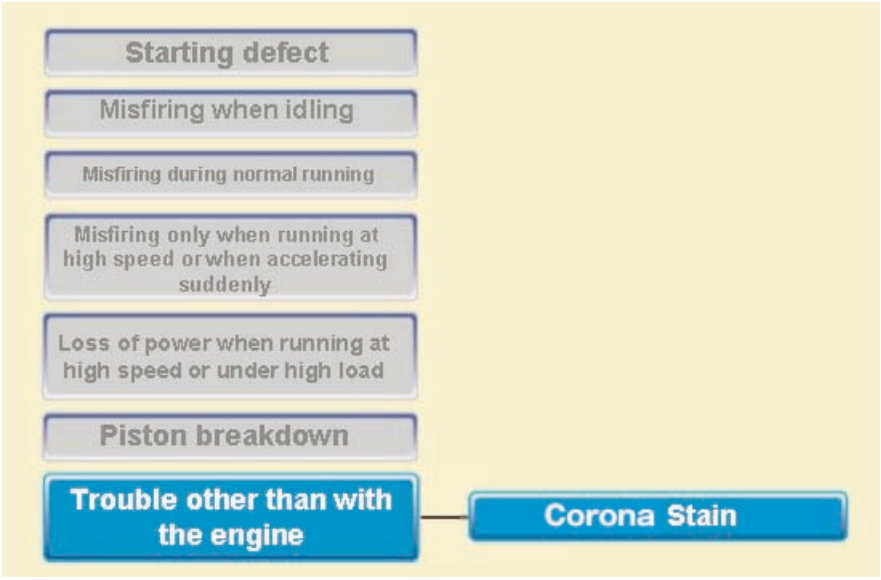
[Appearance] The electrode is bent and the insulator nose section is broken. Indentations are sometimes seen on the electrode.

[Results] Misfiring

[Cause] The spark plug thread reach is too long for the engine head or there is some kind of foreign matter (a small bolt, nut, or the like) in the combustion chamber.

6 Ground electrode breakage

[Cause] Overheating of the ground electrode and severe engine vibration.



● Corona stain

[Appearance] Brown deposites on the insulator directly above the housing.

[Result] No impact on the spark plug performance.

[Cause] This occurs due to electrical stress in the air near the insulator. (This is not a spark plug gas leak, for which it is sometimes mistaken.)

8 Comprehensive test

From the following statements about IRIDIUM POWER spark plugs, select the incorrect one.

1. These are high-performance spark plugs that use the world's first ultra-fine 0.4-mm diameter center electrodes.
2. They greatly reduce the required voltage and raise the ignition performance.
3. Thanks to DENSO's unique U-groove ground electrodes, they secure a large volume for flame core formation.
4. The new iridium alloy for the center electrodie improves the oxidation resistance at high temperature.
5. They have longer service life than vehicle manufacturer's genuine iridium spark plugs.
6. When using IRIDIUM POWER spark plugs in vehicles which have used normal spark plugs, check in the application table.
7. Select an IRIDIUM POWER spark plug with the same heat range as the normal spark plug.
8. Since the required voltage is 3-5 kV, lower than it of normal spark plugs, use with a wider gap.
9. When installing new IRIDIUM POWER spark plugs on the engine, the same as for normal spark plugs, turn them in as far as they will go by hand, then tighten 1/4-1/2 rotation with a spark plug wrench.

Answer on next page

Chapter 3

Basics of Ignition

Study Tips

How is the high voltage produced?
When does the spark discharge occur?

1 High Voltage Generation

Let us try. (1)

If you line up the two coils and pass current through one coil (the primary coil), magnetic flux is generated.

When a constant current is flowing in the primary coil, the magnetic flux does not change, so electromotive force is not generated in the secondary coil.

With the coils in this state, let us try cutting off the current in the primary coil with the switch.

Let us try. (2)

When the switch is switched On → Off to cut off the primary current, the magnetic flux generated up until now by the primary current disappears suddenly.

This change in the magnetic flux generates hundreds of volts of counter-electromotive force in the primary coil (self-induction action) and furthermore generates electromotive force in the secondary coil that is amplified by the winding ratio. (Mutual induction action)

This is how the high voltage required for the ignition spark is generated.

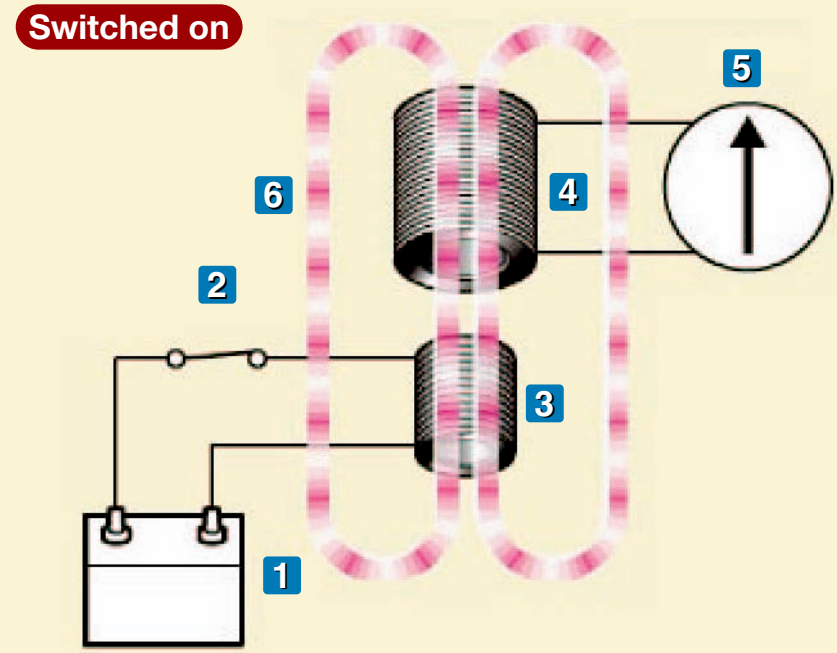
$$\text{Secondary voltage} = \frac{\text{The number of windings in the secondary coil.}}{\text{The number of windings in the primary coil.}} \times \text{(Counter-electromotive force in the primary coil)}$$

Let us try. (3)

Also when the switch is switched Off → On, the magnetic flux changes due to the change in the primary coil and the self-induction action of the coil generates counter-electromotive force, but this does not rise higher than the battery voltage.

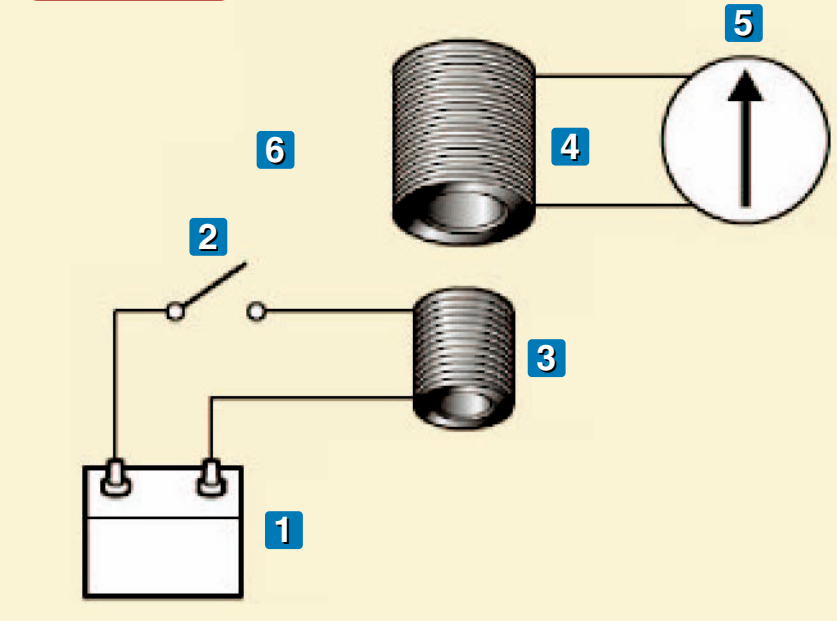
Therefore, the change in the magnetic flux is softened and the voltage generated in the secondary coil is so low that it does not reach the discharge voltage.

Switched on



1 Battery 2 Switch 3 Primary coil
4 Secondary coil 5 Voltmeter 6 Magnetic flux

Switched off



1 Battery 2 Switch 3 Primary coil
4 Secondary coil 5 Voltmeter 6 Magnetic flux

Answer: 5,8

Reference

Self-induction action

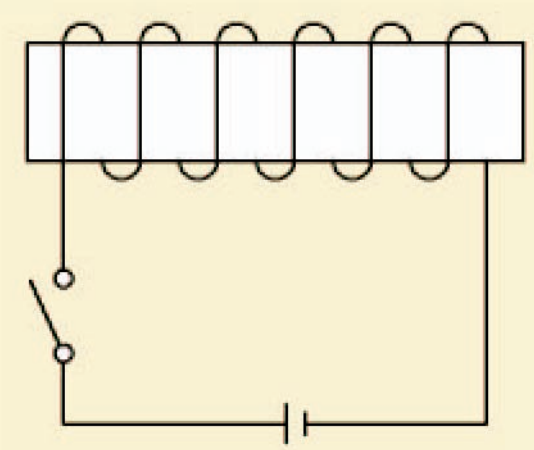
When you change the current flowing through one coil, its magnetic flux also changes and induced electromotive power is generated in the coil.

This phenomenon is called self-induction action. The induced electromotive power works to obstruct the change in the current.

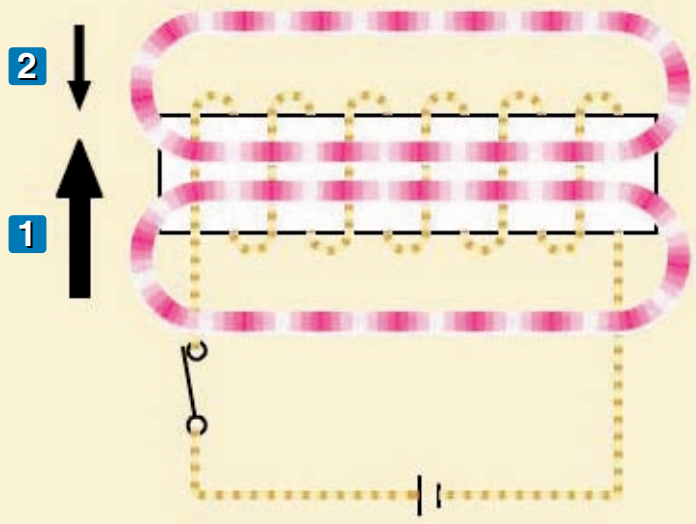
Therefore, when current is passed through a coil, the self-induction action works to obstruct that current, so it takes time for the current to flow into the coil.

This phenomenon is called the primary current rise time.

Switched off



Switched on



1 Current 2 Counter-electromotive force due to self-induction

Chapter 3

Basics of Ignition

Study Tips

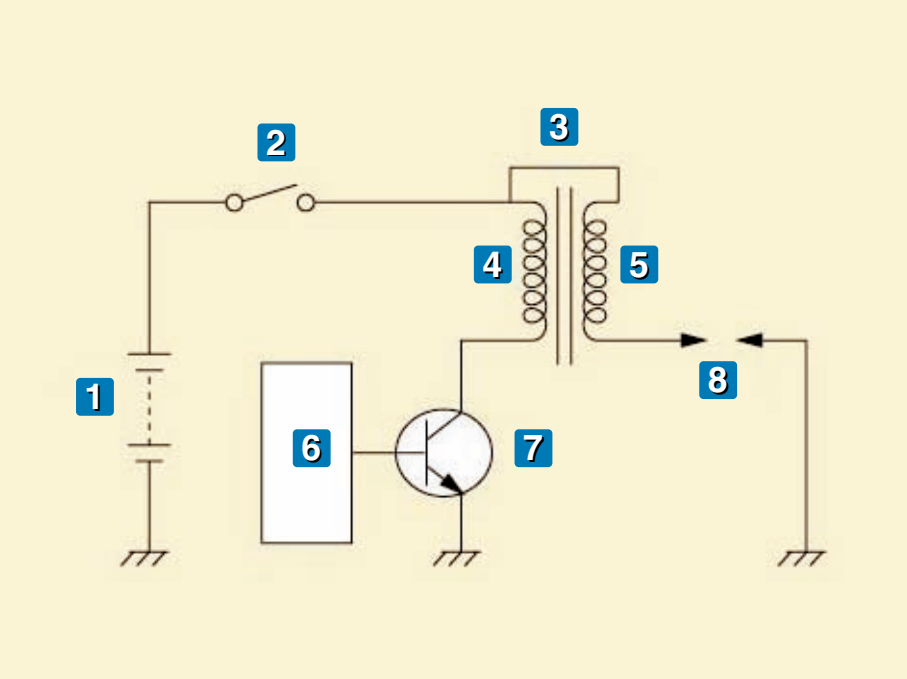
How is the high voltage produced?
When does the spark discharge occur?

Ignition coil

This generation of high voltage through such coil self-induction action and mutual induction action takes place within the ignition coil.

The ignition coil has two coils, the primary coil and the secondary coil, and their winding ratio is about 1:100.

The actual connecting and cutting off of the primary current is handled by transistors in the igniter or by mechanical contacts in the distributor.



Ignition coil circuit

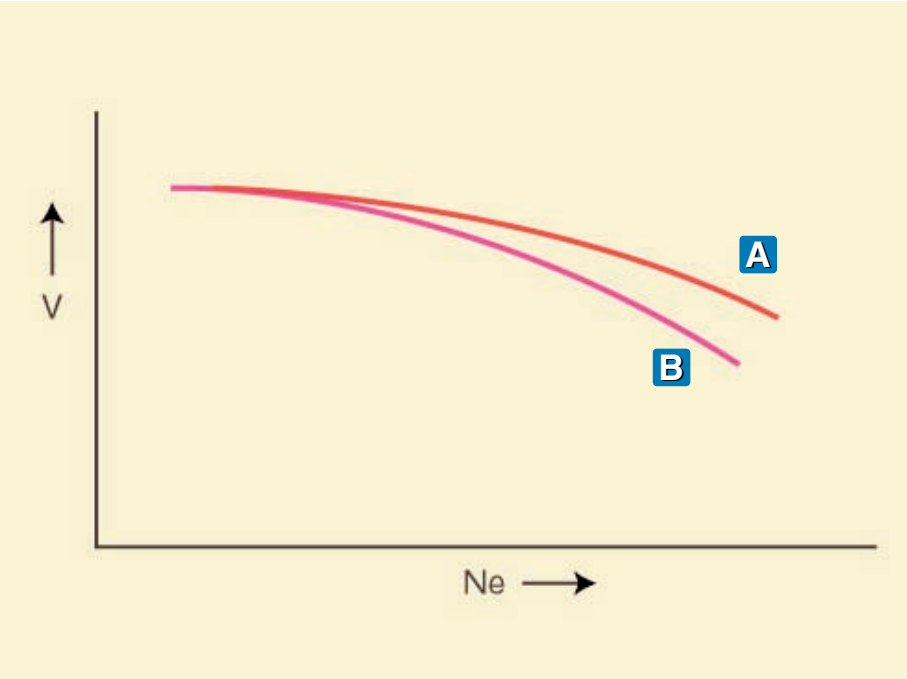
1 Battery 2 Ignition switch 3 Ignition coil 4 Primary coil
5 Secondary coil 6 Signal 7 Transistor 8 Spark plug

Primary current and high voltage

The magnitude of the secondary voltage generated in the ignition coil is proportional to the magnitude of the primary current.

However, generally as the figure shows, the higher the engine speed, the lower the voltage generated. This is because the higher the engine speed, the less time there is for the primary current to build up and the value of this current decreases.

Therefore, it is necessary to control the primary current to be constant from low speed to high speed. One method for this control is dwell angle control.



Secondary voltage generation

Ne: Engine speed V: Secondary voltage A Coil A B Coil B

2 High Voltage Control

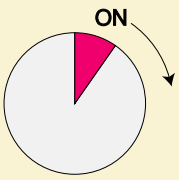
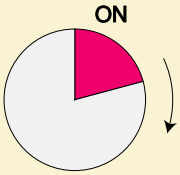
Dwell angle control (1)

The dwell angle expresses the primary coil energized duration proportion (magnitude) with the distributor rotation angle. When the speed is constant,

Large dwell angle = Long energized duration

is the relationship.

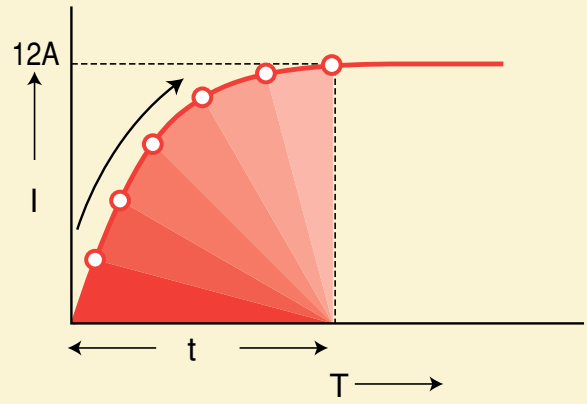
Dwell angle control is to control the primary coil energized duration (dwell angle) according to the speed of the engine.

Distributor Rotation angle	Dwell angle	Energized duration
	Small	Short
	Large	Long

Dwell angle control (2)

For example, if the coil resistance is 1 ohm, the primary current is 12 A (for 12 V).

However, until the primary current reaches 12A, it is obstructed by the self-induction action, so some time (t) is required.



Primary current rise characteristic

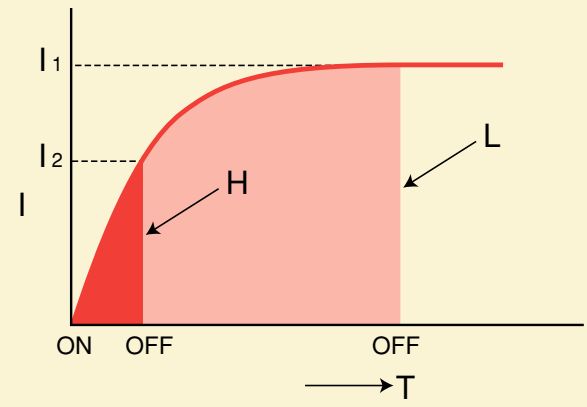
T: Time I: Primary current

Dwell angle control (3)

When the dwell angle is constant, as the engine speed reaches high speed, the energized duration becomes shorter, so the primary current decreases and the secondary voltage decreases too.

Therefore, when the engine is rotating at high speed, if the start of the energized duration is made earlier to lengthen the energized duration, the decrease in the coil primary current can be prevented.

In this manner, the energized duration proportion, in other words the dwell angle, is controlled to be the optimum value for the engine speed.



Primary current and engine speed

T: Time I: Primary current H: For high speed L: For low speed

Chapter 3
Basics of Ignition

Study Tips
How is the high voltage produced?
When does the spark discharge occur?

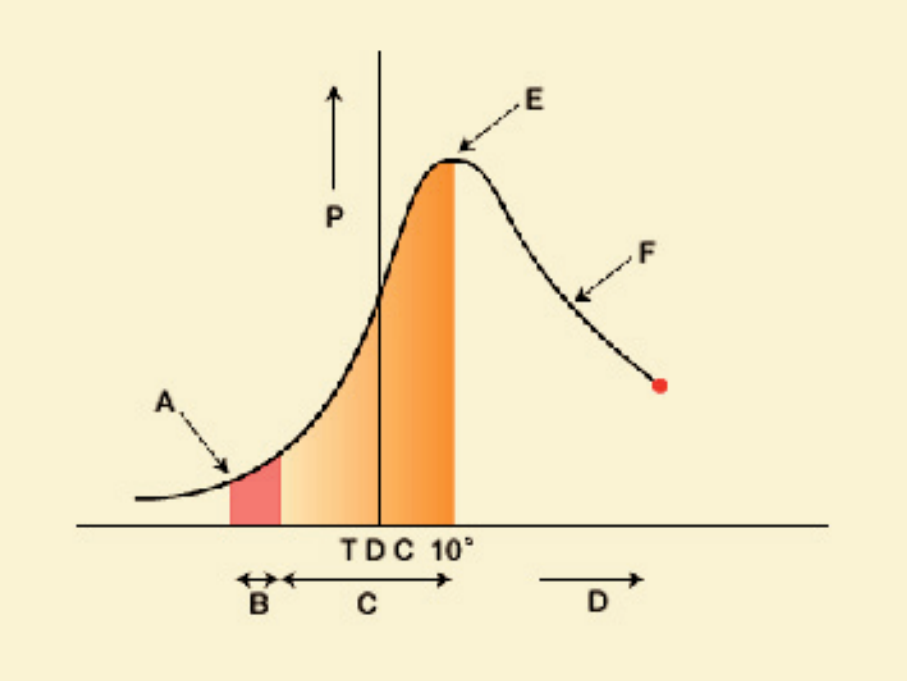
3 Ignition Timing

Ignition timing and combustion pressure

Until the air-fuel mixture ignites and the combustion reaches the maximum pressure requires a certain time. (Ignition lag, flame propagation)

Generally, the engine releases the maximum pressure when the maximum pressure due to combustion comes at the position where the crankshaft position is about 10 degrees after top dead center (ATDC10°CA), so the ignition timing is set ahead of that time by the duration of the flame propagation and the ignition lag.

Furthermore, since the combustion speed until the maximum pressure is reached depends on the engine speed, the engine load, etc., it is necessary to control the ignition timing according to those factors.



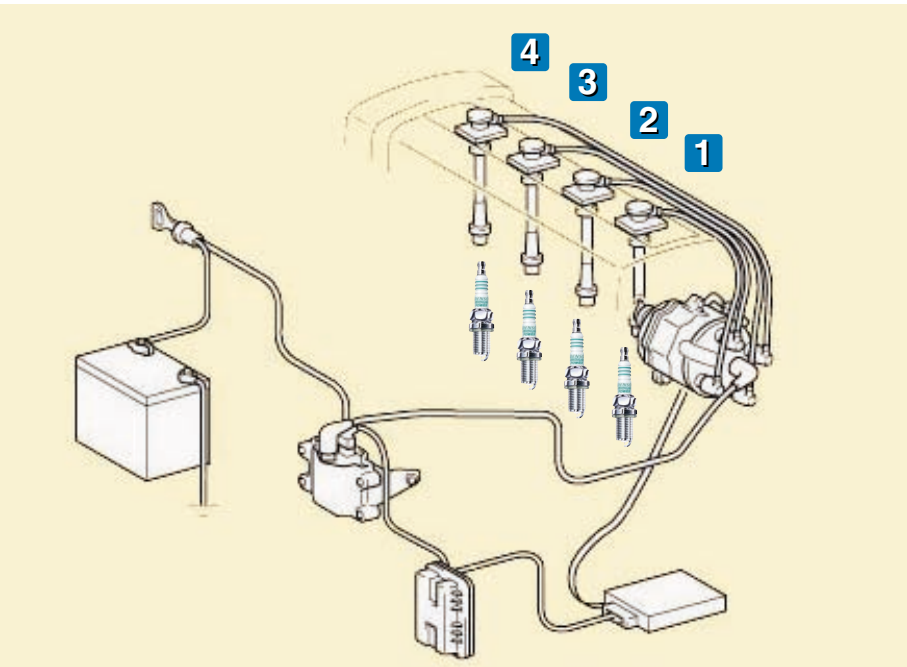
A: Ignition B: Ignition lag C: Flame propagation D: Crankshaft angle
E: Maximum combustion pressure F: Combustion completion P: Pressure

4 Ignition Order

In multi-cylinder engines, in order to make the engine run smoothly, the cylinders are combusted in a specific order.

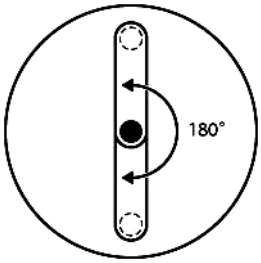
Example of the ignition order for a 4-cycle multi-cylinder engine

- 4 cylinders
- 6 cylinders
- 8 cylinders

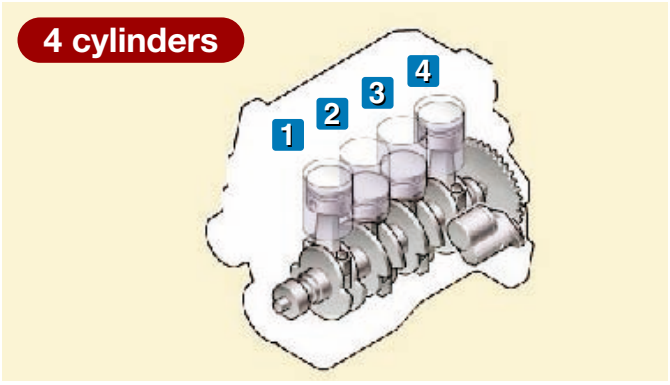


Example of 4-cylinder engine ignition order

a) 1-3-4-2
b) 1-2-4-3

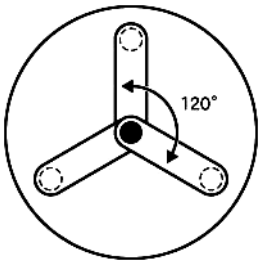


Crankshaft position



Example of 6-cylinder engine ignition order

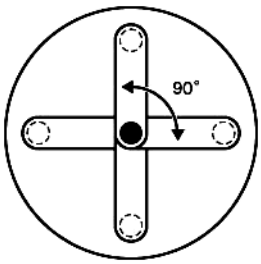
a) 1-5-3-6-2-4
b) 1-4-2-6-3-5



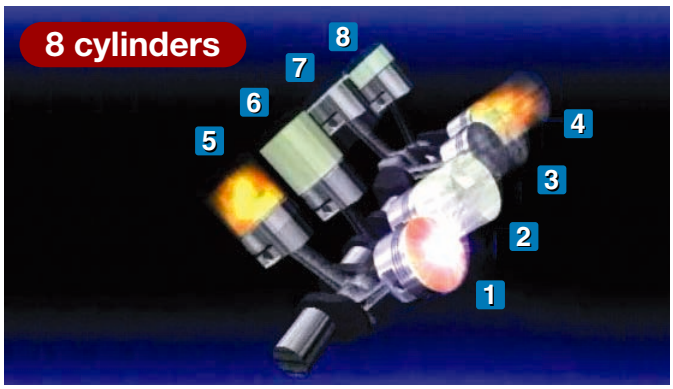
Crankshaft position

Example of 8-cylinder engine ignition order

a) 1-8-6-2-7-3-4-5
b) 1-8-4-3-6-5-7-2



Crankshaft position



5 Comprehensive Test

From the following statements about ignition, select the incorrect one.

1 The winding ratio between the comparatively thick primary coil and the comparatively thin secondary coil is about 1:100.

2 The primary coil energized duration expressed as the distributor rotation angle is called the dwell angle.

3 When the primary coil current is switched Off, mutual electromotive induction power is generated in the secondary coil.

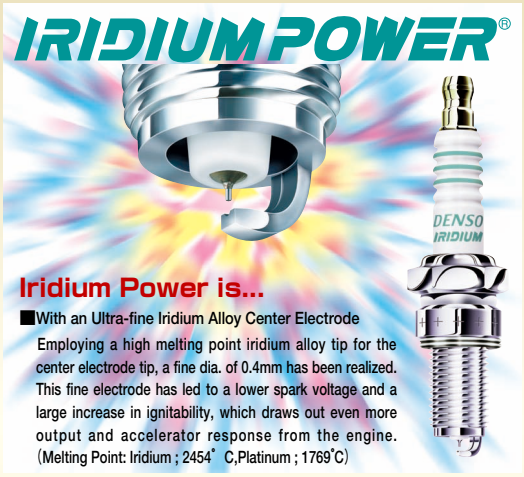
4 As the engine speed increases, the secondary voltage falls.

5 As the engine speed increases, the primary current falls.

6 4-cylinder engines ignite the cylinders in order from No. 1 to No. 4.

Answer on next page

The PLUGS CONFIGURATIONS



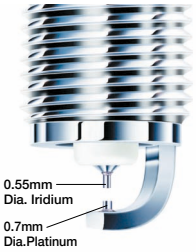
Needle to needle Iridium Plug

(Example) **FXE20HE11**

- Used as a genuine Nissan TIIDA and NOTE part. FXE20HE11 is a 12mm Diameter x 26.5mm Length, and 14mm Hex new type

Iridium Plug

(Example) **FK20HR11**



- The ground electrode of this revolutionary iridium plug features DENSO's very own technology and is needle-shaped, resulting in an unparalleled reduction in quenching action.
- Used in the Toyota Sienta and the Toyota Crown since 2003.

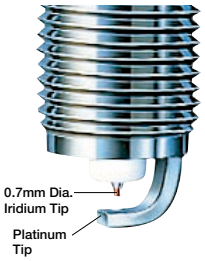
Iridium Plug

(Example) **ZXE20HR13**

- By using the 0.55mm diameter fine iridium center electrode and the platinum tipped ground electrode, lifetime has been improved.
- 12mm Diameter x 26.5mm Length, and 14mm Hex new type
- Used as a genuine Nissan LAFESTA part.

Iridium Plug

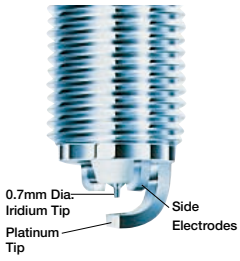
(Example) **SK16R-P11·SK20R11**



- We developed the 0.7mm diameter ultra-fine iridium alloy electrode, the first the world. Ignitability and lifetime have been improved dramatically. SK16R-P11 comes standard with the Toyota Century.

