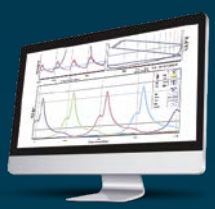
PRODUCT CATALOG

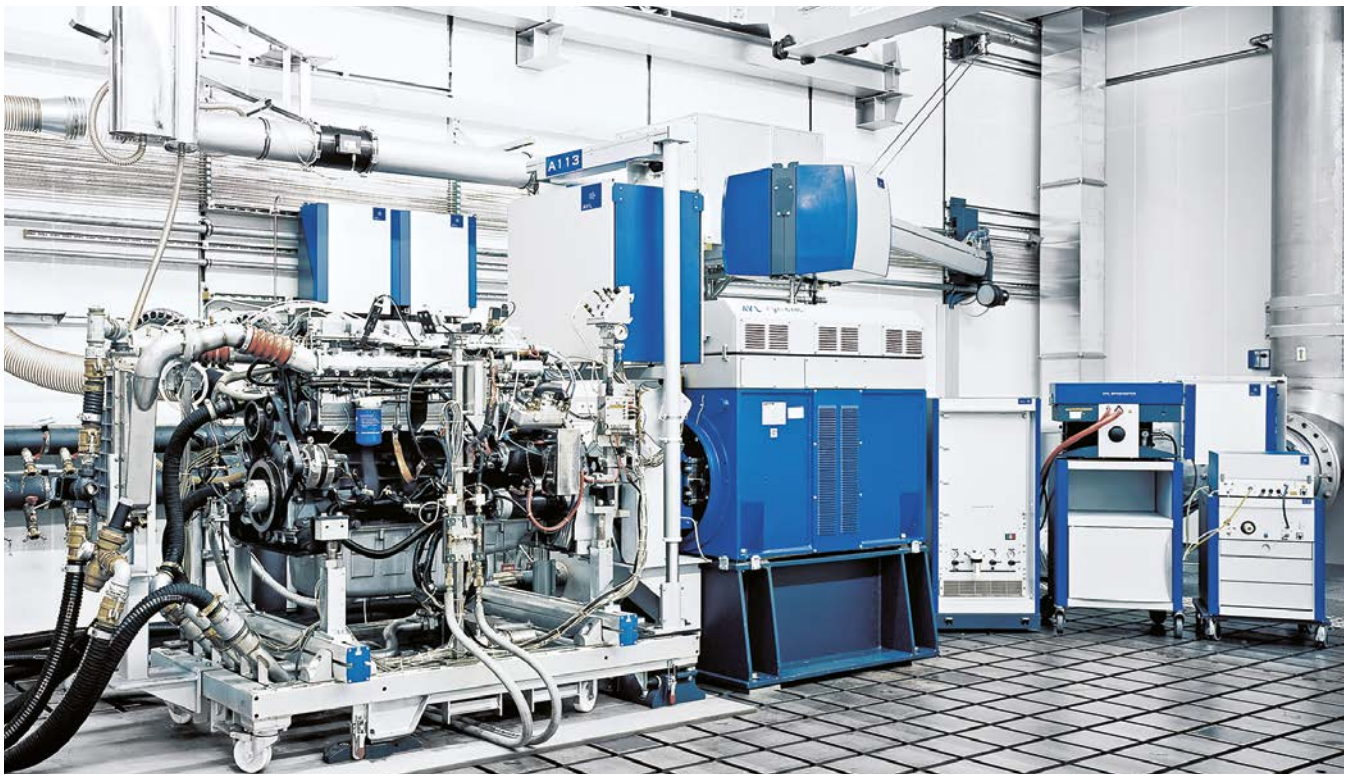
SENSORS FOR COMBUSTION ANALYSIS

Content

1 Introduction



Combustion measurement technology from AVL



CHALLENGE

These days legislation acts as a major driving force in the automotive industry and pushes current development trends. Effective drive systems with the lowest emissions possible at moderate costs will be in high demand for all engine sizes. At the same time the market is changing rapidly as a result of new manufacturers appearing on the market and intensifying the competitive pressure on all OEMs. All these circumstances lead to radically shortened development cycles in general. Due to peripheral conditions combustion analysis will increasingly become the central focus of tests because future engine maps for example will incorporate several combustion concepts. Therefore all test engineers, calibration engineers, development engineers as well as test-field managers are facing increasing complexity and need stronger interaction and correlation between combustion analysis results.

COMPLETE TOOLBOX FOR COMBUSTION ANALYSIS

AVL is worldwide the only supplier being able to offer solutions for the complete field of combustion analysis. Based on detailed knowledge and experience in the methodology of combustion analysis AVL has created practical tools and devices that make the complex thermodynamic processes in the engine visible and understandable.

SINGLE CYLINDER RESEARCH ENGINE

AVL single cylinder research engines offer the significant advantage of testing under realistic engine conditions before translating to the full production engine. From small car engines up to commercial engines they are equipped with optical top works which offer transparent access to the combustion chamber.

AVL PRESSURE SENSORS

A precise, stable, and highly accurate cylinder pressure signal delivered by the pressure sensor is the basis for high quality combustion analysis. AVL provides a wide range of sensors needed for combustion analysis tasks.

DATA ACQUISITION PLATFORM – AVL X-ion™

Confronted with the growing diversity and complexity of modern powertrains, AVL has developed AVL X-ion™ – the cutting-edge high-speed data acquisition platform. X-ion is a modular acquisition system that can be easily adapted to different units under test and test environments. The X-FEMs optimally combine the analog-digital converter with signal conditioning. The unique architecture offers outstanding signal quality, especially of interest for thermodynamic analysis of cylinder pressure signals.

DATA ACQUISITION AND ANALYSIS SOFTWARE – AVL IndiCom™

AVL IndiCom™ provides deep understanding of the combustion process, which is essential to making modern engines clean and efficient. The software offers advanced measurement setup and automation, multiple interfaces, versatile calculation tools, and powerful display objects. AVL IndiCom™ and its offline counterpart – AVL CONCERTO™ – guarantee unparalleled robustness and quality of the engine development process.

MONITORING SOFTWARE – AVL EPOS™

AVL provides a complete measuring chain for condition monitoring consisting of robust monitoring sensors with in-line signal amplifiers and an acquisition system with intelligent system diagnostic software implemented. The system is especially designed for use with large marine or stationary engines.

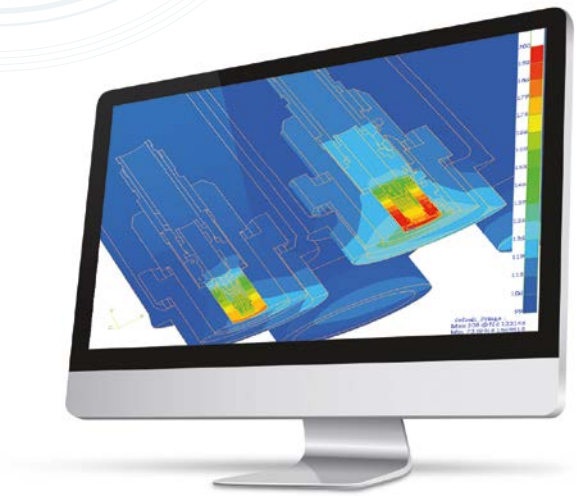
Pressure sensors for combustion analysis from AVL

SENSOR PORTFOLIO FOR COMBUSTION ANALYSIS

AVL offers sensors for a wide range of combustion analysis applications. Sensors for measurement of the combustion pressure are available as well as sensors for absolute pressure measurements in injection lines and hydraulic systems. TDC (top dead center) sensors, sensors for needle lift and valve lift can also be found in the portfolio. The precise determination of the crankshaft position can be achieved with AVL crank angle encoders.

QUALITY STANDARDS AND PRODUCTION TECHNIQUES

To control carefully the entire production process, AVL manufactures all of its critical sensor components in-house. Our own advanced processes were developed for temperature resistant coatings, clean room mounting, electron beam welding, state-of-the-art calibration and testing procedures. To guarantee the highest quality standards for the customer every single sensor is tested on a real engine and calibrated before it is delivered.



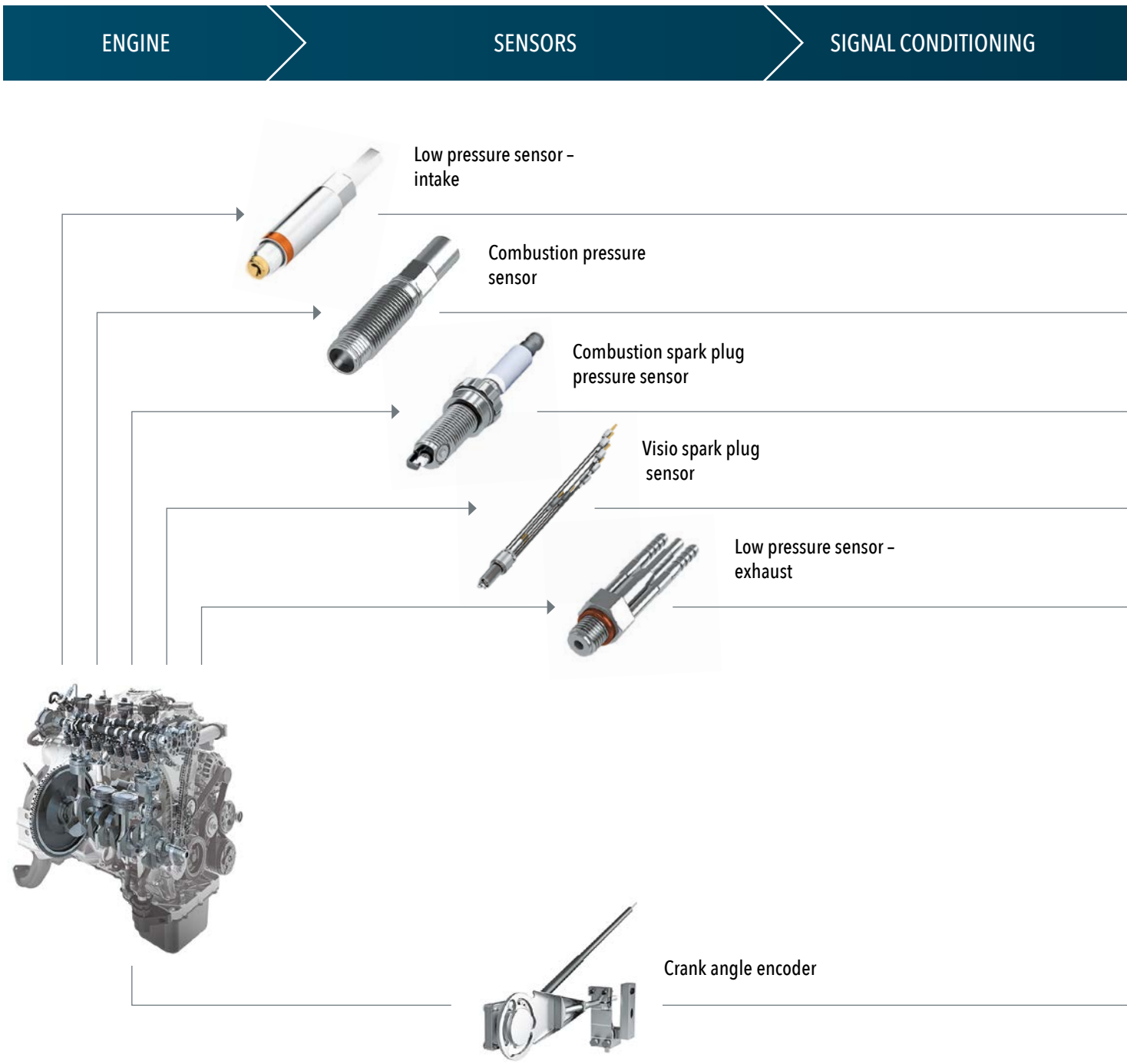
RESEARCH AND DEVELOPMENT

To achieve the desired precision the design of every single part requires high-tech know-how from the development department along with innovative computer aided modeling algorithms. One example of the unique methods AVL practices is the use of trimmed piezo elements together with the Double Shell™ design of the sensor housing. This helps to reduce any negative influences on the signal to a non detectable level and ensures optimum results.

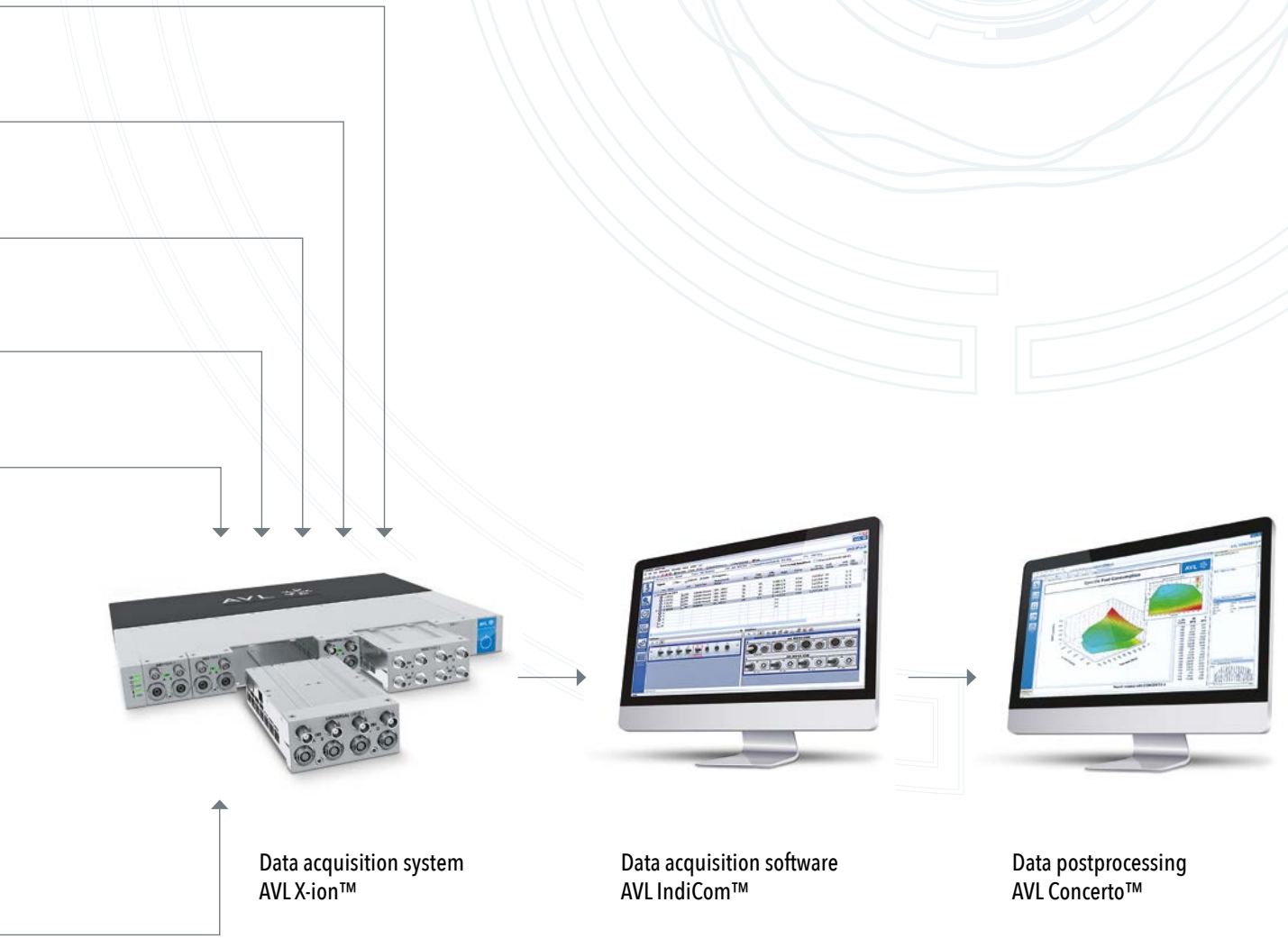
PRECISION MANUFACTURING AND ASSEMBLY

A piezoelectric sensor consists of up to 22 parts. Some of them are just a few tenths of a millimeter in size. This requires production tolerances similar to those for optical parts and assembly techniques like those used for mechanical watches. The core of all piezoelectric sensors is a set of piezoelectric crystals. Uncooled and one type cooled sensors from AVL use the patented crystal material $GaPO_4$ which is produced only at the AVL headquarters in Austria.

Setup of the measurement chain



DATA ACQUISITION | PARAMETERIZATION / ONLINE EVALUATION | OFFLINE PAST PROCESSING

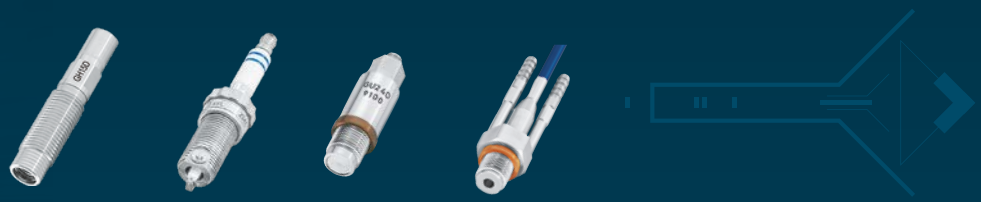


Data acquisition system
AVL X-ion™

Data acquisition software
AVL IndiCom™

Data postprocessing
AVL Concerto™

2 Pressure Sensors



How to choose the right sensor and accessory

Each measurement task and application requires a specific solution to achieve maximum precision and high quality data. AVL offers a complete range of pressure sensors and accessories for combustion analysis. In order to make the choice of the right equipment more convenient AVL offers several tools.

The product selection guide starts with a list of common questions and problems a customer typically faces in the decision making process when selecting a sensor. Depending on how the question is answered a page reference within the chapter is given which can act as a starting point in selecting the correct pressure sensor.

The use and interpretation of icons

"How can sensors be quickly classified according to their performance and usability?" The icons used in the datasheets and in the comparison chart help to classify a sensor quickly according to its strengths and key features. There are two different types of icons. The first type 'strength' indicates how well a sensor is suitable for a specific measurement task or application field. Further the icons for strength are rated from one to three stars (standard, good, excellent suitability). The second type "key feature" gives information about the special technical components or design features.

ICONS OF STRENGTH / MEASUREMENT TASK

Toughness / knock applications

Purpose: Specially designed to withstand under extreme and harsh conditions.

Examples: Analysis of knocking combustion, operation under high engine loads and supercharged engines

Precision / thermodynamic analysis

Purpose: Highly accurate measurements for critical thermodynamic analysis.

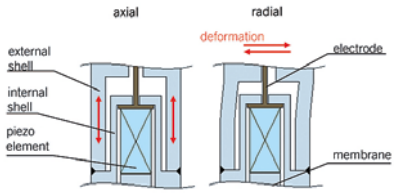
Examples: Measurements for heat release and friction loss calculations

Durability / endurance testing

Purpose: Permanent, non-stop monitoring.

Examples: Onboard monitoring of large marine or stationary engines

ICONS OF KEY FEATURES



GaPO4

Gallium Orthophosphate $GaPO_4$ – Patented unique high temperature resistant crystal material for high durability and excellent linearity

Today $GaPO_4$ is by far the best suitable piezoelectric material to be used in engine applications. It has a combination of several unique properties that make it the first choice. It has unparalleled stability up to a temperature of 970 °C with twice the sensitivity of quartz and performs better with respect to sensitivity shifts if compared to Langasite crystals. The outstanding stability of $GaPO_4$ gives AVL the ability to produce pressure sensors which show excellent measurement behavior, even at high temperatures and pressures. The inherent physical rigidity of $GaPO_4$ allows the realization of excellent signal qualities in very compact designs. For details see also page 22.

double shell

Double Shell™ – Special sensor design which decouples the crystals mechanically from the housing for premium signal quality

The piezoelectric elements are supposed to measure only the pressure changes which are caused by the combustion process. Due to their high sensitivity these elements are also susceptible to any other kind of applied pressure. For example the mechanical stress which occurs due to mounting the sensor into the mounting bore of the engine can cause a misreading of the combustion pressure. The Double Shell™ is a special design feature which allows isolation of the piezoelectric measuring elements from any of these negative influences and helps to ensure absolute measurement precision.

SDM

SDM Sensor Data Management – Increasing efficiency due to organized workflow

SDM guarantees end-to-end automated data transfer and thus ensures error-free measurements. This solution covers the complete measurement chain running from the sensor to the post-processing software.
AVL Sensor Data Management™ SDM consists of several hardware and software components:

- Automated sensor calibration system AVL RCU 601/300
- Sensor and testfield data base (SDB)
- Sensoridentification (SID, SIC, SDC)
- Amplifier AVL X-ion™ and AVL IndiCom™

For details see also page 24.

Table of mounting types

"Which sensor type is necessary in which mounting situation?"

Depending on the engine and measurement task for which a pressure sensor is required specific sensor types should be used. The choice of the sensor type typically defines the maximum achievable precision. In general two mounting families can be distinguished. One is the situation where a modification of the cylinder head of the engine e.g. drilling and milling of indicating passages is feasable and the other where modifications are not possible. If the available space is very limited or a modification is not possible a glow- or spark-plug adaptor solution is an option. On the other hand if a modification of the cylinder head is allowed it opens up the choices between several sizes of threaded, plug or probe type sensors.

CYLINDER PRESSURE

Mechanical modifications of cylinder head

probe

- slim sensor design
- also for glow-plug adaptation

plug

- less thermal deformation
- less influence of mounting bore

thread

- best heat dissipation
- simple installation

Use of existing standard bores

spark-plug

glow-plug

- no indicating passages necessary
- custom tailored design

Decision tree for cylinder pressure sensors

"Which cylinder pressure sensor is typically the best solution for a certain application?"

With a certain application in mind this diagram allows the engineer to identify the recommended standard indicating solution. Depending on the detailed measurement task it is possible that other sensor types might be suitable as well.

Start →

small sized engines →

Usage of existing bore? →

yes →	gasoline →	spark plug →	ZI22 ZI33
	diesel →	glow plug →	GH13G GH14P + AG0x
no →		general purpose →	GH01D GH15DK
		thermodynamic →	GH15D+PH08
		knock analysis →	GP15DK

medium sized engines →

Usage of existing bore? →

yes →	gasoline →	spark plug →	ZI22 ZI33 ZI45
	diesel →	glow plug →	GH13G GH14P + AG0x
no →		general purpose →	GH01D GH15DK GU22CK GU24DK GC24DK
		thermodynamic →	GH15D+PH08 GU22C+PH04 GU24D GC24D
		knock analysis →	GP15DK GU22CK

large sized engines →

general purpose →	GH15DK GP15DK GU22CK
thermodynamic →	GH15DK+PH08 GU22CK+PH04 GU24D QC34C QC34D GU31D GU41D

racing →

GP15DK
GR15D
GO15DK Gen2

Comparison chart of sensor specifications

"How does a specific sensor perform compared to others?"

