Instruction Manual

Measuring spark plugs

Type 6113C...
Type 6115C...
Type 6118C...

6113C_002-797e-07.23

Foreword

Thank you for choosing a Kistler quality product characterized by technical innovation, precision and long life.

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Content

Total pages 24

1. Introduction

Please take the time to thoroughly read this instruction manual. It will help you with the installation, maintenance, and use of this product.

To the extent permitted by law Kistler does not accept any liability if this instruction manual is not followed or products other than those listed under Accessories are used.

Kistler offers a wide range of products for use in measuring technology:

- Piezoelectric sensors for measuring force, torque, strain, pressure, acceleration, shock, vibration and acoustic-emission
- Strain gage sensor systems for measuring force and torque
- Piezoresistive pressure sensors and transmitters
- Signal conditioners, indicators and calibrators
- Electronic control and monitoring systems as well as software for specific measurement applications
- Data transmission modules (telemetry)

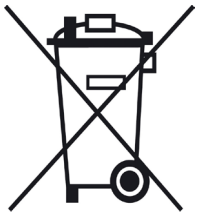
Kistler also develops and produces measuring solutions for the application fields engines, vehicles, manufacturing, plastics and biomechanics sectors.

Our product and application brochures will provide you with an overview of our product range. Detailed data sheets are available for almost all products.

If you need additional help beyond what can be found either on-line or in this manual, please contact Kistler's extensive support organization.

2. General notes

2.1 Disposal instructions for electrical and electronic equipment



Do not dispose of old electronic instruments in municipal trash. For disposal when the product has come to the end of its service life, please return it to an authorized local electronic waste disposal service or contact the nearest Kistler Instrument sales office for return instructions.

2.2 Software upgrades and updates

Kistler may occasionally supply upgrades or updates for embedded software. Such upgrades or updates must always be installed.

Kistler declines any liability whatsoever for any direct or consequential damage caused by products running on embedded software that has not been upgraded or updated with the latest available software.

3. Features and selection of spark plugs

3.1 General

Kistler measuring spark plugs Type 6113C…(M10), 6115C…(M12) and 6118C…(M14) permit cylinder pressure measurement without a separate measuring bore. The world's smallest piezoelectric high temperature cylinder pressure sensor is integrated into the measuring spark plug. The sensor is installed flush-mounted, ensuring that the system has a high natural frequency. All three types are therefore also suitable for indication at high engine speeds and for knock detection.
The sensor cable and the ceramic of the measuring spark plugs are exchangeable and serviceable (Chapter 5).
All three types are available in different geometries with various heat ranges and spark positions. Kistler PiezoSmart automatic sensor recognition is available as an option.

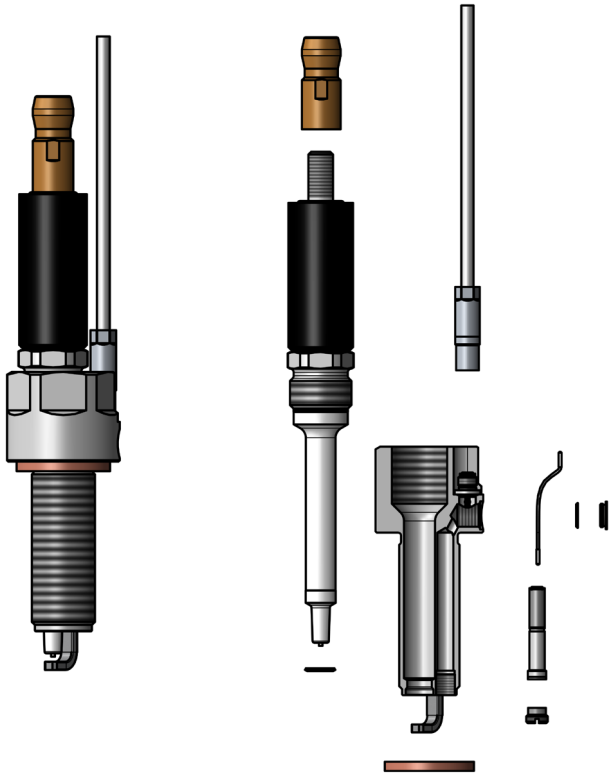


Fig. 1: A typical measuring spark plug and its components

3.2 Characteristic data of a spark plug

Spark plugs are available in various geometries and designs.
The most commonly used thread sizes are M10, M12, and M14.
Depending on the engine used, spark plugs can vary in terms of:

- Thread length
- Seal seat (flat or tapered seal)
- Heat range
- Spark position
- Max. depth
- Electrode gap
- Diameter of the ceramic and length of the insulator

Fig. 2: Example of an original spark plug

3.3 Ignition voltage

Kistler spark plugs are designed for a maximum ignition voltage of 40 kV (Type 6113C) and 45 kV (Type 6115C and 6118C). This value can be exceeded depending on the electrode gap and ignition energy. It is therefore important to maintain the electrode gap defined by Kistler. The greater the gap, the greater the ignition voltage, and, consequently, the more the unit is subject to wear. Also see section 3.5.4.