New Triple Electrode Iridium Plug

(Example) **SK20BR11**



- During regular operation, it sparks with the main electrode, but when it becomes fouled, it sparks with the side electrodes to burn off the carbon - this plug is the optimum design for direct injection engines. It comes standard with the Toyota Crown's 3R direct injection engine (D-4).

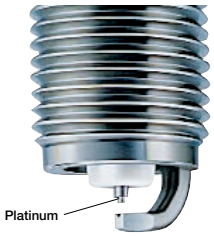
U-Groove Plug

(Example) **W16EX-U**

- With a U-Groove ground electrode, large ignition energy can be obtained, easily igniting even lean mixtures.
- Because it is fully projected (2.5mm insulator projection), carbon fouling is reduced, and smooth starting and acceleration performance are realized.

Platinum ZU Plug

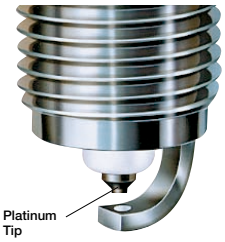
(Example) **W31ES-ZU**



- With a taper-cut ground electrode, quenching action is dramatically reduced, increasing ignitability.
- With a special platinum alloy in the center electrode (0.7mm dia.). The attached part is spot welded in three locations for a high degree of reliability.

Platinum Plug

(Example) **PK20R11**



- Platinum is used in both the center electrode and the ground electrode.
- By making the center electrode fine and by using a platinum tip, fuel consumption, drivability, and durability have been increased.

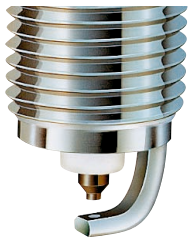
Platinum Plug for DLI (+ -Discharge)

(Example) **PK20R-P11**

- To prevent wear during plus (+) discharge, the size of the platinum has been increased.

Extended Platinum Plug

(Example) **PKJ20CR-L11**



- By extending the spark position into the combustion chamber, the combustion efficiency is increased and fuel consumption and drivability are improved.

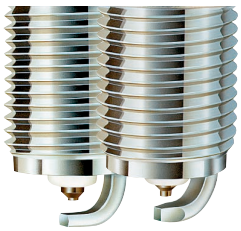
Dual Electrode Platinum Plug

(Example) **PK20TR11**

- The parts of the center electrode facing the ground electrodes have been platinum tipped.
- The dual electrode construction results in a lower required voltage during the plus (+) discharge.

Single-Side Platinum Plug

(Example) **Q20PR-P11·K16PR-TP11**



- Only the center electrode is platinum tipped, allowing the electrode to be made fine which increases fuel consumption, drivability, and durability.
- K16PR-TP11 has had the ground electrode taper cut, further increasing ignitability.

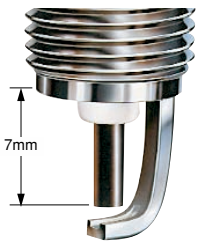
Semi-Surface Gap Plug for Rotary Engines

(Example) **S29A**

- Employing a semi-surface gap discharge, ignitability, fouling resistance, and durability have been increased.
- Reduced voltage loss using a 7 rib design.

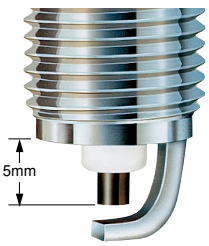
Extended Plugs

(Example) **J16AR-U11**



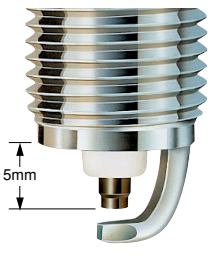
- Using a U-grooved ground electrode, a large ignition performance is obtained, allowing even lean mixtures to be ignited easily.
- The spark position is extended into the ignition chamber, improving combustion efficiency, fuel consumption, and drivability.

(Example) **KJ20CR11 · KJ20CR-U11**



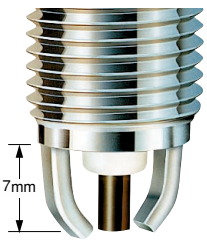
- For Mazda and Mitsubishi Vehicles.
- KJ20CR11 has no U-groove. KJ20CR-U11 has a U-groove.

(Example) **KJ20CR-L11**



- The ground electrode is taper cut and the center electrode is made finer, improving ignitability.

(Example) **J16AY**



- Specifically for Daihatsu, there are two ground electrodes, ensuring durability.

Semi-Surface Gap Plug

(Example) **W20EKR-S11 · W20EPR-S11**

- Using a semi-surface discharge, ignitability and fouling resistance are increased.
- W20EKR-S11 are for Honda vehicles, while W20EPR-S11are for Mitsubishi vehicles.

Because these are specialty plugs, installation on any other than the specified vehicles is not possible

Answer: 6

The PLUGS CONFIGURATIONS

Semi-Surface Double Electrode Plug

(Example) **W20ETR-S11**

- A double ground electrode with a 1mm gap is used.
- Using a short opposed-type dual ground electrode, excellent durability is obtained.
- Improved ignitability because it is fully projected.
- With the new addition of a supplementary gap, fouling resistance is improved.
- Used for Toyota and Daihatsu.

Shrouded Semi-Surface Gap Double Electrode Plug

(Example) **K20DTR-S11 · W20DTR-S11**

- In addition to a semi-surface gap construction, the end of the threaded portion has been extended into the combustion chamber, and a shroud has been attached to improve fouling resistance.
- Used for Daihatsu and Subaru.

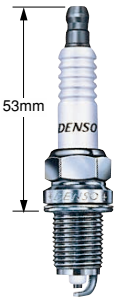
Triple Electrode Plug

(Example) **K22PB · W20EPB**

- Durability is increased with triple ground electrodes.
- For Audi, VW, Citroen, Fiat, Mercedes-Benz, Renault.

Small Hex Plug

(Example) **Q16R-U11 · Q16PR-U11**



- By reducing the hex size (16mm), the plug has been made smaller.

ISO Compatible Small Hex Plug

(Example) **K16R-U11 · K16PR-U11**

- This product is compatible with ISO standards.

*Because the installed height (H) is 2.5mm shorter than with the Q type, be careful during installation.

Small Plug for Small Cars

(Example) **XU22EPR-U**

- By reducing the hex size (16mm), the plug has been made compatible with small cars. Thread size is 12mm.

Long Housing Plugs

(Example) **QL20PR-U · QL20TR-S**

- By making the middle cylinder longer, installation dimensions have been secured.
- Exclusively for Daihatsu.
- QL20TR-S has double ground electrodes and a semi-surface gap resulting in improved anti-fouling properties.

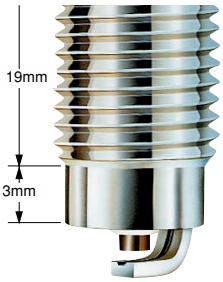
TaperSeat Plug

(Example) **T16EPR-U**

- Solely for non-Japanese vehicles that do not have a gasket.

Motorcycle Plugs

(Example) **X24GPR-U**



- Because the thread end has a 3mm shroud, and the reach is 22mm, it can be used only for the specified vehicles.
- For Honda

(Example) **X24EPR-U9**

- 12mm Diameter X 19mm Length

Motorcycle Plugs

(Example) **W27EMR-C**

- Plug with a compact insulator head.
- For Suzuki and Honda.

(Example) **U27FER9**

- A 10mm Diameter X 19mm Length, half-threaded.
- With a wider gap of 0.9mm compared to conventional plugs (0.6 to 0.7mm), this plug has improved ignitability.
- For Honda

(Example) **U31ETR**

- With double ground electrodes, heat resistance is improved.
- For Kawasaki and Suzuki.

(Example) **U27ESR-N**

- 10mm Diameter X 19mm Length, fully threaded.
- By making the projection 0.5mm greater, fouling resistance has been improved.
- For Kawasaki, Suzuki, and Yamaha.

(Example) **U20FSR-U**

- 10mm Diameter X 12.7mm Length

Motorcycle Plugs

(Example) **Y27FER**

- Very Miniature Plug (8mm Diameter X 19mm Length, half-threaded).
- Cannot be used on any other than the specified vehicles.
- For Honda .

Resistor Plug

Reduces the amount of radio noise generated during ignition.

Reduced Radio Noise

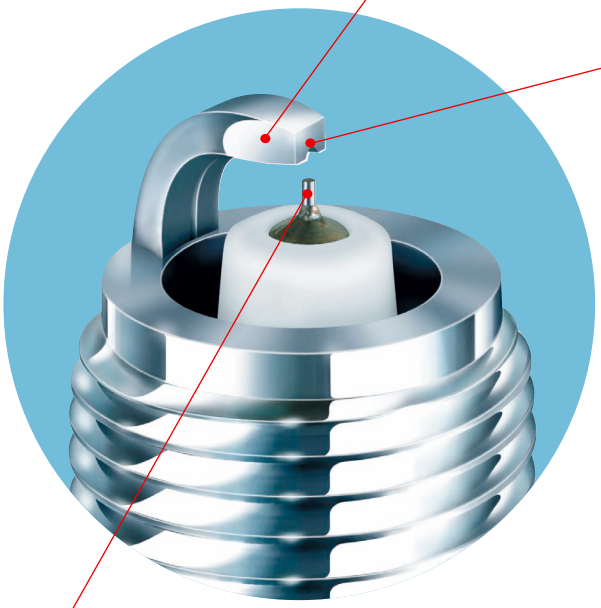
- By adding a 5kΩ resistor between the center electrode and the center electrode core, we have created a plug that has less radio noise during ignition. With the increasing number of electronic devices on vehicles, most new cars today come standard with resistor plugs.

Q1 What type of spark plug is the IRIDIUM POWER ?

A This is a new generation of high-performance spark plug that uses the world's smallest (*1) iridium center electrode that is a mere 0.4 mm in diameter.

Tapered Cut

The tip of the ground electrode has been cut to form a taper. This greatly improves firing performance by reducing quenching.



U-Groove

A U-groove has been cut inside the ground electrode to maintain the large volume of space required to form the nucleus of a flame.
While still keeping the required voltage low, this technology enables excellent firing performance without increasing the spark gap.

Ultra-fine 0.4 mm diameter iridium electrode

Use of a "new iridium alloy" that has a high melting point has enabled miniaturization of the center electrode. Required voltage has been lowered and firing performance improved.

(All types): Japan (2877035, 2921524, 3000955), U.K. (2302367), U.S.A. (5977695, 6078129, 6093071, 6094000, 6262522), People's Republic of China (961022841), Republic of Korea (0292083)

Highly corrosion-resistant (*2) bright nickel plating

Bright nickel plating, as used in racing car spark plugs, is used in the housing to give the plug high resistance against corrosion.

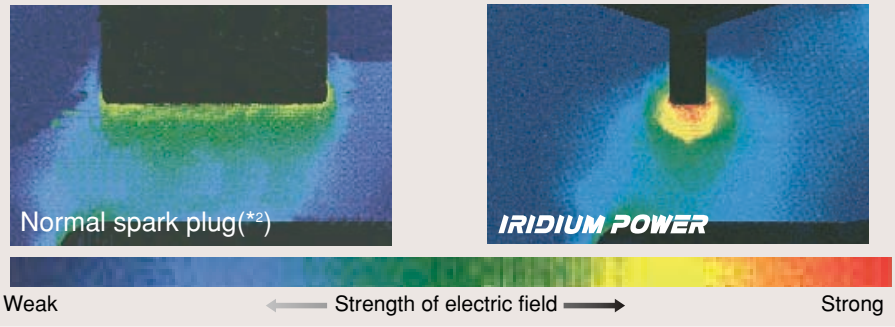
*1: As of Nov. 1999, this excludes flush type electrodes that do not protrude from the insulator.
*2: Excluding some types

Q2 Why was the center electrode of the IRIDIUM POWER reduced to only 0.4 mm?

A **To lower the required voltage and improve firing performance. The most advanced technology in the world has been employed to enable use of the world's smallest(*) electrode, at 0.4 mm in diameter, in the IRIDIUM POWER .**

The smaller the electrode the more concentrated the electric potential at the tip of the electrode and the stronger the electric field that affects **required voltage** and the lower the **required voltage**. As a result, combustion is good for all types of driving, the engine starts easily, and acceleration improves.

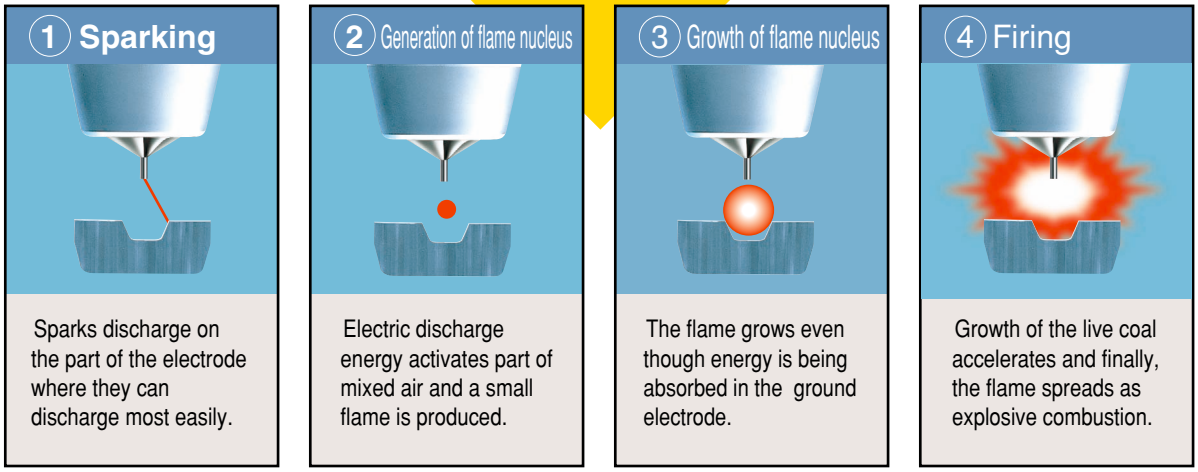
Electric field strength shown using FEM(*1) analysis



The above shows the strength of electrical field in case certain voltage changes on normal spark plug and IRIDIUM POWER .
The more electrical field strength is getting high, the more it becomes easy to fire with low voltage.
*1 FEM (Finite Element Method analysis): General method to measure electrical field strength.
*2 Normal spark plug mentioned in this brochure is resistor plug.

The electrode also has a quenching (cooling) effect (effect where the electrode takes away the heat of the spark as soon as firing occurs). Therefore, in a thick electrode the cooling effect is great and sometimes firing does not occur as shown in Figure 4 . The characteristics of this firing is called **firing performance**. To improve **firing performance**, the contact area between the electrode and the flame nucleus needs to be made reduced in size.
Accordingly, the electrode was made as fine as possible in the IRIDIUM POWER to improve **firing performance**.

Pattern from sparking to firing

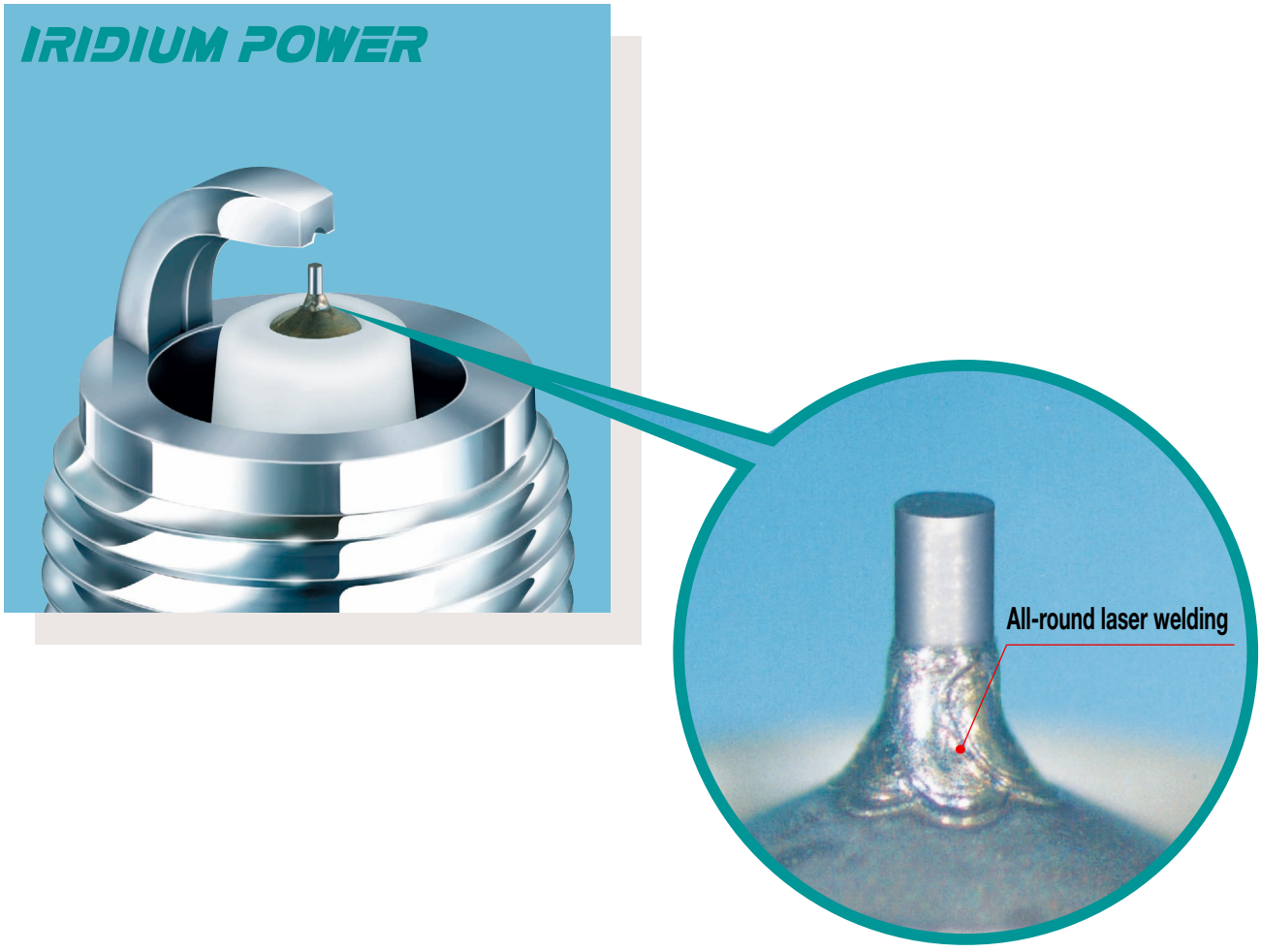


*: As of Nov. 1999, this excludes flush type electrodes that do not protrude from the insulator.

Q3 How is the iridium tip of the IRIDIUM POWER welded to the electrode?

A We use all-round laser welding to ensure a highly reliable joining.

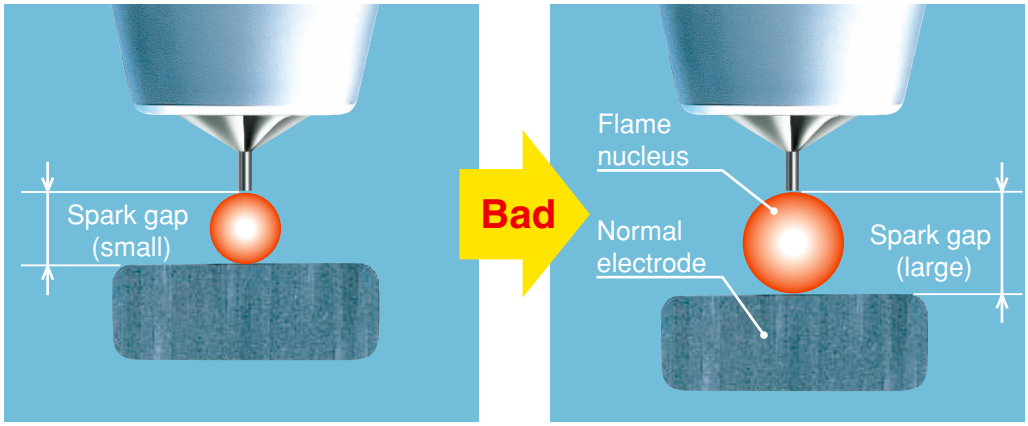
The 0.4 mm iridium tip that generates the high performance of the IRIDIUM POWER is an alloy with a very high melting point. Therefore, ordinary resistance welding cannot be used because the iridium does not melt enough and an adequate weld strength cannot be guaranteed.
“All-round laser welding”, which employs a high-energy laser, is used in the IRIDIUM POWER to melt and weld all around welding points.
Because all area to be welded is completely melted, the welding point is extremely reliable, thus ensuring stable and quality response without changes in the electrode, even under heavy driving conditions.



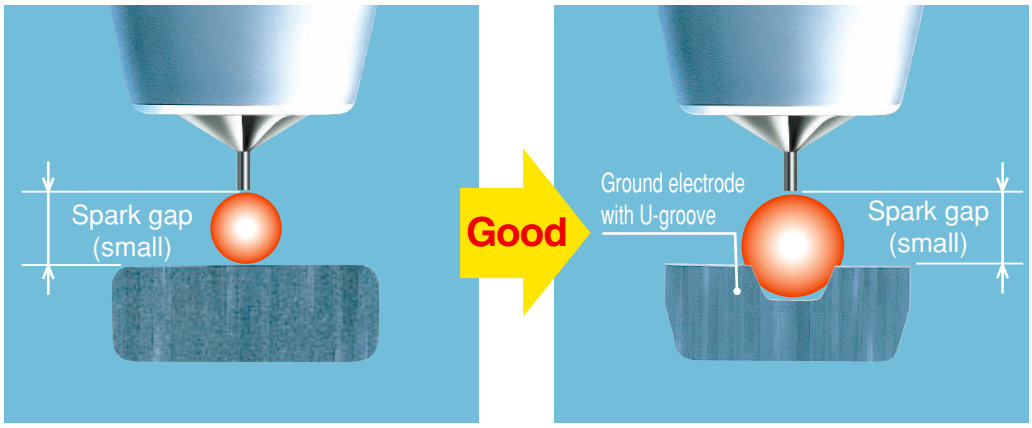
Q4 What advantages does the U-groove in the IRIDIUM POWER ground electrode have?

A Ignitability can be improved without increasing the required voltage. (The U-groove is original DENSO technology and a patent for it was acquired in 1975.)

To improve ignitability, it is important to allow the good growth of the flame nucleus (live coal) created in discharge.
The usual way of ensuring this is increasing the spark gap, but this also increases the required voltage and thus places a great load on the ignition coil and plug cords.



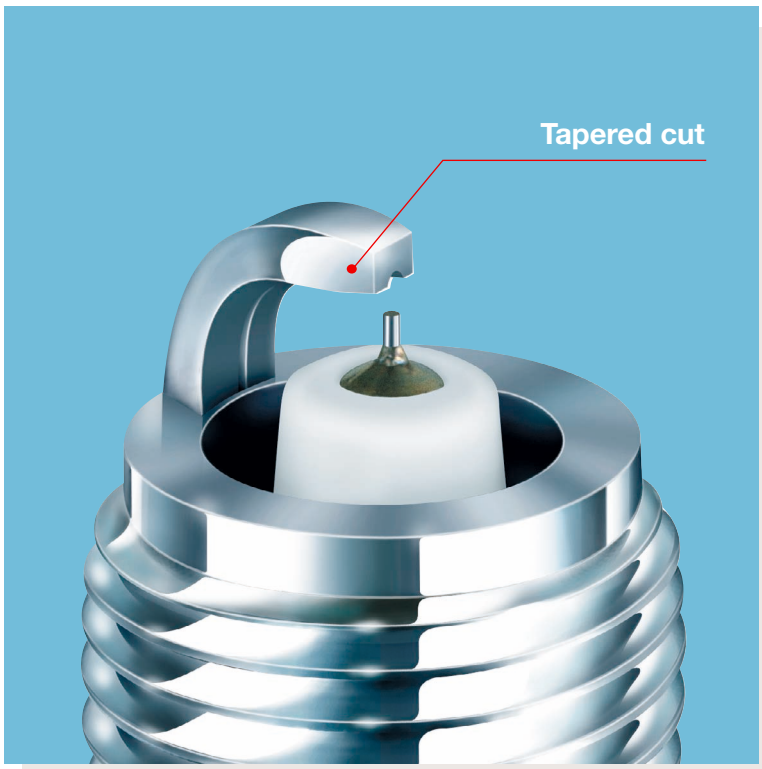
The ground electrode, with its U-groove, maintains a large volume of space without altering the spark gap. Therefore, excellent firing ignitability is enabled even though the sparking required is kept low.



Q5 What advantages does the tapered cut in the IRIDIUM POWER ground electrode have?

A Ignitability is improved. Also, the heat and vibrations experienced by the electrodes at combustion are decreased, enabling an increase in driving performance.

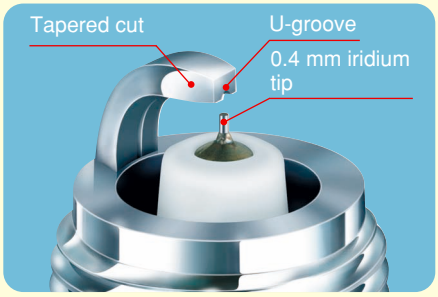
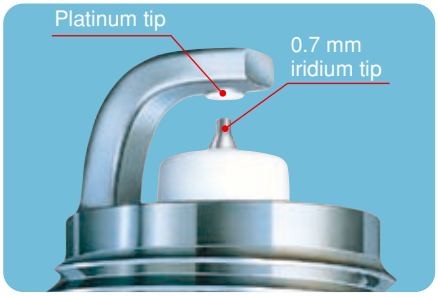
As explained in the answer to Q2, to improve ignitability, an important characteristic of spark plugs, it is important to minimize the portion of the electrode that comes in contact with the flame nucleus. Because the area of **the ground electrode with tapered cut** that comes into contact with the flame nucleus is small, the heat lost to the electrode is lessened and firing performance improves dramatically. Also, the surface area and weight of the ground electrode tip is reduced and so the load in terms of heat and vibrations is lessened. This means that the spark plug can cope with heavier driving conditions.



Q6 What are the differences between IRIDIUM POWER and iridium spark plugs offered as genuine parts by car manufacturers?

A They use iridium of the same quality in the tip but the purposes and specifications of the spark plugs differ.

The IRIDIUM POWER is a high performance spark plug. The iridium spark plugs offered as genuine parts by car manufacturers are long-life spark plugs. The center electrode in both is made from the new iridium alloy but the purpose of both are different. Therefore, the electrode diameter and ground electrode specifications also differ.

	IRIDIUM POWER	Iridium spark plugs provided as genuine parts
Type	High performance type	Long life type
Appearance		
Electrode		
Longevity	15,000 to 20,000 km	100,000 km
Type	IK20	SK20R11

DENSO precious metal spark plugs are classified into the four types shown in the following table according to the center electrode material and type.

Type / Electrode material	High performance type	Long life type
Iridium alloy	IRIDIUM POWER (ϕ 0.4)	Iridium plug (ϕ 0.7)
Platinum alloy	ZU plug (ϕ 0.7)	Platinum plug (ϕ 1.1)

The figures in parentheses represent the diameter of the center electrode.

Q7 What type of material is used to produce the electrode employed for IRIDIUM POWER ?

A Iridium is the same type of precious metal as platinum. It is characterized by its extremely high melting point and great strength.

	Iridium (Ir)	Platinum (Pt)	Nickel (Ni)	Gold (Au)	Silver (Ag)
Melting point (°C)	2454	1769	1453	1063	960
Strength (kgf/mm²)	112	14	68	13	13
Electrical resistance (μΩ・cm)	5.3	10.6	6.8	2.3	1.6
Hardness (HV,20°C)	240	40	160	25	26

Melting point The melting point of iridium is approximately 680°C higher than that of platinum and is difficult to melt even in the high temperatures produced by electrical discharges and combustion.

Strength Iridium has high material strength compared to other materials and provides stable performance under heavier driving conditions.

Electrical resistance Because the electrical resistance is lower than platinum and the base material of electrodes, nickel, iridium is suitable for use in spark plug electrodes.

Hardness Iridium is harder than other materials and has great material strength.

Q8 Why can iridium now be used in IRIDIUM POWER electrodes?

A **DENSO is now able to use iridium because of our technology in the field of precious metals, for which we are a world-leader and also because of our advanced laser welding technology.**

As explained in the answer to Q7, iridium is an extremely hard material. In the past, sintering material was generally cut and this meant **high costs** and **restrictions on processing form and dimensions**. Therefore, it could not be used as a material in spark plugs. However, our new precious metals technology has meant that we can now process **iridium by drawing** it in its melted form. This enables iridium to be processed in all dimensions and forms. Therefore, DENSO has moved quickly to use it as a material for use in spark plug electrodes.

Q9 In what other fields is iridium commonly used for?

A **Because of its high melting point and superb corrosion resistance, iridium is used widely in fields employing state-of-the-art technology such as the aerospace, medical, and motor vehicle industries.**

- Components in aerospace industry
- Electrodes for equipment used in clinical medicine such as pacemakers and catheters
- Metal pots for growing crystals for electronic industries
- Automobile catalyzers
- Jewelry

Q10 Is the tip in the IRIDIUM POWER made of pure iridium?

A We use a new iridium alloy developed at DENSO.