To get an overview of the portfolio of pressure sensors, this chart can be used to compare a selected sensor with others. The most important features and parameters are listed for all pressure sensors.

Pressure Sensors	Measurement task			Mounting type					Thread / bore diameter												Sealing type		Cable connection					SDM				
	Toughness	Precision	Durability	Plug type	Threaded type	Probe	Spark-plug	Glow-plug	M3.5 × 0.35	M5 × 0.5	M7 × 0.75	M8 × 0.75	M8 × 1	M10 × 1	M12 × 1.25	M14 × 1.25	Ø 4.3 mm	Ø 4.4 mm	Ø 6.3 mm	Ø 10 mm	Front sealed	Shoulder sealed	M2 × 0.25	M3 × 0.35	M4 × 0.35	Mirco-Dot 10-32 UNF	Bürklin 70F 8251	Double Shell	$GaPO_4$	SID	SIC	SDC
	Knock applications	Thermodynamic analyis	Endurance tests																												
	Cylinder pressure sensors for engine development																														
GH01D	★★	★	★★		•				•												•		•					•	•		o	o
GH15D	★	★★★	★★		•					•											•			•				•	•	•		o
GH15DK	★★	★★	★★		•					•											•			•				•	•	•		o
GH15DKE	★★	★★	★★		•					•											•			•				•	•	•		o
GP15DK	★★★	★	★★★		•					•											•			•				•	•		o	o
GR15D	★	★★	★★		•					•											•			•				•	•		o	o
GH14P	–	★★★	★★			•		o									•				•			•				•	•	•		o
GA16P	–	★★★	★★			•		o										•			•			•				•	•		o	o
GH13G	–	★★	★★					•				o		o	o							•		•					•	•		o
GU22C	★	★★★	★★	•															•			•			•				•	•		o
GU22CK	★★	★★	★★	•															•			•			•				•	•		o
GU21D	★	★★★	★★		•						•											•			•				•	•		o
GU24D	★	★★★	★★		•							•										•			•			•	•	•		o
GU24DE	★	★★★	★★		•							•										•			•			•	•	•		o
GU24DK	★★	★★	★★		•							•										•		•					•	•		o
GU31D	★★	★★	★★★		•									•								•			•			•	•		o	o
GU41D	★★	★★	★★★		•											•					•	•			•			•	•		o	o
ZI22	★★	★★	★				•							•								•		•					•		o	o
ZI33	★★	★★	★				•								•							•		•					•		o	o
ZI45	★★	★★	★				•									•						•		•					•		o	o
GC24D	★	★★★	★★★		•							•										•		•					•	•		o
GC24DK	★★	★★	★★★		•							•										•		•					•	•		o
QC34C	★	★★★	★★★	•																•		•			•					•		o
QC34D	★	★★	★★★		•									•								•			•					•		o
QC43D	★	★★	★★★		•											•						•				•						o
	Low pressure sensors for engine development																														
LP12DA	–	★★★	★★		•					•												•				•						
LP22DA	–	★★★	★★		•							•										•				•						
	Cylinder pressure sensors for engine monitoring																														
GO15DK Gen2	★★★	★	★★★		•					•											•			•				•	•		o	o

★ › Good, ★★ › Very Good, ★★★ › Excellent, • › Standard, o › Optional

Pressure Range									Temp.	Sensitivity													Cyclic temperature drift								Natural frequency												Page
5 bar	10 bar	30 bar	200 bar	250 bar	300 bar	350 bar	500 bar	1000 bar	Maximum Temperature	1.5 pC/bar	5.3 pC/bar	10 pC/bar	11 pC/bar	15 pC/bar	16 pC/bar	19 pC/bar	20 pC/bar	34 pC/bar	35 pC/bar	45 pC/bar	68 pC/bar	< ± 0.3 bar	< ± 0.35 bar	< ± 0.4 bar	< ± 0.5 bar	< ± 0.6 bar	< ± 0.7 bar	< ± 0.8 bar	< ± 1.5 bar	50 kHz	69 kHz	85 kHz	90 kHz	92 kHz	96 kHz	100 kHz	115 kHz	130 kHz	150 kHz	160 kHz	≥ 170 kHz	
					•				400 °C		•																•														•	26
				•					400 °C							•										•														•		28
					•				400 °C							•											•														•	30
					•				400 °C							•											•														•	32
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				•					400 °C												•		•											•									66
					•				400 °C											•							•																68
				•					350 °C								•						•									•												70
				•					350 °C								•						•									•												72
			•						80 °C													•		•							•												74
•	•	•							200 °C	333, 1000, 2000 mV/bar																																		76
	•								1100 °C	1000 mV/bar																																		78
								•	350 °C	•																			•												•			80

Datasheet information

How to interpret datasheet parameters / Which specification is crucial for a certain application?

List of all specifications with their definition and how important they are in context with the specific application.

A

Acceleration sensitivity [bar/g]

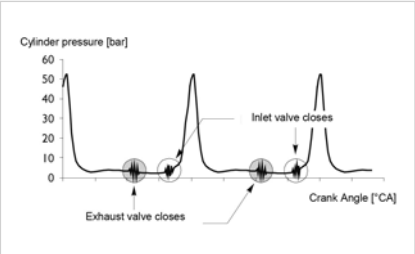


Figure 1

Inertial forces due to vibration or shock can cause an apparent change of the output signal. This parameter has to be as small as possible.
The acceleration sensitivity of water-cooled pressure sensors is additionally influenced by the mass of the cooling water in the pressure sensor and tubes. It is usually significantly higher than in uncooled pressure sensors. For pressure measurements at positions with high acceleration load, such as close to the intake or exhaust valves but also in racing engines at high speed, pressure sensors with low acceleration sensitivity should be used. The sensor is rated on its axial acceleration sensitivity. The sensor itself could also be effected in case of high radial acceleration load. In this case a sensor with dedicated construction like GR15D should be used. Figure 1 shows an example of the influence of acceleration on the pressure signal. The high frequency oscillations superimposed on the pressure signal are caused in this specific measurement arrangement by the impact of the intake and exhaust valves on the valve seat which are transmitted by structure-borne noise.

B

Burn off resistance [Ω]

The burn off resistance of a spark-plug is limiting the electric current between the electrodes during the flashover. This value has no influence on the measurement performance of the pressure sensor.

Burst pressure [bar]

The burst pressure characterizes the maximum pressure before a sensor gets destroyed. The operating pressure always has to be smaller to guarantee safe operation.

C

Cable connection

The cable connection specifies the type and size of the electric connection of sensor and piezoelectric cable. Most of the piezoelectric pressure sensors are equipped with either a M3 x 0.35 or a M4 x 0.35 connector. Older sensor types like, e.g. some water cooled quartz piezoelectric sensors, use so called microdot 10-32 UNF connectors. Line and low pressure sensors have a Bürklin - 7 pin plug. Monitoring sensors require either an M4 x 0.35 or an M12-8 pin connector. Our newest sensor, the GH01D, is equipped with a M2 × 0.25 connector.
AVL does not recommend the use of cables of other suppliers. Due to small incompatibilities the ceramic insulator inside the sensor gets permanently damaged and proper signal transmission can not be guaranteed.

Capacitance [F]

In principle, the capacitance is the ability of a device to hold electrical charge between electrodes.
Old amplifier technologies require this value for accurate measurements. In state of the art indicating measurement systems this value has no practical relevance anymore and therefore no influence on the signal quality.

Cooling rate [l/h]

Quartz sensors require active water cooling. The cooling rate is a constant flow rate of the water through the sensor at a certain pressure. This rate has influence on the thermal sensitivity change. That explains also the reason why the value for the thermal sensitivity change of sensors with quartz material is stated in %/°C and not in %.

Cyclic temperature drift [bar]

Due to the fact that the membrane of the sensor is periodically heated by the combustion in the cylinder the local temperature at the membrane

changes periodically. Similar to the thermal sensitivity change the output signal gives a wrong pressure value due to change of temperature. The maximum misreading within one cycle due to this thermal effect is called cyclic temperature drift or thermal shock error.
The cyclic temperature drift is one of the most significant parameters for thermodynamic analysis. This is due to the fact that it acts over a large crank angle range. The influence on parameters that are integrated over one cycle (e.g. the indicated mean effective pressure IMEP) is therefore significant. Consequently a smaller cyclic temperature drift results in a higher accuracy of the measurement. It is crucial how the procedure to measure this value is defined. At the moment there exists no standard procedure which defines under which conditions the cyclic drift has to be measured. This makes a direct comparison between values of different manufacturers almost impossible. At AVL the measuring conditions are chosen in that way that they are as critical as possible. The values given in this catalog are measured on a DI diesel engine at 1300 rpm and an IMEP of 7 bar. The choice of the combustion engine type for the determination of cyclic drift is significant. In addition to the AVL standard values Δp is also stated in order to allow comparisons with sensors from other manufacturers. This value is measured at 9 bar IMEP and 1500 rpm on a typical gasoline engine.

E

Eccentricity [mm]
In a standard spark plug the center electrode is exactly in the axial middle of the spark plug. Sparkplugs with diameter M10 and integrated pressure sensor require a small eccentricity of the electrode due to the limited available space.

Electric strength [V]
Based on the design of the center electrode the electric strength indicates the maximum electric voltage capability of the spark plug.

Electrode gap [mm]
The optimal electrode gap of a spark plug is determined by the gap of the original spark plug.
The maximum electric strength of the spark plug defines the maximum possible electrode gap of the measurement spark plug. The electrode gap must be adjusted according to the final compression pressure (FCP) from the compression stroke. This is a convenient metric which is roughly proportional to the voltage demand required to jump the gap. For detailed instructions please refer to the document AT4370E which can be requested from your technical sales support or downloaded from our website.
The maximum electric strength of the new generation of spark plugs (ZI22, ZI33 and ZI45) is high enough (45 kV) to use the same gap as the original spark plug.

F

Front sealed
Front sealed sensors have the sealing surface at the rim of the sensor membrane. This kind of sealing prevents deposits in the thread and can be important for long time monitoring installations. Front sealed mounting requires always a recessed mounting. Depending on the mechanical strength of the cylinder head the recessing of the membrane results in an indicating channel. If the dimensions of this indicating channel are not well chosen, pipe oscillations can occur. This physical effect can limit the signal quality during the measurement. On the other hand front sealed sensors show in principal a better thermal conductivity to the cylinder head than shoulder sealed sensors and can reduce thermal effects and improve signal precision. Shoulder sealed sensors seal at the upper end of the housing which results in almost no mechanical stress on the membrane. It allows also a flush mounted membrane which eliminates the chance for pipe oscillations.

G

Gallium Orthophosphate $GaPO_4$

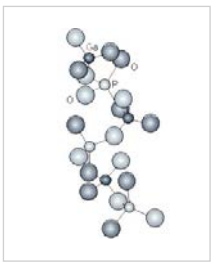
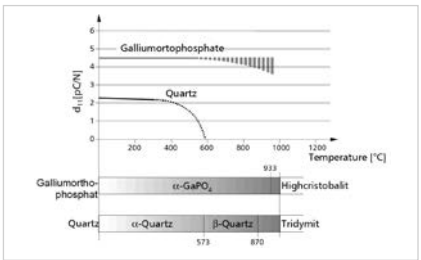


Figure 2

The $GaPO_4$ is the patented high temperature resistant piezoelectric material developed by AVL. It allows high signal linearity and temperature stability like no other material on the market. The crystal material is grown and manufactured only in the headquarters of AVL. Even though the hydrothermal growing process of $GaPO_4$ takes several months AVL produces this piezoelectric material in high quantities. In numbers this means simultaneous growing up to 300 crystals which corresponds to almost 200 kg crystal material per year. Each crystal has a size larger than a man's palm giving thousands of thin slices and cubes in the cutting process which can be used with high yield for hundreds of pressure sensors.



The crystal structure of Gallium Orthophosphate can be derived from α-quartz by replacing silicon alternatively with gallium and phosphorus, see Figure 2.
α-Gallium Orthophosphate is stable up to a temperature of 933 °C. Above that it changes into the high cristobalite type.
The excellent thermal behaviour and the high sensitivity of Gallium Orthophosphate have made great performance advantages over quartz and Langasite realized in AVL's uncooled pressure sensors.
Langasite crystals tend to have higher longitudinal sensitivities than Gallium Orthophosphate. However, if measurement accuracy and precision are of importantance terms like sensitivity change and linearity of a sensor are more relevant. These are the areas where $GaPO_4$ shows its superior performance. The importance of the sensitivity change becomes clear in context with the sensor housing. Designing a pressure sensor for automotive applications requires the piezoelectric crystal to be packed into a rigid sensor housing. The material of the sensor housing has to be chosen in a way that the thermal expansion of the sensor housing and crystal cancel out to zero. With Langasite crystals this process is much more difficult and results in higher design effort and costs. Gallium Orthophosphate allows a much better optimization of the design which results in sensors with higher measurement precision.

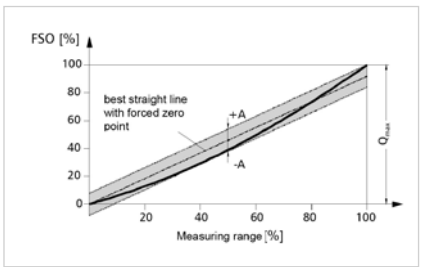
I

Insulation resistance [Ω]

The insulation resistance is the electrical (ohmic-) resistance measured between the electrodes of the sensor (electrical contacts of the connector). Piezoelectric sensors have to have a resistance in the range of more than 10^{12} Ω to ensure proper operation.
A higher resistance value allows full sensor performance in quasi-static measurements. If liquids, moisture or particles contaminate the connector or start to enter the interior of the sensor the electrical resistance can drop. This indicates that the sensor needs to be serviced immediately by the manufacturer.

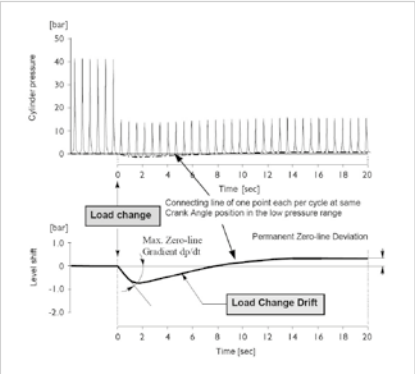
L

Linearity [%]



As the sensitivity defines how much signal is generated per pressure unit it is furthermore expected that this sensitivity is the same for all applied pressures. A variation in this context is defined by the term called linearity. The maximum deviation (+A, -A) is expressed as a percentage of the maximum pressure of the measuring range which is called full scale output (FSO). This value should be as close to zero as possible.

Load change drift [bar/s]



The load change drift is a slow drift of the pressure signal after a load change which is caused by a change of temperature level and heat flux. The characteristic value for the load change drift is determined in real engine operation, by first running the engine at a specific load point and then changing to motored mode by shutting off the fuel supply thus producing a quick change in the heating effect on the pressure sensor (by a sudden load change). The drift itself is defined by the maximum change of the pressure level per unit of time and is called maximum zero-line gradient dp/dt.
The resulting permanent zero-line deviation has no relevance due to drift compensating modes of modern charge-amplifiers and is only mentioned for the sake of completeness.

M

Max. temperature of plug seat [°C]

This temperature defines the maximum allowed temperature of the plug seat of a spark-plug adaptor.

Measuring range [bar]

This is the pressure range in which the sensor meets the specifications. For analysis of the cylinder pressure this range should be at least 0…200 bar.
Under severe conditions like supercharged engines and knocking the maximum pressure range becomes an issue. High pressure peaks can fatigue the membrane and make the sensor fail. The maximum allowed pressure is mainly defined by the design and the material of the sensor membrane. The trade-off to improved maximum pressure is in most cases the decrease in resolution and sensitivity which is on the other hand required for thermodynamic analysis.

Mounting bore [mm]

Diameter of the indicating bore for plug- and probe-types. The diameter of the mounting thread is only listed for the thread-types (see “thread diameter”).

Mounting torque [Nm]

Each sensor, adaptor and threaded connector needs to be mounted with a specific torque. This ensures safe operation and best performance of all components. To apply the right torque, tools like calibrated torque wrenches should be used.

N

Natural frequency [Hz]

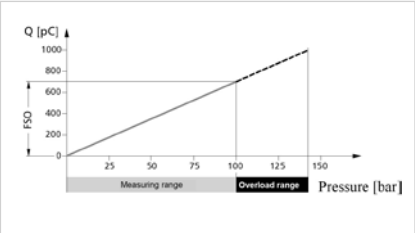
The natural frequency is the lowest possible frequency of free (non-forced) oscillations in the measuring element of a fully assembled pressure sensor.
This value should be at low engine speeds at least 50 kHz.
At high engine speeds the moving actions of the valves generate mainly high frequency noise. This noise can become visible as an artefact in the measurement signal if the natural frequency is in the frequency range of this noise. Therefore for testing with high engine speeds the natural frequency of the sensor should be at least above 100 kHz.
In contrast, with the term natural frequency, the basic resonance frequency defines the frequency of the measurement quantity at which the pressure sensor gives the output signal with the highest amplitude. Where there is little attenuation, as it is generally the case for piezoelectric pressure sensors, the basic resonance frequency is the same as the natural frequency 1st order.

O

Operating temperature range [°C]

Temperature range in which the pressure sensor meets the specifications of the data sheet. For typical combustion analysis this range should be at least 0…400 °C. The temperature which is meant here is the maximum temperature at the mounting position.

Overload [bar]



The overload is the maximum value of pressure which the sensor can withstand for short time periods. It is above the maximum pressure of the measuring range.
At high pressures within the overload range it cannot be guaranteed that the sensor signal works according to the specifications but the sensor is not permanently damaged.

P

Pipe oscillations [Hz]

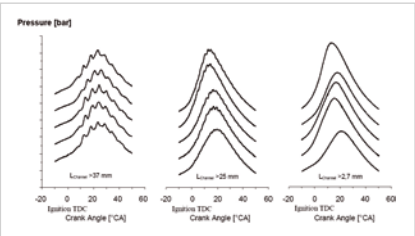


Figure 3

The indicating channel represents an acoustic resonator which is excited by changes in pressure and produces oscillations. This effect is illustrated in Figure 3 where the measured pressure curves relate to indicating channels of different lengths. Five pressure curves from single cycle measurements are shown for each indicating channel length. They have been shifted in level to provide a clear overview.

R

Resistance of insulator (spark-plug) [Ω]

This is the ohmic resistance between the center electrode and the ceramic body of the insulator.

S

SDB

Acronym for Sensor Database that is part of the SDM Sensor Data Management system.
The SDB is a central digital repository for the management of the sensor specific data. This point can be either a local- or a network database. For each sensor all calibration data is stored, the total number of performed cycles is monitored and service intervals can be scheduled according to the testing needs.

SDC

Acronym for Sensor Data Connector that is part of the SDM Sensor Data Management system.
The sensor is connected to a piezo-input cable which has a special plug with built-in electronics. The difference to SIC is that the SDC does not store only the serial number but also all calibration data of the sensor. No connection to any database or calibration file is required. On the other hand the data is only accessible locally and no additional information can be stored.

SDM

Acronym for Sensor Data Management. For an overview please refer to page 15.

Sensitivity [pC/bar]

DIN1319 defines sensitivity in this context as the ratio of generated electrical charge per pressure unit (bar). This value should be at least 10 pC/bar for high accurate measurement data (e.g. heat release analysis).
The electrical charge is measured in Coulomb (1 C = 10^{12} pC).
The nominal sensitivity is the measured sensitivity at 23 °C.
It might seem to be important to choose a sensor with very high sensitivity. In fact sensitivities in the range of 10 to 20 pC/bar are by far sufficient especially with modern charge amplifiers. Practically, choosing sensors with very high sensitivities can lead to unwanted signal overloads during measurements, especially under supercharged or knocking conditions.

Shock resistance [g]

The maximum acceleration a sensor can withstand without being permanently damaged. The higher this value the more rigid the sensor is against mechanical shocks.
In application fields with extremely high engine speeds (racing) the valve closing noise can cause significant influence on the measurement signal.
The shock resistance is measured in units of the gravitational acceleration which equals to 1 g = 9.81 m/s^2 .

Shoulder sealed
Please refer to the term "Front sealed" stated above for a definition and illustrations.

SIC
Acronym for Sensor Identification Cable that is part of the SDM Sensor Data Management system. The SIC fulfills the same purpose as SID. Like the SID it carries an unique identification number which allows the amplifiers from AVL to recognize and identify the sensor currently connected to the indicating system. The SID is integrated into the piezoelectric cable that connects a sensor to the amplifier system. An SIC solution is an ideal way to upgrade sensors without SID for SDM or if the sensor design does not allow an integration directly inside the sensor housing. To ensure the unique identification number of the SID is always associated with one specific sensor it is necessary not to separate the SIC from the sensor.

SID
Acronym for Sensor Identification that is part of the SDM Sensor Data Management system.
A sensor with SID electronics has a built-in electronic component with an unique digital serial or identification number. Connected to an AVL amplifier this identification number is read by the amplifier and allows the system to identify which specific sensor is connected to the system. The system can automatically request stored calibration data from the SDB Sensor Database that corresponds to the identified sensor. Additionally data like total run-time, number of load cycles and peak pressures can be monitored and stored at the SDB Sensor Database.

T

TEDS
Acronym for the IEEE 1451 standard for smart transducers.
A Transducer Electronic Data Sheet (TEDS) is a standardized method of storing sensor and actuator identification, calibration and manufacturer related information. TEDS formats are defined in the IEEE1451 interface standards developed by an IEEE Committee. This standard describes a set of network-independent communication interfaces for connecting transducers to instrumentation systems-, and control/field networks. The TEDS, in essence, is a memory device attached to the transducer and contains information needed by a measurement instrument or control system to interface with a transducer.

Thermal sensitivity change [%]
This term classifies how the average temperature at the mounting position is influencing the sensitivity of the sensor. The maximum change of sensitivity within a certain temperature range is expressed as a percentage of the nominal sensitivity. The thermal sensitivity change of water cooled quartz sensors depends additionally on the flow rate of the cooling water. The value for the thermal sensitivity change should be as small as possible.

Thermo shock error
Refer to the explanation of "Cyclic Temperature Drift" on page 20.

Thread diameter [metric]
Diameter of the metric or UNF mounting thread of thread-type sensors.