3.4 Kistler Type designation for measuring spark plugs

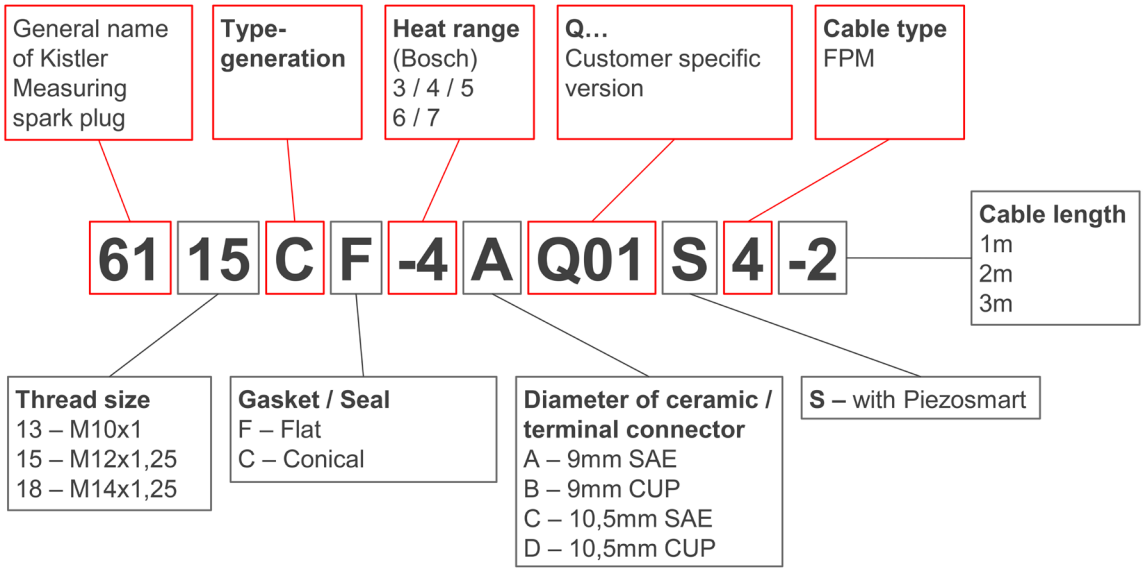
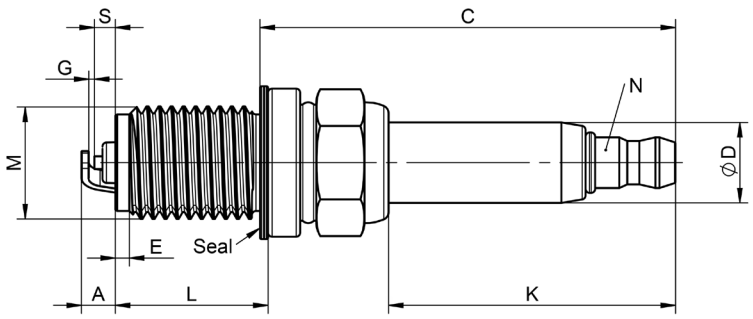


Fig. 3: Ordering keys of measuring spark plugs

3.5 Selecting a measuring spark plug

The selection of a measuring spark plug is determined by the original spark plug used. To be able to select a suitable measuring spark plug for your application, Kistler needs to know the specification of the original spark plug when you make an inquiry. The request sheet (Fig. 4) can be found in the datasheet. If this information is not available, an original spark plug can also be measured. It is not possible to make selection solely from the type number. There is no reference list available containing the exact geometric and electrical data of spark plugs. Kistler relies on the information provided by the customer for this.