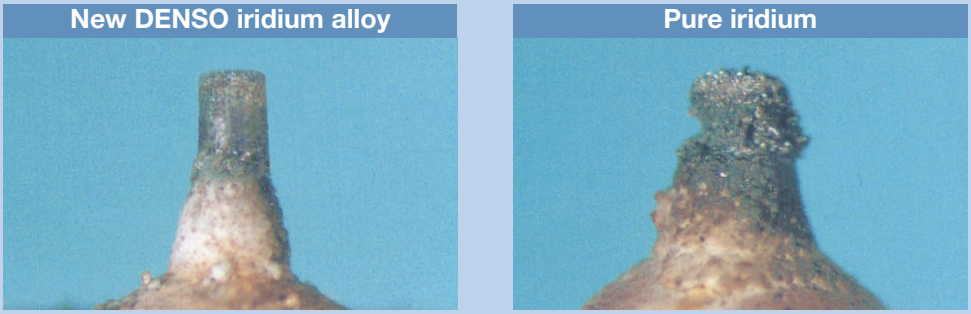
Iridium is characterized by a higher melting point than either nickel or platinum. Therefore, it wears very well when subject to electrical discharge. However, at high temperatures it oxidizes a little too much and so we are unable to use pure iridium for spark plug electrodes.

Melting point(˚C)	Element	Oxidation resistance
3410	Tungsten (W)	Bad
2610	Molybdenum (Mo)	Bad
2454	Iridium (Ir)	Good
1769	Platinum (Pt)	Better
1453	Nickel (Nl)	Good
1063	Gold (Au)	Better
960	Silver (Ag)	Better

(The above is analyzed in DENSO.)

DENSO studied many additives with a view to improving the corrosion resistance of iridium and has now developed a new iridium alloy (the alloy of iridium and rhodium) highly suitable for use in spark plug electrodes. This new product is covered by the following DENSO patents; JP2877035, GB2302367; and other patents pending in USA, Germany, Canada, Italy and South Korea.

The following photographs compare the durability of the new iridium alloy and pure iridium when used in an engine under the same conditions.



Test engine: 90 cc 4-cycle 1-cylinder Test conditions:Full×9000rpm×30h

Part of the pure iridium material was shed and corroded. The new DENSO iridium alloy showed no corrosion on the electrode and mainfained good condition.

Q11 Tell me about the firing performance of the IRIDIUM POWER.

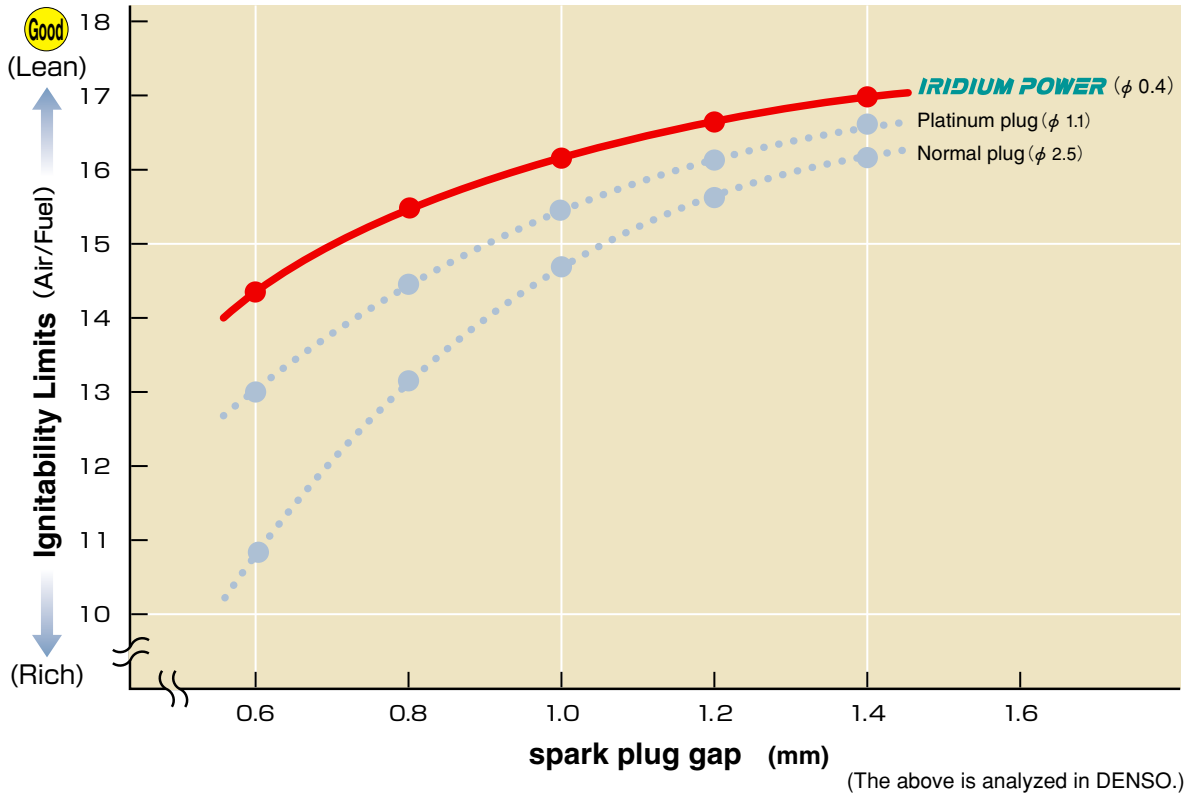
A Use of a ultra-fine 0.4 mm diameter iridium center electrode and a tapered cut and a U-groove in the ground electrode has enabled us to achieve previously unparalleled firing performance in the IRIDIUM POWER.

Ordinarily, the leaner the air mix the more difficult the firing.
The greater the ignitability limits, that is the leaner the air mix in which a plug can spark, the better firing performance a plug is said to have.

The following graph shows some examples of ignitability limits (*) for various spark plugs.

*: Ignitability limits (Air/Fuel);
1)Lean limits to be able to fire
2)As this figure is getting higher, it will become easier to fire.

Test engine: 1600 cc, 4-valve, 4-cylinder



(The above is analyzed in DENSO.)

Compared to normal spark plugs, with a spark gap of 0.8mm, the Ignitability limits is better by 2.5.

Q12 Tell me about the required voltage in the IRIDIUM POWER.

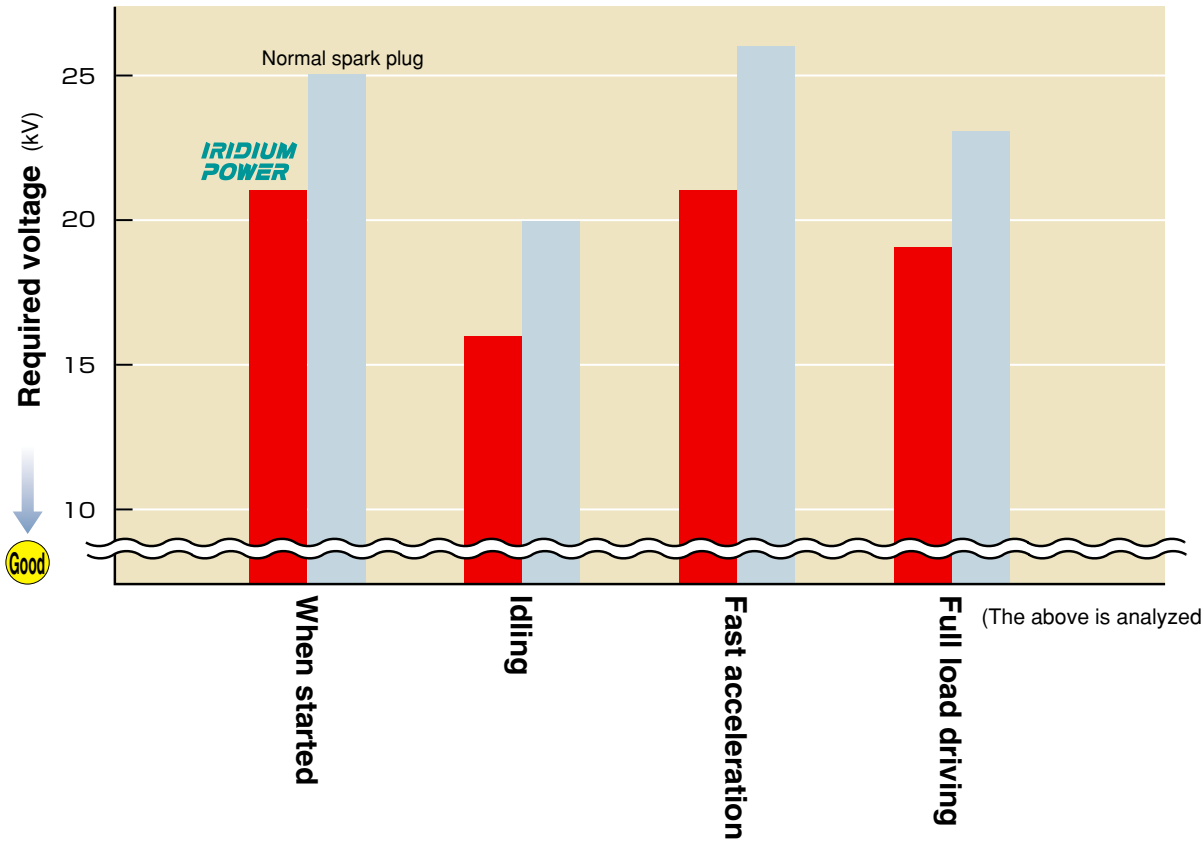
A The required voltage is reduced by the use of the ultra-fine 0.4 mm diameter center electrode.

Recently, there has been a trend to increase the compression ratio to increase output in engines. This means that the required voltage of spark plugs tends to increase and high compression is required in highly tuned engines. When this occurs, the required voltage increases and, in the worst case, sparking ceases while the engine is running. Minimization of the electrode diameter is an effective way of avoiding this. (Refer to the answer for Q2 .)

In the IRIDIUM POWER, the center electrode has a diameter of 0.4 mm. Because required voltage is kept low, this enables the IRIDIUM POWER to be used in high performance engines and for high response driving.

The following graph gives examples of required voltage measurements for IRIDIUM POWER and normal spark plugs.

Test engine: 660 cc, Carburetor, 3-cylinders



(The above is analyzed in DENSO.)

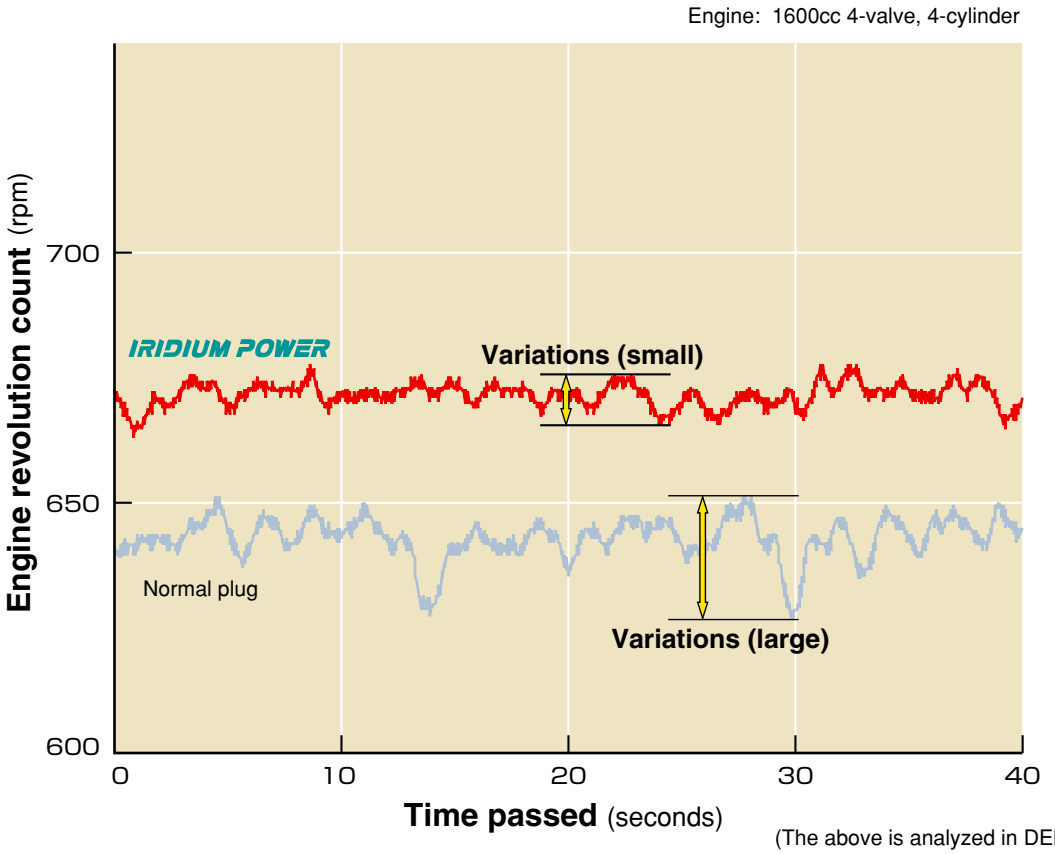
The required voltage in the IRIDIUM POWER is between 3 and 5 kv less than in normal plugs.

Q13 What happens at idling when an IRIDIUM POWER is used?

A Owing to stable combustion, less variation in the idling revolutions is produced, hence there is less need for 'engine-breathing' during idling.

When an engine is idling, firing can become particularly bad. Because the IRIDIUM POWER has a low required voltage and high ignitability, sparking continues to work properly during idling. This stabilizes the idling revolution count and quietens the engine.

The following graph gives some examples of idling revolution counts.



(The above is analyzed in DENSO.)

Whereas normal plugs have highly variable revolution counts, the IRIDIUM POWER maintains very smooth idling.
Also, because combustion is good, the explosive energy raises the revolution count.

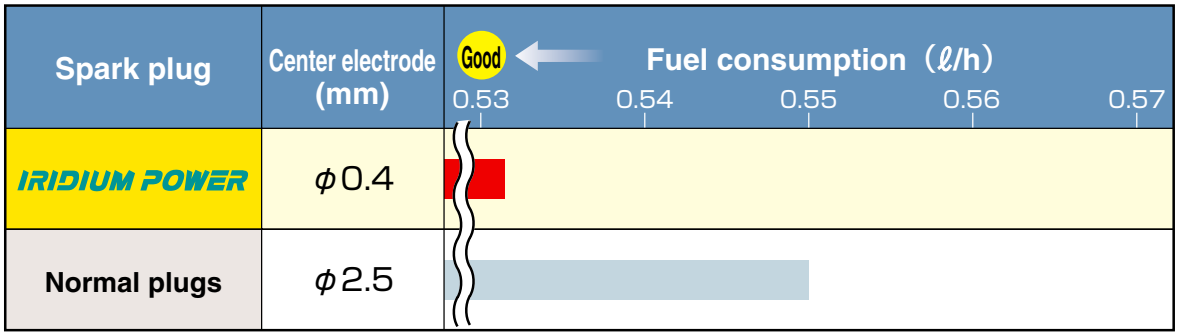
Q14 What happens to fuel consumption when IRIDIUM POWER is used?

A In many cases, fuel consumption is improved.

When IRIDIUM POWER spark plugs are used, accidental fire and misfiring rarely occur under various driving conditions. Therefore, combustion is extremely good. In turn, a healthy engine can be maintained and fuel consumption is improved.
In the idling examples given in the answer to Q13, combustion improved and therefore the revolution count increased. However, if the engine's idling revolution control is operated, control that returns an increased revolution count will be operated and the throttle constricted, thus improving fuel consumption during idling.

The following graph is the comparison of fuel consumption during idling.

Test engine: 1600 cc 4-valve 4-cylinder

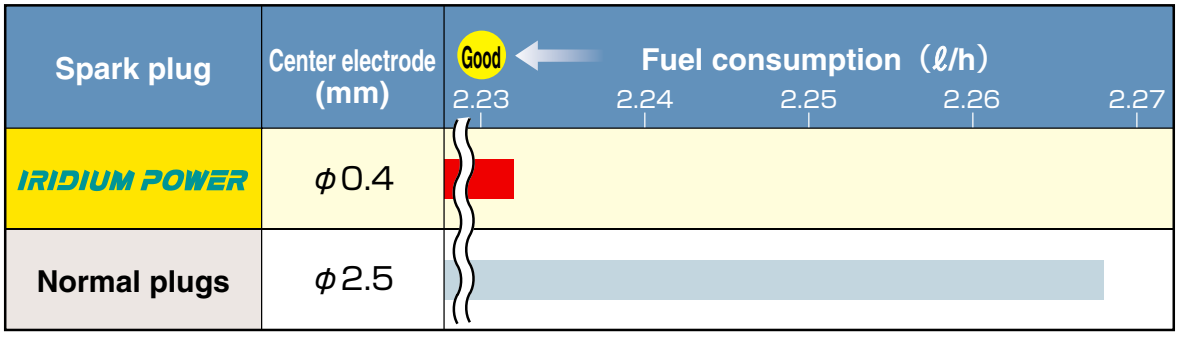


(The above is analyzed in DENSO.)

In many cases, fuel consumption will also improve for the same reason during actual running.

The following graph is an example that shows an improved fuel consumption when a car is being driven at 60 km/h on flat ground.

Test engine: 1600 cc 4-valve 4-cylinder



(The above is analyzed in DENSO.)

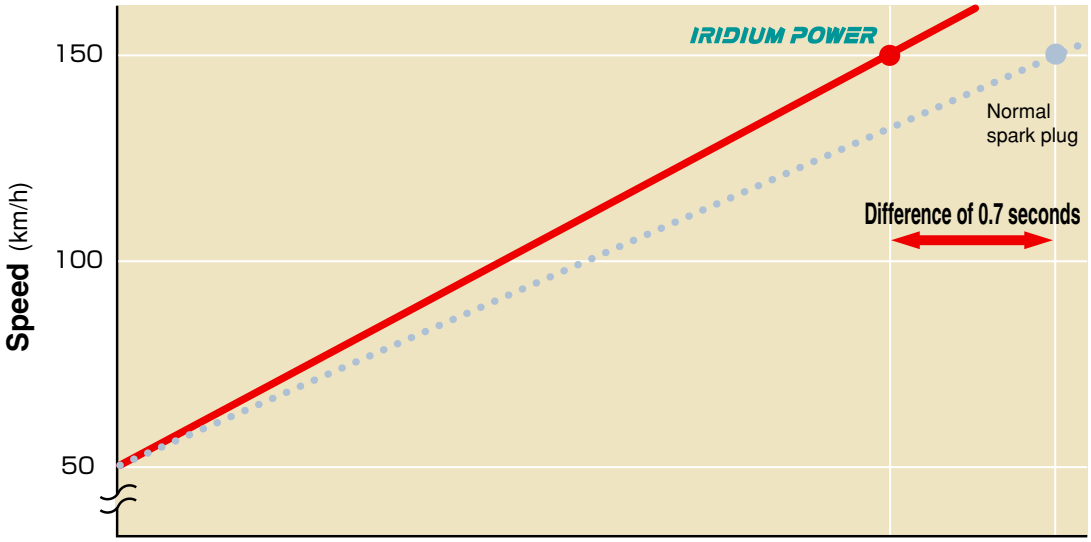
Q15 Does engine performance improve when IRIDIUM POWER is used?

A IRIDIUM POWER spark plugs enhances the performance of an engine. Acceleration is improved when compared against normal spark plugs.

The 0.4 mm iridium center electrode and the specially shaped ground electrode in an IRIDIUM POWER enable a superior ignitability and a lower required voltage than any seen in the past. Accordingly, there is less misfire in areas where required voltage is high, and less misfiring in areas where firing is difficult. No matter how heavy the conditions, high response driving is enabled. As a result, acceleration is better than when normal spark plugs are used.

The following graph is an example of an acceleration test.

Vehicle: 250 cc (2-cycle, water-cooled, V2 cylinders)
Conditions: Fixed in sixth gear
Flat out acceleration from 50 km/h using an automatic driving device



(The above is analyzed in DENSO.)

Vehicle: 250 cc (2-cycle, water-cooled, V2 cylinders)
Conditions: Fixed in sixth gear
Flat out acceleration from 50 km/h using an automatic driving device

Running distance difference at 150km/h between ordinaly spark plug and IRIDIUM POWER .

Spark plug	Center electrode diameter (mm)	Distance run (m) 790 800 810 Good
IRIDIUM POWER	φ0.4	
Normal spark plug	φ2.5	Difference of 6m

There was a difference of 0.7 seconds between IRIDIUM POWER and normal spark plugs in the time taken to reach 150 km/h. There was also a difference of 6 m in the distance covered to reach that speed.

Q16 Can spark plugs of other brand-names be substituted with IRIDIUM POWER?

A Our spark plugs are compatible with almost all spark plugs manufactured by other companies.

IRIDIUM POWER spark plugs can replace almost all spark plugs fitted as standard in Japanese and foreign cars. Check for the spark plug you are using in the following table and select the IRIDIUM POWER spark plug that corresponds to it.
IRIDIUM POWER plugs are also compatible not only with standard spark plugs but also with high performance and racing spark plugs and can also be used in engines where the required heat range is high, such as in highly tuned engines.

If the spark plug you are using is not in this table, select an IRIDIUM POWER to suit your car from the following table which lists spark plugs by vehicle type.

IRIDIUM POWER Comparative Spark Plug Table

IRIDIUM POWER	DENSO	NGK	NGK RACING	TRUST	BLITZ
IK16	K16PR-○, K16R-U○, KJ16C○ K16TR○ PK16○, PKJ16○	BKR5○, ZFR5F, J○ PFR5○(except A.K) PZFR5○			
IK20	K20PR-○, K20R-U○, KJ20C○ K20TR○ PK20○, PKJ20○	BKR6○, ZFR6F, J○ PFR6○(except A.K) PZFR6○			
IK22	K22○	IRIWAY7, BKR7E○ PFR7○(except A.K),PZFR7○	R6326-7, R6255-7	07 ISO	R6427-7
IK24	K24○	IRIWAY8 ,PFR8B	R6326-8, R6255-8	08 ISO	R6427-8
IK27	K27○	IRIWAY9	R6326-9, R6255-9	09 ISO	R6427-9
IQ16	Q16PR-○, Q16R-U○ PQ16○	BCPR5○ PFR5A,K○			
IQ20	Q20PR-○, Q20R-U○, QJ20C○ PQ20○	BCPR6○ PFR6A,K○			
IQ22	Q22○	IRITOP7 ,BCPR7E○, PFR7A	R6337-7, R5400-7	07	R6105-7
IQ24	Q24○	IRITOP8, BCPR8E○	R6337-8, R5400-8	08	R6105-8
IQ27	Q27○	IRITOP9	R6337-9, R5400-9	09	R6105-9
IW16	W16E○ P16○	BPR5E○ PGR5○			
IW20	W20E○ P20○	BPR6E○ PGR6○			
IW22	W22E○ P22○	BPR7E○ PGR7○			
IXU22	XU22○	DCPR7E○			
IXU24	XU24○	IRIMAC8, DCPR8E○			

For normal engines, select a spark plug with the same heat range as a standard spark plug. For highly tuned engines, select one with the heat range that suits the tuning level.

Q17 What type of cars can current be fitted with IRIDIUM POWER ?

A At present, IRIDIUM POWER spark plugs can be fitted into almost all Japanese and foreign cars.

There are 85 types of IRIDIUM POWER spark plugs (as of Aug. 2005).At least one of these 85 types will be able to be fitted into almost any car.

Q18 Does the engine need to be specially set when fitting IRIDIUM POWER ?

A No. The plugs can just replace the ones you take out.

The IRIDIUM POWER spark plug itself has a low required voltage and high ignitability and is able to draw out the power of an engine. The superb performance of IRIDIUM POWER spark plugs is obtained merely by installing them in your vehicle. And, of course, there is no need for special tuning.

Q19 How do I select the correct heat-range when fitting IRIDIUM POWER to my vehicle?

A **In ordinary cars, use a spark plug with the same heat range as a normal spark plug. In highly tuned vehicles, select a heat range to suit the tuning level of the engine.**
(Ordinarily, the heat range of a highly tuned engine tends to be colder.)

Refer to the following table to compare the heat range of the IRIDIUM POWER and other spark plugs.

DENSO	16	20	22	24	27	29	31	34
NGK	5	6	7	8	9	9.5	10	11
CHAMPION	12,11	10,9	8,7	63,61	59	57	55	
BOSCH	8	7,6	5	4	3		2	

* The above heat range is extracted from other companies' brochure.

Q20 How would IRIDIUM POWER compare against high-performance spark plugs offered by other spark plug manufacturers?

A **The following table gives examples of high performance plugs marketed by other companies.**

Manufacturer	Spark plug	Center electrode diameter (mm)	Center electrode material	Tapered cut
DENSO	IRIDIUM POWER	φ0.4	Iridium alloy	Yes
	ZU spark plug	φ0.7	Platinum alloy	Yes
NGK	*1 Iriseries spark plug	φ0.6	Iridium alloy	Yes
	*2 VX spark plug	φ0.8	Platinum alloy	Yes
CHAMPION	*3 Project Gold	φ2.0	Gold-palladium alloy	Yes
BOSCH	*4 Blue Platinum	φ0.9	Platinum	Yes

*1: From NGK Iriseries Plug catalog
*2: From the NGK catalog
*3: From the CHAMPION Project Gold catalog
*4: From the BOSCH catalog

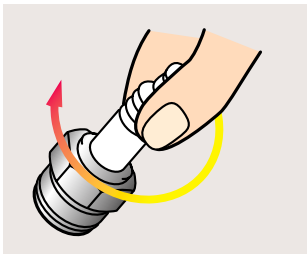
The use of an iridium alloy for the ultra-fine 0.4 mm diameter center electrode, a tapered cut, synonymous with high performance spark plugs, in the ground electrode, and DENSO's original U-groove, make IRIDIUM POWER spark plugs high performance spark plugs.

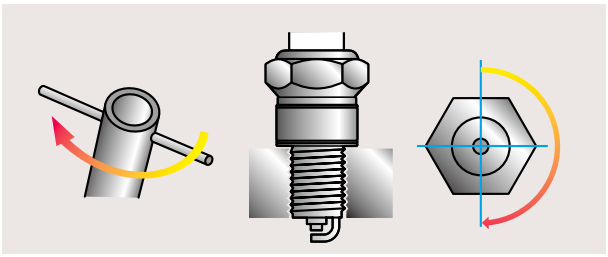
Q21 Is there anything I need to be aware of when fitting IRIDIUM POWER ?

A As with normal spark plugs, install IRIDIUM POWER spark plugs using the correct procedure and appropriate torque.

Notes for Installing and Removing IRIDIUM POWER Spark Plugs

1. Use a spark plug wrench to suit the hexagonal part of the spark plug to ensure that no burring occurs.
2. When removing the spark plug, ensure that no fouling, such as oil on the outside of the plug, enters inside the engine.
3. When installing IRIDIUM POWER spark plugs, clean the seat for the spark plug in the engine, check the gasket,and then mount the plugs on their seats.
4. Place the plugs in vertically and screw in by hand until tight.
5. Then, using a spark plug wrench, rotate for between 1/4 and 1/2 of a turn (or between 1/5 and 1/4 of a turn when they are to be re-used).





6. Do not over-tighten spark plugs as this may damage the engine (in particular, aluminum engines) and cause fracturing of the thread.

Q22 Can the IRIDIUM POWER gap be adjusted? Can I use any spark plug cleaners with the IRIDIUM POWER ?

A Do not adjust the spark plug gap.
Use of a spark plug cleaner for short periods is acceptable if low pressure is used.

IRIDIUM POWER spark plugs use a ultra-fine 0.4 mm iridium center electrode and the spark gap is already set at the optimum distance.
If the electrode is damaged by gap adjustment or cleaning, the spark plugs will not perform to their best.

IRIDIUM POWER® LINEUP

IKH series

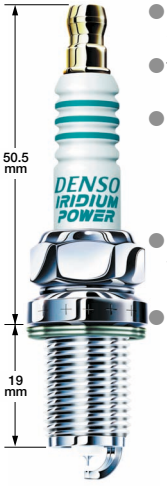
IKH16. IKH20. IKH22 IKH24. IKH27

- 14mm dia. X 26.5mm length long reach type
- For Subaru 3 Liter, Nissan, Peugeot, Citroen, and Yamaha Marine.
- Iridium Tough VKH16, VKH20, and VKH22 are also on sale at the same time.

IK series

On Sale Spring 2005 (IK16L IK20L)
On Sale Summer 2005 (IK16G IK20G)

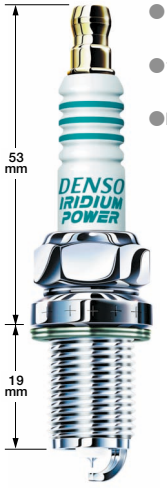
IK16. IK20. IK22. IK16L. IK20L. IK16G. IK20G. IK22G. IK24. IK27. IK31. IK34



- Mainly used for cars. ISO type.
- 14mm dia. X 19mm length type.
- IK22 and above are for tuned engines, with a spark gap of 0.8mm.
- IK□L is extended type (spark position 5mm)
- IK□G equips a sus (stainless steel) Gasket

IQ series

IQ16. IQ20. IQ22. IQ24. IQ27. IQ31. IQ34



- Mainly used for cars.
- 14mm dia. X 19mm length type.
- IQ22 and above are for tuned engines, with a spark gap of 0.8mm.

IW series

IW16. IW20. IW22. IW24. IW27. IW29. IW31. IW34

- 14mm dia. X 19mm length fully threaded type.
- IW16 to 22 are focused on ignitability with a 1.5mm projection, whereas IW24 to 34 are focused on heat resistance with a projection of -1.5mm.
- The spark position of IW24 to 34 is projected 0.5mm compared to normal (1.0 → 1.5mm).