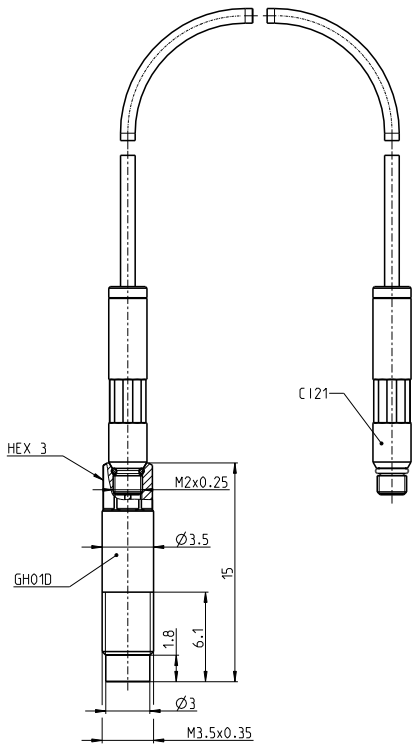
W

Weight [g]
Physical weight of the sensor without the connecting cable.

GH01D

TIGG2118A.01

The GH01D has the slimmest contour due to a M2 cable connector and is a miniaturized and robust M3.5 sensor. This sensor is suitable for mounting bores where access is a problem, a max. diameter of 3.5 mm makes it happen. It has thermally optimized piezoelectric crystal elements and the special Double Shell™ design. It decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. Additionally it has an improved membrane material and geometry.



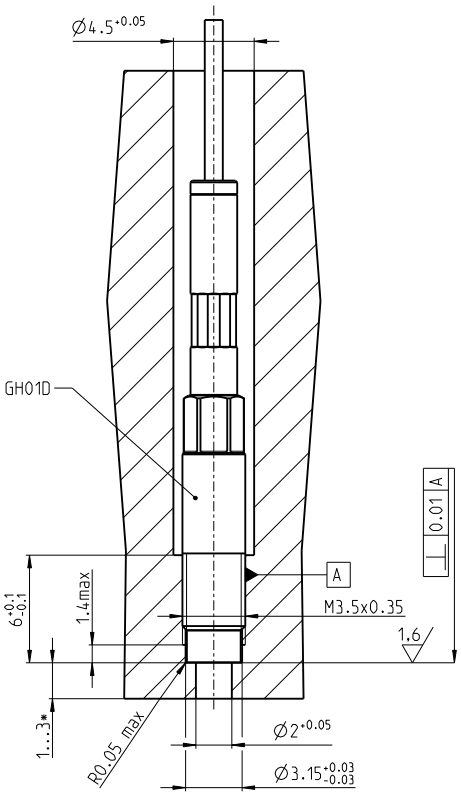
SCOPE OF SUPPLY

Sensor GH01D
Piezo-input cable CI21-1
Fitted coupling CC21
Calibration sheet
Documentation

SPECIFICATIONS

Measuring range			0…300 bar	
Overload			350 bar	
Sensitivity			5.3 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…300 bar	
Natural frequency			170 kHz	
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			3.5 pF	
Sensor operating temperature range [1]			- 40…400 °C	
Thermal sensitivity change	≤		2 %	20…400 °C and 0…300 bar
	≤	±	0.5 %	250 ± 100 °C and 0…300 bar typ.
Load change drift	≤		2.0 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.7 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Thread diameter			M3.5×0.35	front sealed
Cable connection			M2×0.25	positive
Weight			0.8 grams	without cable
Mounting torque			0.5 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1300 rpm, diesel
[3] at 9 bar IMEP and 1500 rpm, gasoline



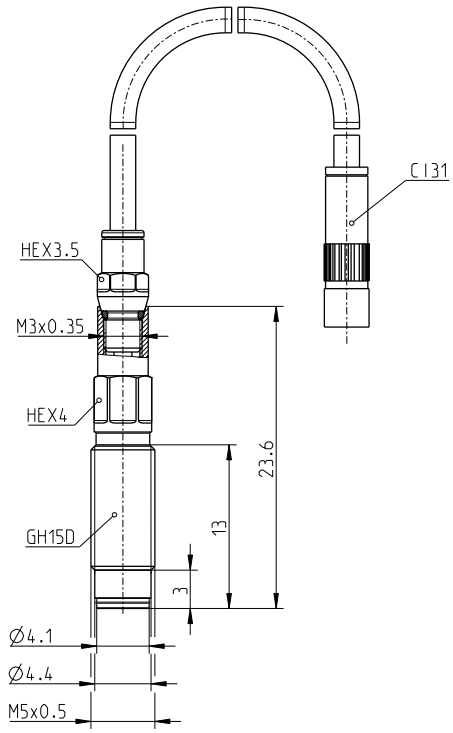
Front sealed direct installation.
*) 1 mm for steel, 3 mm for cast iron and aluminium alloys.

ACCESSORIES			
Cables & couplings	CI21, CC21		See pages 100 to 105
Cable mounting tool	TC21	TIWG0690A.01	See page 95
Dummy	DG41	TIWG0668A.01	See page 91
Dummy removal tool	TD41	TIWG0669A.01	See page 96
Mounting tool	Mounting socket TT66 Torque wrench TT02	TIWG0664A.01 TIWG0117A.01	See pages 94 to 97
Machining tool	Step drill MD27 Tap drill MT32	TIWG0665A.01 TIWG0667A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96

GH15D

TIGG1349B.01

The GH15D has the slimmest contour due to a M3 cable connector and allows very precise thermodynamic measurements with a sensor of size M5. This is realized by thermally optimized piezoelectric crystal elements and the special Double Shell™ design. It decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. Using a thermo protection like PH08 can improve the cyclic drift by 0.3 bar. The sensor is equipped with built in SID for SDM.



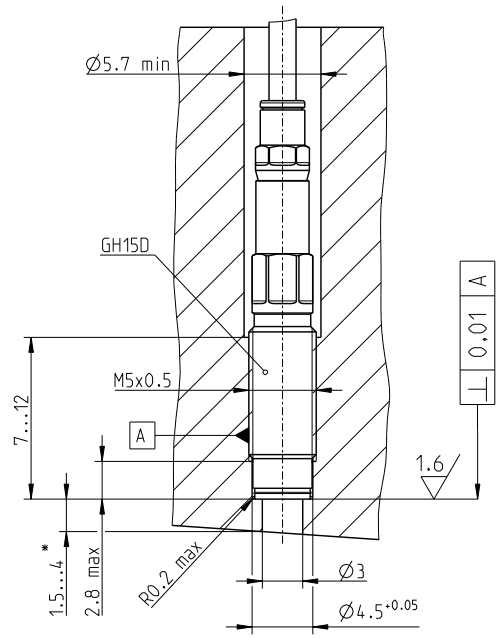
SCOPE OF SUPPLY

- Sensor GH15D
- Piezo-input cable CI31-1
- Coupling CC31
- Accessory kit (protection cap + 2 spare o-rings)
- Calibration sheet
- Documentation

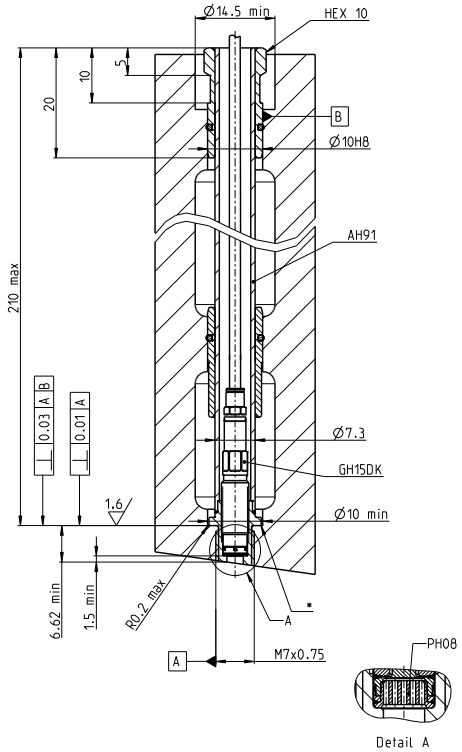
SPECIFICATIONS

Measuring range			0 … 250 bar	
Overload			300 bar	
Sensitivity			19 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 250 bar	
Natural frequency			160 kHz	
Acceleration sensitivity	≤		0.0005 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			7.5 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤		1 %	20 … 400 °C and 0 … 250 bar
	≤	±	0.25 %	250 ± 100 °C and 0 … 250 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.5 bar	
Thermo shock error Δp [3]	≤	±	0.3 bar	typ.
Thread diameter			M5×0.5	front sealed
Cable Connection			M3×0.35	negative
Weight			2.2 grams	without cable
Mounting torque			1.5 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Front sealed direct installation.
*) 1.5 mm for steel, 4 mm for cast iron and aluminium alloys.



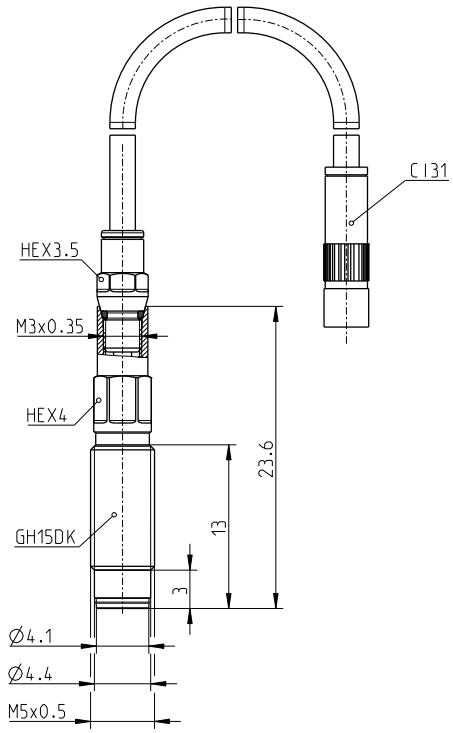
Installation with an AH91 adaptor and the PH08.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

ACCESSORIES

Cables & couplings	CI31, CI32, CI3V, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Dummy	DG24	TIWG0334A.01	See page 91
Dummy removal tool	TD13	TIWG0224A.01	See page 96
Adaptor sleeves	AH01, AH01A, AH91, MA01, MA02, MA03, MA07		See page 87
Mounting tool	Toolset TS21 (TT21, TT02) Mounting socket TT21 Torque wrench TT02 PH08 dismounting tool TT51	TIWG0213A.01 TIWG0214A.01 TIWG0117A.01 TIWG0532A.01	See pages 94 to 97
Machining tool	Toolset MS15 (MD12, MT12) Step drill MD12 Tap drill MT12 Seat dressing tool MR01-85 Seat dressing tool MR01-160	TIWG0337A.01 TIWG0335A.01 TIWG0346A.01 TIWG0616A.01 TIWG0632A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96
Flame arrestor	PH01, PH08		See page 99

GH15DK

TIGG1383B.01



The GH15DK has the slimmest contour due to a M3 cable connector and is an accurate and robust M5 sensor especially suited for super-charged engines with high specific output. It has thermally optimized piezoelectric crystal elements and the special Double Shell™ design. It decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. Additionally it has an improved membrane material and geometry. This makes the sensor more robust suitable as the standard solution for research and development work with perfect trade off between accuracy and robustness. Using a thermo protection like PH08 can improve the cyclic drift by 0.4 bar. The sensor is equipped with built in SID for SDM.

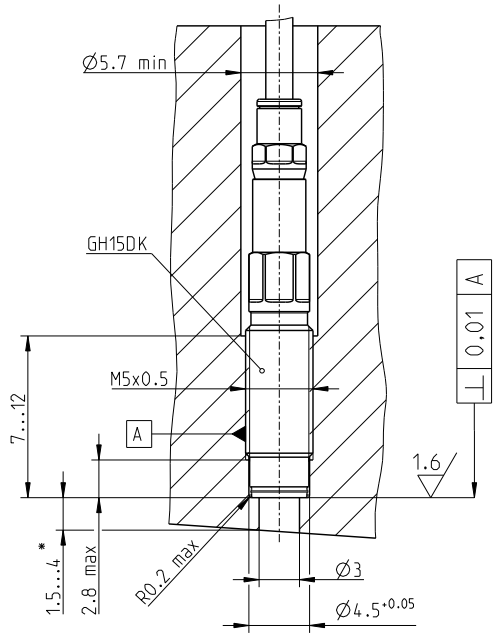
SCOPE OF SUPPLY

Sensor GH15DK
Piezo-input cable CI31-1
Coupling CC31
Accessory kit (protection cap + 2 spare o-rings)
Calibration sheet
Documentation

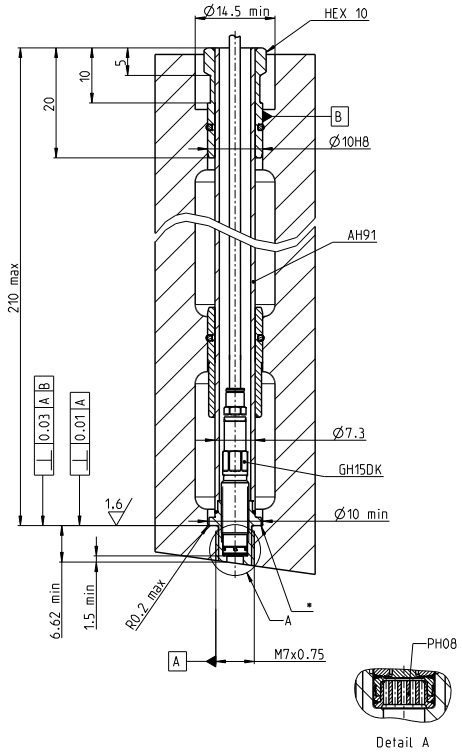
SPECIFICATIONS

Measuring range			0 … 300 bar	
Overload			350 bar	
Sensitivity			19 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 300 bar	
Natural frequency			170 kHz	
Acceleration sensitivity	≤		0.0005 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			7.5 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤		2 %	20 … 400 °C and 0 … 300 bar
	≤	±	0.5 %	250 ± 100 °C and 0 … 300 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.7 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Thread diameter			M5×0.5	front sealed
Cable Connection			M3×0.35	negative
Weight			2.2 grams	without cable
Mounting torque			1.5 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Front sealed direct installation.
*) 1.5 mm for steel, 4 mm for cast iron and aluminium alloys.



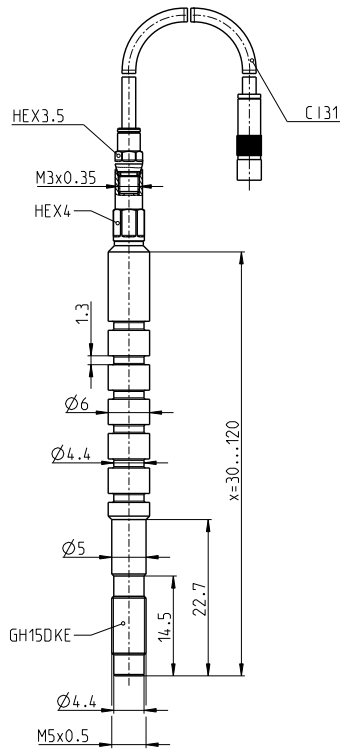
Installation with an AH91 adaptor and the PH08.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

ACCESSORIES

Cables & couplings	CI31, CI32, CI3V, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Dummy	DG24	TIWG0334A.01	See page 91
Dummy removal tool	TD13	TIWG0224A.01	See page 96
Adaptor sleeves	AH01, AH01A, AH91, MA01, MA02, MA03, MA07		See page 87
Mounting tool	Toolset TS21 (TT21, TT02) Mounting socket TT21 Torque wrench TT02 PH08 dismounting tool TT51	TIWG0213A.01 TIWG0214A.01 TIWG0117A.01 TIWG0532A.01	See pages 94 to 97
Machining tool	Toolset MS15 (MD12, MT12) Step drill MD12 Tap drill MT12 Seat dressing tool MR01-85 Seat dressing tool MR01-160	TIWG0337A.01 TIWG0335A.01 TIWG0346A.01 TIWG0616A.01 TIWG0632A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96
Flame arrestor	PH01, PH08		See page 99

GH15DKE

TIGG1595A.01 (A-type)
TIGG1597A.01 (B-type)



The GH15DKE is the elongated version of GH15DK and could be used within oil and water jackets without the need of an adaptor sleeve. It is an accurate and robust M5 sensor especially suited for supercharged engines with high specific output. It has thermally optimized piezoelectric crystal elements and the special Double Shell™ design. It decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. Additionally it has an improved membrane material and geometry. This makes the sensor more robust suitable as the standard solution for research and development work with perfect trade off between accuracy and robustness. Using a thermo protection like PH08 can improve the cyclic drift by 0.4 bar. The sensor is equipped with built in SID for SDM.

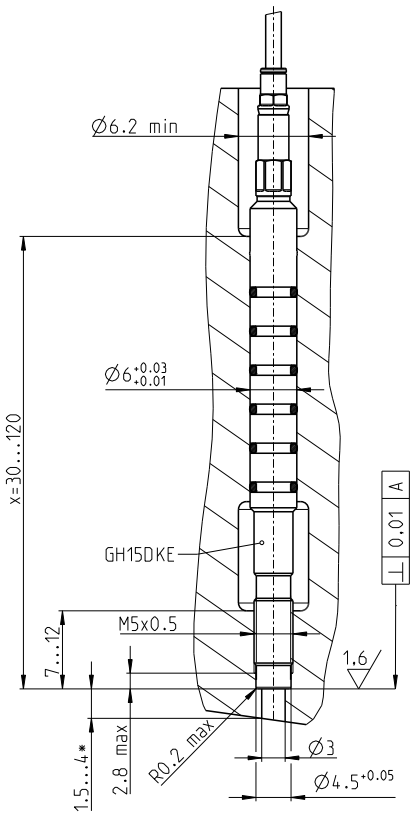
SCOPE OF SUPPLY

Sensor GH15DKE
Piezo-input cable CI31-1
Coupling CC31
Accessory kit (protection cap + 2 spare o-rings)
Calibration sheet
Documentation

SPECIFICATIONS

Measuring range			0…300 bar	
Overload			350 bar	
Sensitivity			19 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…300 bar	
Natural frequency			170 kHz	
Acceleration sensitivity	≤		0.0005 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			7.5 pF	
Sensor operating temperature range [1]			- 40…400 °C	
Thermal sensitivity change	≤		2 %	20…400 °C and 0…300 bar
	≤	±	0.5 %	250 ± 100 °C and 0…300 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.7 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Thread diameter			M5×0.5	front sealed
Cable Connection			M3×0.35	negative
Weight			6.7–10.2 grams	without cable
Mounting torque			1.5 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Front sealed direct installation.
*) 1.5 mm for steel, 4 mm for cast iron and aluminium alloys.

ACCESSORIES

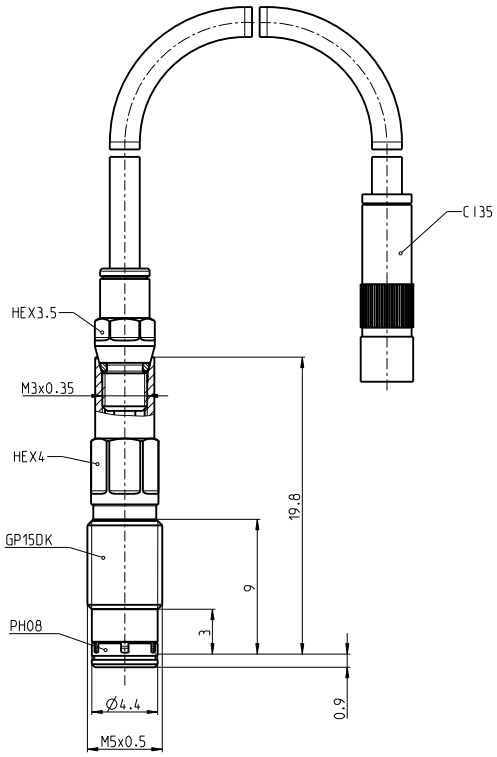
Cables & couplings	CI31, CI32, CI3V, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Mounting tool	Toolset TS21 (TT21, TT02) Mounting socket TT21 Torque wrench TT02 PH08 dismounting tool TT51	TIWG0213A.01 TIWG0214A.01 TIWG0117A.01 TIWG0532A.01	See pages 94 to 97
Machining tool	Tool set MS15 (MD12, MT12) Step drill MD12 Tap drill MT12 Seat dressing tool MR01-85 Seat dressing tool MR01-160	TIWG0337A.01 TIWG0335A.01 TIWG0346A.01 TIWG0616A.01 TIWG0632A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96
Flame arrestor	PH01, PH08		See page 99

GP15DK

TIGG1892A.01

★★★ | ★ | ★★★ | GaPO4 | double shell

The GP15DK has the slimmest contour due to a M3 cable connector and is a robust M5 sensor especially suited for supercharged engines with high knock events. The Double-Shell™ design decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. In addition to this, it has an improved membrane material and geometry. This makes the sensor to the standard solution for development work with heavy knock events and pre-ignition. The sensor could be equipped with SIC for SDM.



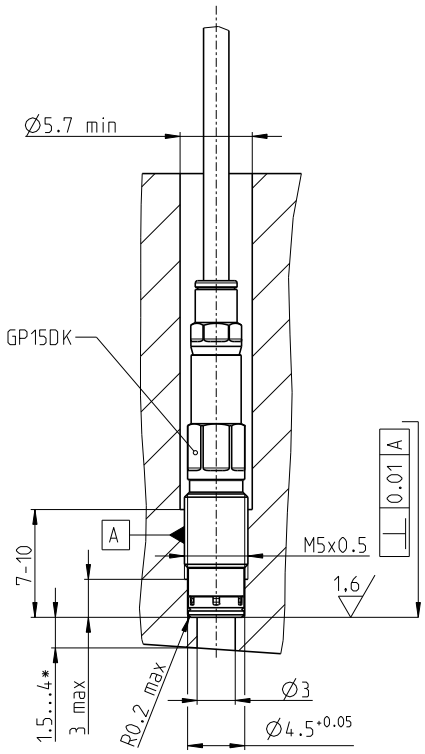
SCOPE OF SUPPLY

Sensor GP15DK
Thermo protection PH08
Piezo-input cable CI35-1
Coupling CC31
Accessory kit (protection cap + 2 spare o-rings)
Calibration sheet
Documentation

SPECIFICATIONS

Measuring range			0 … 500 bar	
Overload			600 bar	
Sensitivity			10 pC/bar	nominal
Linearity	≤ ±	± ±	0.3 % 0.5 %	0 … 150 bar FSO 0 … 300 bar FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 300 bar	
Natural frequency			170 kHz	
Acceleration sensitivity	≤		0.0005 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			7.5 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤ ≤	 ±	2 % 0.5 %	20 … 400 °C and 0 … 300 bar 250 ± 100 °C and 0 … 300 bar typ.
Load change drift			7 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	1.5 bar	
Thermo shock error Δp [3]	≤	±	0.8 bar	typ.
Thread diameter			M5×0.5	front sealed
Cable Connection			M3×0.35	negative
Weight			1.6 grams	without cable
Mounting torque			1.5 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Front sealed direct installation.
*) 1.5 mm for steel, 4 mm for cast iron and aluminium alloys.