Selecting a Measuring Spark Plug



Date	
Sales Center	
Kistler Account Manager	
Customer	

Questions Regarding the Engine

Brand/type		
Spark plug bore: Minimum diameter	mm	Shape: ☑ straight ☒ bent
Fuel	☐ Gasoline / E0 - E10 ☐ E85 / E100 ☐ CNG / LPG ☐ _____	

Questions Regarding the Spark Plug

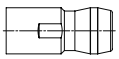
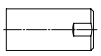
Brand/type					
Thread	**M**	M x	Thread length	**L**	mm
Spark position	**S**	mm	Maximum depth	**A**	mm
Electrode spacing	**G**	mm	Insulator diameter	**D**	mm
Isolator length	**K**	mm	Length from seal	**C**	mm
Thread retreat	**E**	mm	Heat value (Bosch/OEM)		
Cable length (indicate)		☑ 1 m ☒ 2 m ☒ 3 m	PiezoSmart (indicate):		☒ Yes ☑ No
Ground electrode shape factor		☐ none ☐ Roof electrode	☐ Roof electrode with needle ☐ Side electrode(s)		
Seal type	**SEAL**	☑ flat ☒ Compression seal	☒ conical ☒ Solid seal (thickness ____ mm)		
Cable connection nut	**N**	☑ SAE 	☒ CUP 		
Defined ground electrode system (indexed mounting)		✓ no (standard)	☒ yes (please send OEM spark plug)		
Initial order amount		Piece			
Customer contact person			Signature		
Note					

Fig. 4: Original spark plug data

3.5.1 Thread Type "M" and thread length "L"

The following Kistler measuring spark plugs are used according to the dimensions of the original spark plug:

- Type 6113C with M10x1 thread
- Type 6115C with M12x1,25 thread
- Type 6118C with M14x1,25 thread

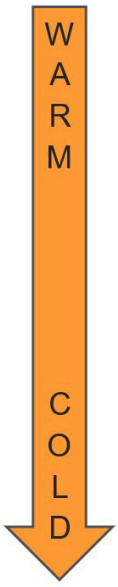
M12 and M14 spark plugs are the most common for passenger car engines, while motor cycle engines predominantly use M10 spark plugs. The thread length is based on the geometry of the cylinder head.

3.5.2 Seal seat

Selecting a seal seat is determined by the original spark plug. Kistler measuring spark plugs are available with a flat seal or conical seal seat.

3.5.3 Heat range

The heat range of a spark plug describes its ability to absorb heat and dissipate it. The heat range is important since, on the one hand, a determined minimum temperature needs to be reached (self-cleaning temperature) to prevent deposits (primarily during idle running and at low load) and hence misfires. On the other hand, it should also not result in overheating and pre-ignitions. The correct heat range of the original spark plug is determined by full load measurements and also takes into account any changes which may occur due to aging of the spark plug and/or engine. How the heat range for the original spark plug is defined, however, varies from manufacturer to manufacturer. Kistler spark plugs are classified according to the Bosch heat range. A comparison table therefore needs to be used to determine the corresponding heat range (Fig. 5). If possible, the original heat range should be applied. An original spark plug can be replaced with a measuring spark plug of a colder heat range but not with one of a warmer heat range. For example, a spark plug of heat range 6 can be replaced with a spark plug of heat range 5 but not vice versa.



NGK	DENSO	CHAMPION	BOSCH
2	9	18, 19	10
4	14	14, 16	9
5	16	11, 12	8
6	20	9, 10	6, 7
7	22	7, 8	5
8	24	6, 61, 63	4
9	27	4, 59	3
9,5	29	57	
10	31	55	2
10,5	32	53	
11	34		09
11,5	35		07
12	37		

Fig. 5: Heat ranges of original spark plugs

3.5.4 Spark position "S" and maximum depth "A"

The optimum position of the ignition spark depends on the geometry of the combustion chamber and the combustion process. With a spray-guided combustion process in particular, the injection spray is pointed directly at the electrode. The spark position "S" and the position of the ground electrode are particularly important in such cases. Measuring spark plugs with a precisely defined ground electrode position when installed, can be manufactured on request.
The spark position "S" of the measuring spark plug should be orientated towards the value of the original spark plug. The maximum depth "A" indicates how far the ground electrode protrudes into the combustion chamber. The measuring spark plug must not protrude any further into the chamber than the original spark plug. This is to prevent collision with moving parts.

3.5.5 Electrode gap "G"

In a gasoline engine, the mixture of gasoline and air is ignited externally by flashover between the electrodes of the spark plug. This flashover depends on the density of the gasoline mixture between the electrodes, electrode gap and the electrode geometry. The required ignition voltage must be provided for all the operating conditions of the engine, particularly at high load as well as with increased electrode wear.
For this reason, Kistler recommends checking the electrode gap periodically every 50 h and adjusting it to the minimum.