IWM series

IWM24. IWM27. IWM31

- This type has a gasket face height shortened by approximately 10mm from the IW Type.
- The Iridium Power version of the IWM01-□ Iridium Racing plugs.
- Sold as street-use plugs for 2-cycle 250cc sports bikes.
- For Honda NSR250, Yamaha TZ250R, Suzuki RGV250γ (Gamma), Aprilia RS250, KTM260, 300, and 380 ('99 and later).
- Can also be used for water cooled kart engines.

IWF series

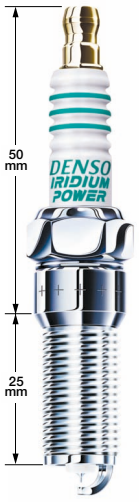
On Sale Summer 2004 (IWF16 IWF20)

IWF16. IWF20. IWF22. IWF24. IWF27

- 14mm dia. X 12.7mm length short reach type.
- IWF27 utilizes the heat resistance of the iridium electrode to extend the spark position 0.5mm (1.0 → 1.5mm)
- Harnessing the low required voltage of the 0.4mm dia. iridium, the gap is wider than in standard types (0.7 →0.8mm). ignitability is increased even further.

ITV series

ITV16. ITV20. ITV22. ITV24. ITV27

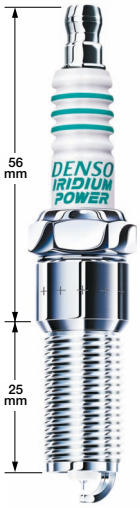


- 14mm dia.. X 25.0mm length tapered seat, long reach type.
- For the Ford Focus, Mondeo, Escape; Chevrolet Blazer and Mazda Tribute.

ITL series

On Sale Summer 2004 (ITL16 ITL20)

ITL16. ITL20



- 14mm diameter X 25.0mm length tapered seat, long reach type.
- Designed so that the head of the plug is 6mm higher than in the ITV
- For the Chrysler PT Cruiser and Voyager

IT series

IT16. IT20. IT22. IT24. IT27

- 14mm dia. X 17.5mm length tapered seat type.
- For use with GM, Ford, Citroen, Jaguar, Peugeot, Volvo, Mercedes-Benz, Lancia, Renault, Audi, and Mazda.

ITF series

ITF16. ITF20. ITF22. ITF24. ITF27

- 14mm dia. X 11.2mm length tapered seat type.
- For use with GM and Ford.

IXU series

IXU22. IXU24. IXU27

- 12mm dia. X 19mm length fully threaded type.
- The insulator is fully projected (1.5mm), creating a wide heat range and greater ignitability.
- 16mm Hex
- For use with small cars and imported motorcycles such as Ducati.

IX series

IX22. IX24. IX27

- 12mm dia. X 19mm length fully threaded type.
- Using the high heat resistance of the iridium electrode, the spark position is projected 0.4mm more than in standard types. (1.6 → 2.0mm)
- Harnessing the low required voltage of the 0.4mm dia. iridium the gap is wider than in the standard types (0.7 →0.8mm). A further increase in ignitability.
- 18mm Hex

IX-B series

IX22B. IX24B. IX27B

- 12mm dia. X 19mm length fully threaded type.
- Compared to the IX type, the insulator projection is extended 0.9mm (0.6 → 1.5mm), resulting in a wider heat range.
- The spark position is projected 0.8mm more than the IX type. (2.0 → 2.8mm)
- 18mm Hex

IXG series

IXG24. IXG27

- The Iridium Power versions of the 2mm shroud type plugs (X24/27GP-U) used by Honda.
- Applicable to CB400SS. An expansion of applications is planned.
- Applicable to Honda CB400SS, XR400RR, CL400/RS, XLR250R, CBX250S, FTR250, CBX400F, XR250R.

IU series

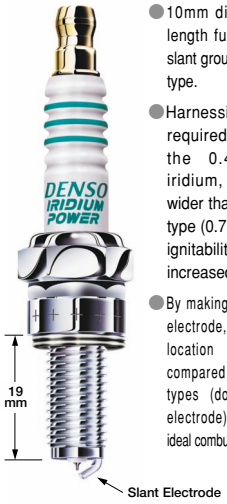
On Sale Summer 2004 (IU20)

IU20. IU22. IU24. IU27. IU31

- 10mm dia. X 19mm length fully threaded type.
- Harnessing the low required voltage of the 0.4mm iridium center electrode, the spark gap is wider than in normal type. A further increase in ignitability.
- For motorcycles such as Yamaha and Kawasaki, also for Ferarri, Maserati, and Alfa Romeo.

IU-A series

IU24A. IU27A. IU31A



- 10mm dia. X 19mm length fully threaded slant ground electrode type.
- Harnessing the low required voltage of the 0.4mm dia. iridium, the gap is wider than in normal type (0.7 → 0.9mm). ignitability is greatly increased.
- By making this a single electrode, the spark location is stabilized compared to in normal types (double ground electrode), securing an ideal combustion condition.

IUH series

IUH24. IUH27

- 10mm dia. X 19mm length half-threaded type.
- Using the high heat resistance of the iridium electrode, the spark position is extended 0.4mm compared to standard types (1.6 → 2.0mm)
- For Honda

IUF series

IUF22. IUF24. IUF14-UB

- 10mm dia. X 12.7mm length short reach type.
- Using the high heat resistance of the iridium, the spark position is extended 0.4mm compared to standard types (1.6 → 2.0mm)
- Harnessing the low required voltage of the 0.4mm dia. iridium, the spark gap is wider than in normal types (0.7 → 0.8mm).

IUF-A series

IUF27A. IUF31A

- 10mm dia. X 12.7mm length short type.
- Ideal for Gorilla/ Monkey Racing
- The ground electrode has a slant shape, reducing the thermal stress on it.

IY series

IY24. IY27. IY31

- 8mm diameter X 19mm length tapered seat, half thread type.
- The world's first 8mm thread diameter iridium plug
- Can be used with Honda Smart Dio ('04-), VFR400, RVF400, Kitaco Monkey Head, and NR750.

IRIDIUM POWER® SPECIFICATIONS

	TYPE	SPEC	DIA. (mm)	REACH (mm)	HEX (mm)	GAP (mm)	PROJECTION (mm)	Spark position (mm)	Ground electrode height (mm)	Terminal shape	RESISTOR (kΩ)	No.	IRIDIUM POWER® ONE PC BOX		IRIDIUM POWER® 2pcs BLISTER PACK	
													BARCODE	DENSO P/N	BARCODE	DENSO P/N
	IQ16	JIS	14	19	16	1.1	1.5	3.0	5.5	RC	5	I01	0 42511 05301 4	067700-8700	0 42511 02301 7	100676-3380
	IQ20	JIS	14	19	16	1.1	1.5	3.0	5.5	RC	5	I02	0 42511 05302 1	067700-8710	0 42511 02302 4	100676-3390
	IQ22	JIS	14	19	16	0.8	1.5	3.0	5.5	RC	5	I13	0 42511 05313 7	067700-8480	0 42511 02313 0	100676-3480
	IQ24	JIS	14	19	16	0.8	1.5	3.0	5.5	RC	5	I14	0 42511 05314 4	067700-8490	0 42511 02314 7	100676-3490
	IQ27	JIS	14	19	16	0.8	1.5	3.0	5.5	RC	5	I15	0 42511 05315 1	067700-8500	0 42511 02315 4	100676-3500
	IQ31	JIS	14	19	16	0.8	-0.5	1.0	3.2	RC	5	I23	0 42511 05323 6	067700-9230	0 42511 02323 9	100676-3520
	IQ34	JIS	14	19	16	0.8	-0.5	1.0	3.2	RC	5	I24	0 42511 05324 3	067700-9600	0 42511 02324 6	100676-3830
	IK16	ISO	14	19	16	1.1	1.5	3.0	5.5	RC	5	I03	0 42511 05303 8	067700-8680	0 42511 02303 1	100676-3360
	IK20	ISO	14	19	16	1.1	1.5	3.0	5.5	RC	5	I04	0 42511 05304 5	067700-8690	0 42511 02304 8	100676-3370
	IK22	ISO	14	19	16	0.8	1.5	3.0	5.5	RC	5	I10	0 42511 05310 6	067700-8430	0 42511 02310 9	100676-3450
	IK24	ISO	14	19	16	0.8	1.5	3.0	5.5	RC	5	I11	0 42511 05311 3	067700-8460	0 42511 02311 6	100676-3460
	IK27	ISO	14	19	16	0.8	1.5	3.0	5.5	RC	5	I12	0 42511 05312 0	067700-8470	0 42511 02312 3	100676-3470
	IK31	ISO	14	19	16	0.8	-0.5	1.0	3.2	RC	5	I21	0 42511 05321 2	067700-9220	0 42511 02321 5	100676-3510
	IK34	ISO	14	19	16	0.8	-0.5	1.0	3.2	RC	5	I22	0 42511 05322 9	067700-9590	0 42511 02322 2	100676-3600
New	IK16G	ISO,SUS GASKET	14	19	16	1.1	1.5	3.0	5.2	S	5	I51	0 42511 05351 9	267700-5610		
New	IK20G	ISO,SUS GASKET	14	19	16	1.1	1.5	3.0	5.2	S	5	I52	0 42511 05352 6	267700-5620		
	IK22G	ISO,SUS GASKET	14	19	16	0.8	1.5	3.0	5.2	S	5	I48	0 42511 05348 9	267700-5660	0 42511 02348 2	100676-5350
New	IK16L	ISO,EXTENDED	14	19	16	1.1	2.5	5.0	7.8	RC	5	I57	0 42511 05357 1	267700-5120		
New	IK20L	ISO,EXTENDED	14	19	16	1.1	2.5	5.0	7.8	RC	5	I58	0 42511 05358 8	267700-5130		
	IKH16	Long Reach26.5mm	14	26.5	16	1.1	1.5	3.0	5.5	RC	5	I43	0 42511 05343 4	267700-3660	0 42511 02343 7	100676-5160
	IKH20	Long Reach26.5mm	14	26.5	16	1.1	1.5	3.0	5.5	RC	5	I44	0 42511 05344 1	267700-3670	0 42511 02344 4	100676-5140
	IKH22	Long Reach26.5mm	14	26.5	16	0.8	1.5	3.0	5.5	RC	5	I45	0 42511 05345 8	267700-2650	0 42511 02345 1	100676-5170
	IKH24	Long Reach26.5mm	14	26.5	16	0.8	1.5	3.0	5.5	RC	5	I46	0 42511 05346 5	267700-4280	0 42511 02346 8	100676-5180
	IKH27	Long Reach26.5mm	14	26.5	16	0.8	1.5	3.0	5.5	RC	5	I47	0 42511 05347 2	267700 4290	0 42511 02347 5	100676-5190
	IW16		14	19	20.6	1.1	1.5	3.0	5.5	RC	5	I05	0 42511 05305 2	067700-8650	0 42511 02305 5	100676-3400
	IW20		14	19	20.6	1.1	1.5	3.0	5.5	RC	5	I06	0 42511 05306 9	067700-8660	0 42511 02306 2	100676-3410
	IW22		14	19	20.6	0.8	1.5	3.0	5.2	RC	5	I07	0 42511 05307 6	067700-8670	0 42511 02307 9	100676-3420
	IW24		14	19	20.6	0.7	-0.5	1.5	3.6	RC	5	I16	0 42511 05316 8	067700-8890		
	IW27		14	19	20.6	0.7	-0.5	1.5	3.6	RC	5	I17	0 42511 05317 5	067700-8900		
	IW29		14	19	20.6	0.7	-0.5	1.5	3.6	RC	5	I18	0 42511 05318 2	067700-8910		
	IW31		14	19	20.6	0.7	-0.5	1.5	3.6	RC	5	I19	0 42511 05319 9	067700-8920		
	IW34		14	19	20.6	0.7	-0.5	1.5	3.6	RC	5	I20	0 42511 05320 5	067700-8930		
	IWM24	INSULATOR COMPACT	14	19	20.6	0.8	-1.5	0.5	2.7	S	5	I91	0 42511 05391 5	267700-2890		
	IWM27	INSULATOR COMPACT	14	19	20.6	0.8	-1.5	0.5	2.7	S	5	I92	0 42511 05392 2	267700-2900		
	IWM31	INSULATOR COMPACT	14	19	20.6	0.8	-1.5	0.5	2.7	S	5	I93	0 42511 05393 9	267700-2910		
New	IWF16		14	12.7	20.6	0.8	1.5	3.0	5.2	R	5	I59	0 42511 05359 5	267700-5000		
New	IWF20		14	12.7	20.6	0.8	1.5	3.0	5.2	R	5	I78	0 42511 05378 6	267700-5010		
	IWF22		14	12.7	20.6	0.8	-0.5	1.5	3.7	R	5	I79	0 42511 05379 3	067700-9410		
	IWF24		14	12.7	20.6	0.8	-0.5	1.5	3.7	R	5	I80	0 42511 05380 9	067700-9420		
	IWF27		14	12.7	20.6	0.8	-0.5	1.5	3.7	R	5	I81	0 42511 05381 6	067700-9430		
	ITV16	Long Reach(Taper Seat)	14	25	16	1.1	1.5	3.0	5.5	RC	5	I38	0 42511 05338 0	267700-3700		
	ITV20	Long Reach(Taper Seat)	14	25	16	1.1	1.5	3.0	5.5	RC	5	I39	0 42511 05339 7	267700-3710		
	ITV22	Long Reach(Taper Seat)	14	25	16	0.8	1.5	3.0	5.2	RC	5	I40	0 42511 05340 3	267700-2500		
	ITV24	Long Reach(Taper Seat)	14	25	16	0.8	-0.5	1.0	3.2	RC	5	I41	0 42511 05341 0	267700-2510		
	ITV27	Long Reach(Taper Seat)	14	25	16	0.8	-0.5	1.0	3.2	RC	5	I42	0 42511 05342 7	267700-2520		
New	ITL16	Longer Insulator Long Reach(Taper Seat)	14	25	16	1.1	1.5	3.0	5.5	RC	5	I49	0 42511 05349 6	267700-4980		
New	ITL20	Longer Insulator Long Reach(Taper Seat)	14	25	16	1.1	1.5	3.0	5.5	RC	5	I50	0 42511 05350 2	267700-4990		
	IT16	TAPER SEAT	14	17.5	16	1.1	1.5	3.0	5.5	RC	5	I25	0 42511 05325 0	267700-0610	0 42511 02325 3	100676-3610
	IT20	TAPER SEAT	14	17.5	16	1.1	1.5	3.0	5.5	RC	5	I26	0 42511 05326 7	267700-0620	0 42511 02326 0	100676-3620
	IT22	TAPER SEAT	14	17.5	16	0.8	1.5	3.0	5.2	RC	5	I27	0 42511 05327 4	267700-0630	0 42511 02327 7	100676-3630
	IT24	TAPER SEAT	14	17.5	16	0.8	-0.5	1.0	3.2	RC	5	I28	0 42511 05328 1	267700-0640	0 42511 02328 4	100676-3640
	IT27	TAPER SEAT	14	17.5	16	0.8	-0.5	1.0	3.2	RC	5	I29	0 42511 05329 8	267700-0650	0 42511 02329 1	100676-3650
	ITF16	TAPER SEAT	14	11.2	16	1.1	1.5	3.0	5.5	RC	5	I30	0 42511 05330 4	267700-0660	0 42511 02330 7	100676-3660
	ITF20	TAPER SEAT	14	11.2	16	1.1	1.5	3.0	5.5	RC	5	I31	0 42511 05331 1	267700-0670	0 42511 02331 4	100676-3670
	ITF22	TAPER SEAT	14	11.2	16	0.8	1.5	3.0	5.2	RC	5	I32	0 42511 05332 8	267700-0680	0 42511 02332 1	100676-3680
	ITF24	TAPER SEAT	14	11.2	16	0.8	-0.5	1.0	3.2	RC	5	I33	0 42511 05333 5	267700-0690	0 42511 02333 8	100676-3690
	ITF27	TAPER SEAT	14	11.2	16	0.8	-0.5	1.0	3.2	RC	5	I34	0 42511 05334 2	267700-0700	0 42511 02334 5	100676-3700
	IXU22		12	19	16	0.9	1.3	2.8	5.0	RC	5	I08	0 42511 05308 3	067700-8721	0 42511 02308 6	100676-3430
	IXU24		12	19	16	0.9	1.3	2.8	5.0	RC	5	I09	0 42511 05309 0	067700-8731	0 42511 02309 3	100676-3440
	IXU27		12	19	16	0.9	1.3	2.8	5.0	RC	5	I37	0 42511 05337 3	067700-8601	0 42511 02337 6	100676-3820
	IX22		12	19	18	0.8	0.6	2.0	4.1	R	5	I71	0 42511 05371 7	067700-9350		
	IX24		12	19	18	0.8	0.6	2.0	4.1	R	5	I72	0 42511 05372 4	067700-9360		
	IX27		12	19	18	0.8	0.6	2.0	4.1	R	5	I73	0 42511 05373 1	067700-9370		

	TYPE	SPEC	DIA. (mm)	REACH (mm)	HEX (mm)	GAP (mm)	PROJECTION (mm)	Spark position (mm)	Ground electrode height (mm)	Terminal shape	RESISTOR (kΩ)	No.	IRIDIUM POWER® ONE PC BOX		IRIDIUM POWER® 2pcs BLISTER PACK	
													BARCODE	DENSO P/N	BARCODE	DENSO P/N
	IX22B		12	19	18	0.9	1.5	2.8	5.0	R	5	I75	0 42511 05375 5	067700-9380		
	IX24B		12	19	18	0.9	1.5	2.8	5.0	R	5	I76	0 42511 05376 2	067700-9390		
	IX27B		12	19	18	0.9	1.5	2.8	5.0	R	5	I77	0 42511 05377 9	067700-9400		
	IXG24	SHROUD	12	22	18	0.7	0.7	2.0	4.1	R	5	I94	0 42511 05394 6	267700-2920		
	IXG27	SHROUD	12	22	18	0.7	0.7	2.0	4.1	R	5	I95	0 42511 05395 3	267700-2930		
New	IU20		10	19	16	0.9	-0.5	0.7	2.6	R	5	I60	0 42511 05360 1	267700-5020		
	IU22		10	19	16	0.9	-0.5	0.7	2.6	R	5	I61	0 42511 05361 8	267700-9260		
	IU24		10	19	16	0.9	-0.5	0.7	2.6	R	5	I62	0 42511 05362 5	267700-9270		
	IU27		10	19	16	0.9	-0.5	0.7	2.6	R	5	I63	0 42511 05363 2	067700-9280		
	IU31		10	19	16	0.9	-0.5	0.7	2.6	R	5	I64	0 42511 05364 9	067700-9290		
	IU24A		10	19	16	0.9	-0.5	1.0	2.9	R	5	I65	0 42511 05365 6	067700-9300		
	IU27A		10	19	16	0.9	-0.5	1.0	2.9	R	5	I66	0 42511 05366 3	067700-9310		
	IU31A		10	19	16	0.9	-0.5	1.0	2.9	R	5	I67	0 42511 05367 0	067700-9320		
	IUH24	HALF THREAD	10	19	16	0.9	0.6	2.0	3.9	R	5	I68	0 42511 05368 7	067700-9330		
	IUH27	HALF THREAD	10	19	16	0.9	0.6	2.0	3.9	R	5	I69	0 42511 05369 4	067700-9340		
	IUF22		10	12.7	16	0.8	0.6	2.0	3.8	R	5	I83	0 42511 05383 0	067700-9480		
	IUF24		10	12.7	16	0.8	0.6	2.0	3.8	R	5	I84	0 42511 05384 7	067700-9490		
	IUF27A		10	12.7	16	0.9	-0.5	1.0	2.9	R	5	I85	0 42511 05385 4	067700-9700		
	IUF31A		10	12.7	16	0.9	-0.5	1.0	2.9	R	5	I86	0 42511 05386 1	067700-9710		
	IY24	HALF THREAD	8	19	13	0.7	0.6	1.4	2.9	R	5	I100	0 42511 05400 4	267700-4490		
	IY27	HALF THREAD	8	19	13	0.7	0.6	1.4	2.9	R	5	I101	0 42511 05401 1	267700-4500		
	IY31	HALF THREAD	8	19	13	0.7	-0.5	0.5	2.0	R	5	I102	0 42511 05402 8	267700-4510		

φ0.4mm IRIDIUM PLUG(OEM TYPE)

	TYPE	SPEC	DIA. (mm)	REACH (mm)	HEX (mm)	GAP (mm)	PROJECTION (mm)	Spark position (mm)	Ground electrode height (mm)	Terminal shape	RESISTOR (kΩ)	No.	IRIDIUM ONE PC BOX		IRIDIUM 2pcs BLISTER PACK	
													BARCODE	DENSO P/N	BARCODE	DENSO P/N
	IK24C11	ISO	14	19	16	1.1	1.5	3.0	5.7	S	5	I35	0 42511 05335 9	067700-9550		
	IK27C11	ISO	14	19	16	1.1	0.5	2.0	4.7	S	5	I36	0 42511 05336 6	067700-9520		
	VK16PR-Z11	Ground Elec. Pt.&TAPERCUT	14	19	16	1.1	1.5	3.0	5.7	S	5	V28	0 42511 05628 2	267700-1840		
	VK20PR-Z11	Ground Elec. Pt.&TAPERCUT	14	19	16	1.1	1.5	3.0	5.7	S	5	V15	0 42511 05615 2	267700-1850		
	VK22PR-Z11	Ground Elec. Pt.&TAPERCUT	14	19	16	1.1	1.5	3.0	5.7	S	5	V29	0 42511 05629 9	267700-1860		
	VK24PR-Z11	Ground Elec. Pt.&TAPERCUT	14	19	16	1.1	1.5	3.0	5.7	S	5	V16	0 42511 05616 9	267700-1870		
	VK27PR-Z11	Ground Elec. Pt.&TAPERCUT	14	19	16	1.1	0.5	2.0	4.7	S	5	V30	0 42511 05630 5	267700-2050		
	VKJ20RZ-M11	Ground Elec. Pt.&TAPERCUT	14	19	16	1.1	3.0	5.0	7.7	S	5	V33	0 42511 05633 6	267700-1970		
	SVK20RZ8	Ground Elec. Pt.&TAPERCUT	14	19	16	0.8	1.5	3.5	5.7	S	5		-	067700-9740		
	SVK20RZ11	Ground Elec. Pt.&TAPERCUT	14	19	16	1.1	1.5	3.5	6.0	S	5		-	067700-8620		
	VW16R-A13	Ground Elec. Pt.&TAPERCUT	14	19	20.6	1.3	2.5	4.0	6.9	S	5		-	267700-1640		
	VX20BC	Ground Elec. Pt.	12	19	18	0.9	1.5	2.8	5.0	T	5	V34	0 42511 05634 3	067700-9830		
	VX22BC	Ground Elec. Pt.	12	19	18	0.9	1.5	2.8	5.0	T	5	V14	0 42511 05614 5	067700-9720		
	IXU22C・	No U-Groove	12	19	16	0.8	1.3	2.8	4.9	S	5		-	267700-5170		
	IU27D		10	19	16	0.9	0.5	1.8	3.8	T	5	I90	0 42511 05390 8	267700-0850		
	IUH24D	HALF THREAD	10	19	16	0.9	0.6	2.0	4.0	R	5	I87	0 42511 05387 8	067700-9560		
	IUH27D	HALF THREAD	10	19	16	0.9	0.6	2.0	4.0	R	5	I88	0 42511 05388 5	067700-9570		
	VUH24D	HALF THREAD,Ground Elec. Pt.&TAPERCUT	10	19	16	0.9	0.6	2.0	4.0	T	5	V26	0 42511 05626 8	267700-2010		
	VUH27D	HALF THREAD,Ground Elec. Pt.&TAPERCUT	10	19	16	0.9	0.6	2.0	4.0	T	5	V27	0 42511 05627 5	267700-1931		
New	VUH27ES	HALF THREAD,Ground Elec. Pt.&TAPERCUT,SUS GASKET	10	19	16	0.9	0.6	2.0	4.0	T	5		-	267700-4770		
	VNH24Z	HALF THREAD,Ground Elec. Pt.&TAPERCUT	10	19	16	0.9	0.6	2.0	4.0	S	5	V32	0 42511 05632 9	267700-2060		
	VNH27Z	HALF THREAD,Ground Elec. Pt.&TAPERCUT	10	19	16	0.9	0.6	2.0	4.0	S	5	V31	0 42511 05631 2	267700-2070		
	IUF14-UB		10	12.7	16	0.7	0.6	1.6	3.3	S	5	I89	0 42511 05389 2	267700-0540		

New ……Anything shown with this is a product that is "On Sale in 2004～2005"
Spark gap ……For example, for a 1.1mm gap, it is set at the range between 1.0 and 1.1mm.
Insulator projection ……This is the distance from the end of the housing to the end of the insulator. The + direction is the direction of the piston.
Spark position ……This is the distance from the end of the housing to the tip of the center electrode. The + direction is the direction of the piston.
Ground electrode height …This is the distance from the end of the housing to the tip of the ground electrode. The + direction is the direction of the piston.
Terminal shape ……S；Solid R；Removable RC；Crimped T；Threaded

DENSO Spark Plugs Package Lineup

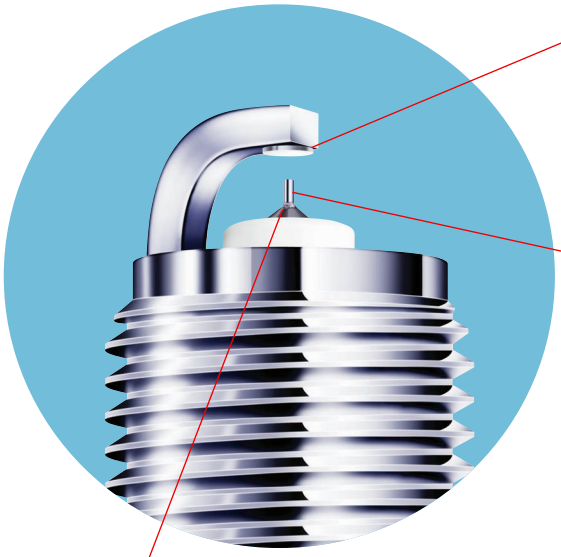
TYPE \ MARKET	Japan	Asia/Europe	USA
IRIDIUM POWER®			
IRIDIUM TOUGH®			
IRIDIUM PLUS®			
IRIDIUM RACING®			
PLATINUM			
IRIDIUM			
General		   	 

Question 1

What type of spark plug is the IRIDIUM TOUGH® ?

Answer 1

This new plug from DENSO uses the world's smallest center electrode*1, a ultra-fine 0.4mm dia. iridium alloy electrode that provides high performance. In addition, the plug has a platinum on the ground electrode, ensuring the long life of a platinum plug.



■Platinum ground electrode

Platinum taken from proven platinum plug technology has been added to the ground electrode. The long life of a platinum plug is assured by greatly reducing electrode wear.

■Ultra-fine 0.4mm dia. iridium electrode

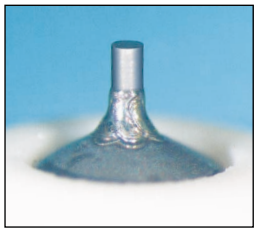
Use of a "iridium alloy" that has a high melting point has enabled miniaturization of the center electrode. Required voltage has been lowered and ignitability improved.

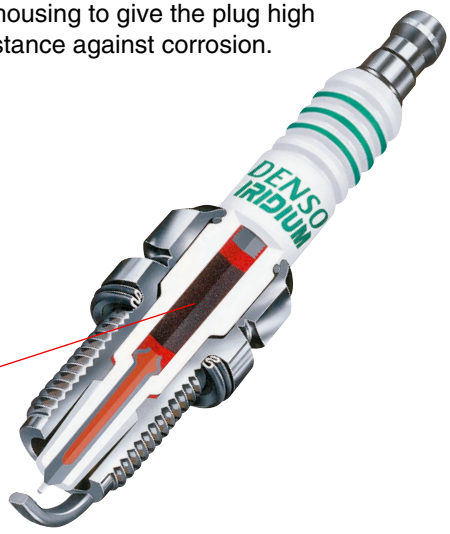
■Highly corrosion-resistant bright nickel plating

Bright nickel plating, as used in racing car spark plugs, is used in the housing to give the plug high resistance against corrosion.

■360° laser welding

The union of the iridium is made highly reliable by "360° laser welding", preventing failure in even the severe conditions.





■Built-in high reliability resistor

The resistor specification is similar to all types. However, a high reliability monolithic resistor is built in. This shuts out noise to all other electrical equipment.

*1: As of Aug. 2005, this excludes flush type electrodes that do not protrude from the insulator.

Question 2

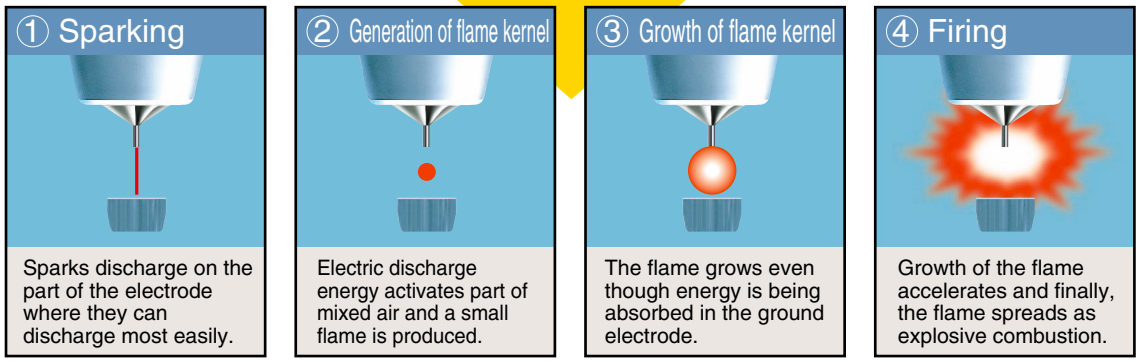
What makes the ignitability of IRIDIUM TOUGH® so good?