ACCESSORIES

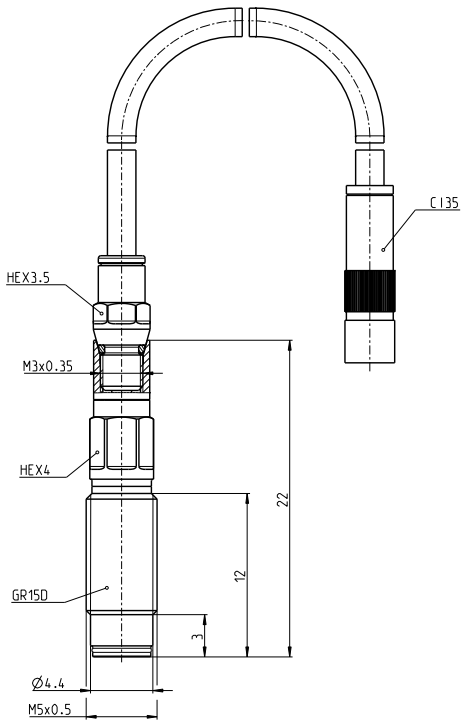
Cables & couplings	CI35, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Dummy	DG39	TIWG0593A.01	See page 91
Dummy removal tool	TD13	TIWG0224A.01	See page 96
Adaptor sleeves	AH01, AH01A, AH91, MA01, MA02, MA03, MA07		See page 87
Mounting tool	Toolset TS21 (TT21, TT02) Mounting socket TT21 Torque wrench TT02 PH08 dismounting tool TT51	TIWG0213A.01 TIWG0214A.01 TIWG0117A.01 TIWG0532A.01	See pages 94 to 97
Machining tool	Toolset MS15 (MD12, MT12) Step drill MD12 Tap drill MT12 Seat dressing tool MR01-85 Seat dressing tool MR01-160	TIWG0337A.01 TIWG0335A.01 TIWG0346A.01 TIWG0616A.01 TIWG0632A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96
Flame arrestor	PH01, PH08		See page 99

GR15D

TIGG1977A.01

★ ★★ ★★ GaPO4

The GR15D has the slimmest contour due to a M3 cable connector and is an accurate and robust M5 sensor especially suited for engines with high vibration. It has thermally optimized piezoelectric elements. In addition to this it has an improved internal design of the measurement cell and charge output. Using a thermo protection like PH08 can improve the cyclic drift by 0.4 bar. The sensor could be equipped with SIC for SDM.



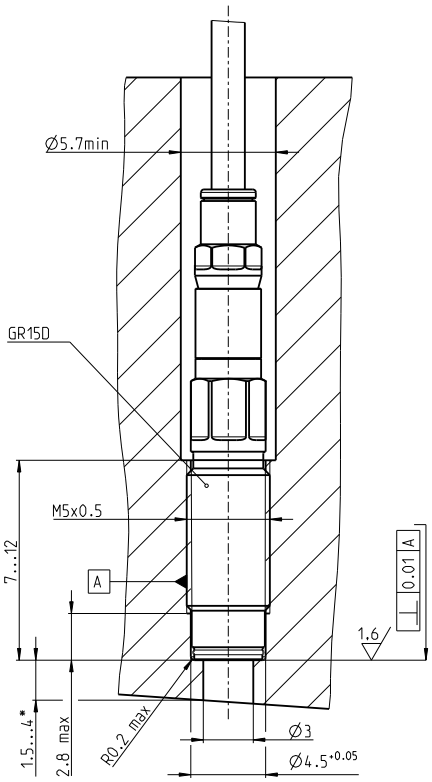
SCOPE OF SUPPLY

- Sensor GR15D
- Piezo-input cable CI35-1
- Coupling CC31
- Accessory kit (protection cap + 2 spare o-rings)
- Calibration sheet
- Documentation

SPECIFICATIONS

Measuring range			0 … 300 bar	
Overload			350 bar	
Sensitivity			15 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 300 bar	
Natural frequency			160 kHz	
Acceleration sensitivity	≤		0.0008 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			7 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤		2 %	20 … 400 °C and 0 … 300 bar
	≤	±	0.5 %	250 ± 100 °C and 0 … 300 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.7 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Thread diameter			M5×0.5	front sealed
Cable Connection			M3×0.35	negative
Weight			2.2 grams	without cable
Mounting torque			1.5 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



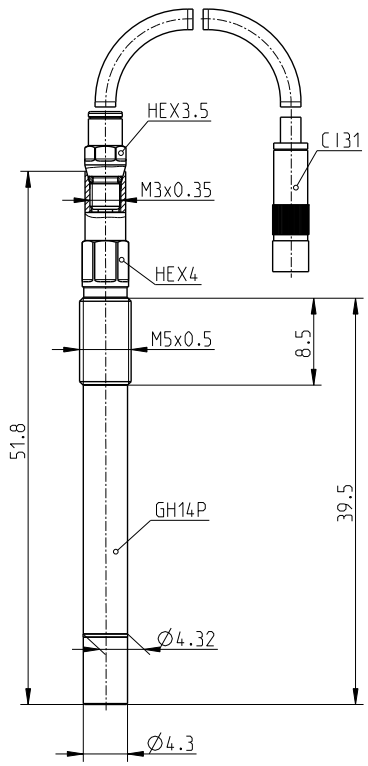
Front sealed direct installation.
*) 1.5 mm for steel, 4 mm for cast iron and aluminium alloys.

ACCESSORIES

Cables & couplings	CI35, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Dummy	DG24	TIWG0334A.01	See page 91
Dummy removal tool	TD13	TIWG0224A.01	See page 96
Adaptor sleeves	AH01, AH01A, AH91, MA01, MA02, MA03, MA07		See page 87
Mounting tool	Toolset TS21 (TT21, TT02) Mounting socket TT21 Torque wrench TT02 PH08 dismounting tool TT51	TIWG0213A.01 TIWG0214A.01 TIWG0117A.01 TIWG0532A.01	See pages 94 to 97
Machining tool	Toolset MS15 (MD12, MT12) Step drill MD12 Tap drill MT12 Seat dressing tool MR01-85 Seat dressing tool MR01-160	TIWG0337A.01 TIWG0335A.01 TIWG0346A.01 TIWG0616A.01 TIWG0632A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96
Flame arrestor	PH01, PH08		See page 99

GH14P

TIGG1323A.01



The GH14P is in combination with a glow-plug adaptor (direct mount) a nearly flush mounted solution for diesel engines. It allows measurements without pipe oscillations and pressures of up to 250 bar. The GH14P comes with an M3 connector which allows the smallest installation tool clearance diameters. The glow plug adaptor dimensions are custom tailored to the requirements of the customer. The Double-Shell™ design decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the adaptor or engine. Using a thermo protection like PH08 can improve the cyclic drift by 0.3 bar. The sensor is equipped with built in SID for SDM.

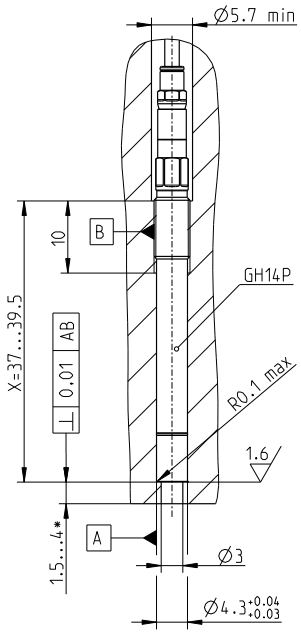
SCOPE OF SUPPLY

Sensor GH14P
Piezo-input cable CI31-1
Coupling CC31
Accessory kit (protection cap + 2 o-rings)
Calibration sheet
Documentation

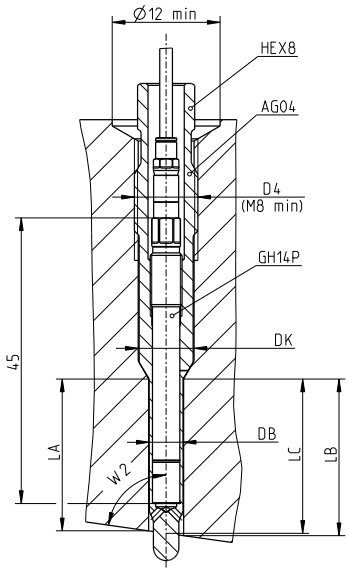
SPECIFICATIONS

Measuring range			0 … 250 bar	
Overload			300 bar	
Sensitivity			15 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 250 bar	
Natural frequency			115 kHz	
Acceleration sensitivity	≤		0.001 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			7 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤		2 %	20 … 400 °C and 0 … 250 bar
	≤	±	0.5 %	250 ± 100 °C and 0 … 250 bar typ.
Load change drift			1 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.5 bar	
Thermo shock error Δp [3]	≤	±	0.3 bar	typ.
Mounting bore			4.3 mm	front sealed
Cable Connection			M3×0.35	negative
Weight			5.4 grams	without cable
Mounting torque			1.5 Nm	using SF01

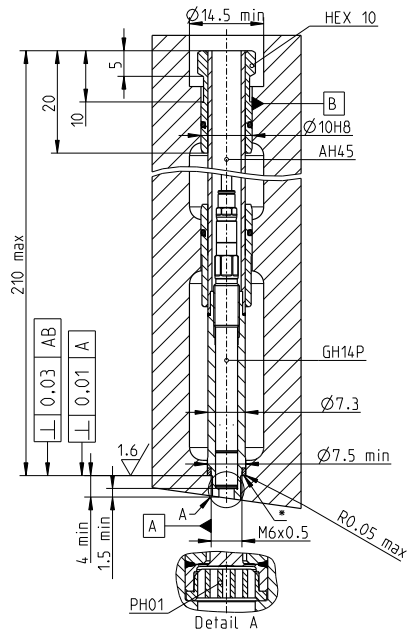
[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation.
*) 1.5 mm for steel, 4 mm for cast iron and aluminium alloys.



Installation with glow-plug adaptor AG04.



Installation with an AH45 adaptor

ACCESSORIES

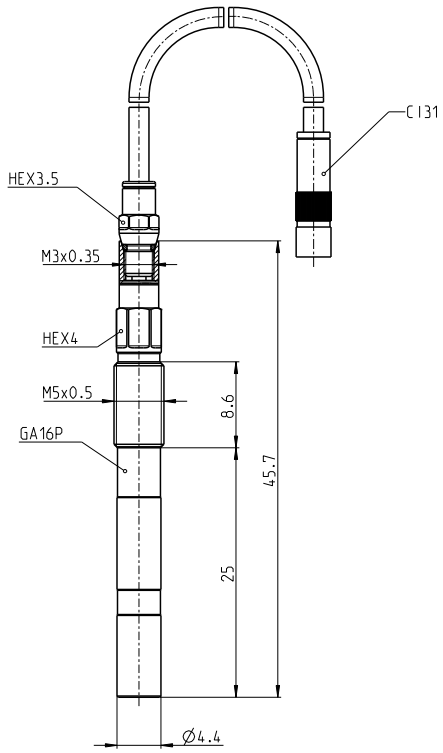
Cables & couplings	CI31, CI32, CI3V, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Dummy	DG13	TIWG0219A.01	See page 91
Dummy removal tool	TD13	TIWG0224A.01	See page 96
Adaptors	AG03, AG04, AH13, AH45		See page 87
Mounting tool	Toolset TS21 (TT21, TT02) Mounting socket TT21 Torque wrench TT02	TIWG0213A.01 TIWG0214A.01 TIWG0117A.01	See pages 94 to 97
Machining tool	Step drill MD26 Tap drill MT11 Seat dressing tool MR05	TIWG0574A.01 TIWG0154A.01 TIWG0575A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96
Flame arrestor	PH01	TIYF0592A.01	See page 99

GA16P

TIGG1924A.01

IMEP ★★★ | non stop ★★ | $GaPO_4$ | double shell

The GA16P is a derivate of the GH14P sensor. It can be used in combination with glow-plug adaptors with sensor bores of 4.4 mm in diesel engines. The GA16P comes with an M3 connector which allows the smallest installation tool clearance diameters. The Double-Shell™ design decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the adaptor or engine. The sensor could be equipped with SIC for SDM.



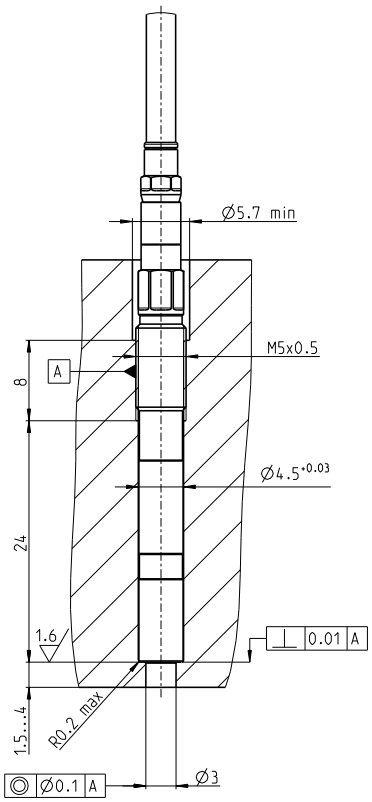
SCOPE OF SUPPLY

Sensor GA16P
Piezo-input cable CI31-1
Coupling CC31
Accessory kit (protection cap + 2 o-rings)
Calibration sheet
Documentation

SPECIFICATIONS

Measuring range			0 … 250 bar	
Overload			300 bar	
Sensitivity			19 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 250 bar	
Natural frequency			160 kHz	
Acceleration sensitivity	≤		0.0005 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			8.2 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤		1 %	20 ... 400 °C and 0 ... 250 bar
	≤	±	0.25 %	200 ± 100 °C and 0 ... 250 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.5 bar	
Thermo shock error Δp [3]	≤	±	0.3 bar	typ.
Mounting bore			4.4 mm	front sealed
Cable Connection			M3×0.35	negative
Weight			4.0 grams	without cable
Mounting torque			1.5 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



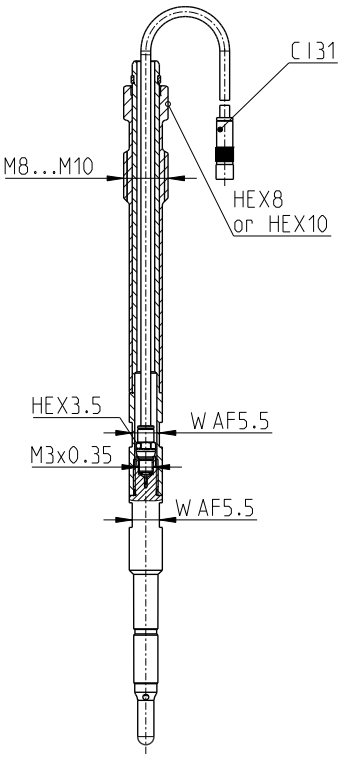
Direct installation.

ACCESSORIES

Cables & couplings	CI31, CI32, CI3V, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Mounting tool	Toolset TS21 (TT21, TT02) Mounting socket TT21 Torque wrench TT02	TIWG0213A.01 TIWG0214A.01 TIWG0117A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See page 96

GH13G

TIGH13GPA.01



The GH13G is a glow-plug sensor for diesel applications where the cylinder head design requires glow-plug diameters down to 4.3 mm. The membrane of this glow-plug sensor is nearly flush mounted which leads to high signal quality without pipe oscillations. The shape of the glow-plug sensor is custom tailored to the requirements of the customer. The sensor is equipped with built in SID for SDM.

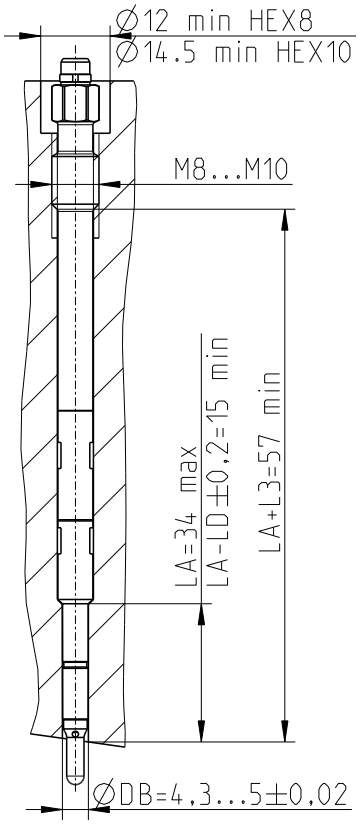
SCOPE OF SUPPLY

- Sensor GH13G
- Piezo-input cable CI31-1
- Coupling CC31
- Accessory kit (protection cap + 2 o-rings)
- Calibration sheet
- Documentation

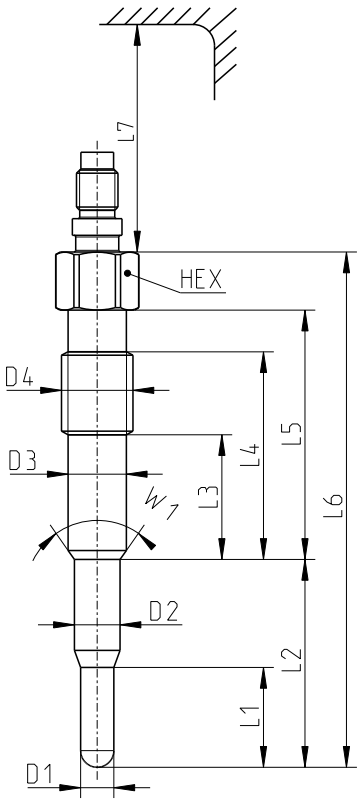
SPECIFICATIONS

Measuring range			0…250 bar	
Overload			300 bar	
Sensitivity			16 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…250 bar	
Natural frequency			130 kHz	
Acceleration sensitivity	≤		0.001 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			8 pF	
Sensor operating temperature range [1]			- 40…400 °C	
Thermal sensitivity change	≤		2 %	20…400 °C and 0…250 bar
	≤	±	0.5 %	250 ± 100 °C and 0…250 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.5 bar	
Cable Connection			M3×0.35	negative
Weight			12.6 grams	without sleeve and cable
Mounting torque			4 Nm	using SF01

[1] surface temperature around the cable connection < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel



Example of direct installation.



Dimensions of the glow-plug.

ACCESSORIES

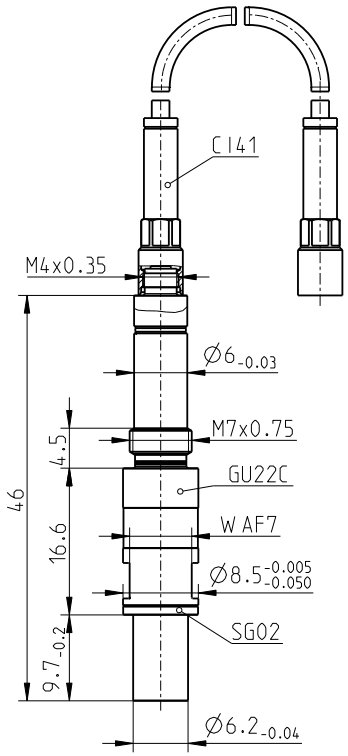
Cables & couplings	CI31, CI32, CI3V, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Design costs		TIAGDESA.01	See page 90
Mounting tool	Mounting socket TT09 (for M8 versions) Mounting socket TA16 (for M10 versions) Torque wrench TT18	TIWG0140A.01 TIWG0200A.01 TIWG0209A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See page 96

GU22C

TIGG1073A.01

★ IMEP ★★★ non stop ★★ GaPO4 SDM

The GU22C is a 6.2 mm plug-type sensor for precise thermodynamic analysis which fulfills reference class requirements when used in combination with the PH04 flame arrestor. It is based on a well established design concept that allows high accuracy. It has thermally optimized piezoelectric elements and no influence from the mounting bore on the pressure signal due to minimized mechanical contact between the mounting bore and the sensor housing. A thermo protection can improve the cyclic drift down below ± 0.4 bar. The sensor is equipped with built in SID for SDM.



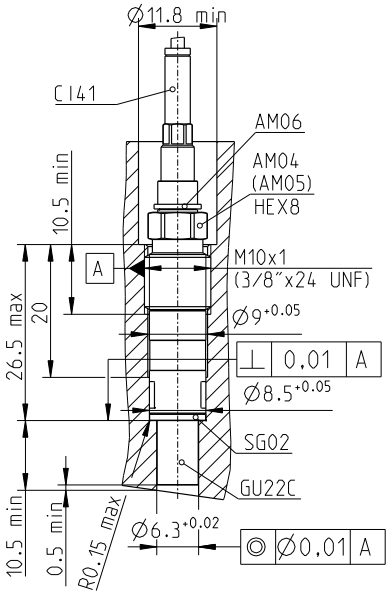
SCOPE OF SUPPLY

- Sensor GU22C
- Piezo-input cable CI41-1
- Coupling CC41
- Gasket SG02
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG02
- Calibration sheet
- Documentation

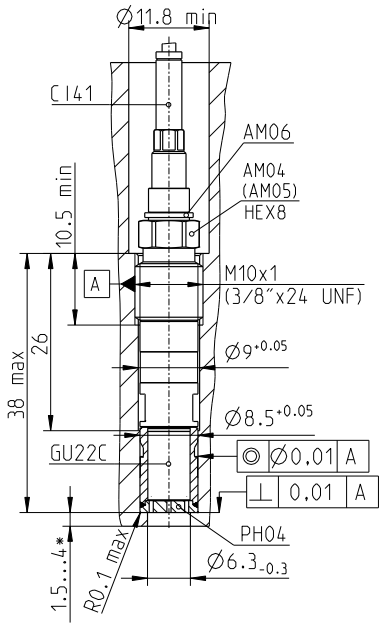
SPECIFICATIONS

Measuring range			0…250 bar	
Overload			300 bar	
Sensitivity			34 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…250 bar	
Natural frequency			100 kHz	
Acceleration sensitivity	≤		0.001 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			8 pF	
Sensor operating temperature range [1]			- 40…400 °C	
Thermal sensitivity change	≤		1 %	20…400 °C and 0…250 bar
	≤	±	0.25 %	250 ± 100 °C and 0…250 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.4 bar	
Thermo shock error Δp [3]	≤	±	0.2 bar	typ.
Mounting bore			6.3 mm	shoulder sealed
Cable Connection			M4×0.35	negative
Weight			12.5 grams	without cable
Mounting torque			10 Nm	using SF01

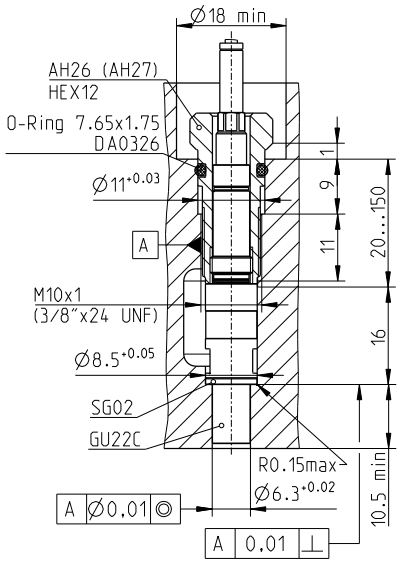
[1] surface temperature around the cable connection < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation with the mounting nipple AM04 (AM05).