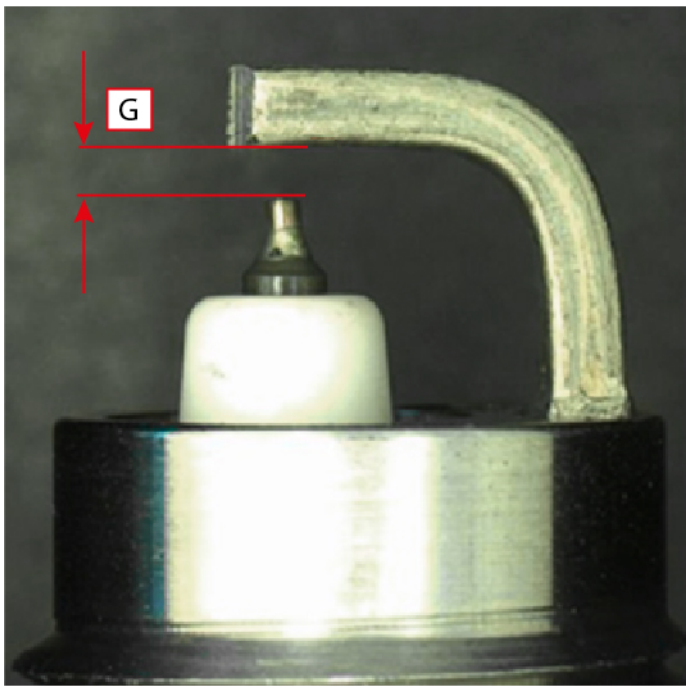
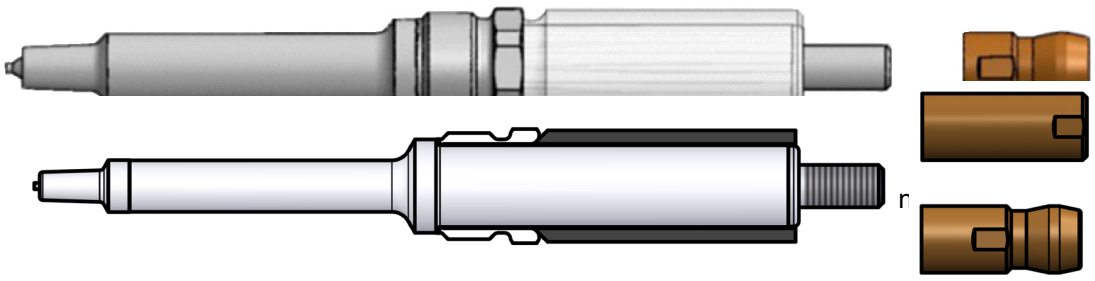


Fig. 6: Electrode gap

3.5.6 Ceramic diameter "D" and insulator length "K"

The diameter of the ceramic "D" and length of the insulator "K" should ensure an optimum connection between the ignition coil and the measuring spark plug. Special attention should be paid to make sure that there is no air gap between the insulator and the ignition coil. Kistler uses isolators of size 7,7 mm with built-in diameter adaption made from glass fibre reinforced plastic (GRP), size 9 mm or 10,5 mm.
Length and connector type of the insulator can be adapted to that of the original spark plug using an individually adjusted SAE nut or a CUP connector.