Answer 2

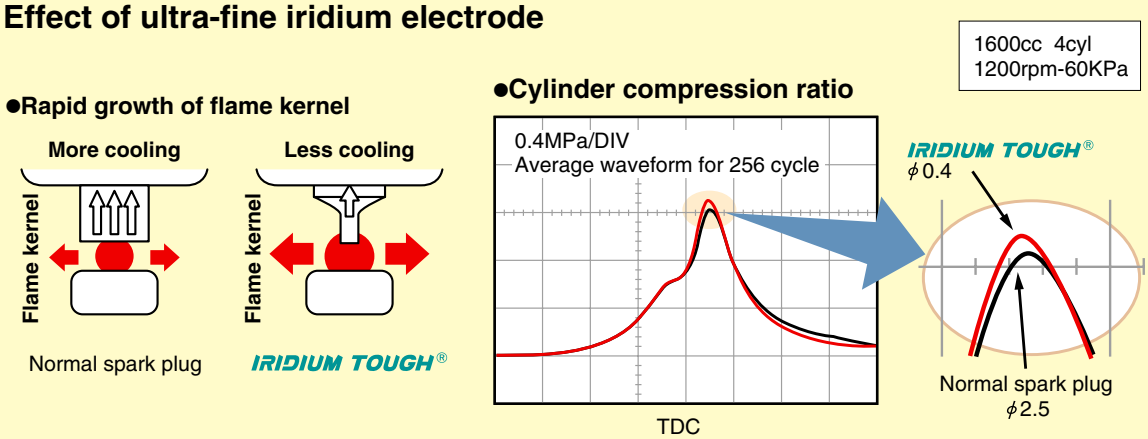
The quenching effect of the plug is reduced by using the ultra-fine 0.4mm dia. center electrode.

The electrode also has a quenching (cooling) effect (effect where the electrode takes away the heat of the spark as soon as firing occurs). Therefore, in a thick electrode the cooling effect is large and sometimes firing does not occur as shown in Figure 4. The characteristics of this firing is called **ignitability**. To improve **ignitability**, the contact area between the electrode and the flame kernel needs to be made reduced in size. Accordingly, the electrode was made as fine as possible in the IRIDIUM TOUGH® to improve **ignitability**.

Pattern from sparking to firing



Effect of ultra-fine iridium electrode



Question 3

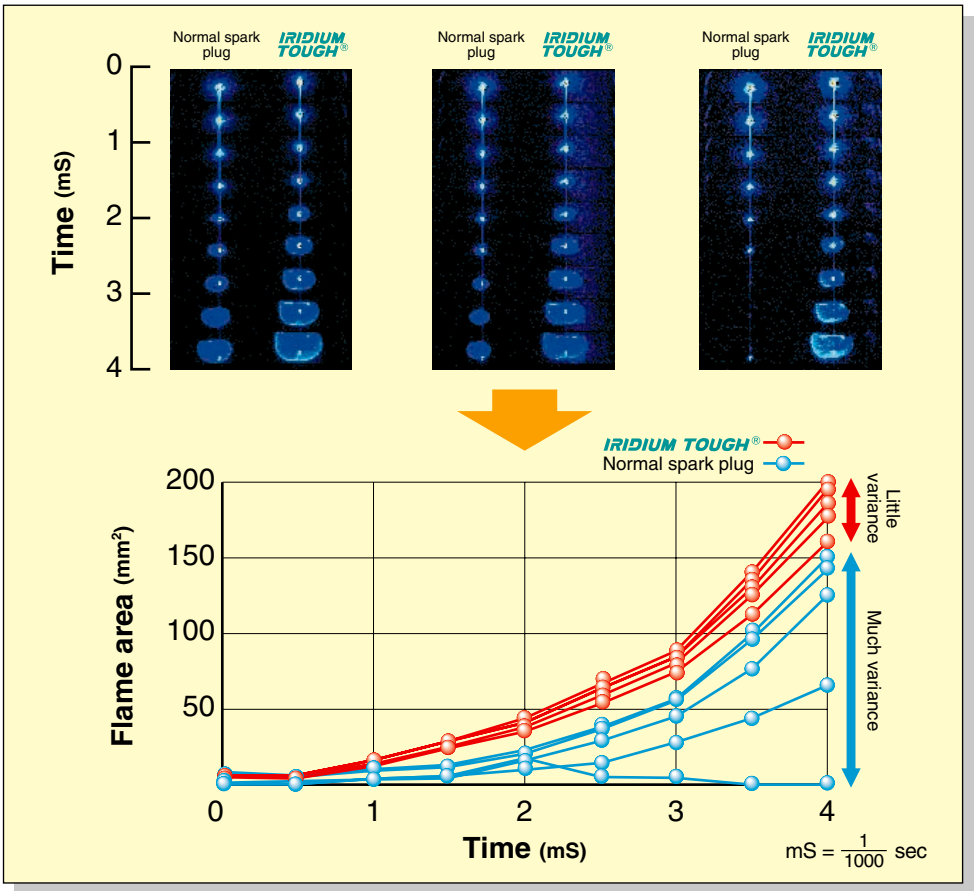
How does the superior ignitability of IRIDIUM TOUGH® influence combustion?

Answer 3

The flame is rapidly spread for quick combustion in comparison to a normal spark plug.

By decreasing the cooling effect of the center electrode has on the growth of the flame kernel, IRIDIUM TOUGH® forms a stronger flame kernel for ensuring ignition.
The result is faster spread of combustion, more stability and improved engine performance in comparison to normal spark plugs.

A combustion chamber observation device has been used to show in the photographs below the spread of combustion for IRIDIUM TOUGH® and a normal spark plug.



Clearly the result is a much faster spread of combustion with IRIDIUM TOUGH®.
With IRIDIUM TOUGH®, combustion has spread throughout nearly the entire combustion chamber within 4/1000 seconds of discharge. The normal spark plug has only spread half as much in that time. The regular plug also fails to spread the flame in some occurrences. The same combustion results occur in an actual engine, becoming a good reason to choose the high performance of 0.4mm iridium center electrode plugs.

Question 4

How is the iridium tip of the IRIDIUM TOUGH® welded to the electrode?

Answer 4

We use 360° laser welding to ensure a highly reliable joining.

The 0.4mm iridium tip that generates the high performance of the IRIDIUM TOUGH® is an alloy with a very high melting point. Therefore, ordinary resistance welding cannot be used because the iridium does not melt enough and an adequate weld strength cannot be guaranteed.

"360° laser welding", which employs a high-energy laser, is used in the IRIDIUM TOUGH® to melt and weld all around welding points.

Because all area to be welded is completely melted, the welding point is extremely reliable, thus ensuring stable and quality response without changes in the electrode, even under heavy driving conditions.

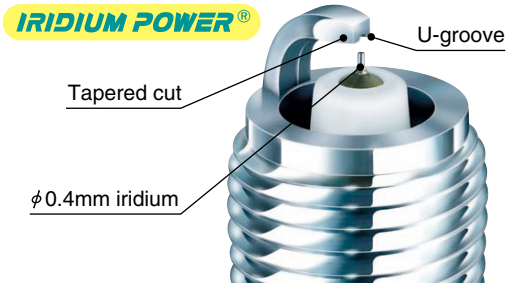
Question 5

What is the difference between IRIDIUM POWER® and IRIDIUM TOUGH®?

Answer 5

The IRIDIUM POWER®, with its 0.4mm iridium center electrode and U-groove + tapered cut ground electrode, is a high performance plug providing ultimate running results. The IRIDIUM TOUGH®, with its 0.4mm iridium center electrode and platinum ground electrode, is a high performance plug with an emphasis on longer life.

The ground electrode of the IRIDIUM POWER® has a tapered cut and a U-shaped groove on its underside, reducing the quenching effect during flame formation and providing exceptional ignitability.
The ground electrode of the IRIDIUM TOUGH® has a platinum at the discharge point, suppressing electrode wear at discharge and providing the working life of a platinum plug.



Question 6

What patented technologies are used with IRIDIUM TOUGH®?

Answer 6

The 0.4mm ultra-fine iridium center electrode used in IRIDIUM TOUGH® is original technology from DENSO covered by the following patents.

■Material composition of iridium

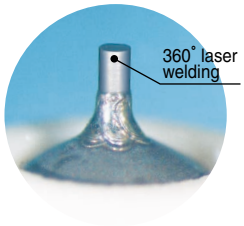
By adding a small amount of rhodium to the primary iridium material, resistance to oxidation is increased and corrosion in the high temperature combustion environment is suppressed. Japan Patent 2877035, UK Patent 2302367, US Patents 6094000, 6262522, People's Republic of China Patent 961022841, Republic of Korea Patent 0292083.

■Manufacture of iridium

Rather than using the usual sintering method, a melting method enables manufacture in any shape and dimension. Japan Patent 3000955, US Patent 5977695.

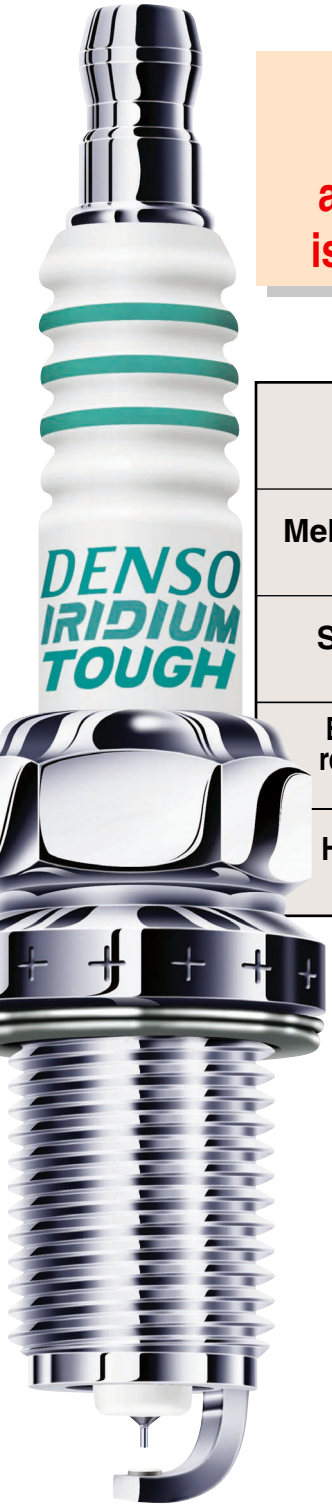
■Welding of iridium

"360° laser welding" melts the entire circumference of the part with a high energy laser to maintain a fit state even under harsh running conditions.
Japan Patent 2921524,
US Patent 6078129.



Question 7

What type of material is used to produce the electrode employed for IRIDIUM TOUGH®?



Answer 7

A precious metal similar to platinum, iridium, a member of the platinum group with the atomic number 77, is extremely strong and has an unusually high melting point.

	Iridium (Ir)	Platinum (Pt)	Nickel (Ni)	Gold (Au)	Silver (Ag)
Melting point (℃)	2454	1769	1453	1063	960
Strength (kgf/mm²)	112	14	68	13	13
Electrical resistance (μΩ•cm)	5.3	10.6	6.8	2.3	1.6
Hardness (HV, 20℃)	240	40	160	25	26

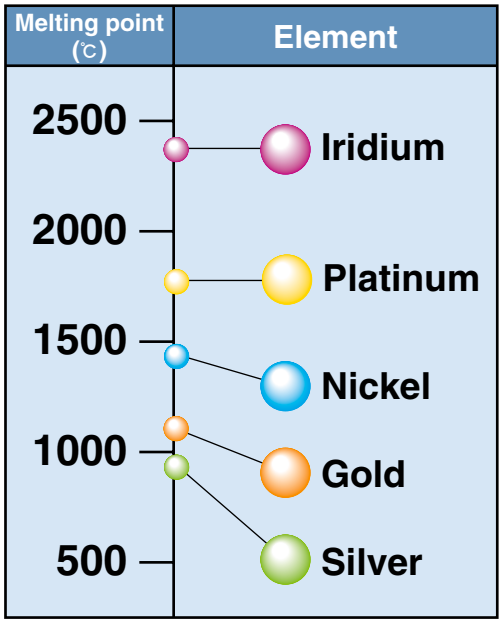
Melting point The melting point of iridium is approximately 680℃ higher than that of platinum and is difficult to melt even in the high temperatures produced by electrical discharges and combustion.

Strength Iridium has high material strength compared to other materials and provides stable performance under heavier driving conditions.

Electrical resistance Because the electrical resistance is lower than platinum and the base material of electrodes, nickel, iridium is suitable for use in spark plug electrodes.

Hardness Iridium is harder than other materials and has great material strength.

Melting points of various metals



Question 8

Why can iridium now be used in IRIDIUM TOUGH® electrodes?

Answer 8

DENSO is now able to use iridium because of our technology in the field of precious metals, for which we are a world-leader and also because of our advanced laser welding technology.

As explained in the answer to *Question 6*, iridium is an extremely hard material.
In the past, sintering material was generally cut and this meant **high costs** and **restrictions on processing form and dimensions**.
Therefore, it could not be used as a material in spark plugs. However, our new precious metals technology has meant that we can now process **iridium by drawing** it in its melted form. This enables iridium to be processed in all dimensions and forms. Therefore, DENSO has moved quickly to use it as a material for use in spark plug electrodes.

Question 9

In what other fields is iridium commonly used for?

Answer 9

Because of its high melting point and superb corrosion resistance, iridium is used widely in fields employing state-of-the-art technology such as the aerospace, medical, and motor vehicle industries.

- Components in aerospace industry
- Electrodes for equipment used in clinical medicine such as pacemakers and catheters
- Metal pots for growing crystals for electronic industries
- Automobile catalyzers
- Jewelry

Question 10

Is the tip in the IRIDIUM TOUGH® made of pure iridium?

Answer 10

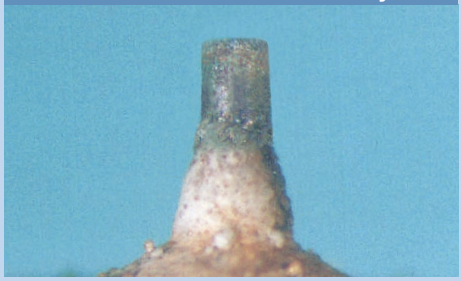
We use a new iridium alloy developed at DENSO.

Iridium is characterized by a higher melting point than either nickel or platinum. Therefore, it wears very well when subject to electrical discharge. However, at high temperatures it oxidizes a little too much and so we are unable to use pure iridium for spark plug electrodes.

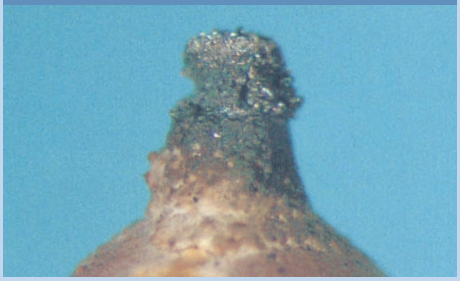
Melting point(℃)	Element	Oxidation resistance
3410	Tungsten (W)	Bad
2610	Molybdenum (Mo)	Bad
2454	Iridium (Ir)	Good
1769	Platinum (Pt)	Better
1453	Nickel (Nl)	Good
1063	Gold (Au)	Better
960	Silver (Ag)	Better

DENSO studied many additives with a view to improving the corrosion resistance of iridium and has now developed a new iridium alloy (the alloy of iridium and rhodium) highly suitable for use in spark plug electrodes. Patents for this iridium alloy have been secured in Japan, the United Kingdom, the United States, People's Republic of China and Republic of Korea. (Japan Patents 2877035, 3000955, 2921524. UK Patent 2302367. US Patents 6094000, 6262522, 5977695, 6078129. People's Republic of China Patent 961022841. Republic of Korea Patent 0292083.) The following photographs compare the durability of the new iridium alloy and pure iridium when used in an engine under the same conditions.

New DENSO iridium alloy



Pure iridium



Test engine: 90 cc 4-cycle 1-cylinder Test conditions: Full×9000rpm×30h

Part of the pure iridium material was shed and corroded. The new DENSO iridium alloy showed no corrosion on the electrode and mainfained good condition.

Question 11

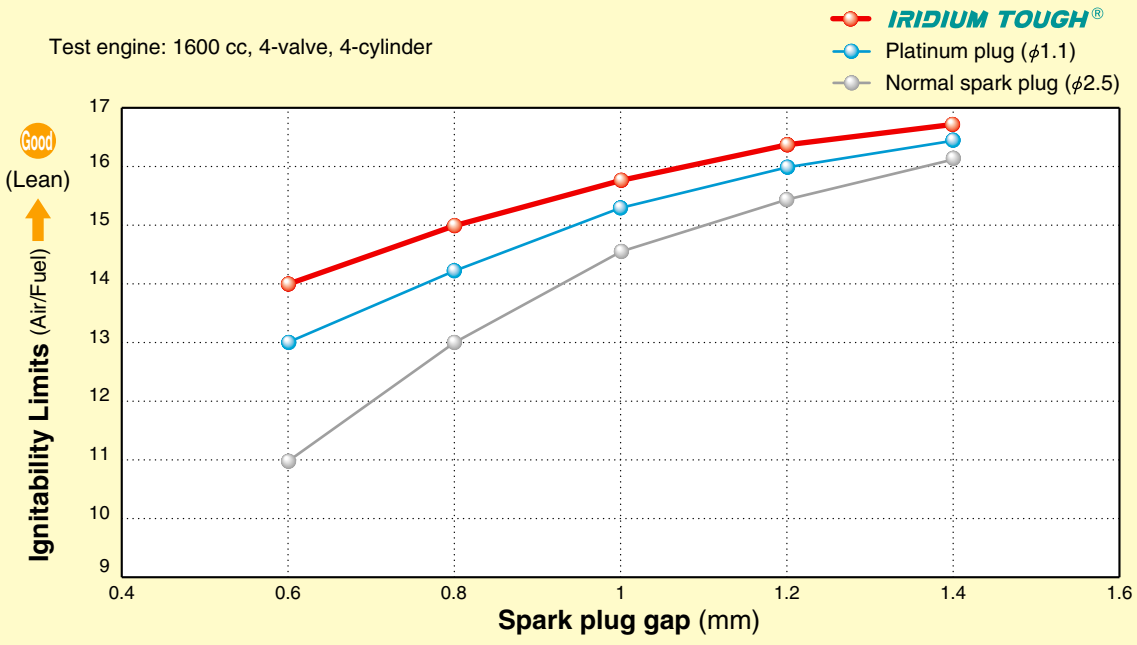
Tell me about the ignitability of the IRIDIUM TOUGH®.

Answer 11

Use of a ultra-fine 0.4mm dia. iridium center electrode has enabled us to achieve previously unparalleled ignitability in the IRIDIUM TOUGH®.

Ordinarily, the leaner the air mix the more difficult the ignition.
The greater the ignitability limits, that is the leaner the air mix in which a plug can spark, the better ignitability a plug is said to have.

The following graph shows some examples of ignitability limits for various spark plugs.



With spark gap set to 0.8mm, the air-fuel mixture ignitability limit for IRIDIUM TOUGH® is 2.0 points higher than a normal spark plug. This high ignitability improves idling stability and acceleration performance through correct firing even under running conditions that easily cause poor igniting performance at idling or acceleration.

Question 12

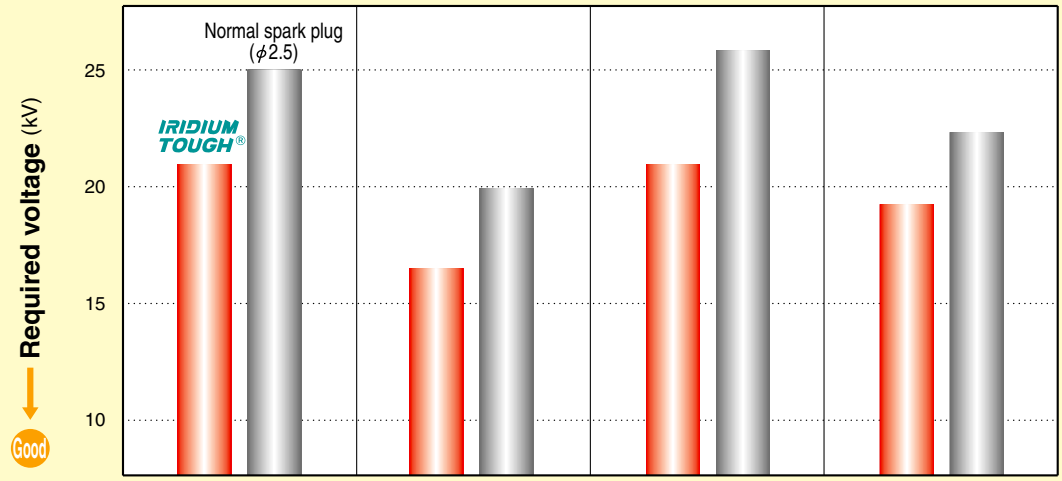
Tell me about the required voltage in the IRIDIUM TOUGH®.

Answer 12

The ultra-fine 0.4mm center electrode lowers the required voltage by several kV.

Recently, there has been a trend to increase the compression ratio to increase output in engines. This means that the required voltage of spark plugs tends to increase and high compression is required in highly tuned engines. When this occurs, the required voltage increases and, in the worst case, sparking ceases while the engine is running. Minimization of the electrode diameter is an effective way of avoiding this.
In the IRIDIUM TOUGH®, the center electrode has a diameter of 0.4mm. Because required voltage is kept low, this enables the IRIDIUM TOUGH® to be used in high performance engines and for high response driving.

The following graph gives examples of required voltage measurements for IRIDIUM TOUGH® and normal spark plugs.



The required voltage is reduced by 3~5kV for IRIDIUM TOUGH® as compared to normal spark plugs.

Question 13

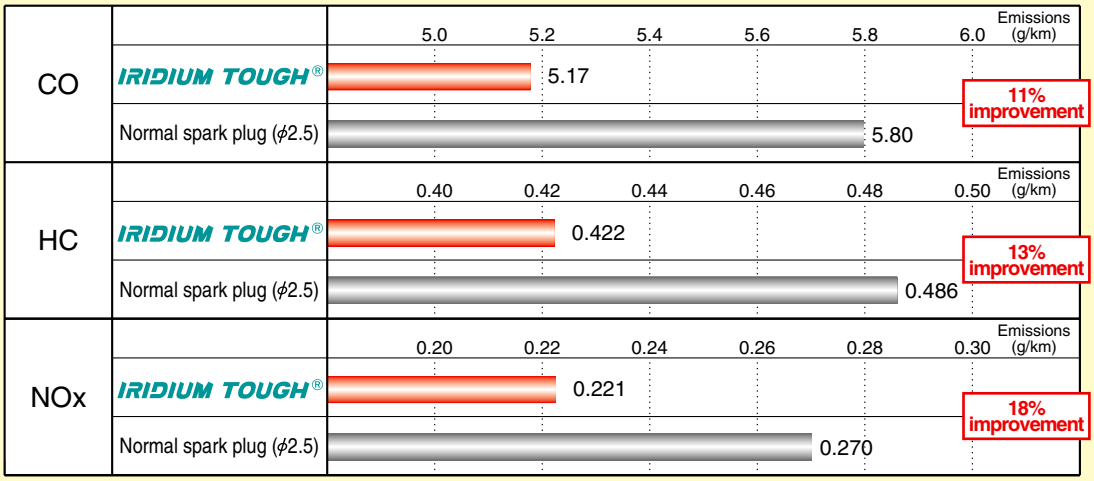
What happens at emission when an IRIDIUM TOUGH® is used?

Answer 13

Emissions become cleaner because the combustion conditions are made stable.

Installing IRIDIUM TOUGH® plugs eliminates misfires and misspark in all running conditions, resulting in greatly improved combustion.
This in turn makes emissions much cleaner.

Vehicle: 2000cc 4cyl 4-cycle
Operating condition: 11 modes



Question 14

What happens to fuel consumption when IRIDIUM TOUGH® is used?

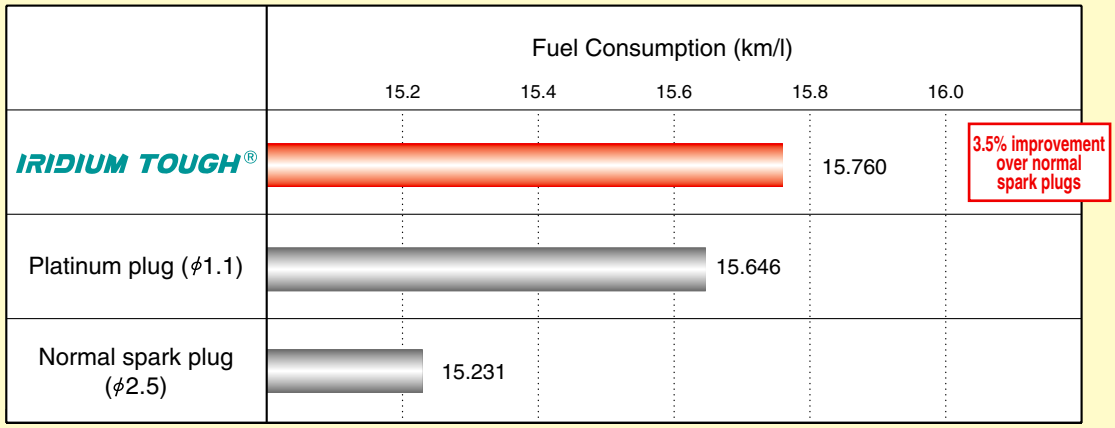
Answer 14

In many cases, fuel consumption is improved.

When IRIDIUM TOUGH® plugs are installed, combustion dramatically improves because misfires and misspark are eliminated for all running conditions. This improves fuel consumption since favorable engine performance is maintained even when minimum required fuel is being used.

The following plug performance is an example of improved fuel consumption at fixed 60km/h running.

Vehicle: 2000cc 4cyl 4-cycle



Question 15

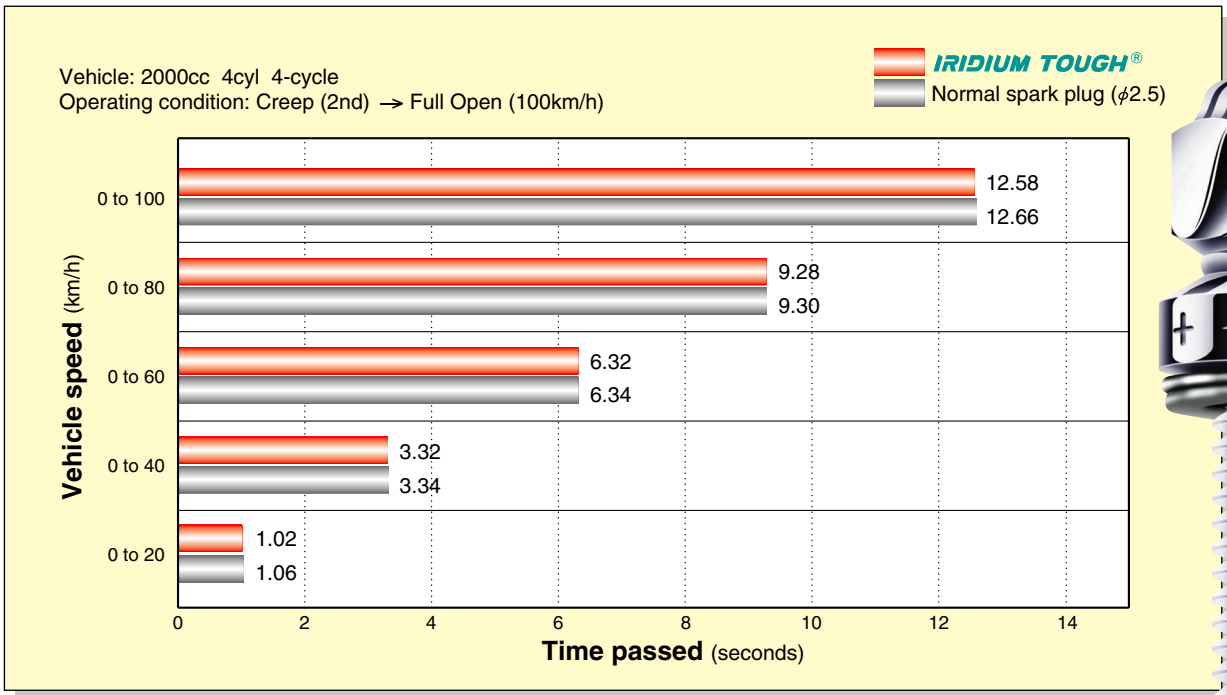
Does engine performance improve when IRIDIUM TOUGH® is used?