Direct installation with the mounting nipple AM04 (AM05) and thermo protection PH04.



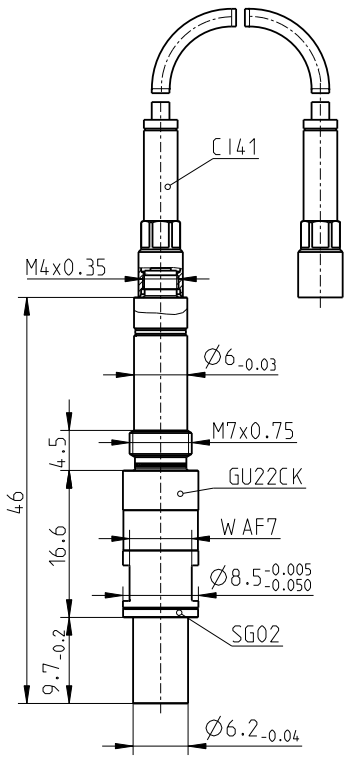
Direct installation with the mounting sleeve AH26 (AH27).

ACCESSORIES

Cables & couplings	CI41, CI42, CI4V, CC41, CC42, E124		See pages 100 to 105
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG02	TIBQ0227A.01	See page 98
Mounting nipples	AM04 (M10×1) AM05 (3/8×24 UNF)	TIWG0240A.01 TIWG0253A.01	See page 88
Safety ring for mounting nipples	AM06	TIWG0417A.01	See page 88
Mounting sleeves	AH26, AH27, AH28		See page 87
Dummy	DG10 (GU22C), DG14 (GU22C + PH04)		See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Mounting adaptors	MA05 (GU22C + PH04), MA06 (GU22C)		See page 86
Mounting tool	Toolset TS02 (TT09, TT18) (for AM04, 05) Mounting socket short TT09 (for AM04, 05) Mounting socket TA13 (for AM04, 05) Mounting socket TT07 (for AH26, 27, 28) Torque wrench TT18	TIWG0128A.01 TIWG0140A.01 TIWG0136A.01 TIWG0133A.01 TIWG0209A.01	See pages 94 to 97
Machining tool	Step drill MD10 (with thread 3/8``x 24 UNF) Step drill MD16 (with thread M10×1) Tap drill MT31 (M10×1) Tap drill MT13 (3/8×24 UNF)	TIWG0257A.01 TIWG0418A.01 TIWG0156A.01 TIWG0369A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96
Flame arrestor	PH04	TIYF0760A.01	See page 99

GU22CK

TIGG1355A.01



The GU22CK is an accurate and robust 6.2 mm plug-type sensor. It is based on a well established design concept that allows high accuracy. It has thermally optimized piezoelectric elements and no influence from the mounting bore on the pressure signal due to minimized mechanical contact between mounting bore and the sensor housing. A thermo protection can improve the cyclic drift down below ± 0.3 bar. The sensor is equipped with built in SID for SDM.

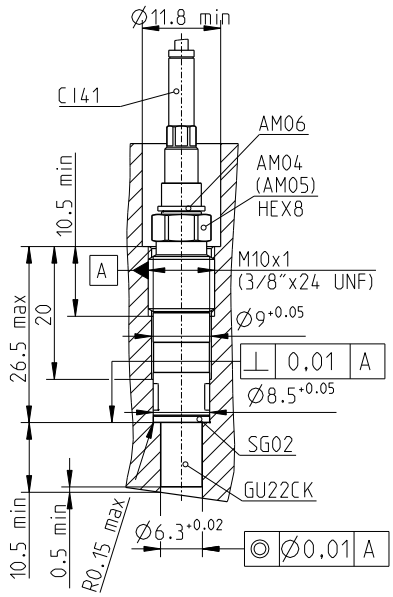
SCOPE OF SUPPLY

- Sensor GU22CK
- Piezo-input cable CI41-1
- Coupling CC41
- Gasket SG02
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG02
- Calibration sheet
- Documentation

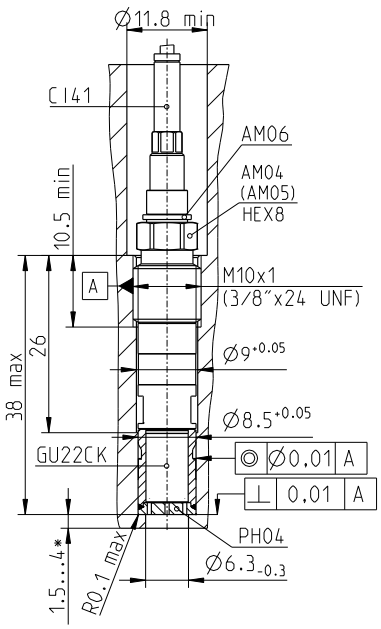
SPECIFICATIONS

Measuring range			0 … 350 bar	
Overload			400 bar	
Sensitivity			34 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 300 bar	
Natural frequency			96 kHz	
Acceleration sensitivity	≤		0.001 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			8 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤		1 %	20 … 400 °C and 0 … 300 bar
	≤	±	0.25 %	250 ± 100 °C and 0 … 300 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.6 bar	
Thermo shock error Δp [3]	≤	±	0.3 bar	typ.
Mounting bore			6.3 mm	shoulder sealed
Cable Connection			M4×0.35	negative
Weight			12.5 grams	without cable
Mounting torque			10 Nm	using SF01

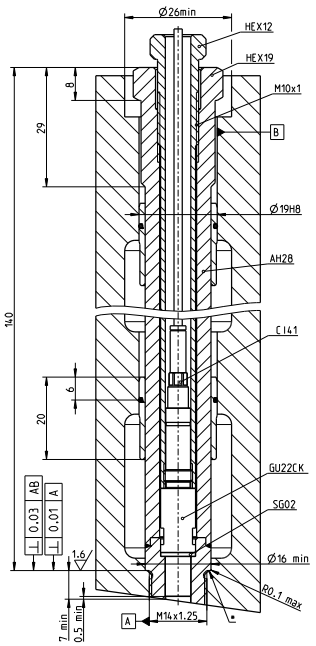
[1] surface temperature around the cable connection < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation with the mounting nipple AM04 (AM05).



Direct installation with the mounting nipple AM04 (AM05) and thermo protection PH04.



Installation with adaptor AH28.

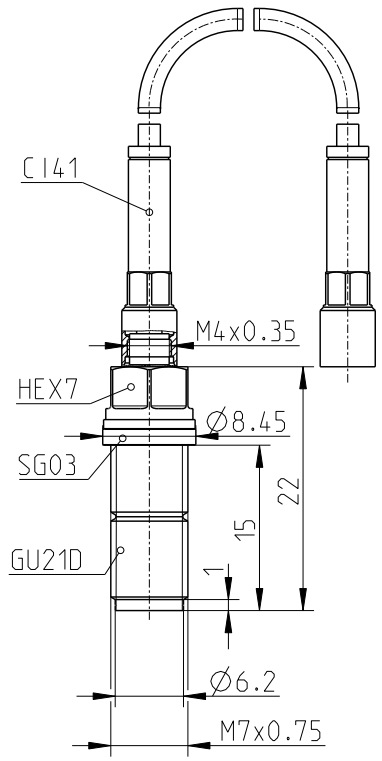
ACCESSORIES			
Cables & couplings	CI41, CI42, CI4V, CC41, CC42, E124		See pages 100 to 105
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG02	TIBQ0227A.01	See page 98
Mounting nipples	AM04 (M10×1), AM05 (3/8``×24 UNF)	TIWG0240A.01	See page 88
Safety ring for mounting nipples	AM06	TIWG0417A.01	See page 88
Mounting sleeves	AH26, AH27, AH28		See page 87
Dummy	DG10 (GU22C), DG14 (GU22C + PH04)		See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Mounting adaptors	MA05 (GU22C + PH04), MA06 (GU22C)		See page 86
Mounting tool	Toolset TS02 (TT09, TT18) (for AM04, 05) Mounting socket short TT09 (for AM04, 05) Mounting socket TA13 (for AM04, 05) Mounting socket TT07 (for AH26, 27, 28) Torque wrench TT18	TIWG0128A.01 TIWG0140A.01 TIWG0136A.01 TIWG0133A.01 TIWG0209A.01	See pages 94 to 97
Machining tool	Step drill MD10 (with thread 3/8``×24 UNF) Step drill MD16 (with thread M10×1) Tap drill MT31 (M10×1) Tap drill MT13 (3/8×24 UNF)	TIWG0257A.01 TIWG0418A.01 TIWG0156A.01 TIWG0369A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96
Flame arrestor	PH04	TIYF0760A.01	See page 99

GU21D

TIGG0558A.01

★ ★★★ ★★ GaPO4 SDM

The GU21D is an M7 solution for precise thermodynamic analysis especially when a smaller thread diameter than M8 is preferred. An integrated heat conducting element ensures excellent thermal coupling of the piezo elements to the cylinder head and therefore minimizes any negative thermal effects. The split mounting thread reduces negative influences like mechanical stresses from the mounting bore. The sensor is equipped with built in SID for SDM.



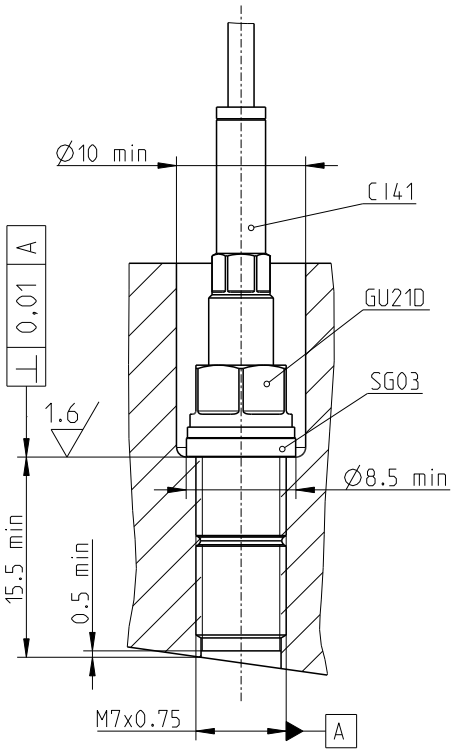
SCOPE OF SUPPLY

- Sensor GU21D
- Piezo-input cable CI41-1
- Coupling CC41
- Gasket SG03
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG03
- Calibration sheet
- Documentation

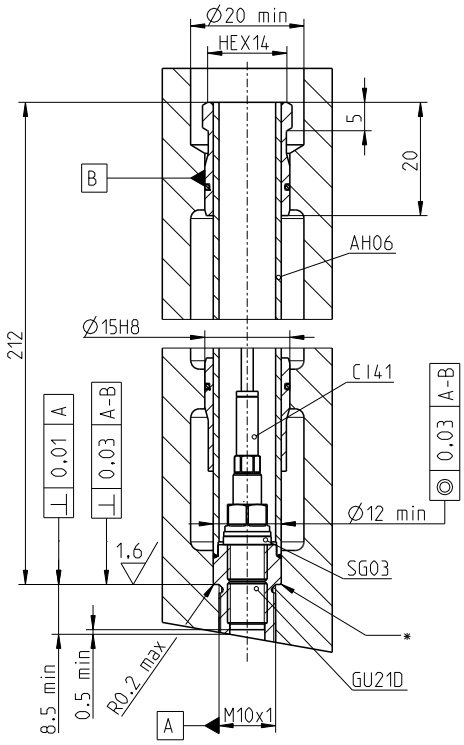
SPECIFICATIONS

Measuring range			0…250 bar	
Overload			300 bar	
Sensitivity			35 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…250 bar	
Natural frequency			85 kHz	
Acceleration sensitivity	≤		0.002 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			8 pF	
Sensor operating temperature range [1]			- 40…400 °C	
Thermal sensitivity change	≤		2 %	20…400 °C and 0…250 bar
	≤	±	0.5 %	250 ± 100 °C and 0…250 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.4 bar	
Thermo shock error Δp [3]	≤	±	0.3 bar	typ.
Thread diameter			M7×0.75	shoulder sealed
Cable Connection			M4×0.35	negative
Weight			6 grams	without cable
Mounting torque			3 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation.



Installation with adaptor sleeve AH06.

ACCESSORIES

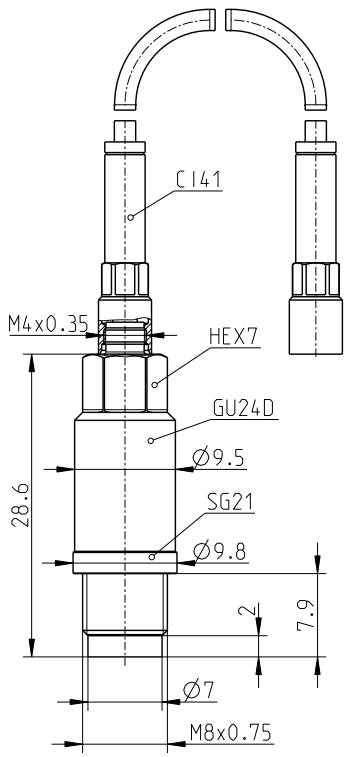
Cables & couplings	CI41, CI42, CI4V, CC41, CC42, E124		See pages 100 to 105
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG03	TIBQ0228A.01	See page 98
Gasket dismounting tool	TT17	TIWG0185A.01	See page 96
Dummy	DG04	TIWG0170A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Adaptor sleeves	AH06	TIWG0175A.01	See page 87
Mounting tool	Toolset TS03 (TT11, TT02) Mounting socket TT11 Torque wrench TT02	TIWG0181A.01 TIWG0180A.01 TIWG0117A.01	See pages 94 to 97
Machining tool	Toolset MS22 (MD22, MT21, MG22) Step drill MD22 Tap drill MT21	TIWG0165A.01 TIWG0151A.01 TIWG0155A.01	See pages 92 to 93
Machining tool for AH06	Toolset MS24 (MD24, MT31) Step drill MD24 Tap drill MT31	TIWG0167A.01 TIWG0153A.01 TIWG0156A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96

GU24D

TIGG1329A.01

★ | IMEP ★★★ | non stop ★★ | $GaPO_4$ | SDM | double shell

The GU24D is a sensor which combines the convenient installation of M8 thread-type sensors with high accuracy that is required for precise thermodynamic analysis. The Double-Shell™ design decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. The sensor is equipped with built in SID for SDM.



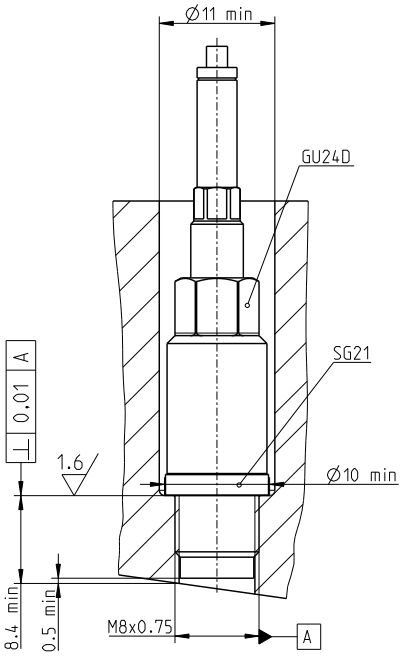
SCOPE OF SUPPLY

- Sensor GU24D
- Piezo-input cable CI41-1
- Coupling CC41
- Gasket SG21
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG21
- Calibration sheet
- Documentation

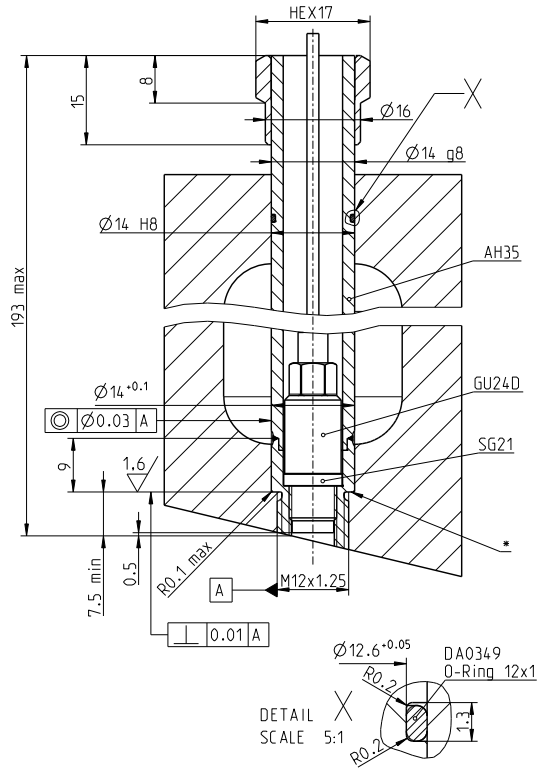
SPECIFICATIONS

Measuring range			0…250 bar	
Overload			300 bar	
Sensitivity			45 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…250 bar	
Natural frequency			92 kHz	
Acceleration sensitivity	≤		0.002 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			8 pF	
Sensor operating temperature range [1]			- 40…400 °C	
Thermal sensitivity change	≤		1 %	20…400 °C and 0…250 bar
	≤	±	0.25 %	250 ± 100 °C and 0…250 bar typ.
Load change drift			4 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.3 bar	
Thermo shock error Δp [3]	≤	±	0.2 bar	typ.
Thread diameter			M8×0.75	shoulder sealed
Cable Connection			M4×0.35	negative
Weight			14 grams	without cable
Mounting torque			6 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation.



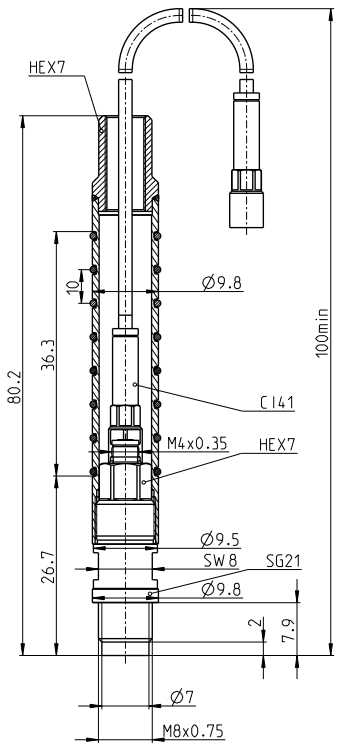
Installation with an AH35 adaptor.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

ACCESSORIES

Cables & couplings	CI41, CI42, CI4V, CC41, CC42, E124		See pages 100 to 105
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG21	TIYF0718A.01	See page 98
Gasket dismounting tool	TT33	TIWG0281A.01	See page 96
Dummy	DG09	TIWG0278A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Adaptor sleeves	AH35, MA04		See page 87
Mounting tool	Mounting socket TT11 Torque wrench TT32	TIWG0180A.01 TIWG0236A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See page 96

GU24DE

TIGG1478A.01



The GU24DE is a sensor which combines the convenient installation of M8 thread-type sensors with the high accuracy that is required for precise thermodynamic analysis. The sensor has also a special extension tube which allows it to cross water and oil jackets of the engine without the need of an adaptor sleeve. The Double-Shell™ design decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. The sensor is equipped with built in SID for SDM.

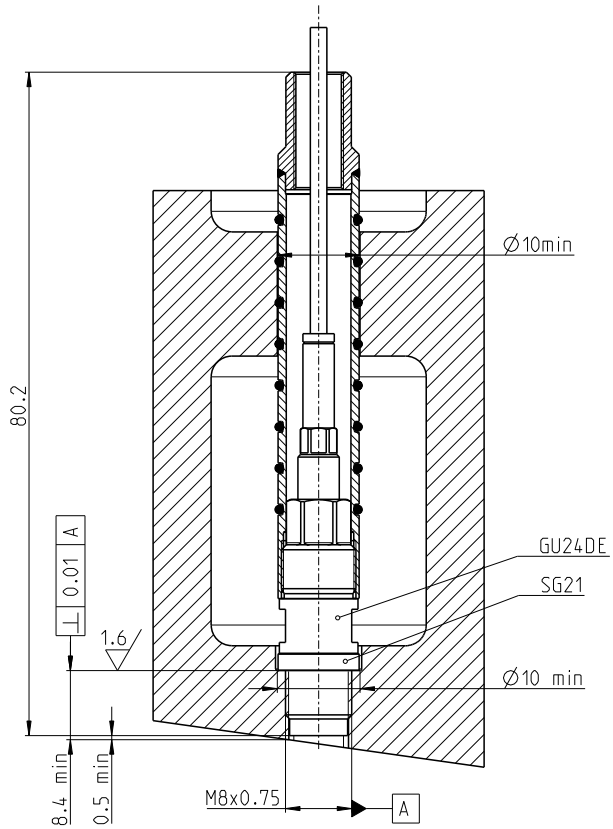
SCOPE OF SUPPLY

- Sensor GU24DE
- Piezo-input cable CI41-1
- Coupling CC41
- Gasket SG21
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG21
- Calibration sheet
- Documentation

SPECIFICATIONS

Measuring range			0 … 250 bar	
Overload			300 bar	
Sensitivity			45 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 250 bar	
Natural frequency			92 kHz	
Acceleration sensitivity	≤		0.002 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			8 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤		1.5 %	20 … 400 °C and 0 … 250 bar
	≤	±	0.25 %	250 ± 100 °C and 0 … 250 bar typ.
Load change drift			4 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.3 bar	
Thermo shock error Δp [3]	≤	±	0.2 bar	typ.
Thread diameter			M8×0.75	shoulder sealed
Cable Connection			M4×0.35	negative
Weight			22.5 grams	without cable
Mounting torque			6 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation.