4. Commissioning

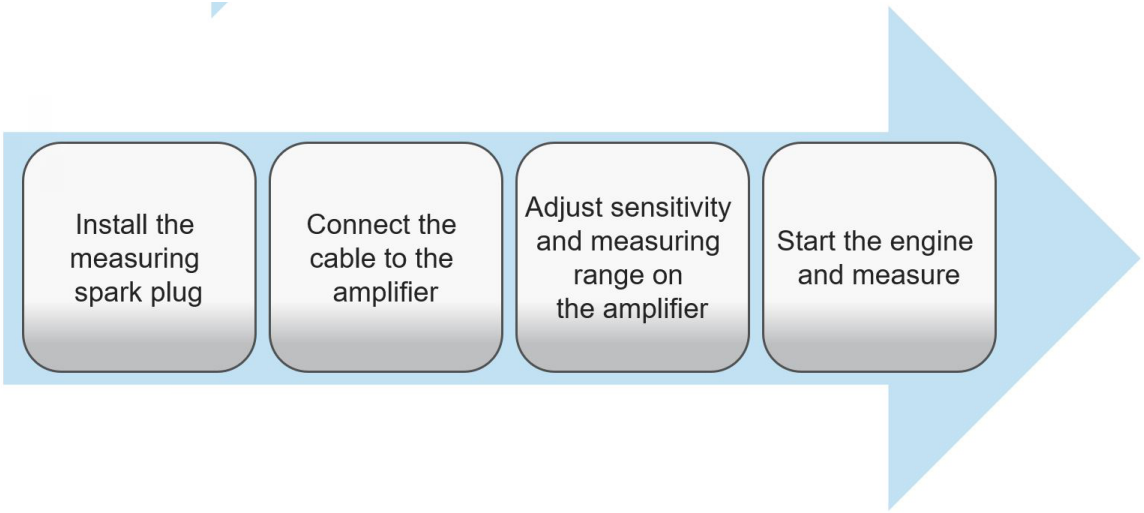


Fig. 8: Installation process

In engines equipped with aluminum cylinder heads, the material around the measuring spark plug expands more than the measuring spark plug itself when heated. This can cause the measuring spark plug to become stuck. As a general rule, Kistler therefore recommends mounting and removing the measuring spark plugs only when the engine has cooled down completely.
Depending on the installation situation and the type of measuring spark plug, it is important to check how the sensor cable can be mounted before installation. There is no space for this in the ignition coil and it can therefore result in damage to the sensor cable and the connector. The connector of the ignition coil is to be adapted to the installation situation using workshop tools if required.

4.1 Scope of delivery and accessories

Please refer to the data sheets of the measuring spark plug for the scope of delivery and accessories:

- Type 6113C document number 003-281
- Type 6115C document number 003-269
- Type 6118C document number 003-280

4.2 Installation

Please pay attention to the following when mounting the measuring spark plug:

The contact surfaces on the spark plug and the cylinder head, as well as the thread of the measuring spark plug and the mounting bore in the cylinder head must be clean. The cable and the ignition coil must also be clean, dry and free of oil. The sensor cable in particular should be free from oil contamination and should not be damaged.
Guide the cable of the sensor carefully through the mounting tool. Hold on to the sensor and mounting tool while doing this; there should be no tension on the cable. Mounting examples for various bore diameters and the suitable mounting tools can be found in the datasheets. Gently lubricate the thread with anti-seize paste for high alloy steels and screw in the measuring spark plug by hand. The measuring spark plug must then be tightened using Type 1300A11 torque wrench and the correct torque in accordance with the recommendation in Fig. 10. Once this has been done, the installation wrench can be carefully removed – make sure not to damage the cable.

Fig. 9: Torque wrench Type 1300A11 and fork wrench insert Type 1300A15

Tightening torque in Nm		
Thread	**Cylinder head**	
Flat seal	Cast iron	Light metal
M10x1	10 … 15Nm	10 … 12Nm
M12x1,25	15 … 25Nm	10 … 15Nm
M14x1,25	20 … 35Nm	15 … 30Nm
Conical seal	Cast iron	Light metal
M12x1,25	15 … 25Nm	10 … 15Nm
M14x1,25	15 … 25Nm	12 … 20Nm

Fig. 10: Tightening torque

4.3 Mounting the spark plug terminal/ignition coil

Apply a thin layer of ZK mounting grease Type 1067 to the insulator. This prevents the plug to become fastened in place and facilitates later removal.

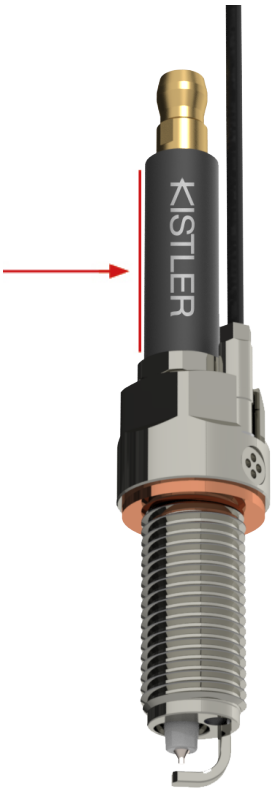


Fig. 11: Application of a thin layer of mounting grease Type 1067 to the ceramic / adaption (arrow)

Then, mount the spark plug terminal or ignition coil carefully to the measuring spark plug. It is particularly important to ensure that the ignition coil is fixed properly to minimize the lateral forces occurring on the insulator of the spark plug.