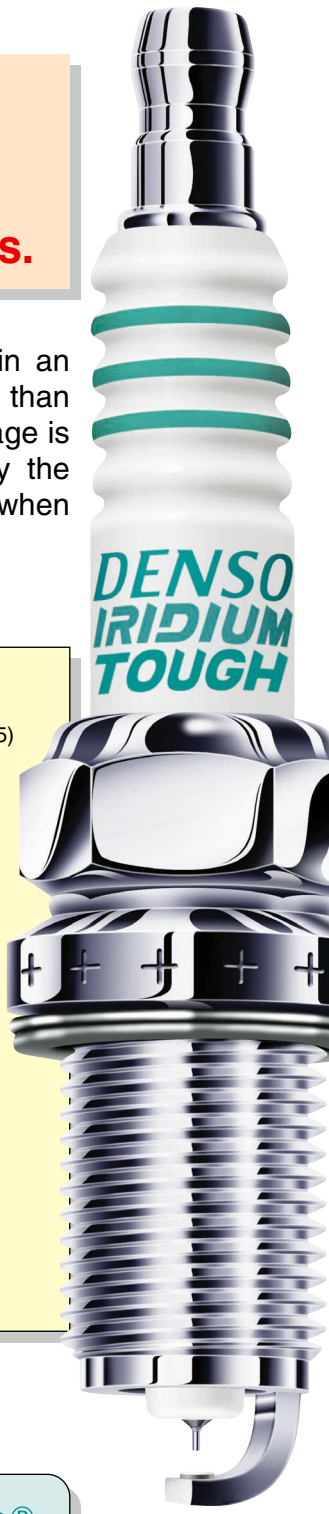
Answer 15

IRIDIUM TOUGH® enhances the performance of an engine. Acceleration is improved when compared against normal spark plugs.

The 0.4mm iridium center electrode and the specially shaped ground electrode in an IRIDIUM TOUGH® enable a superior ignitability and a lower required voltage than any seen in the past. Accordingly, there is less misfire in areas where required voltage is high, and less misfiring in areas where firing is difficult. No matter how heavy the conditions, high response driving is enabled. As a result, acceleration is better than when normal spark plugs are used.

The following graph is an example of an acceleration test.





There was a difference of 0.08 seconds between IRIDIUM TOUGH® and normal spark plugs in the time taken to reach 100km/h.

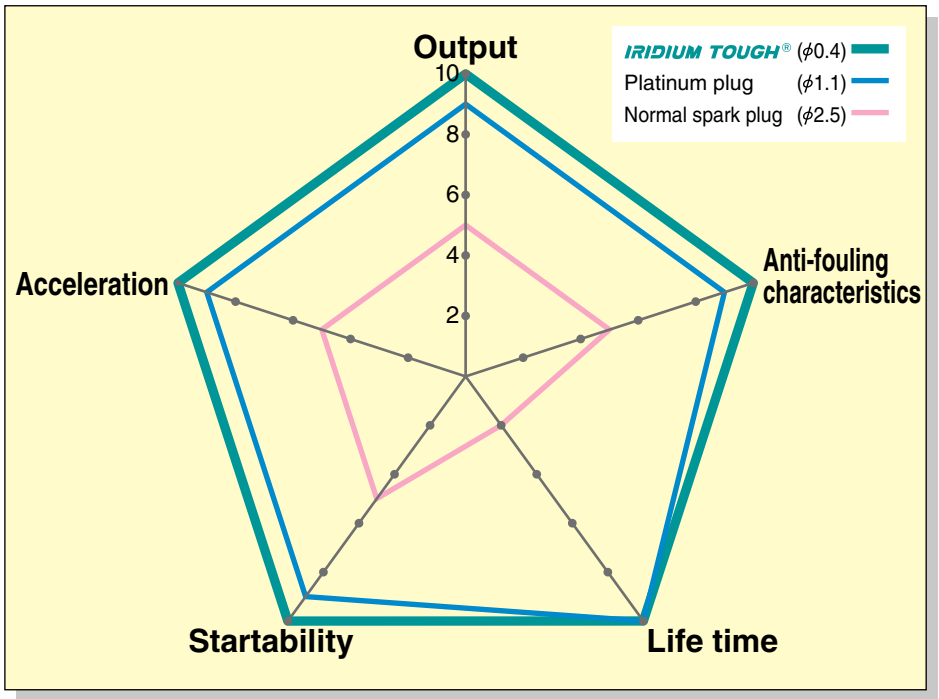
Question 16

How does the IRIDIUM TOUGH® compare to the ϕ0.6mm iridium plugs, platinum plugs and normal spark plugs?

Answer 16

The IRIDIUM TOUGH® provides better performance than ϕ0.6mm iridium plugs, platinum plugs and normal spark plugs.

IRIDIUM TOUGH® combines an excellent balance of output, stain resistance, work life, starting power and acceleration.



DENSO Data Comparison
Performance of other plugs as measured against IRIDIUM TOUGH® with value of 10.

Question 17

Can spark plugs of other brand-names be substituted with IRIDIUM TOUGH® ?

Answer 17

Our spark plugs are compatible with almost all spark plugs manufactured by other companies.

IRIDIUM TOUGH® can replace almost all spark plugs fitted as standard in Japanese and foreign cars. Check for the spark plug you are using in the following table and select the IRIDIUM TOUGH® that corresponds to it.
IRIDIUM TOUGH® are also compatible not only with standard spark plugs but also with high performance and racing spark plugs and can also be used in engines where the required heat range is high, such as in highly tuned engines.

If the spark plug you are using is not in this table, select an IRIDIUM TOUGH® to suit your car from the following table which lists spark plugs by vehicle type.

IRIDIUM TOUGH® Comparative spark plug table

IRIDIUM TOUGH®	IRIDIUM POWER®	DENSO	NGK
VK□□	IK□□	K□□PR, K□□R-U, KJ□□C, K□□TR, PK□□, PKJ□□, SK□□, SKJ□□	BKR□, ZFR□, PFR□, IRIWAY□, PZFR□, IFR□, IZFR□
VQ□□	IQ□□	Q□□PR, Q□□R-U, PQ□□, QJ□□	BCPR□, ZFR□A, IRITOP□
VW□□	IW□□	W□□E, P□□, S□□	BPR□E, IGR□, GR□
VXU□□	IXU□□	XU□□EP-U, XU□□EPR-U	DCPR□E, DCP□E, IRIMAC□, KR□AI/BI, PKR/IKR□A
VK20Y	——	K20PR-U, PK20PR-P8	BKR6E, PFR6B
VK□G	IK□G	SK22PR-M11S, PK22PR-L11S, SK20PR-L9S, K20PR-U9S	IFR7G11KS, PFR7G11S
VKA□□	——	SK□□BGR, PK□□GR	BKR□EKUC/D, ZFR□D/E/G, BKR□EP8
VKB□□	——	SK□□BR	IZFR□B/C, PZFR□B/C
VKH□□	IKH□□	K□□HPR-U, K□□HR-U, SK□□HR	ILZFR□, ILFR□, PLFR□, LFR□
VT□□	IT□□	T□□EP-U, T□□EPR-U, PT□□EPR	BPR□EFS, ITR□□, PTR□, TR□

For normal engines, select a spark plug with the same heat range as a standard spark plug. For highly tuned engines, select one with the heat range that suits the tuning level.

Question 18

Does the engine need to be specially set when fitting IRIDIUM TOUGH® ?

Answer 18

No. The plugs can just replace the ones you take out.

The IRIDIUM TOUGH® itself has a low required voltage and high ignitability and is able to draw out the power of an engine.
The superb performance of IRIDIUM TOUGH® is obtained merely by installing them in your vehicle. And, of course, there is no need for special tuning.

Question 19

How do I select the correct heat-range when fitting IRIDIUM TOUGH® to my vehicle?

Answer 19

In ordinary cars, use a spark plug with the same heat range as a normal spark plug. In highly tuned vehicles, select a heat range to suit the tuning level of the engine.
(Ordinarily, the heat range of a highly tuned engine tends to be colder.)

Refer to the following table to compare the heat range of the IRIDIUM TOUGH® and other spark plugs.

DENSO	16	20	22	24	27	29	31	32	34	35
NGK	5	6	7	8	9	9.5	10	10.5	11	11.5
CHAMPION	12, 11	10, 9	8, 7	6, 63, 61	4, 59	57	55	53		
BOSCH	8	7, 6	5	4	3		2			

Question 20

How does the IRIDIUM TOUGH® compare to iridium plugs from other makers?

Answer 20

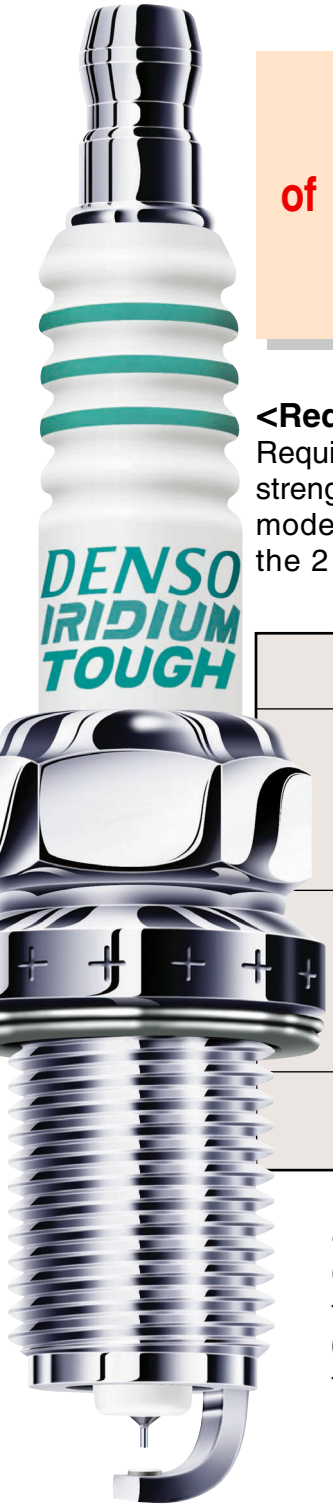
With its 0.4mm dia. iridium center electrode, the world's smallest, IRIDIUM TOUGH® offers better acceleration and starting than any plugs. The addition of the platinum on the ground electrode results in high performance and long life not seen in the product lines.

Manufacturer	Spark plug	Center electrode diameter (mm)	Center electrode material	Ground electrode specifications
DENSO	High performance+Long life IRIDIUM TOUGH® ('00.6~)	φ0.4	Iridium alloy (Rhodium added)	Platinum attached No tapered cut
	Ultra-high performance IRIDIUM POWER® ('98.5~)	φ0.4	Iridium alloy (Rhodium added)	Tapered cut U-groove
NGK	High performance Iriseries※ ('97.4~)	φ0.6	Iridium sintering material (Yttria added)	Tapered cut
	High performance Iridium IX※ ('00.4~)	φ0.6	Iridium sintering material (Yttria added)	Tapered cut
	Iridium MAX※	φ0.6	Iridium sintering material (Yttria added)	Platinum attached No tapered cut

※ DENSO research July 2003

Question 21

Can IRIDIUM TOUGH® be used to replace plugs with 2, 3 or 4 ground electrodes?

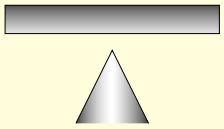
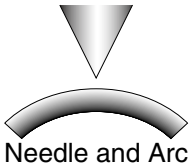


Answer 21

Yes. The reason is that the 0.4mm center electrode of IRIDIUM TOUGH® lowers the required voltage compared to 2, 3 and 4 electrode plugs and provides superior ignitability.

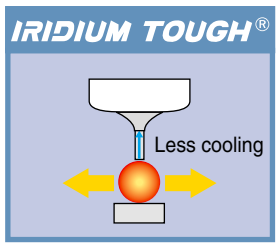
<Required voltage>

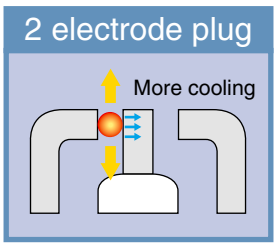
Required voltage decreases as the electrode gets thinner because the electric field strength affecting required voltage becomes stronger. As shown in the following diagram modeling each electrode shape, IRIDIUM TOUGH® requires less voltage than the 2 electrode plug.

		IRIDIUM TOUGH®	2 electrode plug	Normal spark plug
Plug				
Electrode model	Ground electrode			
	Center electrode			
		Plate and Needle	Needle and Arc	Plate and Plate
Required voltage		Lower → Higher		

<Ignitability>

Cooling effect from the electrode decreases and ignitability increases to the extent that the contact area between the flame kernel and electrodes is smaller. Due to its 0.4mm center electrode, IRIDIUM TOUGH® has less contact area between the flame kernel and electrodes and better ignitability than 2 electrode plugs.





Question 22

Is there anything I need to be aware of when fitting IRIDIUM TOUGH® ?

Answer 22

As with normal spark plugs, install IRIDIUM TOUGH® using the correct procedure and appropriate torque.

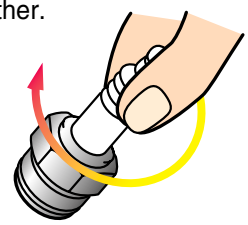
Recommended Torque and Tightening Angle for DENSO plugs.

❶ Use the correct wrench for the hex on the plug, and be careful not to damage the insulator.

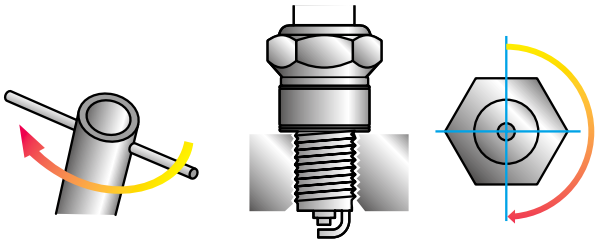
❷ When changing, make sure that the oil, etc. on the outside of the plug does not enter the engine interior.

❸ When putting the plugs in, clean the engine side of the flange, and put in the plugs after making sure the gasket is in the flange.

❹ Make sure the plugs are vertical, and tighten them by hand until they cannot be tightened any further.



❺ Then, use a plug wrench to tighten them accurately to the torque or rotation angle showed in the chart below.



⚠ If a thread lubricant such as grease is coated on the thread, tightening to the recommended torque is tightening too much; this has been linked to seal leakage.
Do not use a thread lubricant.

⚠ Tightening more than the tightening angles and torques shown on the right could result in damage to the engine and furthermore could result in the plug coming off at the thread.

Thread Size	Applicable Models	Recommended Torque	Recommended Tightening Angle	
			New Plug	Previously Used
M8	All Types	8-10N・m	About 1 turn	About 1/12 turn
M10	Types other than the ones shown below	10-15N・m	About 1/3 turn	About 1/12 turn
M10	UFE, IUH, VUH, VNH Types	10-15N・m	About 2/3 turn	About 1/12 turn
M10	Stainless Gasket Type (※1)	10-15N・m	About 3/4 turn	About 1/12 turn
M12	All Types	15-20N・m	About 1/3 turn	About 1/12 turn
M14	Types other than the ones shown below	20-30N・m	About 1/2 turn	About 1/12 turn
M14	Stainless Gasket Type (※2)	20-30N・m	About 2/3 turn	About 1/12 turn
M18	All Types	30-40N・m	About 1/4 turn	About 1/12 turn
M14 Taper seat	All Types	20-30N・m	About 1/16 turn	About 1/16 turn

(※1) IUH27ES, U24FER9S (※2) PK22PR-L11S, SK22PR-M11S, IK16G, IK20G, IK22G, VK16G, VK20G, VK22G, K20PR-U9S, SK20PR-L9S SKJ20DR-M11S, KJ20DR-M11S, K20PR-L11S

Question 23

Can the IRIDIUM TOUGH® gap be adjusted? Can I use any spark plug cleaners with the IRIDIUM TOUGH® ?

Answer 23

Do not adjust the spark plug gap.
Use of a spark plug cleaner for short periods is acceptable if low pressure is used.

IRIDIUM TOUGH® use a ultra-fine 0.4mm iridium center electrode and the spark gap is already set at the optimum distance. If the electrode is damaged by gap adjustment or cleaning, the spark plugs will not perform to their best.

Question 24

What plugs are in the IRIDIUM TOUGH® lineup?

Answer 24

VQ series
VQ16 • VQ20 • VQ22

- Used primarily for cars
- JIS type small plug
- Installation screw ø14xL19
- 0.8mm gap VQ22 can be used for tune-ups

VK series
VK16 • VK20 • VK22
VK16G • VK20G
VK22G • VK20Y

- Used primarily for cars
- ISO type small plug
- Installation screw ø14xL19
- Stainless gasket (VK16G~VK22G)

VKA series
VKA16 • VKA20

- Compatible with SK16/20BGR11/PK20GR8
- Shroud type
- 22mm thread length
- For Toyota D4
- For Mitsubishi GDI

VKB series
VKB16 • VKB20

- Compatible with SK16/20BR11
- 19mm thread length
- For Toyota D4
- For Mitsubishi GDI

VKH series
VKH16 • VKH20 • VKH22
VKH20Y

- Subaru, Peugeot, Citroën, Nissan, Renault, Mitsubishi, Mercedes Benz, Toyota, Isuzu, etc.
- Thread length is 26.5mm.

VW series
VW16 • VW20 • VW22

- Used primarily for cars
- Installation screw ø14xL19
- Mark II, Sunny, Familia, BMW, Audi, etc.

VT series
VT16 • VT20

- Mercedes Benz, Mazda, Ford, etc.

VXU series
VXU22 • VXU24

- Used for small cars
- Installation screw ø12xL19
- Insulator full projection (1.5mm) provides wider heat value range and improves ignitability
- Wagon R, Mira, Preo, Minica, Laputa, etc.

IRIDIUM TOUGH® SPECIFICATIONS

	TYPE	SPEC	DIA. (mm)	REACH (mm)	HEX (mm)	GAP (mm)	PROJECTION (mm)	Spark position (mm)	Ground electrode height (mm)	Terminal shape	RESISTOR (kΩ)	No.	IRIDIUM TOUGH® ONE PC BOX BARCODE	IRIDIUM TOUGH® ONE PC BOX DENSO P/N	IRIDIUM TOUGH® 2pcs BLISTER PACK BARCODE	IRIDIUM TOUGH® 2pcs BLISTER PACK DENSO P/N
	VQ16	JIS	14	19	16	1.1	1.5	3.0	5.7	RC	5	V01	0 42511 05601 5	267700-0740	0 42511 02601 8	100676-3740
	VQ20	JIS	14	19	16	1.1	1.5	3.0	5.7	RC	5	V02	0 42511 05602 2	267700-0750	0 42511 02602 5	100676-3750
	VQ22	JIS	14	19	16	0.8	1.5	3.0	5.4	RC	5	V13	0 42511 05613 8	267700-0760	0 42511 02613 1	100676-3760
	VK16	ISO	14	19	16	1.1	1.5	3.0	5.7	RC	5	V03	0 42511 05603 9	267700-0710	0 42511 02603 2	100676-3710
	VK20	ISO	14	19	16	1.1	1.5	3.0	5.7	RC	5	V04	0 42511 05604 6	267700-0720	0 42511 02604 9	100676-3720
	VK22	ISO	14	19	16	0.8	1.5	3.0	5.4	RC	5	V10	0 42511 05610 7	267700-0730	0 42511 02610 0	100676-3730
new	VK16G	ISO,SUS GASKET	14	19	16	1.1	1.5	3.0	5.7	S	5	V40	0 42511 05640 4	267700-5610		
new	VK20G	ISO,SUS GASKET	14	19	16	1.1	1.5	3.0	5.7	S	5	V41	0 42511 05641 1	267700-5620		
new	VK22G	ISO,SUS GASKET	14	19	16	0.8	1.5	3.0	5.4	S	5	V36	0 42511 05636 7	267700-5670	0 42511 02636 0	100676-5340
	VK20Y	ISO	14	19	16	0.8	1.5	3.0	5.4	RC	5	V20	0 42511 05620 6	267700-3720	0 42511 02620 9	100676-3950
	VKA16	NEW 3 ELECTRODE SHROUD	14	22	16	1.1	2.5	4.0	6.5	RC	5	V22	0 42511 05622 0	267700-5030	0 42511 02622 3	100676-5360
	VKA20	NEW 3 ELECTRODE SHROUD	14	22	16	1.1	2.5	4.0	6.5	RC	5	V23	0 42511 05623 7	267700-5040	0 42511 02623 0	100676-5370
	VKB16	NEW 3 ELECTRODE	14	19	16	1.1	2.5	4.0	6.5	RC	5	V24	0 42511 05624 4	267700-5050	0 42511 02624 7	100676-5380
	VKB20	NEW 3 ELECTRODE	14	19	16	1.1	2.5	4.0	6.5	RC	5	V25	0 42511 05625 1	267700-5060	0 42511 02625 4	100676-5390
	VKH16	Long Reach	14	26.5	16	1.1	1.5	3.0	5.7	RC	5	V17	0 42511 05617 6	267700-3680	0 42511 02617 9	100676-5250
	VKH20	Long Reach	14	26.5	16	1.1	1.5	3.0	5.7	RC	5	V18	0 42511 05618 3	267700-3690	0 42511 02618 6	100676-5150
	VKH22	Long Reach	14	26.5	16	0.8	1.5	3.0	5.4	RC	5	V19	0 42511 05619 0	267700-2680	0 42511 02619 3	100676-5270
	VKH20Y	Long Reach	14	26.5	16	0.8	1.5	3.0	5.4	RC	5	V39	0 42511 05639 8	267700-4540	0 42511 02639 1	100676-5260
	VW16		14	19	20.6	1.1	1.5	3.0	5.5	RC	5	V05	0 42511 05605 3	267700-0770	0 42511 02605 6	100676-3770
	VW20		14	19	20.6	1.1	1.5	3.0	5.5	RC	5	V06	0 42511 05606 0	267700-0780	0 42511 02606 3	100676-3780
	VW22		14	19	20.6	0.8	1.5	3.0	5.2	RC	5	V07	0 42511 05607 7	267700-0790	0 42511 02607 0	100676-3790
	VT16		14	17.5	16	1.1	1.5	3.0	5.5	RC	5	V21	0 42511 05621 3	267700-2810	0 42511 02621 6	100676-5280
	VT20		14	17.5	16	1.1	1.5	3.0	5.5	RC	5	V38	0 42511 05638 1	267700-4480	0 42511 02638 4	100676-5290
	VXU22		12	19	16	0.9	1.3	2.8	5.0	RC	5	V08	0 42511 05608 4	267700-0800	0 42511 02608 7	100676-3800
	VXU24		12	19	16	0.9	1.3	2.8	5.0	RC	5	V09	0 42511 05609 1	267700-0810	0 42511 02609 4	100676-3810

New ·····Anything shown with this is a product that is "On Sale in 2004～2005"
Spark gap ·····For example, for a 1.1mm gap, it is set at the range between 1.0 and 1.1mm.
Insulator projection ·····This is the distance from the end of the housing to the end of the insulator. The + direction is the direction of the piston.
Spark position ·····This is the distance from the end of the housing to the tip of the center electrode. The + direction is the direction of the piston.
Ground electrode height ···This is the distance from the end of the housing to the tip of the ground electrode. The + direction is the direction of the piston.
Terminal shape·····S;Solid R;Removable RC;Crimped T;Threaded

Realizing High Performance and Superior Durability with the 25 Top Types *1!!

Type	Size: Screw Diameter	Size: Thread Reach	Size: Hex Size	GAP (mm)	Heat Range: 16	Heat Range: 20	Heat Range: 22	Heat Range: 24	Applicable Vehicles (*2)
VQ	14	19	16	0.8			●		Cedric, Bluebird, Saab, Mercedes Benz, and others
				1.1	●	●			
VK (ISO)	14	19	16	0.8			●		Camry, Vitz, Wingroad, Inspire, Capella, and others
				1.1	●	●			
VK-G (ISO)	14	19	16	0.8			●		Honda
				1.1	●	●			
VK-Y (ISO)	14	19	16	0.8		●			Subaru Turbo, and others
VKA	14	22	16	1.1	●	●			Toyota D4 Engine, Mitsubishi GDI, and others
VKB	14	19	16	1.1	●	●			
VKH	14	26.5	16	0.8			●		Subaru, Peugeot, Citroen, Nissan, Renault, Mitsubishi, Mercedes Benz, Toyota, and Isuzu
				1.1	●	●			
VKH-Y	14	26.5	16	0.8		●			Subaru Turbo, and others
VW	14	19	20.6	0.8			●		Mark II, Sunny, Familia,BMW Audi, and others
				1.1	●	●			
VT	14	17.5 (taper seat)	16	1.1	●	●			Mercedes Benz, Mazda, Ford
VXU	12	19	16	0.9			●	●	Wagon R, Mira, Pleo, Minica, and Laputa
VK20T	14	19	16	0.8		●			For Taxi (Iridium Plus)
VW20T	14	19	20.6	0.8		●			

*1 25 types of Iridium Tough and 2 types of Iridium Plus *2 Always confirm your selection using the Model Quick Chart

Next Generation High Performance Plugs for Taxi

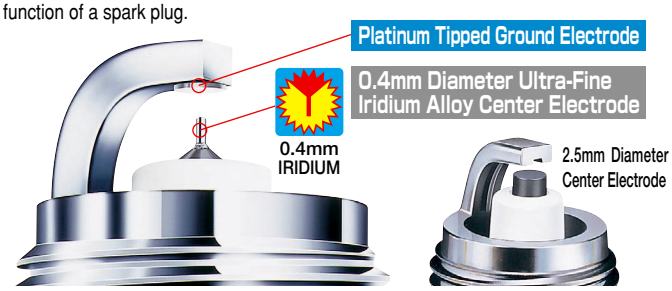
High Performance Spark Plug

IRIDIUM PLUS®

World's Smallest Diameter

This product, the first in the world, uses an ultra-thin 0.4mm iridium alloy center electrode.

A larger center electrode means a greater cooling effect and poorer ignitability. On the other hand, the 0.4mm diameter iridium center electrodes have an extremely small cooling effect, reducing non-firing and realizing assured ignitability, the basic function of a spark plug.



Iridium Plus (Model: VK20T) Normal Plug (Model: K16R-U11)

Also, because taxis use liquefied petroleum gas (LPG) as fuel, a large electrode increases the required voltage, and because this places a larger load on high tension cords and coils, it affects the life of the vehicle. With its ultra-thin 0.4mm center electrode that keeps the required voltage low, it can be said that the Iridium Plus, is a car-friendly spark plug.

Platinum Tip

Using a platinum-tipped ground electrode to realize high-performance operation and long life.

A platinum tip was used, which has a long history of use in platinum plugs. By significantly controlling electrode wear, we've achieved a level of durability equal to that of platinum plugs.

High Strength Insulator

Using a high-strength insulator specially designed for taxis.

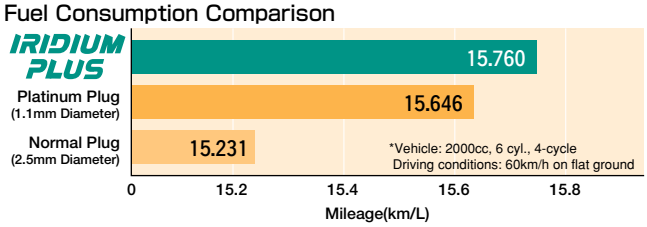
By using a high-strength ceramic insulator for LPG engines, a 20% increase in strength was achieved over conventional insulators.

Improved Mileage

Less fuel consumption with a 0.4mm diameter center electrode.

Even during idling, when it is easy for ignition to degrade, Iridium Plus reduces mis-sparking and stabilizes idling speed. This results in a quieter engine and improved fuel consumption.

Fuel Consumption Comparison



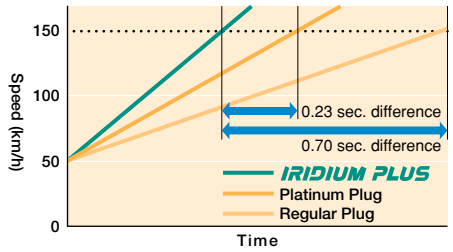
*The data shown is from internal studies. Also, the "Regular Plug" referred to here is a DENSO product.

Improved Acceleration

Through steady ignitability, acceleration performance is greatly improved.

Iridium Plus, through its 0.4mm diameter iridium center electrode, has realized high ignition performance and low spark voltage at levels heretofore unseen. Because of this, there is less non-firing under high spark voltage conditions and fewer misfires under conditions where ignition is difficult, permitting operation with a high level of response under a variety of conditions. As a result, acceleration has been improved.

■Acceleration comparison



*Vehicle: 250cc
(2 cycle water cooled, V2 cylinders)
Conditions: Locked in 6th gear, starting at 50km/h on an automatic test device and accelerating at full throttle.

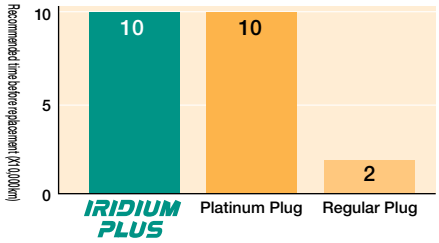
*The data shown is from internal studies. Also, the "Regular Plug" and "Platinum Plug" referred to here are DENSO products.

Excellent Durability

Realizing astounding life and durability with platinum ground electrodes.

By welding a platinum tip to the ground electrode, wear has been controlled to a significant extent in the Iridium Plus. In addition to acceleration performance, the life and durability of this plug has been increased to that of a platinum plug.

■Durability Comparison



*From taxi monitoring test results. Exhaust volume was for the most part 2000cc.
*Durability will differ depending on the driving conditions.
*The service lifetime of Iridium Plus will depend on operating conditions and the vehicle it is installed on. (Service lifetime may become shorter depending on the vehicle's ignition system.)
*Recommended time before replacement is not something that must be followed to guarantee quality.

*The data shown is from internal studies. Also, the "Regular Plug" and "Platinum Plug" referred to here are DENSO products.