ACCESSORIES

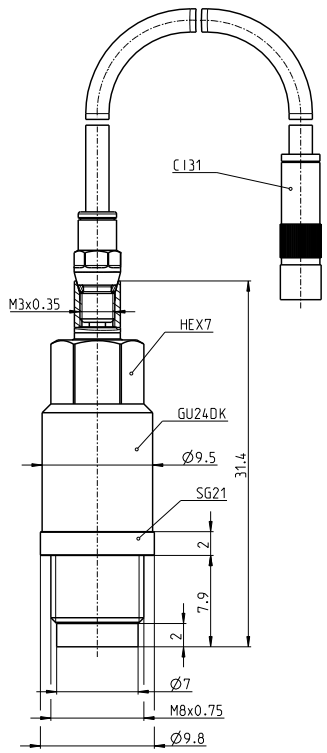
Cables & couplings	CI41, CI42, CI4V, CC41, CC42, E124		See pages 100 to 105
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG21	TIYF0718A.01	See page 98
Gasket dismounting tool	TT33	TIWG0281A.01	See page 96
Dummy	DG25	TIWG0405A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Mounting tool	Mounting socket TT11 Torque wrench TT32	TIWG0180A.01 TIWG0236A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See page 96

GU24DK

TIGG1887A.01

★★ ★★ ★★

The GU24DK is a sensor which combines the convenient installation of M8 thread-type sensors with high accuracy and robustness that is required for typical research and development work. It has thermally optimized piezoelectric elements. The sensor is equipped with built in SID for SDM.



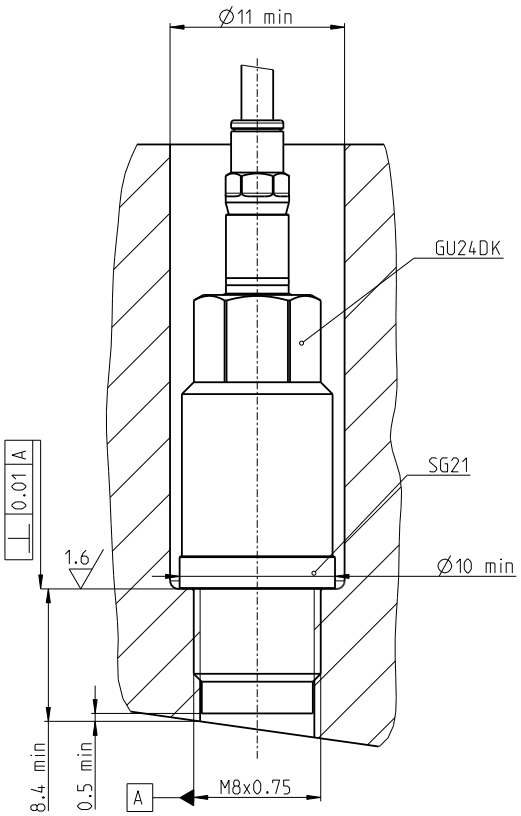
SCOPE OF SUPPLY

- Sensor GU24DK
- Piezo-input cable CI31-1
- Coupling CC31
- Gasket SG21
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG21
- Calibration sheet
- Documentation

SPECIFICATIONS

Measuring range			0…300 bar	
Overload			350 bar	
Sensitivity			35 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…300 bar	
Natural frequency			100 kHz	
Acceleration sensitivity	≤		0.0013 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			12 pF	
Sensor operating temperature range [1]			- 40…400 °C	
Thermal sensitivity change	≤		1.5 %	20…400 °C and 0…300 bar
	≤	±	0.25 %	250 ± 100 °C and 0…300 bar typ.
Cyclic temperature drift [2]	≤	±	0.7 bar	
Thermo shock error Δp [3]	≤	±	0.3 bar	typ.
Thread diameter			M8×0.75	shoulder sealed
Cable Connection			M3×0.35	negative
Weight			14 grams	without cable
Mounting torque			6 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation.

ACCESSORIES

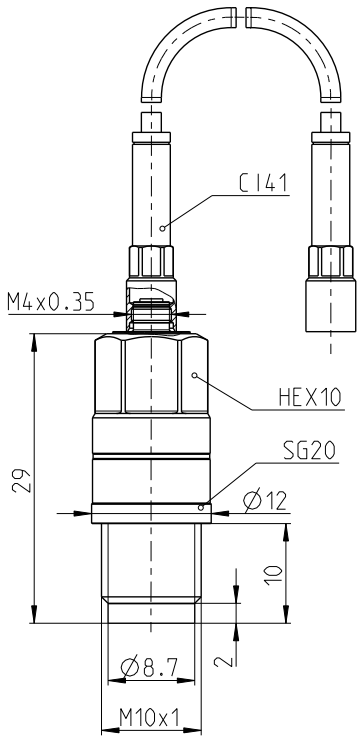
Cables & couplings	CI31, CI32, CI3V, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Gasket	SG21	TIYF0718A.01	See page 98
Gasket dismounting tool	TT33	TIWG0281A.01	See page 96
Dummy	DG09	TIWG0278A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Adaptor sleeves	AH35, MA04		See page 87
Mounting tool	Mounting socket TT11 Torque wrench TT32	TIWG0180A.01 TIWG0236A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See page 96

GU31D

TIGG2057A.01

★★ ★★ ★★★ GaPO4 double shell

GU31D is a durable M10 cylinder pressure sensor for large-bore engines. The sensor can be used with various fuels such as diesel, heavy fuel oil or natural gas. It is equipped with a central preload element that makes this sensor suitable for permanent non-stop operation. The Double-Shell™ design decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. The sensor could be equipped with SIC for SDM.



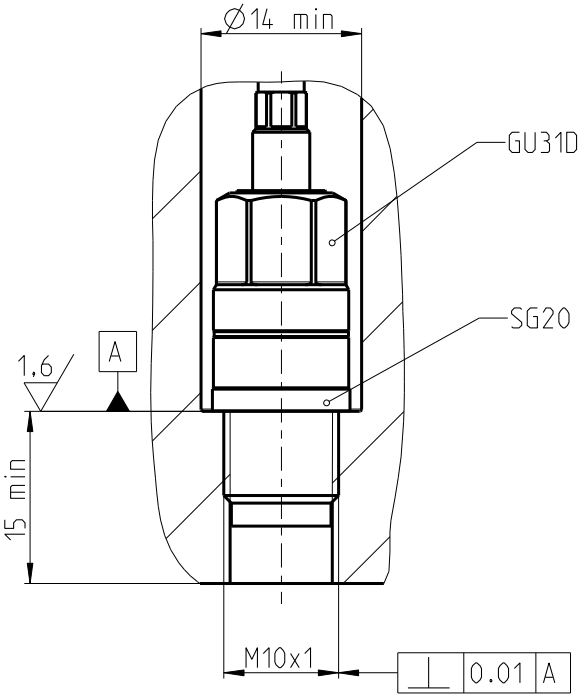
SCOPE OF SUPPLY

- Sensor GU31D
- Piezo-input cable CI41-1
- Coupling CC41
- Gasket SG20
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG20
- Calibration sheet
- Documentation

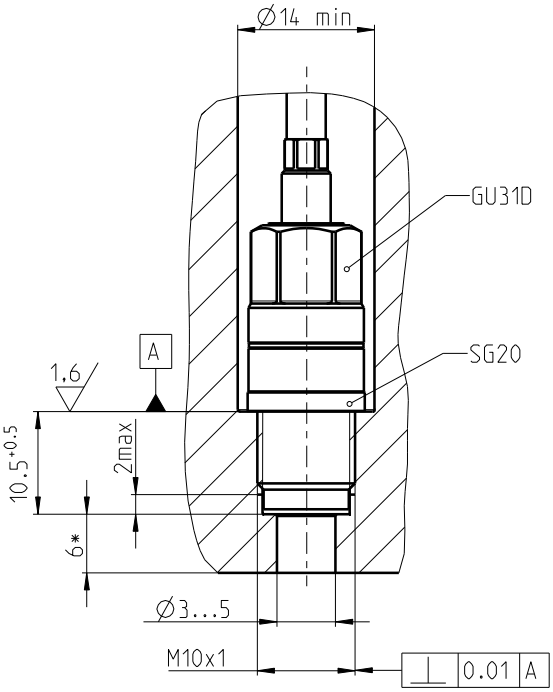
SPECIFICATIONS

Measuring range			0…250 bar	
Overload			300 bar	
Sensitivity			20 pC/bar	nominal
Linearity	≤	±	0.5 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…250 bar	
Natural frequency			90 kHz	
Acceleration sensitivity	≤		0.001 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			7 pF	
Sensor operating temperature range [1]			- 40…350 °C	
Thermal sensitivity change	≤		0.5 %	20…350 °C and 0…250 bar
	≤	±	0.2 %	250 ± 100 °C and 0…250 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.8 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Thread diameter			M10×1	shoulder sealed
Cable Connection			M4×0.35	negative
Weight			22 grams	without cable
Mounting torque			15…20 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Shoulder sealed direct installation.



Recessed shoulder sealed direct installation.
*) recommended

ACCESSORIES

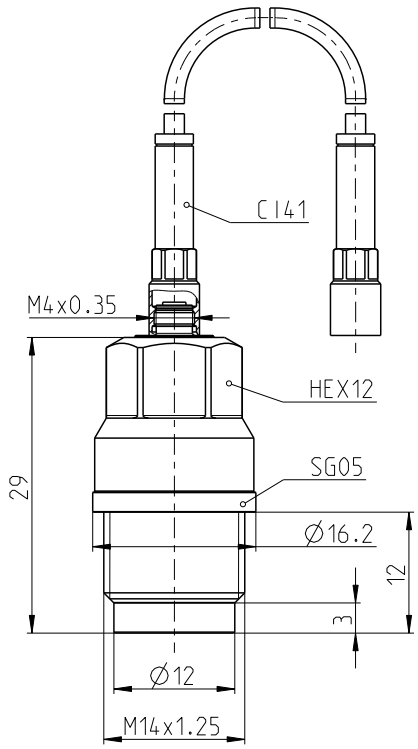
Cables & couplings	CI41, CI42, CI4V, CC41, CC42, E124		See pages 100 to 105
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG20	TIBQ0231A.01	See page 98
Gasket dismounting tool	TT15	TIWG0179A.01	See page 96
Dummy	DG11	TIWG0339A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Mounting tool	Mounting socket TA16	TIWG0200A.01	See pages 94 to 97
Machining tool	Tap drill MT31 Torque wrench TT18	TIWG0156A.01 TIWG0209A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96

GU41D

TIGG2292A.01

★★ ★★ ★★★ GaPO4 double shell

GU41D is a durable M14 cylinder pressure sensor for engine development. The sensor can be used with various fuels such as diesel, heavy fuel oil or natural gas. It is equipped with a central preload element that makes this sensor suitable for permanent non-stop operation. The Double-Shell™ design decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. The sensor could be equipped with SIC for SDM.



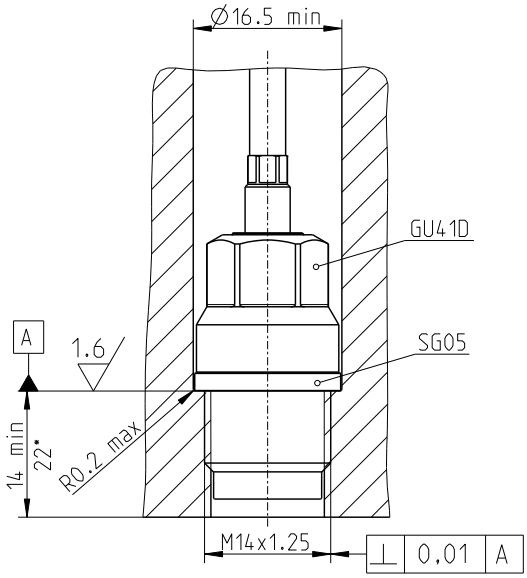
SCOPE OF SUPPLY

- Sensor GU41D
- Piezo-input cable CI41-1
- Coupling CC41
- Gasket SG05
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG05
- Calibration sheet
- Documentation

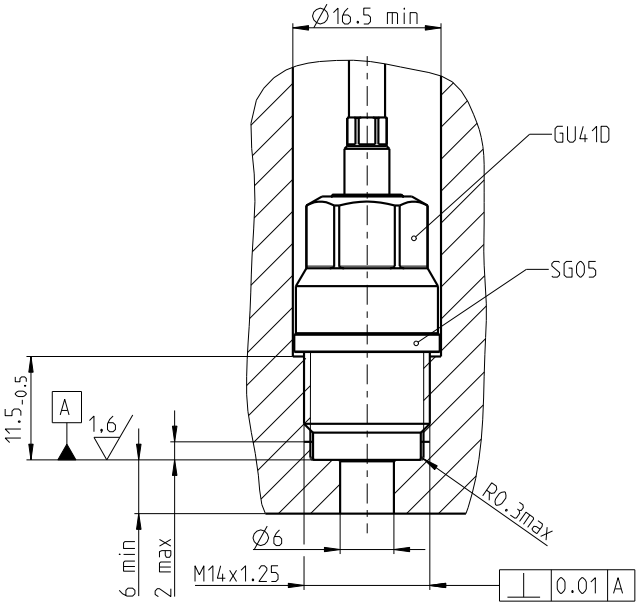
SPECIFICATIONS

Measuring range			0…250 bar	
Overload			300 bar	
Sensitivity			20 pC/bar	nominal
Linearity	≤	±	0.5 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…250 bar	
Natural frequency			90 kHz	
Acceleration sensitivity	≤		0.001 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			7 pF	
Sensor operating temperature range [1]			- 40…350 °C	
Thermal sensitivity change	≤		0.5 %	20…350 °C and 0…250 bar
	≤	±	0.2 %	250 ± 100 °C and 0…250 bar typ.
Load change drift			1.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.8 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Thread diameter			M14×1.25	shoulder or front sealed
Cable Connection			M4×0.35	negative
Weight			34 grams	without cable
Mounting torque			20…25 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Shoulder sealed direct installation.
*) recommended

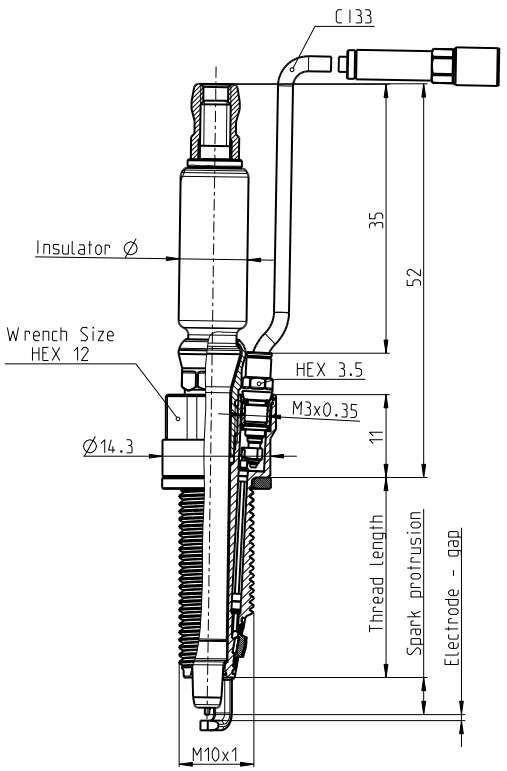


Front sealed direct installation.

ACCESSORIES

Cables & couplings	CI41, CI42, CI4V, CC41, CC42, E124		See pages 100 to 105
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG05	TIBQ0230A.01	See page 98
Gasket dismounting tool	TT14	TIWG0178A.01	See page 96
Dummy	DG12	TIWG0340A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Mounting tool	Mounting socket TT07 Torque wrench TT18	TIWG0133A.01 TIWG0209A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See page 96

ZI22



The ZI22 is a spark-plug with integrated pressure sensor. The new M10 design has a small eccentricity of the center electrode which allows the ignition to behave in nearly the same manner as the original spark plug. In order to maximize the electric strength of the insulator, an increased ceramic diameter and a complete new design of the sensor membrane is used. All this results in an impressive measurement performance and highest reliability. The insulator of the spark-plug is manufactured by Bosch. The sensor could be equipped with SIC for SDM.

SCOPE OF SUPPLY

- Sensor ZI22
- Piezo-input cable CI33-1
- Coupling CC41
- Gasket SG32
- Accessory kit (protection cap + 2 o-rings)
- Calibration sheet
- Documentation

SPECIFICATIONS

Measuring range			0…200 bar	
Overload			250 bar	
Sensitivity			11 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…140 bar 0…200 bar	
Natural frequency	~		150 kHz	
Acceleration sensitivity	≤		0.0001 bar/g	axial/radial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			3.5 pF	
Sensor operating temperature range [1]			- 40…350 °C	
Thermal sensitivity change	≤	±	0.3 %	200 ± 50 °C and 0…200 bar typ.
Load change drift			2 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.5 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Temperature of plug-seat	≤		230 °C	permanent
Spark-plug insulator resistivity	≥		10^8 Ω	at 20 °C, 1 kV
Burn-off resistance			6 kΩ	at 20 °C, 1 kV
Electric strength (ISO 11565, 3.7.2)			45 kV	
Eccentricity of insulator			1.25 mm	
Thread diameter			M10×1	
Cable Connection			M3×0.35	negative
Weight			33 grams	without cable
Mounting torque (into spark plug bore)			10…15 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline

PURCHASE NUMBER

Thread length
S … 12.7 mm
M … 19 mm
L … 26.5 mm
X … 28 mm
Z … specific

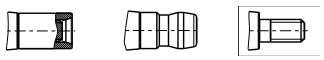
Sealing / wrench size
F … Flat / HEX 12
Z … specific

Heat range (Bosch)
1 … 07
3 … 3
4 … 4[A]
5 … 5
6 … 6[A]
7 … 7
9 … specific
[A] not standard model

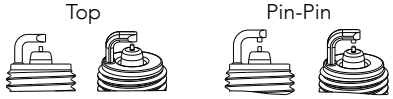
Spark protrusion
1 … 1 mm
2 … 2 mm
3 … 3 mm
4 … 4 mm
5 … 5 mm
6 … 6 mm
9 … specific

TI 22 ☐ ☐ ☐ ☐ ☐ A. ☐ ☐

Connector type / insulator Φ
N … NAPF / 9 mm
S … SAE / 9 mm
M … M4 / 9 mm
A … NAPF / 10.5 mm
E … SAE / 10.5 mm
4 … M4 / 10.5 mm
Z … specific



Electrode type / index mounting
T … Top (Pt)
P … Pin-Pin
D … Top + Index mounting
B … Pin-Pin + Index mounting
Z … specific



Electrode-gap
A … 0.4 mm
B … 0.5 mm
C … 0.6 mm
D … 0.7 mm
E … 0.8 mm
F … 0.9 mm
G … 1.0 mm
Z … specific

Spare insulator*: TI SP ☐ R ☐ IN A. ☐ ☐

Dummy – insulator*: TI DY ☐ R ☐ IN A. ☐ ☐

*) Position-order-sequence as for spark plugs shown above

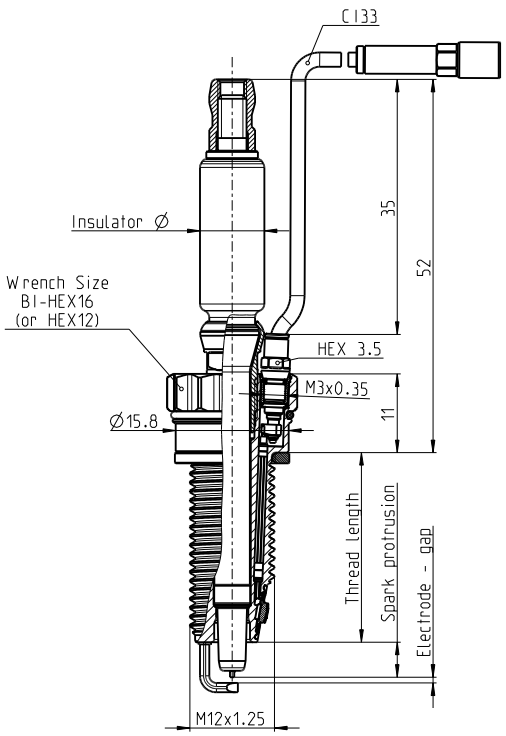
ACCESSORIES

Cables & couplings	CI33, CI37, CC41, CC42, CC43, E124		See pages 100 to 105
Ignition voltage extension cable	CE09	TIBY0679A.01	
Cable mounting tool	TT39	TIWG0510A.01	See page 95
Gaskets (for spark plug)	SG32 (1.5 mm) and customized solutions	TIYG2767A.01	See page 98
Gasket (for insulator)	SG30	TIYG2513A.01	See page 98
Mounting tool	Mounting socket TT30 (Ø=17.0 mm) Mounting socket TT34 (Ø=19.9 mm) Torque wrench for spark plug sensor TT18	TIWG0598A.01 TIWG0606A.01 TIWG0209A.01	See pages 94 to 97
Special tools for spark plugs	Mounting socket TT48 (for insulator exchange) Torque wrench for insulator exchange TT50 Gap adjustment tool TA32	TIWG0469A.01 TIWG0473A.01 TIWG0387A.01	See page 97
Spark-plug insulator grease	ZFK01	TIHS0060A.01	See page 96
Mounting paste	SF01	TIHK0094A.01	See page 96
Spare parts	Napf-connector Spare insulator Insulator dummy (for calibration)	TIYG2453A.01 see above see above	

ZI33

★★ ★★ ★ GaPO4

The ZI33 is a spark-plug with integrated pressure sensor. The new M12 design has 0.0 mm eccentricity of the center electrode which allows the ignition to behave in the same manner as the original spark plug. In order to maximize the electric strength of the insulator, an increased ceramic diameter and a completely new design of the sensor membrane is used. All this results in impressive measurement performance and highest reliability. The insulator of the spark-plug is manufactured by Bosch. The sensor could be equipped with SIC for SDM.