The spark plug terminal/ignition coil must not push down on the cable connector of the measuring spark plug or damage the cable. The connector of the ignition module is to be adapted to the installation situation using workshop tools if required.

4.4 Connecting the sensor cable

The cable must not be kinked or unsupported. It must be routed so that it is protected from vibration and heat (such as exhaust pipe or radiant heat from the turbocharger) and then fixed in place. The cable includes a high-insulation coaxial cable. Any contamination caused by oil, grease, and aggressive liquid substances on the connector can impair the measuring results.

The cable is screwed on to the delivered BNC coupling (Type 1721), hand-tightened, and connected to the amplifier (only measuring spark plugs without PiezoSmart function).

4.5 PiezoSmart

Kistler PiezoSmart automatic sensor recognition is available for all measuring spark plug types.

4.6 Using an ignition cable extension

An extension cable can be used for spark plugs in applications on the test bench in which the engine is accessible and is installed as a stationary unit. Fig. 12 and Fig. 13 show the corresponding cable.

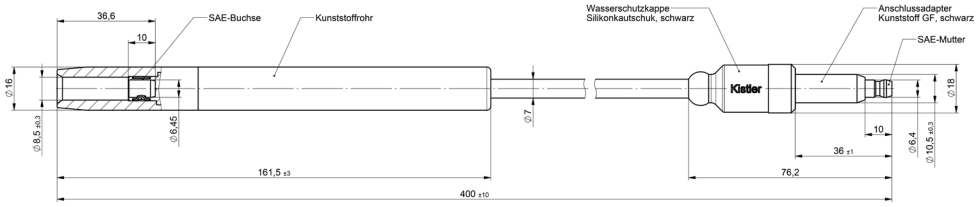


Fig. 12: Ignition extension cable for SAE connection Type 1500B97A1/1500B97A2

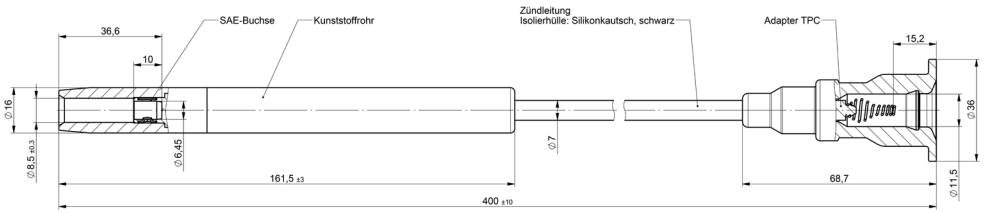


Fig. 13: Ignition extension cable for SAE connection with TPC Adapter Type 1500B97A3/1500B97A4

Kistler offers the following 400mm long cable variants for isolator diameters of 9mm and 10,5mm:
- Types 1500B97A1 and 1500B97A2 with SAE connection
- Types 1500B97A3 and 1500B97A4 with TPC adapter for a direct mounting on the ignition coil.

In this case, the spark plug terminal is extended by around 400 mm. The spark plug rail or the ignition coil do not have to be fixed in the original position. The ceramic must have the correct diameter (d = 10 ... 11 mm) in order to ensure correct installation on the spark plug.
When using measuring spark plugs with CUP connection it is necessary to replace these by the SAE nut of the extension cable (if required, Kistler may provide longer SAE connection nuts). Then, the CUP connection can mounted at the end of the cable to the spark plug replica and the ignition coil can be adapted. Use workshop equipment to secure the ignition coil.

4.7 Removal

First, remove the sensor cable from the amplifier and disconnect it from the BNC coupling (for PiezoSmart versions only). Then, remove the ignition coil / spark plug terminal from the measuring spark plug. After that is done, guide the sensor cable through the mounting tool and engage it with the measuring spark plug. Ensure that the mounting tool sits correctly on the measuring spark plug. Now start to remove the measuring spark plug by turning it carefully anti-clockwise – but only 2 complete rotations at this stage. To prevent any dirt particles entering the thread of the cylinder head or the combustion chamber, the measuring spark plug recess should now be cleaned using compressed air or a brush. The measuring spark plug can now be completely unscrewed. If the measuring spark plug is jammed, just unscrew it a little to prevent the thread of the cylinder head becoming damaged. A few drops of oil or a solvent containing oil can help the thread move smoothly again. Then, screw the measuring spark plug back in again to allow the solvent to take effect. After allowing the solvent to take effect for a short amount of time, the measuring spark plug can be completely unscrewed.