Designated part numbers and the associated vehicle models

Make	Vehicle	CC	Engine	From	Till	OEM Plug Genuine Part No.	IRIDIUM PLUS	QTY
Toyota	Crown/ Majesta	2000	1G-GP (LPG)	91.10	01.2	90919-01180	VK20T	6
Toyota	Crown/ Majesta	2000	3Y-PE (LPG)	89.8		90919-01147	VW20T	4
Toyota	Crown Comfort	2000	1G-GPE (LPG)	95.12		90919-01180	VK20T	6
Toyota	Crown Comfort	2000	3Y-PE (LPG)	95.12		90919-01147	VW20T	4
Toyota	Corona	1800	2Y-PU (LPG)	82.10	01.11	90919-01143	VW20T	4
Toyota	Comfort	2000	3Y-PE (LPG)	95.12		90919-01147	VW20T	4
Toyota	Probox	1500	1NZ-FNE (CNG)	03.4		90919-01190	VK20T	4
Toyota	Mark II; Chaser; Cresta	2000	3Y-P/-PU (LPG)	86.8	95.12	90919-01143	VW20T	4
Nissan	Crew	2000	NA20P (LPG)	93.7		—	VW20T	4
Nissan	Cedric; Gloria	2000	RB20P (LPG)	89.6		—	VK20T	6
Nissan	Cedric; Gloria	2000	NA20P (LPG)	91.6		—	VW20T	4
Nissan	Bluebird	1800	Z18P (LPG)	79.2	01.8	—	VW20T	8
Mazda	Custom Cab	2000	FE (LPG)	89.6	96.1	FE82 18 110	VW20T	4
Mazda	Luce; Cosmo	2000	FE (LPG)	86.9	96.1	FE82 18 110	VW20T	4
Mitsubishi	Galant Sigma; Eterna Sigma	1800	4G93 (LPG)	96.1		MS851738	VK20T	4
Mitsubishi	Debonair	3000	6G72 (LPG)	92.10		MS851473	VW20T	6

The above are excerpted from the catalog. Please refer to Master Catalog for details.

Unbeatable spark technology fine-tuned for racing

High Performance Spark Plug

IRIDIUM RACING®

On the circuit is where it makes the difference

World's smallest 0.4mm-diameter center electrode *

*As of May 2004

Reliability and Durability Borne Out by Race Results and Trusted by Riders like Azuma, Ui, and Matsudo

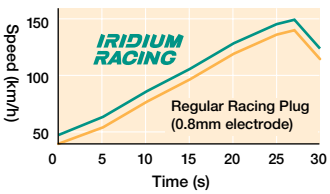
55 Types in All (Some Plugs in Stores 2004)

It's the age of iridium electrodes. Discover more acceleration with 0.4mm DENSO Racing Plugs. DENSO would like you to try the 0.4mm IRIDIUM RACING® advantage. Use IRIDIUM RACING® and experience a ride like never before.

Improved Acceleration

Unbeatable acceleration performance on the circuit.

With an ultra-fine, 0.4mm diameter center electrode, Iridium Racing plugs are the realization of superb ignition performance and spark voltage at unparalleled levels. Misfires have been controlled and will allow you to have steadily high levels of response and increased acceleration.



Time to reach 100km/h (s)

Plug	13.9	14.0
IRIDIUM RACING	13.950	
Regular race plug (0.8mm electrode)	13.985	

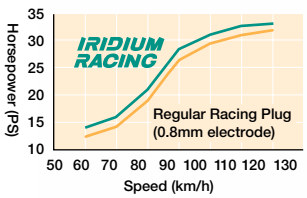
*The data shown is from internal studies. Also, the "Regular Racing Plug" referred to here is a DENSO product.

Vehicle: 250cc (2-cycle water cooled, 2 cylinder) Conditions: R/L 50km/h, then accelerating for 27 seconds at full throttle (locked in 6th gear)

Improved Output

More power with an ideal combustion cycle.

Through superb ignition performance and spark voltage, non-firing and misfires under a variety of conditions has been greatly reduced. As a result, combustion conditions have improved dramatically, increasing engine output.



Output (ps) [at 120km/h]

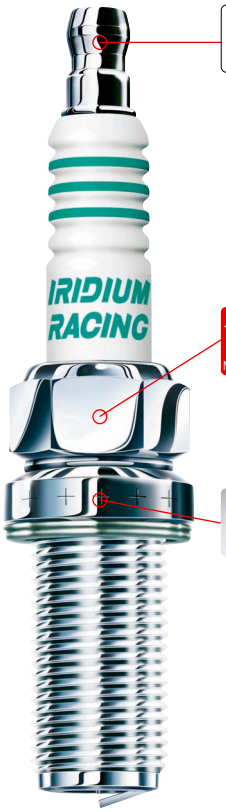
1.3% More!

Plug	33	34
IRIDIUM RACING	33.92	
Regular Racing Plug (0.8mm electrode)	33.49	

*The data shown is from internal studies. Also, the "Regular Racing Plug" referred to here is a DENSO product.

Vehicle: 250cc (2 cycle water cooled, 2 cylinder) Conditions: WOT 60 to 120km/h (locked in 4th gear)

0.4mm Dia. Iridium, only at DENSO!



Specification Includes Terminal

Included with the plug comes with a terminal nut compatible to the Nology HotWire and most plug cords around the world. Please remove for vehicle types that do not require terminals. (There are also types with fixed terminals. Refer to the Cross Reference Chart on P22.) (IRE01/ IW01 specify crimping, while IWM01/ IK01/ IK02/ IQ01/ IQ02/ IA01/ IAE01 are solid terminals.)

Contains a Highly Reliable Resister

All IRIDIUM RACING® plugs specify a resistor, and contain a highly reliable monolithic-type resistor that blocks noise that may affect electronic devices. (IW06 has no resistor.)

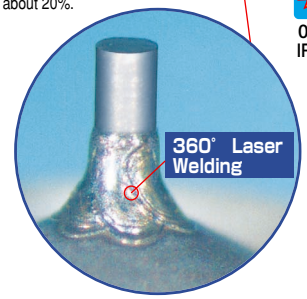
Highly Corrosion Resistant, Bright Nickel Plating

Using a bright nickel plating on the housing, a high level of corrosion resistance has been realized. Also, because the amount on the threads is low, the damage to the female thread in the cylinder is reduced.

360° Laser Welding

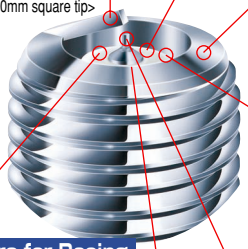
The process used to join the iridium tip is a highly reliable "360° Laser Welding *1" process that is able to withstand various kinds of driving conditions.

*1 This "360° Laser Welding" method has been patented in the U.S.A. and Japan (Japan Patent No.: 2921524, U.S.A. Patent No.: 6078129)



0.8mm All-Platinum Ground Electrode

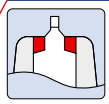
Compared to the nickel alloy used in conventional spark plugs, the high melting point of platinum will reduce such problems as ground electrode melting and wear. Also, the 0.8mm platinum alloy is welded on and gapped without any bending, reducing residual stress and increasing durability.
<IAE01 has a 1.0mm square tip>



Insulators for Racing

Using a new, stronger insulator developed repeating numerous race trials, strength has been increased by about 20%.

Spark Cleaning Pocket



Between the center electrode and the insulator, a small pocket has been opened around the tip clearance. When there is carbon fouling or deposition, this part will discharge and burn off the carbon, restoring electrical resistance. This technology is patented by DENSO (Japan Patent No. 2727558)

Housing End Face Chamfer

To improve the tolerance to abnormal combustion conditions, the housing end face chamfer has been enlarged. Be covered for slight inaccuracies in tuning. Also, because the exhaust of residual gas and the flow of new gas have been facilitated, its self-cleaning performance has been improved, making this a carbon fouling resistant design.

Silicone Oil Coating

During the start of the race, non-starting from carbon fouling and carbon deposits can be fatal. To stop this, the insulator has been coated with a silicone coating. Using the water repellency of silicone, the insulator surface is isolated from moisture and carbon, preventing a decrease in resistance.

0.4mm
IRIDIUM

0.4mm Dia. Ultra-Fine Iridium Center Electrode

The center electrode tip is able to be made fine using a new iridium alloy with a high melting point. The required voltage is reduced, and ignitability is improved greatly. This new iridium alloy's material composition, manufacturing method *1, and welding method *2 have been patented.

*1 The addition of rhodium to improve high temperature oxidation resistance: Japan Patent 2877035, UK Patent 2302367, People's Republic of China Patent 961022841, Republic of Korea Patent 0292083, U.S.A. Patent 6094000/6262522

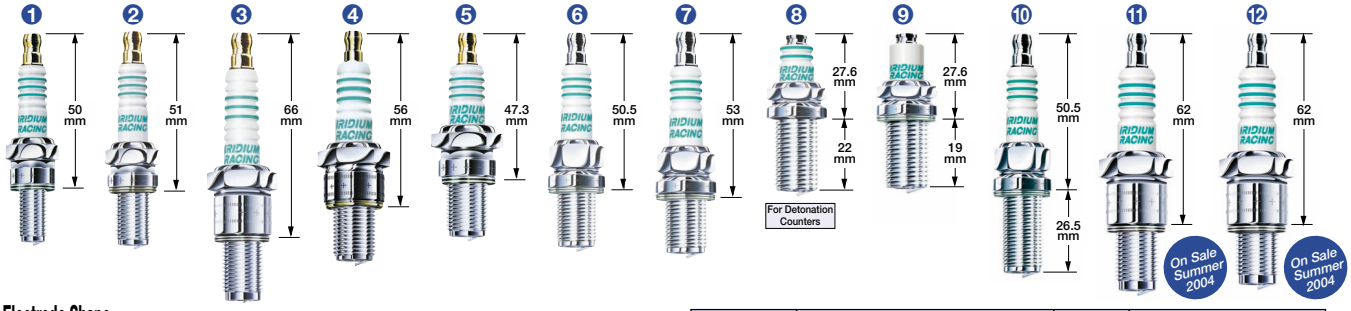
*2 Using a melting method instead of the conventional sintering method. Japan Patent 3000955, U.S.A. Patent 5977695

How To Choose a Racing Plug

Warning: On choosing the right racing plug

○Generally, electrodes that project into the combustion chamber have better ignitability and have better performance. However, because of more exposure to high temperature combustion gases and because ground electrode becomes longer, heat resistance and durability decrease. The higher the level of tuning, the greater the need is to use a less projecting type.
○As the level of tuning is increased, so does the need for a higher heat range.

Overall Shape



Electrode Shape

Identifying IRIDIUM RACING® (Stamped into the Center of the Housing)

I	W	0	1	-	27
Variety	Thread Size	Intermediate Number (Overall Size)	Intermediate Number (Electrode Shape)		Heat Range

Variety
- I : Iridium
- R : Surface Gap

Thread Size
- U : 10mm
- XU : 12mm
- RE : 14mm
- RL : 14mm
- RT : 14mm
- W : 14mm
- WM : 14mm
- K : 14mm
- Q : 14mm
- A : 14mm
- AE : 14mm
- KH : 14mm

Intermediate Number (Overall Size)

Intermediate Number (Electrode Shape)
- 1 : Oblique ground electrode or surface gap plug
- 2 : Flat ground electrode
- 3 : Oblique ground electrode and resistor-less plug

Heat Range
- 24
- 27
- 29
- 31
- 32
- 34
- 35

(Exception) IRE01 has a flat ground electrode.

TYPE (HEAT RANGE□)	TYPE	FIGURE ELECTRODE	CROSS REFERENCE
IU01-□	U-E	1 A	R0373A, R0379A, R016
RU01-□※	U-E(SURFACE)	1 C	R0045J, R0045Q
IXU01-□	XU-E	2 A	R216, R2525
IRE01-□	ROTARY ENGINE	3 B	R6725
IW01-□	W-E	4 A	R6385P, R7376, R6918B
IW06-□	W-E(NON=RESISTOR)	4 A	B-EGP, R4630A
IWM01-□	W-EM	5 A	R5184, R6179AP
IK01-□	ISO(SLANT ELECT.)	6 A	R7116, R7117
IK02-□	ISO(STRAIGHT ELECT.)	6 B	R7279, R7118, R7119
IQ01-□	SLANT ELECT.	7 A	R7236, R7237
IQ02-□	STRAIGHT ELECT.	7 B	R7238, R7239
IA01-□	FOR DETONATION COUNTER	8 A	R7282A, R6120A
IAE01-□	FOR W/OUT DETONATION COUNTER	9 A	R7282, R6120
IKH01-□	K-LONG REACH	10 A	R7438
IRL01-□	ROTARY ENGINE RX8	11 A	R7440A-L
IRT01-□	ROTARY ENGINE RX8	12 A	R7440B-T

※RU01-□ are surface gap plugs, not ones with iridium center electrode and all-platinum ground electrodes.

⚠ Iridium Racing is ideal for racing and tuned-up engines; please choose one based on the heat range of the standard plug or Iridium Power plugs used currently that is suited to your level of tuning.

IRIDIUM RACING® SPECIFICATIONS

TYPE	SPEC	DIA. (mm)	REACH (mm)	HEX (mm)	GAP (mm)	PROJECTION (mm)	Spark position (mm)	Ground electrode height (mm)	Terminal shape	RESISTOR (kΩ)	No.	IRIDIUM RACING ONE PC BOX BARCODE	DENSO P/N
IK01-24	ISO(SLANT ELEC.)	14	19	16	0.7	-1.0	0.5	2.0	S	5	R01	0 42511 05701 2	267700-1310
IK01-27	ISO(SLANT ELEC.)	14	19	16	0.7	-1.0	0.5	2.0	S	5	R02	0 42511 05702 9	267700-1320
IK01-31	ISO(SLANT ELEC.)	14	19	16	0.7	-1.0	0.5	2.0	S	5	R03	0 42511 05703 6	267700-1330
IK01-34	ISO(SLANT ELEC.)	14	19	16	0.7	-1.0	0.5	2.0	S	5	R42	0 42511 05742 5	267700-1340
IK02-24	ISO(STRAIGHT ELEC.)	14	19	16	0.7	-2.3	-0.8	0.7	S	5	R04	0 42511 05704 3	267700-1360
IK02-27	ISO(STRAIGHT ELEC.)	14	19	16	0.7	-2.3	-0.8	0.7	S	5	R05	0 42511 05705 0	267700-1370
IK02-31	ISO(STRAIGHT ELEC.)	14	19	16	0.7	-2.3	-0.8	0.7	S	5	R06	0 42511 05706 7	267700-1380
IKH01-24	LONG REACH	14	26.5	16	0.7	-1.0	0.5	2.0	S	5	R49	0 42511 05749 4	267700-4450
IKH01-27	LONG REACH	14	26.5	16	0.7	-1.0	0.5	2.0	S	5	R50	0 42511 05750 0	267700-4460
IKH01-31	LONG REACH	14	26.5	16	0.7	-1.0	0.5	2.0	S	5	R51	0 42511 05751 7	267700-4470
IQ01-24	SLANT ELEC.	14	19	16	0.7	-1.0	0.5	2.0	S	5	R07	0 42511 05707 4	267700-1410
IQ01-27	SLANT ELEC.	14	19	16	0.7	-1.0	0.5	2.0	S	5	R08	0 42511 05708 1	267700-1420
IQ01-31	SLANT ELEC.	14	19	16	0.7	-1.0	0.5	2.0	S	5	R09	0 42511 05709 8	267700-1430
IQ01-34	SLANT ELEC.	14	19	16	0.7	-1.0	0.5	2.0	S	5	R43	0 42511 05743 2	267700-1440
IQ02-24	STRAIGHT ELEC.	14	19	16	0.7	-2.3	-0.8	0.7	S	5	R10	0 42511 05710 4	267700-1460
IQ02-27	STRAIGHT ELEC.	14	19	16	0.7	-2.3	-0.8	0.7	S	5	R11	0 42511 05711 1	267700-1470
IQ02-31	STRAIGHT ELEC.	14	19	16	0.7	-2.3	-0.8	0.7	S	5	R12	0 42511 05712 8	267700-1480
IW01-24	W-E	14	19	20.6	0.6	-1.5	0.0	1.6	RC	5	R13	0 42511 05713 5	267700-1110
IW01-27	W-E	14	19	20.6	0.6	-1.5	0.0	1.6	RC	5	R14	0 42511 05714 2	267700-1120
IW01-29	W-E	14	19	20.6	0.6	-1.5	0.0	1.6	RC	5	R15	0 42511 05715 9	267700-1130
IW01-31	W-E	14	19	20.6	0.6	-1.5	0.0	1.6	RC	5	R16	0 42511 05716 6	267700-1140
IW01-32	W-E	14	19	20.6	0.6	-1.5	0.0	1.6	RC	5	R17	0 42511 05717 3	267700-1150
IW01-34	W-E	14	19	20.6	0.6	-1.5	0.0	1.6	RC	5	R18	0 42511 05718 0	267700-1160
IW06-27	W-E NON RESISTOR	14	19	20.6	0.6	-1.5	0.0	1.6	S	0	R44	0 42511 05744 9	067600-1810
IW06-31	W-E NON RESISTOR	14	19	20.6	0.6	-1.5	0.0	1.6	S	0	R45	0 42511 05745 6	067600-1820
IW06-34	W-E NON RESISTOR	14	19	20.6	0.6	-1.5	0.0	1.6	S	0	R46	0 42511 05746 3	067600-1830
IRE01-27	ROTARY ENGINE	14	21.5	20.6	0.7	-2.2	-0.7	0.8	RC	5	R19	0 42511 05719 7	267700-1520
IRE01-31	ROTARY ENGINE	14	21.5	20.6	0.7	-2.2	-0.7	0.8	RC	5	R20	0 42511 05720 3	267700-1530
IRE01-32	ROTARY ENGINE	14	21.5	20.6	0.7	-2.2	-0.7	0.8	RC	5	R21	0 42511 05721 0	267700-1540
IRE01-34	ROTARY ENGINE	14	21.5	20.6	0.7	-2.2	-0.7	0.8	RC	5	R22	0 42511 05722 7	267700-1550
IRE01-35	ROTARY ENGINE	14	21.5	20.6	0.7	-2.2	-0.7	0.8	RC	5	R41	0 42511 05741 8	267700-1560
New IRL01-27	ROTARY RX8(LEADING)	14	21	20.6	1.1	-2.5	-0.5	1.6	S	5	R54	0 42511 05754 8	267700-4820
New IRL01-31	ROTARY RX8(LEADING)	14	21	20.6	1.1	-2.5	-0.5	1.6	S	5	R55	0 42511 05755 5	267700-4830
New IRT01-31	ROTARY RX8(TRAILING)	14	19	20.6	1.1	-2.5	-0.5	1.6	S	5	R52	0 42511 05752 4	267700-4840
New IRT01-34	ROTARY RX8(TRAILING)	14	19	20.6	1.1	-2.5	-0.5	1.6	S	5	R53	0 42511 05753 1	267700-4850
IA01-31	WITH DETONATION COUNTER	14	22	16	0.6	-1.0	0.5	1.9	S	5	R23	0 42511 05723 4	267700-1260
IA01-32	WITH DETONATION COUNTER	14	22	16	0.6	-1.0	0.5	1.9	S	5	R24	0 42511 05724 1	267700-1270
IA01-34	WITH DETONATION COUNTER	14	22	16	0.6	-1.0	0.5	1.9	S	5	R25	0 42511 05725 8	267700-1280
IAE01-32	W/OUT DETONATION COUNTER	14	19	16	0.6	-1.3	0.5	2.1	S	5	R47	0 42511 05747 0	267700-2940
IAE01-34	W/OUT DETONATION COUNTER	14	19	16	0.6	-1.3	0.5	2.1	S	5	R48	0 42511 05748 7	267700-2950
IWM01-29	W-EM	14	19	20.6	0.6	-1.5	0.0	1.6	S	5	R26	0 42511 05726 5	267700-1210
IWM01-31	W-EM	14	19	20.6	0.6	-1.5	0.0	1.6	S	5	R27	0 42511 05727 2	267700-1220
IWM01-32	W-EM	14	19	20.6	0.6	-1.5	0.0	1.6	S	5	R28	0 42511 05728 9	267700-1230
IWM01-34	W-EM	14	19	20.6	0.6	-1.5	0.0	1.6	S	5	R29	0 42511 05729 6	267700-1240
IXU01-24	XU-E	12	19	16	0.6	-1.5	0.0	1.4	R	5	R30	0 42511 05730 2	267700-1060
IXU01-27	XU-E	12	19	16	0.6	-1.5	0.0	1.4	R	5	R31	0 42511 05731 9	267700-1070
IXU01-31	XU-E	12	19	16	0.6	-1.5	0.0	1.4	R	5	R32	0 42511 05732 6	267700-1080
IXU01-34	XU-E	12	19	16	0.6	-1.5	0.0	1.4	R	5	R33	0 42511 05733 3	267700-1090
IU01-24	U-E	10	19	16	0.6	-1.8	-0.3	1.2	R	5	R34	0 42511 05734 0	267700-1010
IU01-27	U-E	10	19	16	0.6	-1.8	-0.3	1.2	R	5	R35	0 42511 05735 7	267700-1020
IU01-31	U-E	10	19	16	0.6	-1.8	-0.3	1.2	R	5	R36	0 42511 05736 4	267700-1030
IU01-34	U-E	10	19	16	0.6	-1.8	-0.3	1.2	R	5	R37	0 42511 05737 1	267700-1040
*RU01-27	U-E(SURFACE)	10	19	16	1.1	-0.2	0.0	0.0	R	5	R38	0 42511 05738 8	267700-1570
*RU01-31	U-E(SURFACE)	10	19	16	1.1	-0.2	0.0	0.0	R	5	R39	0 42511 05739 5	267700-1580
*RU01-34	U-E(SURFACE)	10	19	16	1.1	-0.2	0.0	0.0	R	5	R40	0 42511 05740 1	267700-1590

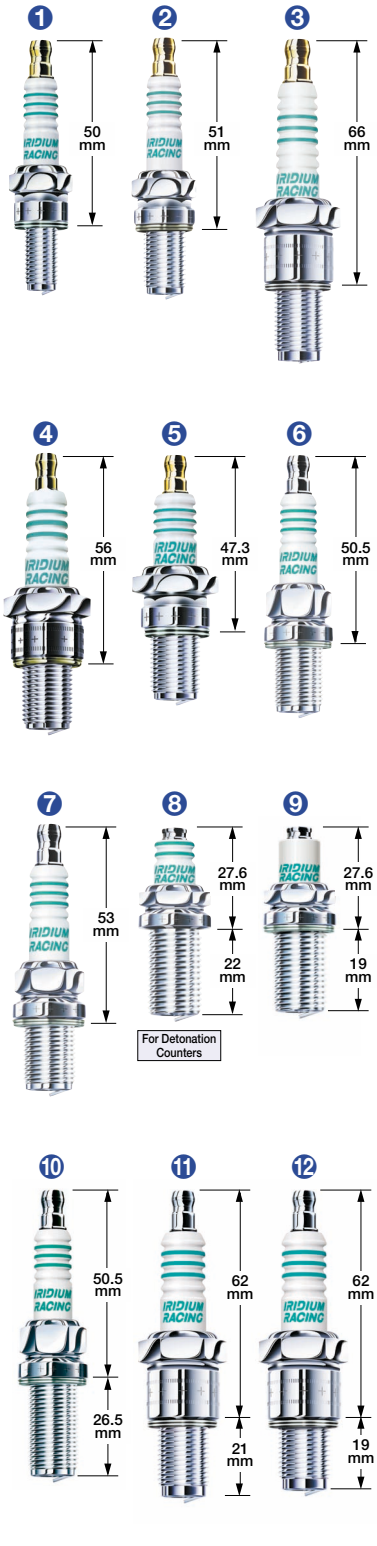
New ·····Anything shown with this is a product that is "On Sale in 2004～2005"
*·····These plugs do not have iridium electrodes.
Spark gap ·····For example, for a 1.1mm gap, it is set at the range between 1.0 and 1.1mm.
Insulator projection ·····This is the distance from the end of the housing to the end of the insulator. The + direction is the direction of the piston.
Spark position ·····This is the distance from the end of the housing to the tip of the center electrode. The + direction is the direction of the piston.
Ground electrode height ·····This is the distance from the end of the housing to the tip of the ground electrode. The + direction is the direction of the piston.
Terminal shape ·····S;Solid R;Removable RC;Crimped T;Threaded

IRIDIUM RACING® CROSS REFERENCE

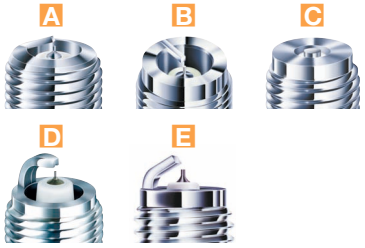
NGK						DENSO		
DIA. (mm)	REACH (mm)	HEX (mm)	RESISTOR	FIGURE	TYPE	IRIDIUM POWER	IRIDIUM RACING	FIGURE
14	19	20.6		BP-E	R4304A-□	IW□		4 D
14	19	20.6		B-E	B□EGP		IW01/IW06-□(Note1)	4 A
14	19	20.6		B-E	B□EGV	IW□		4 D
14	19	20.6		B-E	R4118S-□	IW□		4 D
14	19	20.6		B-E	R4630A-□		IW01/IW06-□(Note1)	4 A
14	19	20.6	R	B-E	R6252K-□		IW01/IW06-□(Note1)	4 A
14	19	20.6	R	B-E	R6918B-□		IW01/IW06-□(Note1)	4 A
14	19	20.6	R	B-E	R6918C-□		IW01/IW06-□(Note1)	4 A
14	19	20.6	R	B-E	R6021E-□	IW□		4 D
14	19	20.6	R	B-E	R6385-□P		IW01/IW06-□(Note1)	4 A
14	19	20.6	R	B-E	R7376(Ir)		IW01/IW06-□(Note1)	4 A
14	19	20.6		B-E SEMISURFACE	R5649-□			
14	19	20.6	R	B-E SEMISURFACE	R6712-□			
14	19	20.6		B-E COMPACT	R5184-□		IWM01-□	5 A
14	19	20.6	R	B-E COMPACT	R5300A-□			
14	19	20.6	R	B-E COMPACT	R5300N-□			
14	19	20.6	R	B-E COMPACT	R5540F-□			
14	19	20.6	R	B-E COMPACT	R6179A-□P		IWM01-□	5 A
14	22	20.6	R	B-E COMPACT	R6179C-□PA			
14	22	20.6	R	B-E	R7376B(Ir)			
14	22	16	R	BC-E COMPACT	R6120A-□		IA01-□	8 A
14	22	16	R	BC-E COMPACT	R7282A-□(Ir)		IA01-□	8 A
14	19	16	R	BC-E COMPACT	R6120-□		IAE01-□	9 A
14	19	16	R	BC-E COMPACT	R6120C-□		IAE01-□(Note2)	9 A
14	19	16	R	BC-E COMPACT	R6120M-□		IAE01-□(Note2)	9 A
14	19	16	R	BC-E COMPACT	R7282-□(Ir)		IAE01-□	9 A
14	19	16	R	BC-E COMPACT	R7282C-□(Ir)		IAE01-□(Note2)	9 A
14	19	16	R	BC-E COMPACT	R7282M-□(Ir)		IAE01-□(Note2)	9 A
14	19	16	R	BK-E ISO	R6888A-□	IK□		6 D
14	19	16		BK-E ISO	R7112-□	IK□		6 D
14	19	16	R	BK-E ISO	R7113-□	IK□		6 D
14	19	16	R	BK-E ISO	R7433-□(ir)	IK□		6 D
14	19	16		BK-E ISO	R7114-□	IK□		6 D
14	19	16	R	BK-E ISO	R7115-□	IK□		6 D
14	19	16		BK-E ISO	R7116-□		IK01-□	6 A
14	19	16	R	BK-E ISO	R7117-□		IK01-□	6 A
14	19	16		BK-E ISO	R7118-□		IK02-□	6 B
14	19	16	R	BK-E ISO	R7119-□		IK02-□	6 B
14	19	16	R	BK-E ISO	R7434-□(Ir)		IK01-□	6 A
14	19	16	R	BK-E ISO	R7279-□(Ir)		IK02-□	6 B
14	19	16	R	BK-E SEMISURFACE	R6601-□			
14	19	16		BK-E SEMISURFACE	R6711-□			
14	19	16	R	BCP-E	R7435-□(Ir)	IQ□		7 D
14	19	16		BCP-E	R7232-□	IQ□		7 D
14	19	16	R	BCP-E	R7233-□	IQ□		7 D
14	19	16		BC-E	R7234-□	IQ□		7 D
14	19	16	R	BC-E	R7235-□	IQ□		7 D
14	19	16		BC-E	R7236-□		IQ01-□	7 A
14	19	16	R	BC-E	R7237-□		IQ01-□	7 A
14	19	16		BC-E	R7238-□		IQ02-□	7 B
14	19	16	R	BC-E	R7239-□		IQ02-□	7 B
14	19	16	R	BC-E	R7436-□(Ir)		IQ01-□	7 A
14	19	16		BC-E SEMISURFACE	R5883-□			
14	19	16	R	BC-E SEMISURFACE	R6690-□			
14	26.5	16	R	LFR	R7437-□(Ir)	IKH□		10 D
14	26.5	16	R	LFR	R7438-□(Ir)		IKH01-□	10 A
14	12.7	20.6		B-H	R5525-□	IWF□		— D
14	12.7	20.6		B-H	R5530-□			
14	21.5	20.6	R	ROTARY	R6725-□		IRE01-□	3 B
14	21.5	20.6	R	ROTARY	R7420-□(Ir)		IRE01-□	3 B
14	21.5	20.6		ROTARY,SURFACE	T813J-N13			
14	21	20.6	R	ROTARY RX-8(L)	R7440A-□L(Ir)		IRL01-□	11 A
14	19	20.6	R	ROTARY RX-8(T)	R7440B-□T(Ir)		IRT01-□	12 A
12	19	18		D-E	R216-□		IXU01-□(Note3)	2 A
12	19	18		D-E	R217-□	IX□(Note3)	IXU01-□(Note3)	2 D,2 A
12	21	18		D-Z	R2188-□			
12	19	16	R	DC-E SEMISURFACE	R2349-□			
12	19	16	R	DC-E	R2525-□		IXU01-□(Note3)	2 A
12	19	16		DC-E SEMISURFACE	R2430-□			
10	19	16		C-E	R016-□		IU01-□	1 A
10	19	16		C-E	R017-□	IU□A		1 E
10	19	16		C-E	R0373A-□(Ir)		IU01-□	1 A
10	19	16		C-E SEMISURFACE	R0045G-□			
10	19	16		C-E SEMISURFACE	R0045J-□		RU01-□	1 C
10	19	16	R	C-E SEMISURFACE	R0045Q-□		RU01-□	1 C
10	19	16	R	C-EH HALF THREAD	R0379A-10(Ir)		IU01-□	1 A
10	12.7	16		C-H	R0161-□	IUF□(A)		–D,–E
8	19	12.7	R	E-EH SEMISURFACE	R847-□	IY□		— D

(Note 1) IW06 is a non resistor type (Note 2) Remove the gasket with nippers before use
(Note 3) IX□B and IX□ is different from IXU01-□ only in the hex size (18mm or 16mm), and are otherwise interchangeable in terms of installation.
(□) show the heat range.