SCOPE OF SUPPLY

- Sensor ZI33
- Piezo-input cable CI33-1
- Coupling CC41
- Gasket SG08
- Accessory kit (protection cap + 2 o-rings)
- Calibration sheet
- Documentation

SPECIFICATIONS

Measuring range			0…200 bar	
Overload			250 bar	
Sensitivity			11 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…140 bar 0…200 bar	
Natural frequency	~		150 kHz	
Acceleration sensitivity	≤		0.0001 bar/g	axial/radial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			3.5 pF	
Sensor operating temperature range [1]			- 40…350 °C	
Thermal sensitivity change	≤	±	0.3 %	200 ± 50 °C and 0…200 bar typ.
Load change drift			2 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.5 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Temperature of plug-seat	≤		230 °C	permanent
Spark-plug insulator resistivity	≥		10^8 Ω	at 20 °C, 1 kV
Burn-off resistance			6 kΩ	at 20 °C, 1 kV
Electric strength (ISO 11565, 3.7.2)			45 kV	
Eccentricity of insulator			0.0 mm	
Thread diameter			M12×1.25	
Cable Connection			M3×0.35	negative
Weight			44 grams	without cable
Mounting torque (into spark plug bore)			15…25 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline

PURCHASE NUMBER

Thread length
S … 12.7 mm
M … 19 mm
L … 26.5 mm
X … 28 mm
Z … specific

Sealing / wrench size
F… Flat / BI-HEX 16
C… Conical[1] / BI-HEX 16
G… Flat / HEX 12
D… Conical[1] / HEX 12
[1] conical: thread length is reduced by 1.5 mm

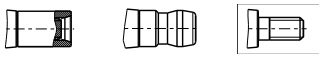
Heat range (Bosch)
1 … 07
3 … 3
4 … 4[A]
5 … 5
6 … 6[A]
7 … 7
9 … specific
[A] not standard model

Spark protrusion
1 … 1 mm
2 … 2 mm
3 … 3 mm
4 … 4 mm
5 … 5 mm
6 … 6 mm
9 … specific

TI 33 ☐ ☐ ☐ ☐ ☐ A. ☐ ☐

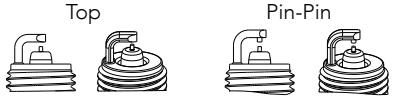
Connector type / insulator Φ
N … NAPF / 9 mm
S … SAE / 9 mm
M … M4 / 9 mm
A … NAPF / 10.5 mm
E … SAE / 10.5 mm
4 … M4 / 10.5 mm
Z … specific

NAPF SAE M4



Electrode type / index mounting
T … Top (Pt)
P … Pin-Pin
D … Top + Index mounting
B … Pin-Pin + Index mounting
Z…specific

Top Pin-Pin



Electrode-gap
A … 0.4 mm
B … 0.5 mm
C … 0.6 mm
D … 0.7 mm
E … 0.8 mm
F … 0.9 mm
G … 1.0 mm
Z … specific

Spare insulator*: TI SP ☐ R ☐ IN A. ☐ ☐

Dummy – insulator*: TI DY ☐ R ☐ IN A. ☐ ☐

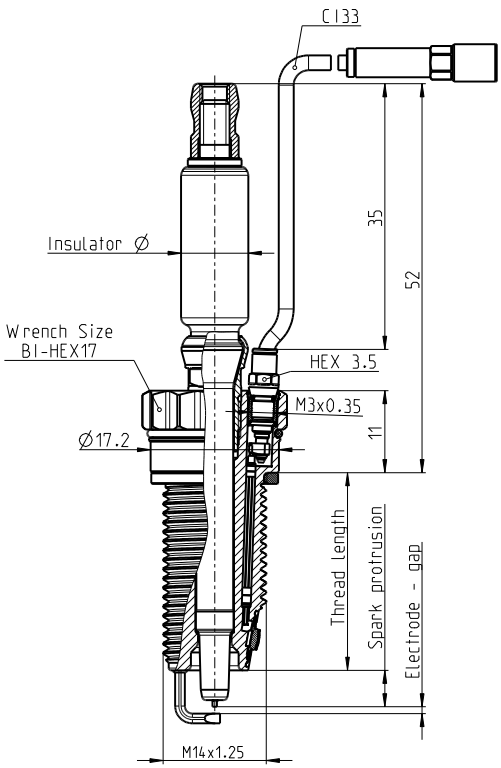
*) Position-order-sequence as for spark plugs shown above

ACCESSORIES

Cables & couplings	CI33, CI37, CC41, CC42, CC43, E124		See pages 100 to 105
Ignition voltage extension cable	CE09	TIBY0679A.01	
Cable mounting tool	TT39	TIWG0510A.01	See page 95
Gaskets (for spark plug)	SG08 (1.5mm) and customized solutions	TIYF0640A.01	See page 98
Gasket (for insulator)	SG30	TIYG2513A.01	See page 98
Mounting tool	Mounting socket TT24 (Ø=20.2 mm) Mounting socket TT57 (Ø=19.9 mm) Mounting socket TT22 (Ø=19.0 mm) Torque wrench for spark plug sensor TT18 Extension TT43 T-handle TT44	TIWG0234A.01 TIWG0585A.01 TIWG0233A.01 TIWG0209A.01 TIYG1026A.01 TIYG1027A.01	See pages 94 to 97
Special tools for spark plugs	Mounting socket TT48 (for insulator exchange) Torque wrench for insulator exchange TT50 Gap adjustment tool TA32	TIWG0469A.01 TIWG0473A.01 TIWG0387A.01	See page 97
Spark-plug insulator grease	ZFK01	TIHS0060A.01	See page 96
Mounting paste	SF01	TIHK0094A.01	See page 96
Spare parts	Napf-connector Spare insulator Insulator dummy (for calibration)	TIYG2453A.01 see above see above	

ZI45

★★ ★★ ★ GaPO4



The ZI45 is a spark-plug with integrated pressure sensor. The new M14 design has 0.0 mm eccentricity of the center electrode which allows the ignition to behave in the same manner as the original spark plug. In order to maximize the electric strength of the insulator, an increased ceramic diameter and a completely new design of the sensor membrane is used. All this results in impressive measurement performance and highest reliability. The insulator of the spark-plug is manufactured by Bosch. The sensor could be equipped with SIC for SDM.

SCOPE OF SUPPLY

- Sensor ZI45
- Piezo-input cable CI33-1
- Coupling CC41
- Gasket SG06
- Accessory kit (protection cap + 2 o-rings)
- Calibration sheet
- Documentation

SPECIFICATIONS

Measuring range			0…200 bar	
Overload			250 bar	
Sensitivity			11 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0…80 bar 0…140 bar 0…200 bar	
Natural frequency	~		150 kHz	
Acceleration sensitivity	≤		0.0001 bar/g	axial/radial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			3.5 pF	
Sensor operating temperature range [1]			- 40…350 °C	
Thermal sensitivity change	≤	±	0.3 %	200 ± 50 °C and 0…200 bar typ.
Load change drift			2 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.5 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Temperature of plug-seat	≤		230 °C	permanent
Spark-plug insulator resistivity	≥		10^8 Ω	at 20 °C, 1 kV
Burn-off resistance			6 kΩ	at 20 °C, 1 kV
Electric strength (ISO 11565, 3.7.2)			45 kV	
Eccentricity of insulator			0.0 mm	
Thread diameter			M14×1.25	
Cable Connection			M3×0.35	negative
Weight			53 grams	without cable
Mounting torque (into spark plug bore)			15…25 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline

PURCHASE NUMBER

Thread length
S … 12.7 mm
M … 19 mm
L … 26.5 mm
X … 28 mm
Z … specific

Sealing / wrench size
F … Flat / BI-HEX17
C … Conical[1] / BI-HEX17

[1] conical: thread length is reduced by 1.5 mm

Heat range (Bosch)
3 … 3
4 … 4[A]
5 … 5
6 … 6[A]
7 … 7
9 … specific

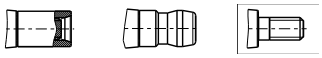
[A] not standard model

Spark protrusion
1 … 1 mm
2 … 2 mm
3 … 3 mm
4 … 4 mm
5 … 5 mm
6 … 6 mm
9 … specific

TI **45** ☐ ☐ ☐ ☐ ☐ A. ☐ ☐

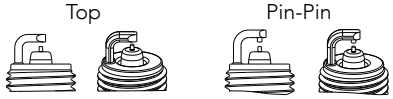
Connector type / insulator Φ
N … NAPF / 9 mm
S … SAE / 9 mm
M … M4 / 9 mm
A … NAPF / 10.5 mm
E … SAE / 10.5 mm
4 … M4 / 10.5 mm
Z … specific

NAPF SAE M4



Electrode type / index mounting
T … Top (Pt)
P … Pin-Pin
D … Top + Index mounting
B … Pin-Pin + Index mounting
Z … specific

Top Pin-Pin



Electrode-gap
A … 0.4 mm
B … 0.5 mm
C … 0.6 mm
D … 0.7 mm
E … 0.8 mm
F … 0.9 mm
G … 1.0 mm
Z … specific

Spare insulator*: TI **SP** ☐ R ☐ IN A. ☐ ☐

Dummy – insulator*: TI **DY** ☐ R ☐ IN A. ☐ ☐

*) Position-order-sequence as for spark plugs shown above

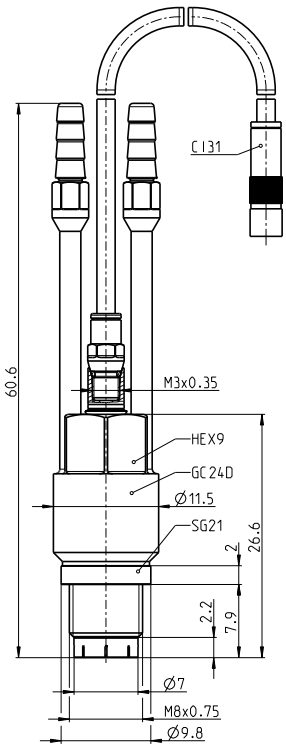
ACCESSORIES

Cables & couplings	CI33, CI37, CC41, CC42, CC43, E124		See pages 100 to 105
Ignition voltage extension cable	CE09	TIBY0679A.01	
Cable mounting tool	TT39	TIWG0510A.01	See page 95
Gaskets (for spark plug)	SG06 (1.5 mm) and customized solutions	TIYF0629A.01	See page 98
Gasket (for insulator)	SG30	TIYG2513A.01	See page 98
Mounting tool	Mounting socket TT42 Torque wrench for spark plug sensor TT18 Extension TT43 T-handle TT44	TIYG1024A.01 TIWG0209A.01 TIYG1026A.01 TIYG1027A.01	See pages 94 to 97
Special tools for spark plugs	Mounting socket TT48 (for insulator exchange) Torque wrench for insulator exchange TT50 Gap adjustment tool TA32	TIWG0469A.01 TIWG0473A.01 TIWG0387A.01	See page 97
Spark-plug insulator grease	ZFK01	TIHS0060A.01	See page 96
Mounting paste	SF01	TIHK0094A.01	See page 96
Spare parts	Napf-connector Spare insulator Insulator dummy (for calibration)	TIYG2453A.01 see above see above	

GC24D

TIGG1785A.01

The GC24D is a watercooled $GaPO_4$ sensor with a convenient installation by M8 threads and allows very precise thermodynamic measurements. It has thermally optimized piezoelectric elements. An active water cooling system is required to ensure long lifetimes and excellent thermodynamic behavior. In case of a failure in the cooling system the GC24D is designed so that the sensor can survive temperatures up to 400 °C. The sensor is equipped with built in SID for SDM.



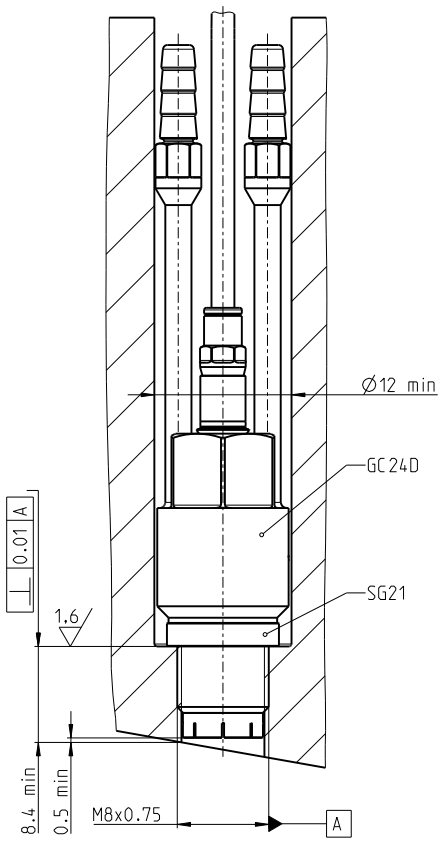
SCOPE OF SUPPLY

- Sensor GC24D
- Piezo-input cable CI31-1
- Coupling CC31
- Gasket SG21
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG21
- Calibration sheet
- Documentation

SPECIFICATIONS

Measuring range			0 … 250 bar	
Overload			300 bar	
Sensitivity			45 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 250 bar	
Natural frequency			90 kHz	
Acceleration sensitivity	≤ ≤		0.01 bar/g 0.001 bar/g	axial, water cooled axial, uncooled
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			12 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤ ≤	 ±	1.5 % 0.25 %	20 … 400 °C and 0 … 250 bar 50 ± 30 °C and 0 … 250 bar typ.
Load change drift			3.0 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.3 bar	
Thermo shock error Δp [3]	≤	±	0.2 bar	typ.
Thread diameter			M8×0.75	shoulder sealed
Cable Connection			M3×0.35	negative
Weight			14 grams	without cable
Mounting torque			6 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation.

ACCESSORIES

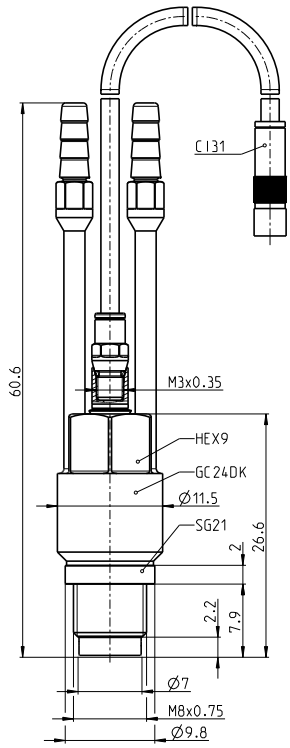
Cables & couplings	CI31, CI32, CI3V, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Gasket	SG21	TIYF0718A.01	See page 98
Gasket dismounting tool	TT54	TIWG0560A.01	See page 96
Dummy	DG09	TIWG0278A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Mounting tool	Mounting socket TT23 (for sensor) Mounting socket TT11 (for dummy) Torque wrench TT32	TIWG0548A.01 TIWG0180A.01 TIWG0236A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See page 96
Cooling system	ZP91.00/1-4 (230 V version) ZP91.00/1-8 (230 V version) ZP91.00/1-4 (115 V version) ZP91.00/1-8 (120 V version) ZP93/1-8 (230 V version)	TIZP91A.04 TIZP91A.08 TIZP91A.14 TIZP91A.28 TIZP93A.08	See pages 106 to 107

GC24DK

TIGG1792A.01

★★ ★★ ★★★ GaPO4 SDM

The GC24DK is a watercooled $GaPO_4$ sensor with a convenient installation by M8 threads and suitable for accurate and robust measurements in supercharged engines with very high specific output. It has thermally optimized piezoelectric elements. An active water cooling system is required to ensure long lifetimes and excellent thermodynamic behavior. In case of a failure in the cooling system the GC24DK is designed so that the sensor can survive temperatures up to 400 °C. The sensor is equipped with built in SID for SDM.



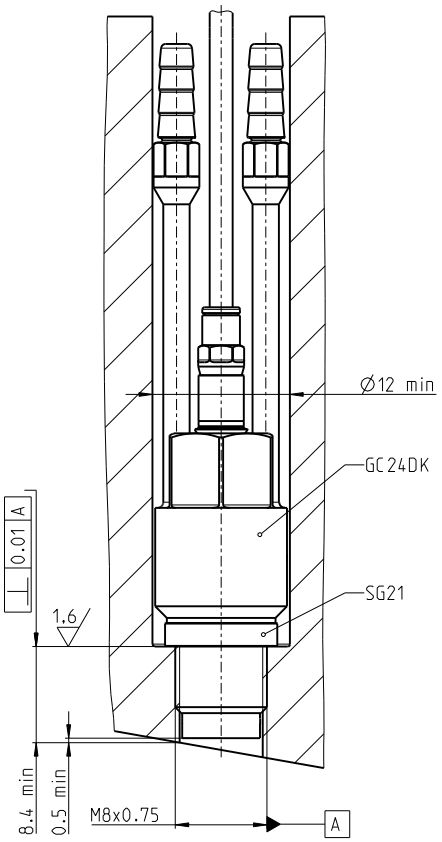
SCOPE OF SUPPLY

- Sensor GC24DK
- Piezo-input cable CI31-1
- Coupling CC31
- Gasket SG21
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG21
- Calibration sheet
- Documentation

SPECIFICATIONS

Measuring range			0 … 300 bar	
Overload			350 bar	
Sensitivity			35 pC/bar	nominal
Linearity	≤	±	0.3 %	FSO
Calibrated ranges			0 … 80 bar 0 … 150 bar 0 … 300 bar	
Natural frequency			100 kHz	
Acceleration sensitivity	≤ ≤		0.13 bar/g 0.0013 bar/g	axial, water cooled axial, uncooled
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			12 pF	
Sensor operating temperature range [1]			- 40 … 400 °C	
Thermal sensitivity change	≤ ≤	 ±	2 % 0.25 %	20 … 400 °C and 0 … 300 bar 50 ± 30 °C and 0 … 300 bar typ.
Cyclic temperature drift [2]	≤	±	0.7 bar	
Thermo shock error Δp [3]	≤	±	0.4 bar	typ.
Thread diameter			M8×0.75	shoulder sealed
Cable Connection			M3×0.35	negative
Weight			14 grams	without cable
Mounting torque			6 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation.

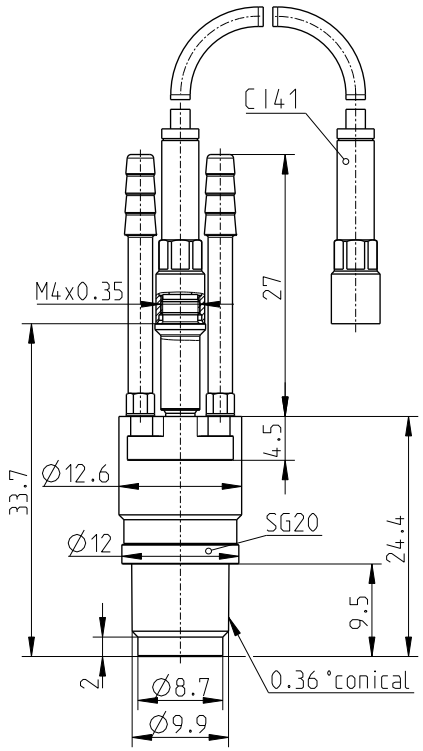
ACCESSORIES

Cables & couplings	CI31, CI32, CI3V, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Gasket	SG21	TIYF0718A.01	See page 98
Gasket dismounting tool	TT54	TIWG0560A.01	See page 96
Dummy	DG09	TIWG0278A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Mounting tool	Mounting socket TT23 (for sensor) Mounting socket TT11 (for dummy) Torque wrench TT32	TIWG0548A.01 TIWG0180A.01 TIWG0236A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See pages 96
Cooling system	ZP91.00/1-4 (230 V version) ZP91.00/1-8 (230 V version) ZP91.00/1-4 (115 V version) ZP91.00/1-8 (120 V version) ZP93/1-8 (230 V version)	TIZP91A.04 TIZP91A.08 TIZP91A.14 TIZP91A.28 TIZP93A.08	See pages 106 to 107

QC34C

TIGG1364A.01

The QC34C is a cooled quartz sensor with a mounting diameter of 9.9 mm designed especially for midrange engines. An active water cooling system is required to ensure long lifetimes and excellent thermodynamic behavior. In case of a failure in the cooling system the QC34C is designed so that the sensor can survive temperatures up to 350 °C. The sensor is equipped with built in SID for SDM.



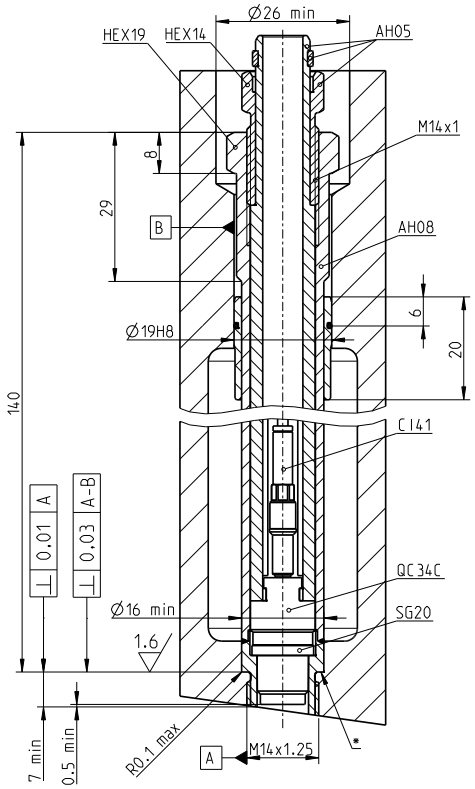
SCOPE OF SUPPLY

- Sensor QC34C
- Piezo-input cable CI41-1
- Coupling CC41
- Gasket SG20
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG20
- Calibration sheet
- Documentation

SPECIFICATIONS

Measuring range			0…250 bar	
Overload			300 bar	
Sensitivity			19 pC/bar	nominal
Linearity	≤	±	0.2 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…250 bar	
Natural frequency			69 kHz	
Acceleration sensitivity	≤ ≤		0.013 bar/g 0.003 bar/g	axial, water cooled axial, uncooled
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			10 pF	
Sensor operating temperature range [1]			- 40…350 °C	
Thermal sensitivity change (cooled)	≤		0.003 %/°C	20…80 °C and 0…250 bar
Load change drift			5.5 mbar/ms	max. gradient typ.
Cyclic temperature drift 2)	≤	±	0.3 bar	
Thermo shock error Δp 3)	≤	±	0.2 bar	typ.
Mounting bore			10 mm	shoulder sealed
Cable Connection			M4×0.35	negative
Cooling rate	≥		20 l/h	
Weight			15 grams	without cable
Mounting torque			15 Nm	using AH05 and SF01

[1] surface temperature around the cable connection < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Installation with an AS02 adaptor set.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

ACCESSORIES

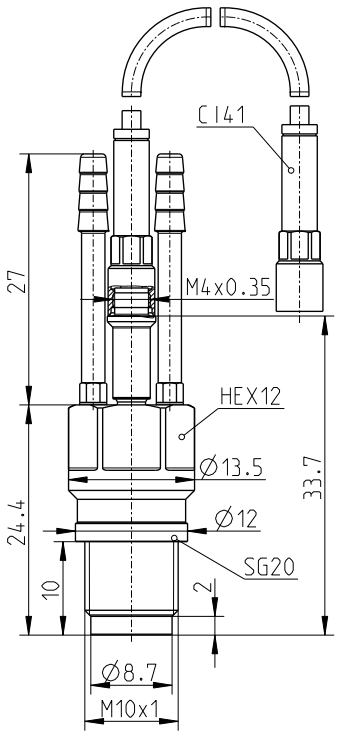
Cables & couplings	CI41, CI42, CC41, CC42, E124		
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG20	TIBQ0231A.01	See page 98
Gasket dismounting tool	TT15	TIWG0179A.01	See page 96
Dummy	DG05	TIWG0187A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Adaptor sleeves	AS02, AH05, AH08		See page 87
Mounting tool	Mounting socket TT08 (for AH05) Torque wrench TT18	TIWG0132A.01 TIWG0209A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See pages 96
Cooling system	ZP91.00/1-4 (230 V version) ZP91.00/1-8 (230 V version) ZP91.00/1-4 (115 V version) ZP91.00/1-8 (120 V version) ZP93/1-8 (230 V version)	TIZP91A.04 TIZP91A.08 TIZP91A.14 TIZP91A.28 TIZP93A.08	See pages 106 to 107

QC34D

TIGG1367A.01

★ IMEP ★★ non stop ★★★ SDM

The QC34D is a cooled quartz sensor with a mounting thread of M10 designed especially for midrange engines. An active water cooling system is required to ensure long lifetimes and excellent thermodynamic behavior. In case of a failure in the cooling system the QC34D is designed so that the sensor can survive temperatures up to 350 °C. The sensor is equipped with built in SID for SDM.