Once the measuring spark plug is completely unfastened, carefully remove it from the mounting bore. Make sure that the cable does not become crushed or damaged as you do this.

5. Maintenance

5.1 Cleaning and checking the electrode spacing

The measuring spark plug requires regular maintenance to ensure that it works reliably throughout its period of use. While the engine is in operation, the spark plug gets dirty (soot and accumulation of oil) and the electrodes become worn. If the spark plug is heavily polluted or worn, this prevents consistent flashover between the electrodes. In such cases, reliable ignition can no longer be ensured. Kistler therefore recommends cleaning the measuring spark plugs periodically, checking the condition of the electrodes every 50 h, and adjusting the electrode spacing if necessary.

How to clean the spark plugs

1. Remove the spark plug from the engine (Chapter 4.7).
2. First, clean the thread with a brass brush and then with Type 1003 cleaning spray.
3. Note: The measuring spark plug must never be cleaned with a spraying machine or abrasives.
4. Check the spark plug for deposits and for any cracks in the insulator, and check for any worn out electrodes.
5. The ceramic isolator must be cleaned – in case of a damage, the isolator can be replaced by Kistler (Chapter 5.4).
6. Test the electrode spacing with a feeler gauge and adjust if necessary (Fig. 14).
7. Screw on the terminal connection nut and then tighten it (0.5 N·m)
8. Maintenance is complete and the spark plug can be re-installed in the engine (Chapter 4.2).

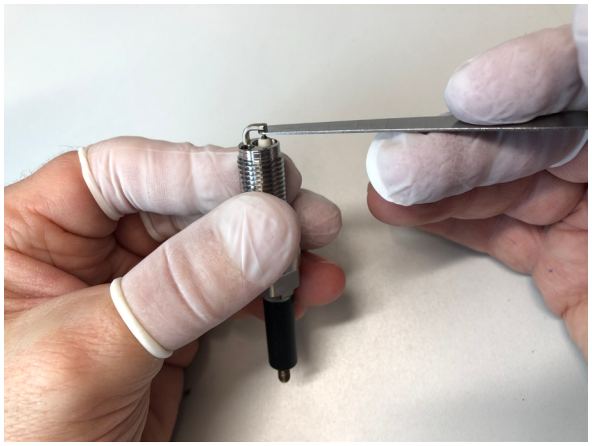


Fig. 14: Checking the electrode spacing with a feeler gauge

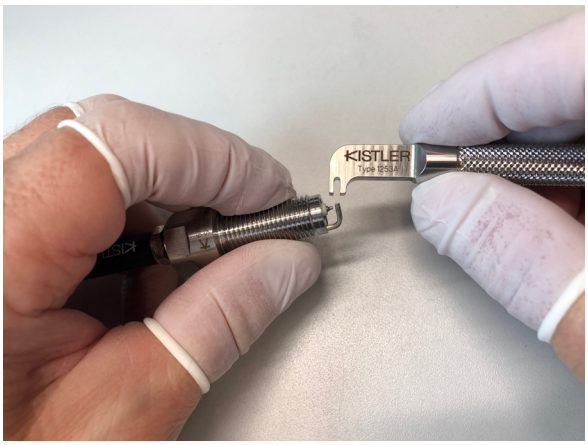


Fig. 15: Adjust the electrode spacing using tool Type 1253A

Fig. 16: Adjusting the electrode spacing using a vise – carefully clamp the electrode

Fig. 17: Adjust the electrode spacing by carefully applying a vertical force

Fig. 18: Commercially available feeler gauge

5.2 Replacing the sensor cable

The sensor cable can be checked by the user and replaced if necessary.

Approach

1. Check the condition of the cable. It should be replaced if it shows any signs of damage (cuts, damaged insulation, excessive bending). Continue with point 3.
2. Test the insulation resistance of the cable using a suitable measuring device (Kistler Type 5493). The cable should be replaced if the insulation is below the required minimum value of 10^{13} Ω.
3. Detach the defective cable from the spark plug with the tool Type 65007991.
4. Take the new cable out of its packaging (See the data sheet of the spark plug for the right part number). Clean the terminal contacts with the Kistler Type 1003 cleaning spray and then dry using compressed air spray. Once this has been done, the cable can be mounted and then tightened (hand-tight).