Overall Shape

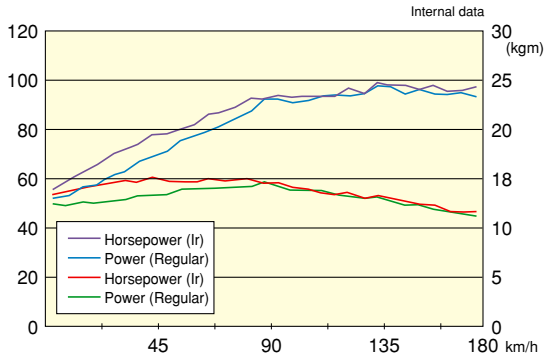


Electrode Shape



Q. 1 Will output and torque increase if I use Iridium Power plugs?

A. 1 These are chassis dynamo test results comparing a Vitz 1300 using Iridium Power plugs and another which uses regular plugs are shown below.
With the normal plugs, the output is 98.2PS, while torque is 14.8 kgf; when this was changed to the Iridium Power plugs, the output was 99.3PS, while torque was 15.2 kgf. (This is approximately a 1.5% improvement in output.)



Q. 2 Will my exhaust emissions be cleaner if I put on Iridium Power plugs?

A. 2 Improved combustion efficiency will clean your exhaust emission! Fuel consumption will improve too!
With the superior ignitability of ultra-thin electrodes (0.4mm), combustion efficiency will be improved.

◎Cleaner Exhaust Emissions

CO and CO2 levels will decrease in the "EURO III" emissions test to be implemented in the future.

◎Improved Mileage

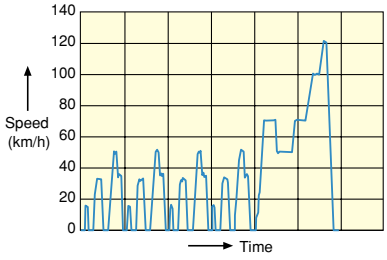
A great bonus for long-distance drivers.

Even for those who are concerned about the environment, we recommend Iridium Power.

■Iridium Plug Motorcycle Emissions Comparison Test

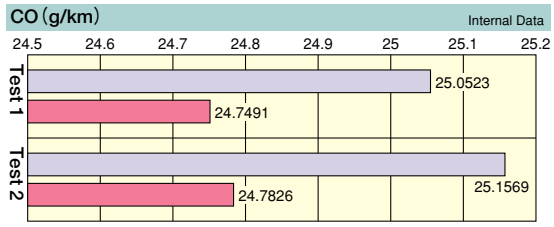
Test Vehicle　:CBR250
Test Conditions:EURO Ⅲ
Test Equipment:MEXA-7400, CVS 7100
Tested Plugs　:U24FER9 (Ni Plug)　Gap: 0.85
　　:IUH24 (Ir Plug)　Gap: 0.85

EURO III Test Pattern　Internal Data

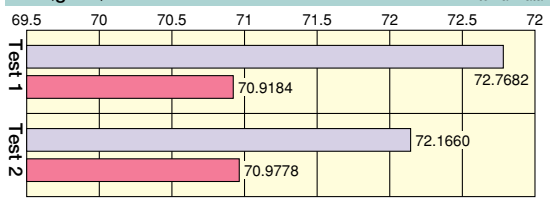


Regular Plug U24FER9　Iridium Power IUH24

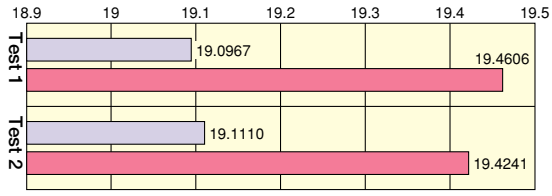
CO (g/km)　Internal Data



CO2 (g/km)　Internal Data



Fuel Consumption (km/L)　Internal Data



Q. 3 I have a 4AG engine NA tuned, with a Solex 44 dia. carburetor installed, giving a 200PS output. Which plug is good for a car such as this?

A. 3 DENSO has Iridium Power and Iridium Racing to meet the needs of tuned and racing engines. For the engine described in the question, the right plug should be around Iridium Power IK (IQ) 22, 24, or 27. Here is an introduction to using the different types of the Iridium Series on racing engines.

- Iridium Power:NA Tuned (Short distance racing), Turbo tuned where a regular turbine has been tuned to increase the boost.
- Iridium Racing (01 Type):The 01 Type is usually called the slant ground electrode type. If your car is turbo tuned where the turbine has been replaced and the boost pressure is above 1.2 to 1.3kg/cm2, an Iridium Racing 01 type is needed. Also, if a NA tuned engine with comparatively high vibration (4 cylinders) is to be raced over long distances, switching to this type can increase the reliability of the ground electrodes.
- Iridium Racing (02 Type):The 02 type (flat ground type) is appropriate for higher output engines than the 01 type, but because the spark position is withdrawn compared to the 01 type, only consider this plug for racing applications.

Q. 4 Is there a standard for differentiating the uses of Iridium Power and Iridium Racing?

A. 4 Iridium Racing uses a platinum tip for the ground electrode and a high strength fine insulator for racing. Also, there is a silicone coating on the insulator giving it an increased resistance to carbon fouling. However, because of the withdrawn spark position, the Iridium Power has the high ignitability of the two. Instead, because of the "extension" in engine revolution felt by many at high revolutions, it is popular with customers who race. Choose "Iridium Power" for response and "Iridium Racing" for high revolutions. Iridium Racing is particularly popular on the circuit scene. (In the '03 Motegi 7 Hour Open, it was found that 45% of the vehicles used Iridium Racing※) ※DENSO findings

Q. 5 I drive a GT-R tuned to 850HP. Would it be okay to install 0.4mm dia. Iridium Power series plugs?

A. 5 The DENSO Iridium Series have the world's thinnest 0.4mm iridium center electrodes, but because the durability of the iridium alloy developed by DENSO is higher that even platinum, which has in the past been said to be the most durable, it can be said that it's the best plug for tuned engines. Specifically, it has the following advantages:

[1] Iridium alloy has a melting point and hardness above that of platinum, even turbo, with its high combustion temperature, can be used with confidence. Also, even when used with powerful ignition systems such as MSD and MDI, these plugs are even more reliable than platinum racing plugs.

[2] The issue for high boost engines is that misfiring that occurs at high revolutions. The fine electrodes of the Iridium series require a lower voltage, allowing the energy generated by the coil to be sparked without losses. It can be said the 0.4mm dia. DENSO Iridium Power series are a strong ally of tuned high-boost turbo systems.

Q. 6 What is the optimum heat range for a tuned up Golf4 GTI 1.8L Turbo?

(Tuning: Turbine Changed, High Volume Injector Installed, and ROM Adjusted to give an output of 200PS from 150PS.)

A. 6 It's difficult to give a heat range based on going from 150PS to 200PS alone, and it's best if you judge the condition of your current plugs and judge for yourself, but as a general rule, for boost pressures between 1.0 and 1.2kg/cm2, an IK24 should be sufficient. During the winter, #22 should improve starting and low speed feel. The heat range is different depending on how the engine has been tuned and how it's used; using an increase in heat range of 1 or 2 as a starting point, decide on a heat range, always looking at the condition of your current plugs.

Q. 7 I have Rover Mini AT ('90). Since changing to Iridium Power, the idling rotation in neutral went up 400rpm from the previous plugs (1000rpm before the change, 1400rpm since). Before the change, going from neutral to drive was 550rpm, but now it goes below 550rpm and stalls. The revolutions increase smoothly and acceleration is good during driving. Why is this?

A. 7 Frequently for older vehicles, the ignition system has degraded, and it is sometimes not possible to see the full effect of Iridium Power. In this case, the spark gap should be adjusted from 1.1mm to 0.8mm. Also, in the VK series, there is the VK20Y plug where the gap has been preset to 0.8mm.

Q. 8 Can I replace my double, triple, or quadruple electrode plugs to Iridium Power or Iridium Tough?

A. 8 This is possible. The reason: because of the 0.4mm center electrode in Iridium Power and Iridium Tough plugs, they have a lower spark voltage compared to double, triple, and quadruple electrode plugs. Please refer to the Standard Resistor Model Quick Chart.

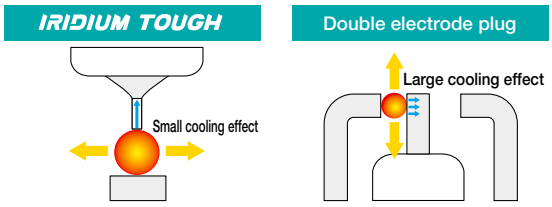
■Spark Voltage

The thinner the electrode is, the stronger the electrical field is. Because the electrical field affects spark voltage, a thinner electrode lowers spark voltage. If each type of electrode shape is modeled as shown below, Iridium Tough has a lower voltage than double electrode plugs.

	IRIDIUM TOUGH	Double electrode plug	Regular Plug
Plug			
Electrode model: Ground / Center	Plate and needle	Needle and sphere	Plate and plate
Spark voltage	Low ←		→ High

■Ignitability

The more the contact area between the flame kernel and the electrode is minimized, the smaller the cooling action from the electrodes and the better ignitability is. Because of the 0.4mm center electrode, the contact area between the flame kernel and the electrode is small, resulting in excellent ignitability.



Q. 9 Can an Iridium Power be installed on an RX-7(SA22C Turbo Model)?

A. 9 In the rotary engines in some old Mazda's on the T (Trailing) side there is a plug, the terminal nut for which must be removed. In others, the removal of the T side plug terminal nut is necessary as in the Cosmo (HB22S). DENSO has Iridium Racing plugs for rotary engines, with a variety of heat ranges from #27 to #35. Iridium Racing Plugs for Rotary Engines come standard with terminal nuts.

Q.10 How is the compatibility with trial vehicles.

A.10 The "IW series" is well suited for most trial vehicles. Though these vehicles frequently use a low heat range, the heat ranges available for Iridium Power starts with IW16, so choose one that matches the type of driving you do. Better accelerator response and torque can be expected with Iridium Power, which has excellent ignitability. Recently, the space to install plugs in trial vehicles has shrunk, and there is a demand for miniature plugs. In these cases try the IK types. However, the space between the plug cord and the insulator will require waterproofing.

Q.11 How does the engine respond to changed settings?

A.11 We sometimes hear that "Iridium Power is too sensitive to setting changes." However, the flip side to sensitivity is that "the response to setting chages is fast and easier," and during races, we hear that it makes setting changes easier. If Iridium Power is used, it should become possible to draw out more performance from your vehicle.

Q.12 What is the difference in the life of an iridium plug used under 2-cycle conditions and one used under 4-cycle conditions?

A.12 In 4-cycle engines, a spark is produced for every 2 revolutions of the crankshaft, resulting in explosion and combustion in the engine.

In 2-cycle engines, a spark is produced for each revolution of the crankshaft, resulting in explosion and engine combustion in the engine.

This simple comparison may lead you to conclude that 2-cycle engines simply have twice the wear; however wear is made up of not only wear from sparking, but also wear from high temperatures (oxidation).

Thus, the amount of wear depends on the driving conditions of the vehicle, how the rotations of the engine are applied (that is, how the shift is used), and whether the resulting combustion temperature is high or low.

2-cycle engines have a higher level of electrode wear. This electrode wear is estimated at approximately 1.5 to 2 times that of 4-cycle engines, and plug life is also shorter with 2-cycle engines. Iridium has a high melting point; however, it will undergo wear from sparking and wear from high temperatures (oxidation). To our knowledge, 2-cycle engines are only found in 2-wheel vehicles, our recommended value in this catalog for lifetime is 3000 to 5000km. (This value is based on a variety of conditions, and, racing use may require even more frequent replacement.) From the above, it is recommended that plugs for 2-cycle engines be replaced about every 3000km. However, the condition of wear depends on operating conditions and the typical engine rpms, so it is also possible to take out the plugs occasionally to confirm the amount of electrode wear and judge when the best time is to replace the plug.

Q.13 I ride a BMW R100RS ('92) motorcycle. I bought Iridium plugs (IW20, as specified in the charts) and installed them, but whenever I stop at the stop light, my engine stalls. Is this a defect with the plug? Or does this mean that my motorcycle is unsuited to Iridium Power? How can I get them to work?

A.13 Because Iridium Power plugs have an ultra-thin center electrode, they will spark even at low voltages (i.e. they have low voltage requirements), and we are proud to say they have excellent compatibility with older cars with weaker electrical systems.

However, in general, some older vehicles (not only the BMW motorcycle in this question) appear to have a degraded ignition systems from age, resulting in sufficient voltage not being available from the coil.

For improved ignitability, the low heat range Iridium Power plugs have a spark gap of 1.1mm, and in vehicles with a significantly weakened electrical system, this may result in symptoms such as "rough idling" and "lack of power." Adjusting the spark to between 0.8 and 1.0mm should solve this problem.

However, because the center electrode is extremely thin, please have this adjustment done by a professional mechanic.

Q.14 I installed Iridium Power plugs on to my 2-wheel vehicle. Sometimes when I start it, there is a loud, explosive "pop." With regular plugs this did not happen. Why is the reason for this?

A.14 A loud explosive "pop" pop sound can have the following two causes:

(1) An afterfiring muffler

(2) Backfiring due to blowback from the carburetor

If it is the same vehicle and these symptoms were not there before changing to the new plugs, the reason for this is (1) afterfiring. The causes of afterfiring are:

(1) An abnormally elevated intake pressure, the combustion becomes unsteady (during engine brake)

(2) A problem with an ignition device (improper ignition timing, misfiring)

(3) The fuel-air mixture is too rich (problem with the carburetor, too much choke)

(4) The valve timing is off

If the problem is during starting, (2), (3), or (4) are thought to be the reason. A specific example for (2) is "ignition timing that is off" and specific examples for (3) include "a dirty air cleaner" and "pulling the choke too much."

We often hear that Iridium plugs improve ignitability so much that people "don't have to pull the choke to start the engine." If you are pulling the choke to full, try pulling it to the "halfway‡ point and see if this solves the problem.

Q.15 What kind of vehicles are surface gap plugs used for?

A.15 These are plugs developed for racing, and there are many people who use these plugs in the All-Japan Road Race Championship JSB1000 class and in drag racing. Because the ground electrode is gone, there are the following advantages and disadvantages.

■Advantages

[1] When the engine is tuned so that the compression ratio is increased, these can avoid interference with the piston.

[2] Because there are no excess projections into the combustion chamber, the combustion efficiency at high revolutions is improved.

[3] Difficulties due to the ground electrode can be prevented.

■Disadvantages

[1] The ignitability becomes worse, and thus feeling and response at low and mid-revolutions deteriorates.

(2) The engine characteristics become peaky; because of this, in the popular ST600 class, where conditions are severe, there are many people who use plugs with ground electrodes.

Q.16 Is it true that installation on Ducati water-cooled 4-valve engines is not possible?

A.16 Since the 996R, the interior of the Testastretta (narrow head) engine's plug holes have been very narrowly machined, and with regular plug wrenches, the socket OD hits the wall and thus the plugs cannot be fully tightened. (Not possible with a 21.5mm OD) In this case, a thin-wall plug wrench is required. [We recommend the "NB3-16SP (nepros)" or the "B3A-16SP" by KTC.]

Q.17 The plugs of racing karts are susceptible to carbon fouling, but how does Iridium Power do in this case?

A.17 We frequently hear that Iridium Power is resistant to carbon fouling compared to plugs from other companies. However, there is no way that they are a 100% solution, and it's good to know these techniques to prevent carbon fouling.

[1] When rolling in the race, close the carburetor's low needle or pinch the fuel pipe with your hand to prevent excess fuel from entering the engine.

[2] By pumping the accelerator during rolling, a rich fuel air mixture goes into the engine, making it easier for carbon fouling to occur. Operate the accelerator gently.

[3] If carbon fouling happens while running with the throttle fully open, this could mean that the heat range is too low or that the fuel mix is to rich. Consult with a kart shop to find the optimum setting.

Q.18 How is the compatibility with plug cords such as Nology?

A.18 There are no particular issues with compatibility. In fact, there are some cord manufactures who sell products "especially for iridium plugs."

Q.19 When changing plugs, is there any need to change the settings?

A.19 For normal vehicles, there is no need to change the settings. It is advisable to reset vehicles with modified exhaust systems, though in most cases adjusting the air screw is sufficient. (Except for racing carburetors such as FCRs)

Q.20 Is there a way to tell them apart when replacing them?

A.20 This can be done by confirming the level of wear (the gap width) on the ground electrode. DENSO's Iridium electrodes are different from conventional products in that their center electrodes hardly wear, and because of this it is better to check for wear on the ground electrode .

Q.21 The terminal on the end of the plug is frequently unnecessary on motorcycle, so why is this included with all types?

A.21 Iridium Power comes standard with a plug terminal (not including combined types). This is because some of the other companies' plug cords require a terminal, and at DENSO we decide our product specifications keeping in mind every customer.

Q.22 Are plugs such as VUH27D and VK24PRZ11 for Honda vehicles available as Iridium Tough plugs? Will they last 100,000km? Also, can Iridium Power be substituted here?

A.22 Plugs for 2-wheel vehicles with a "V" in the part number have a platinum tip welded to the ground electrode, the same as in 4-wheel vehicles. They have more durability than Iridium Power, but do last 100,000km. Thus we do not offer them as Iridium Tough products. You can choose the Iridium Power plug for those vehicle types with a compatible Iridium Power plug shown in the Model Chart; however, please understand that it will be not as durable.

Q.23 I'm using Iridium Power. If there is carbon fouling, can I use a brass brush to clean the plugs?

A.23 Because Iridium Power's center electrode has a fine 0.4mm diameter, there is a chance that this electrode could be bent by a brass brush. If you having the plug cleaned, a sandblaster-type plug cleaner found in maintenance shops is preferable. If this is the case, keep the air pressure low and clean the plug for as short a time period as possible. Also, one trick would be to dissolve the carbon with an engine conditioner or a similar chemical agent. (Parts cleaners will not dissolve carbon). After applying it, take a nylon brush (don't use a wire brush) and scrub it off, wash it well, and dry it off. Repeat this procedure three or four times to remove any carbon. DENSO has confirmed that this does not return the performance of the plugs to 100%, so please use this as a stopgap measure.

Q.24 The vehicle seems to be running worse now that I've installed them?

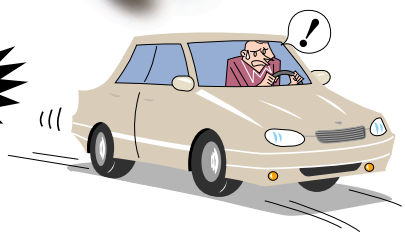
A.24 In most cases there is a problem with the vehicle. Scooters are often run for long periods of time without maintenance, and it is common to see them with richer fuel-air mixtures from dirty air cleaners. Our investigations have found that these vehicles tend to be susceptible to carbon fouling, and when replacing plugs also remember to inspect and clean the air cleaner. The effectiveness of the change should become even more apparent. Also for rough idling and problems starting, sometimes reducing the plug gap by 0.1 to 0.2mm will solve the problem.

By the time you notice, it's too late

Beware of FAKE

DENSO spark plugs. They will cause various kinds of problems!

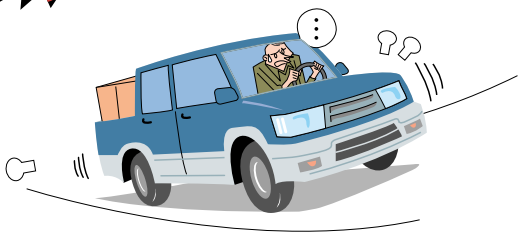
Problem 1



Exhaust fumes are dirty, fuel economy is poor, and ignition performance is poor when you fire up your engine.

Problem 2

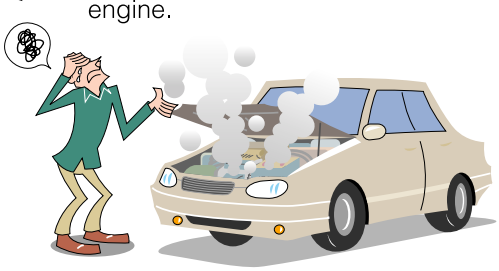
Engine power drops suddenly during an uphill climb or under heavy load.



You won't suffer from these problems with genuine DENSO spark plugs.

Problem 3

A fake DENSO spark plug's electrode will melt when subjected to high temperature, damaging your engine.



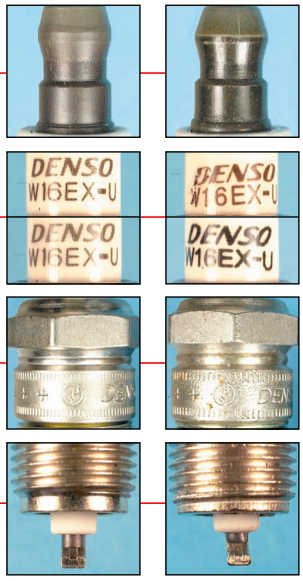
Ask for DENSO spark plugs from our authorized dealers.

Comparison Between Genuine DENSO and Fake Spark Plugs

Comparison of DENSO and Fake

Appearance

DENSO | Fake



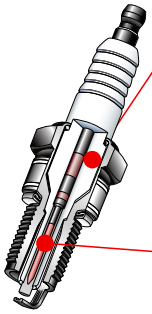
Terminal
Terminal has a glossy finish.

Markings
Printed wording can be scraped off.

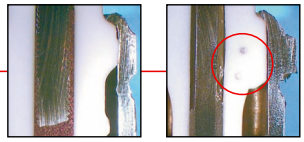
Housing
Poor surface finish.

Screws & Electrode
Poor thread quality and finish.

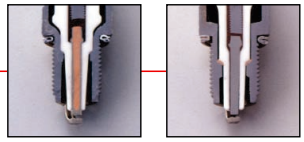
Section



DENSO | Fake



Ceramic Insulator
Poorly manufactured ceramic insulator with visible air bubbles trapped within which affect heat dissipation capability.

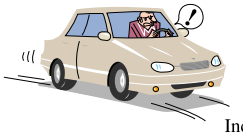


Center Electrode
A genuine DENSO spark plug has a copper-core center electrode with excellent heat conductivity. A fake DENSO spark plug does not, retaining heat that causes meltdown.

Problems Caused by Fake Spark Plugs

Problem 1

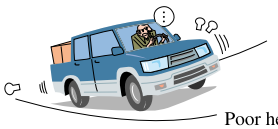
Fuel economy is diminished.



Inconsistent sparking causes incomplete combustion. Unburned fuel forms a black sooty deposit on the spark plug, eventually leading to poor fuel economy and poor start up of the engine.

Problem 2

Engine power drops on uphill roads and highways.



Poor heat dissipation due to the lack of a copper-core center electrode causes pre-ignition. As a result, engine power drops under highway driving or uphill driving conditions.

Problem 3

The plug melts down.

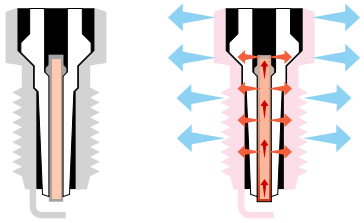
Continued usage of an overheated plug will damage the electrodes.

Why Power Drops and Melting Occurs

(See below)

DENSO

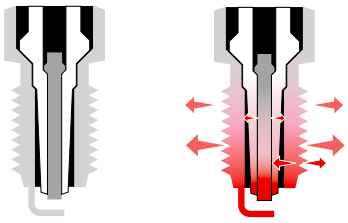
DENSO plug contains copper core



Quick heat dissipation.
Copper is an excellent heat conductor. High temperature heat is quickly dissipated away from the center-electrode to prevent melt down.

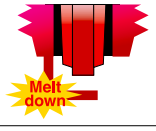
Fake

Fake plug is iron only



Slow heat dissipation.
Absence of a copper-core center electrode results in poor heat dissipation capability. Prolonged use causes power loss due to excessive heat buildup. This results in melt down of the ground electrode, eventually leading to serious engine damage.

Finally ...



DENSO PLUGS site English version opened

Introduction of the IRIDIUM POWER series

PR space

Updated information

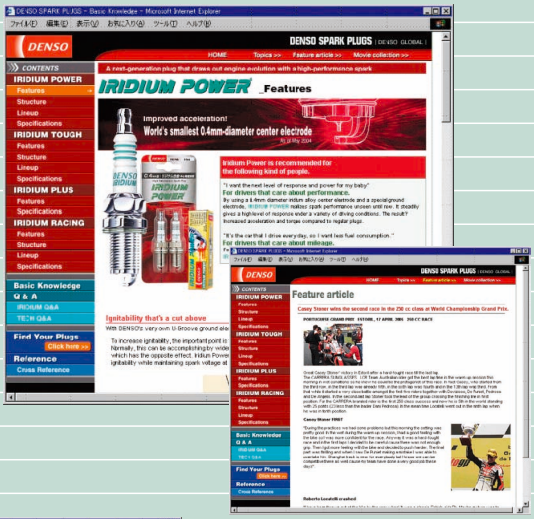
Basic plug information and Q&A

Appropriate information retrieval

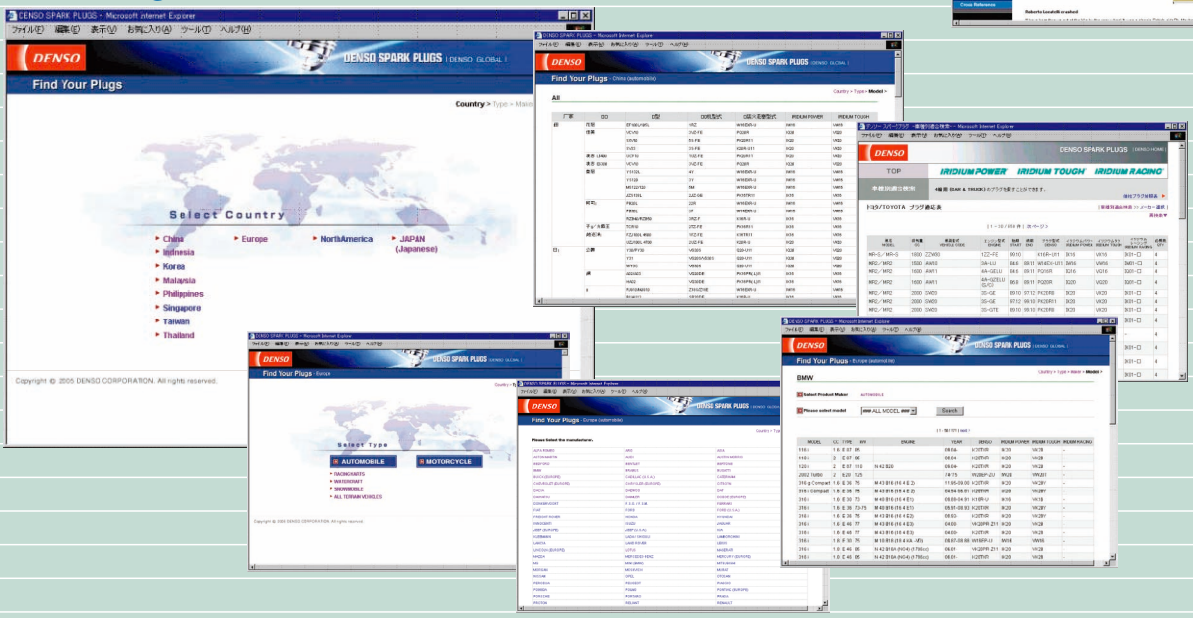
Movie

Master brochure data download

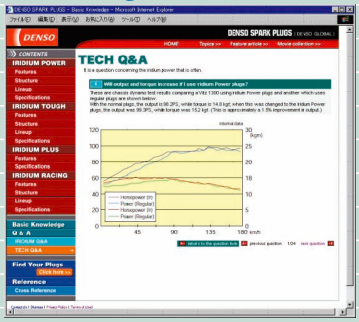
This site mainly provides product and race support information.

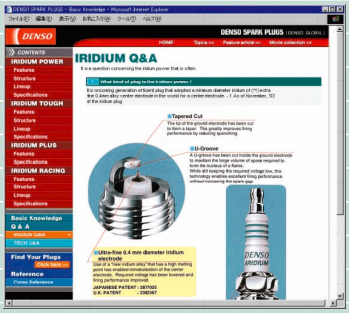


A lot of plug information is contained



Basic plug information and Q&A are provided.





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