Typ 5493

Fig. 19: Insulation measuring device

Typ 1003

Fig. 20: Cleaning spray

5.3 Replacing the pressure sensor

The pressure sensor itself is not intended to be replaced by the user.
The highly insulated parts of the measuring chain must be exchanged under laboratory conditions with absolute cleanliness. Once it has been replaced, the measuring spark plug needs to be calibrated and its seal tightness needs to be checked.
If the pressure sensor needs replacing, the measuring spark plug must be sent to a Kistler Service Center.

5.4 Replacing the insulator

The ceramic insulator can be replaced if damaged. After it has been replaced, the seal tightness of the measuring spark plug needs to be checked.
If the ceramic insulator needs to be replaced, the measuring spark plug must be sent to Kistler.

6. Troubleshooting

6.1 General information

Abnormal engine operation can be caused by several factors:

- Spark erosion and corrosion:
  Result from thermal load, using the wrong or poor-quality fuel as well as the incorrect spark plug heat range. This results in melted electrodes, pre-ignition, and misfiring due to the increased electrode spacing.
  Pre-ignition:
  The air-fuel mixture is ignited erratically by over-heated components (valves, spark plugs with the incorrect heat range) and is not defined by the spark plug. The sharp increase in temperature resulting from this can cause damage to the engine.
- Knocking combustion:
  Is an erratic, quick combustion with a sharp rise in pressure which is triggered by the self-ignition of the air-fuel mixture and not the spark plug. The sharp rise in pressure and the high temperatures can cause damage to the engine. Knocking is triggered by fuel which has an incorrect (too low) octane number, incorrect ignition timing, or too high compression, among other factors. Combustion residues which have an afterglow can also trigger self-ignition (pre-ignition).

6.2 Misfiring

- During idle running:
  Misfires during idle running indicate a defective ceramic insulator or that the electrode spacing is incorrect. In addition, the incorrect heat range could also have been selected.
- At full load:
  The difficult ignition conditions can lead to flash-over on the body of the spark plug. This can be remedied by adjusting the electrode spacing to the lower tolerance level. Another reason could be that the insulator and the ignition coil do not fit correctly. If this is the case, check that the ignition coil and the insulator are fitted securely.

  Check the measuring spark plug in accordance with the check-list in Fig. 21.

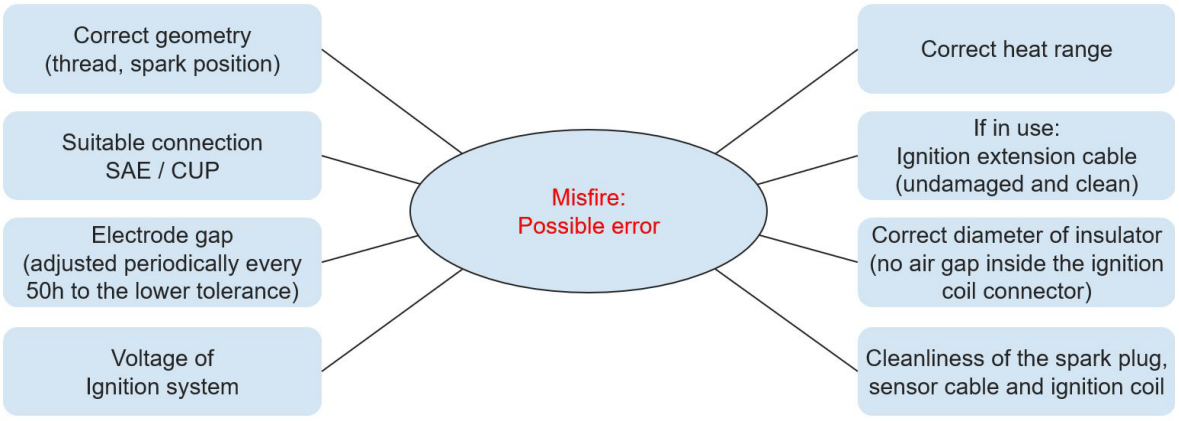


Fig. 21: Checking the important points for measuring spark plug

7. Appendix

A. Technical data

Please refer to the data sheets of the measuring spark plug for the technical data:

Type 6113C document number 003-281
Type 6115C document number 003-269
Type 6118C document number 003-280

B. Publication references

BOSCH technical information [www.bosch.de]

Special print:
Pressure Indication with Measuring Spark Plugs
for a Fuel Injection Gasoline Engine – State of the Art
Doc. no. 920-333e

Special print:
Pressure Indication during Knocking Conditions
Doc. no. 920-349e