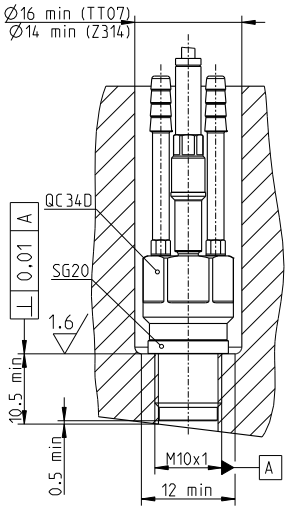
SCOPE OF SUPPLY

- Sensor QC34D
- Piezo-input cable CI41-1
- Coupling CC41
- Gasket SG20
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG20
- Calibration sheet
- Documentation

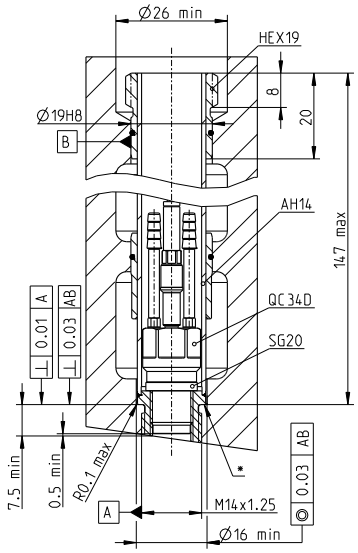
SPECIFICATIONS

Measuring range			0…250 bar	
Overload			300 bar	
Sensitivity			19 pC/bar	nominal
Linearity	≤	±	0.2 %	FSO
Calibrated ranges			0…80 bar 0…150 bar 0…250 bar	
Natural frequency			69 kHz	
Acceleration sensitivity	≤ ≤		0.013 bar/g 0.003 bar/g	axial, water cooled axial, uncooled
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			10 pF	
Sensor operating temperature range [1]			- 40…350 °C	
Thermal sensitivity change (cooled)	≤		0.003 %/°C	20…80 °C and 0…250 bar
Load change drift			4.5 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.3 bar	
Thermo shock error Δp [3]	≤	±	0.2 bar	typ.
Thread diameter			M10×1	shoulder sealed
Cable Connection			M4×0.35	negative
Cooling rate	≥		20 l/h	
Weight			15 grams	without cable
Mounting torque			10 Nm	using SF01

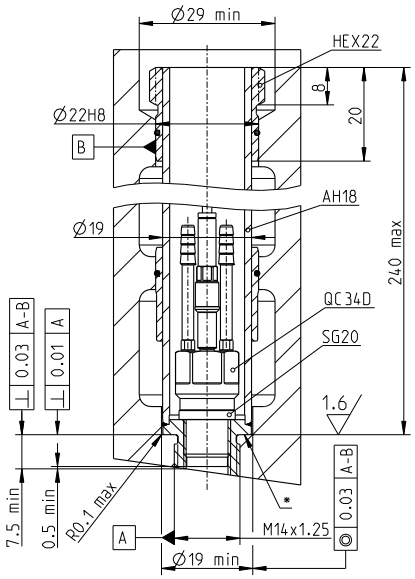
[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation.



Installation with the adaptor AH14 and Pin-Tool Z314.
*) Rigid adhesive, e.g. LOCTITE 648.



Installation with adaptor AH18 and box spanner TT07.
*) Rigid adhesive, e.g. LOCTITE 648.

ACCESSORIES

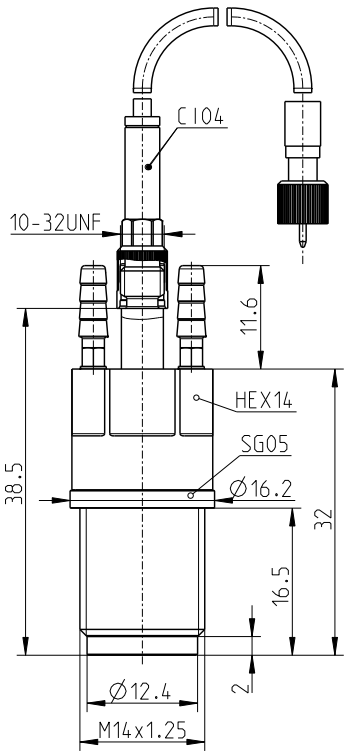
Cables & couplings	CI41, CI42, CC41, CC42, E124		See pages 100 to 105
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG20	TIBQ0231A.01	See page 98
Gasket dismounting tool	TT15	TIWG0179A.01	See page 96
Dummy	DG06	TIWG0188A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Adaptor sleeves	AH14, AH18		See page 87
Mounting tool	Mounting socket TT07 (ø=15.8 mm) Mounting tool Z314 (ø=13.8 mm) Torque wrench TT18	TIWG0133A.01 TIWG0103A.01 TIWG0209A.01	See pages 94 to 97
Machining tool	Tap drill MT31	TIWG0156A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See page 96
Cooling system	ZP91.00/1-4 (230 V version) ZP91.00/1-8 (230 V version) ZP91.00/1-4 (115 V version) ZP91.00/1-8 (120 V version) ZP93/1-8 (230 V version)	TIZP91A.04 TIZP91A.08 TIZP91A.14 TIZP91A.28 TIZP93A.08	See pages 106 to 107

QC43D

TIGG0538A.01

★ ★★ ★★★

The QC43D has a mounting thread of M14 and is especially suited for large diesel engines. It is designed for cylinder bores above 100 mm and if quartz sensors are preferred. An active water cooling system is required to protect the quartz in order to ensure long lifetimes and excellent data reproducibility.



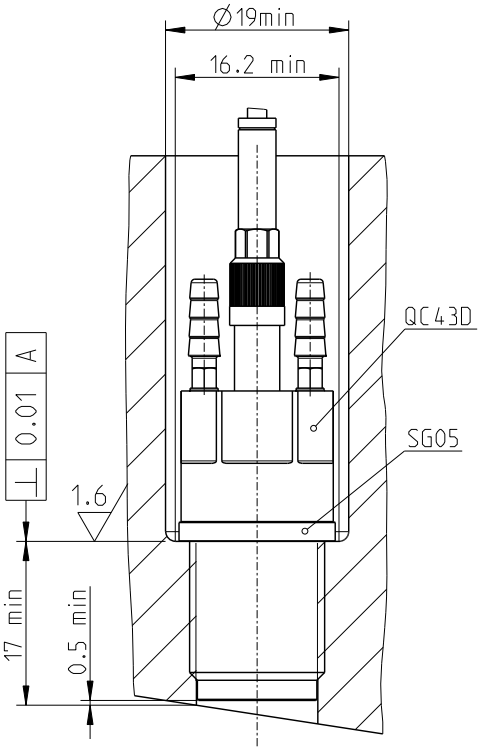
SCOPE OF SUPPLY

- Sensor QC43D
- Piezo-input cable CI04-1
- Coupling E127M
- Gasket SG05
- Accessory kit (protection cap + 2 o-rings)
- Spare gasket SG05
- Calibration sheet
- Documentation

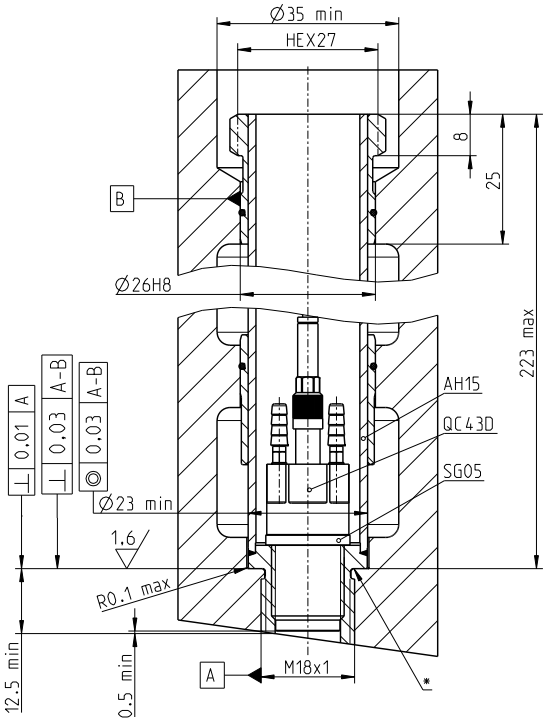
SPECIFICATIONS

Measuring range			0…200 bar	
Overload			250 bar	
Sensitivity			68 pC/bar	nominal
Linearity	≤	±	0.2 %	FSO
Calibrated ranges			0…80 bar 0…140 bar 0…200 bar	
Natural frequency			50 kHz	
Acceleration sensitivity	≤		0.002 bar/g	axial, water cooled
	≤		0.003 bar/g	axial, uncooled
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			18 pF	
Sensor operating temperature range [1]			20…80 °C	
Thermal sensitivity change (cooled)	≤		0.02 %/°C	20…80 °C and 0…200 bar
Load change drift			4 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	0.35 bar	
Thermo shock error Δp [3]	≤	±	0.2 bar	typ.
Thread diameter			M14×1.25	shoulder sealed
Cable Connection			10-32 UNF	Micro-Dot
Cooling rate	≥		20 l/h	
Weight			34 grams	without cable
Mounting torque			20 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Direct installation.



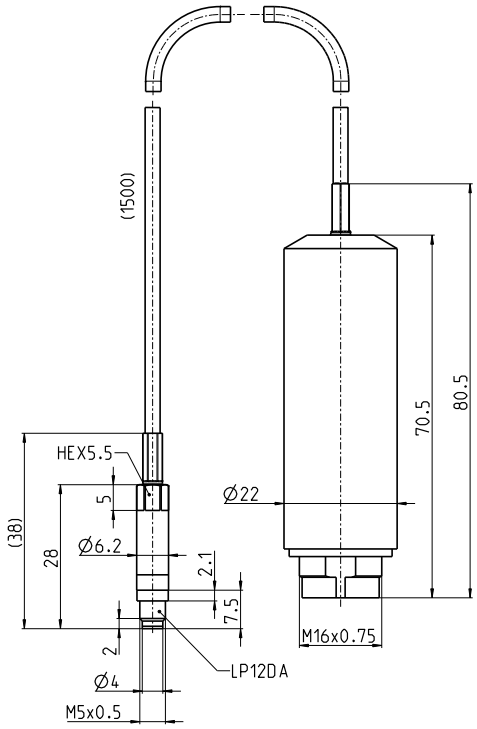
Installation with an AH15 adaptor.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel onmiFIT.

ACCESSORIES

Cables & couplings	CI04, E127M, E124		See pages 100 to 105
Cable mounting tool	TC01	TIWG0131A.01	See page 95
Gasket	SG05	TIBQ0230A.01	See page 98
Gasket dismounting tool	TT14	TIWG0178A.01	See page 96
Dummy	DG07	TIWG0189A.01	See page 91
Dummy removal tool	TD01	TIWG0122A.01	See page 96
Adaptor sleeves	AH15	TIWG0194A.01	See pages 87
Mounting tool	Mounting socket TT08 Torque wrench TT18	TIWG0132A.01 TIWG0209A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See pages 96
Cooling system	ZP91.00/1-4 (230 V version) ZP91.00/1-8 (230 V version) ZP91.00/1-4 (115 V version) ZP91.00/1-8 (120 V version) ZP93/1-8 (230 V version)	TIZP91A.04 TIZP91A.08 TIZP91A.14 TIZP91A.28 TIZP93A.08	See pages 106 to 107

LP12DA

The M5 low pressure indicating sensor LP12DA measures the absolute pressure in the intake or exhaust manifold of combustion engines. The sensor is available in different versions with the pressure ranges of 5, 10 and 30 bar. This piezoresistive sensor is used for precise measurement of static and dynamic pressure variations. Typical applications are gas-exchange analysis, precise friction analysis or turbo charger development. For measurements in the exhaust manifold a cooling adapter is necessary. The sensor is equipped with an integrated amplifier featuring thermal compensation.



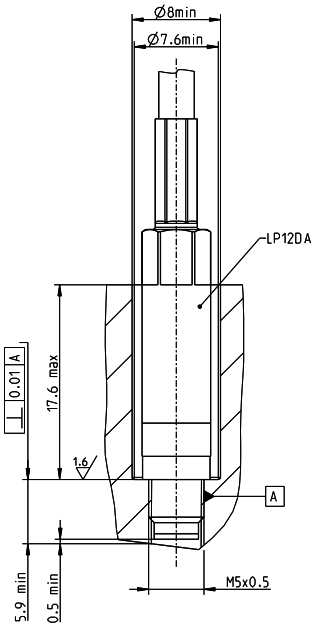
Type	Art. No.	Pressure range
LP12DA05	TIEZ1719A.01	0…5 bar
LP12DA10	TIEZ1720A.01	0…10 bar
LP12DA30	TIEZ1721A.01	0…30 bar

SPECIFICATIONS

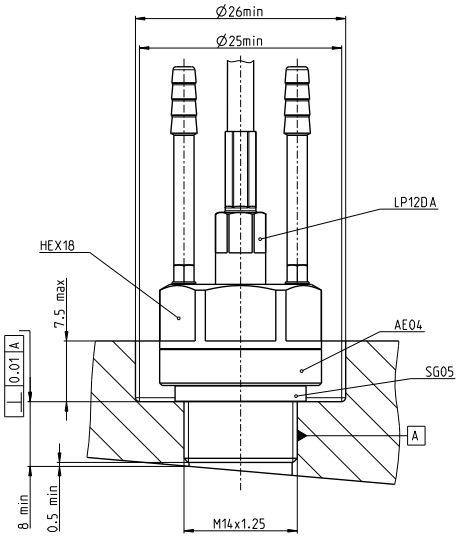
Measuring range			0…5, 10, 30 bar	
Overload			50, 50, 90 bar	
Sensitivity • LP12DA05 • LP12DA10 • LP12DA30	 ≤ ≤ ≤		 2,000 mV/bar 1,000 mV/bar 333 mV/bar	
Linearity	≤	±	0.1 %	FSO
Frequency response	>		50 kHz	
Total error band (accuracy and temperature error)	<		1 %	FSO
Operating temperature range			- 50…200 °C	
Compensated temperature range			- 40…180 °C	
Thread diameter			M5×0.5	
Weight			4 grams	Sensor only
Mounting torque			2 Nm	using SF01
Amplifier output			0…10 V	
Power supply			12…32 V DC	
Media compatibility			oil, fuel (diesel, gasoline, hfo,...), gases, coolant	

SCOPE OF SUPPLY

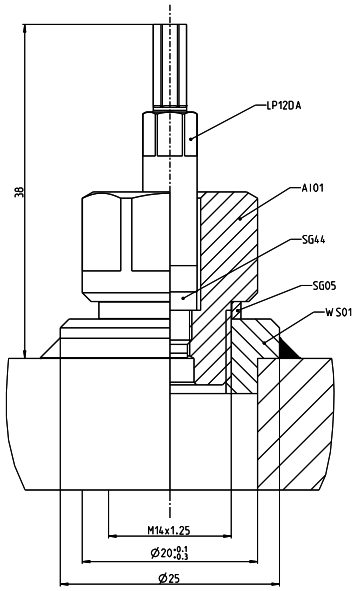
- Sensor LP12DA with cable and integrated amplifier
- Gasket SG44
- Empty 7-pin connector
- Protection cap
- Calibration sheet
- Documentation



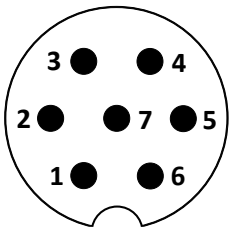
Direct installation of LP12DA.



LP12DA mounted into cooling adaptor AE04.



LP12DA with SG44 and WS01.



PIN	Function	
1	+ Vcc	
2	GND	Internally connected
3	n.c	
4	- OUT	
5	+ OUT	
6	RS485A	
7	RS485B	

Pin assignment.

ACCESSORIES

Measurement cable extension	CS10 (5 m) CS11 (10 m)	TILPCS10A.01 TILPCS11A.01	See page 104
Power supply and cables	CX10 (connection to AVL X-ion) CY10 (connection to y-cable) PY10 (y-cable for multiple supply) PS10 (power supply 24 V)	TIBU0244A.01 TILPYS10A.01 TILPYS10A.01 TILPPS10A.01	See pages 104 to 105
Gasket	SG44	TIYG3136A.01	See page 98
Dummy	DL01	TIDL01A.01	See page 91
Adaptor sleeves	AI01, AE04		See pages 87
Welding bung	WS01 (for AI01 and AE04)	TIYF0821A.01	See page 89
Mounting tool	TT29 (flat wrench) TT64 (slotted box nut)	TIWG0371A.01 TIWG0631A.01	See pages 94 to 97
Mounting paste	SF01	TIHK0094A.01	See pages 96
Cooling system	ZP91.00/1-4 (230 V version) ZP91.00/1-8 (230 V version) ZP91.00/1-4 (115 V version) ZP91.00/1-8 (120 V version) ZP93/1-8 (230 V version)	TIZP91A.04 TIZP91A.08 TIZP91A.14 TIZP91A.28 TIZP93A.08	See pages 106 to 107

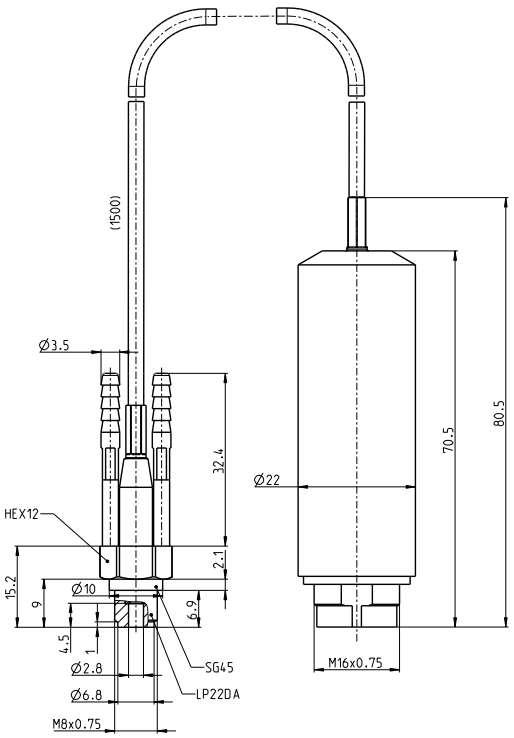
LP22DA

TIEZ1821A.01

IMEP ★★★

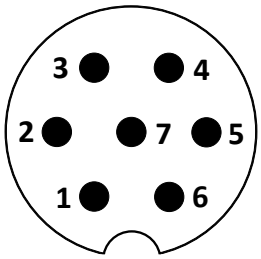
non stop ★★

The M8 water-cooled low-pressure indicating sensor LP22DA measures the absolute pressure in the exhaust system of combustion engines. The sensor is available with the pressure range of 10 bar. This piezoresistive sensor is used for precise measurement of static and dynamic pressure variations. Typical applications are gas-exchange analysis, precise friction analysis or turbo charger development. The integrated water-cooling allows mounting the sensor into very narrow spaces of the exhaust manifold. The sensor is equipped with an integrated amplifier featuring digital thermal compensation.



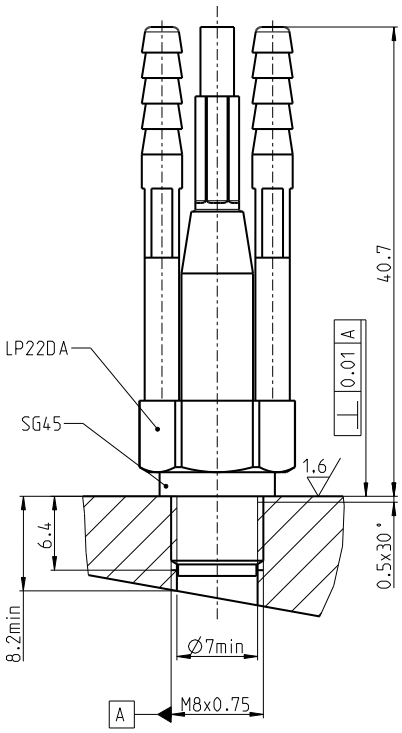
SCOPE OF SUPPLY
Sensor LP22DA with cable and integrated amplifier
Gasket SG45
Empty 7-pin connector
Protection cap
Calibration sheet
Documentation

SPECIFICATIONS				
Measuring range			0 … 10 bar	
Overload			50 bar	
Sensitivity	≤		1,000 mV/bar	
Total error band (accuracy and temperature error)	<		1%	FSO
Linearity	≤	±	0.1 %	FSO
Frequency response	>		50 kHz	
Operating temperature range • Sensor front end • Amplifier			 -40 … 1100 °C -40 … 125 °C	
Thread diameter			M8×0.75	
Weight			12 grams	Sensor only
Mounting torque			max. 6 Nm	using SF01
Amplifier output			0 … 10 V	
Power supply			12 … 32 V DC	
Media compatibility			oil, fuel (diesel, gasoline, hfo, ...), gases, coolant	

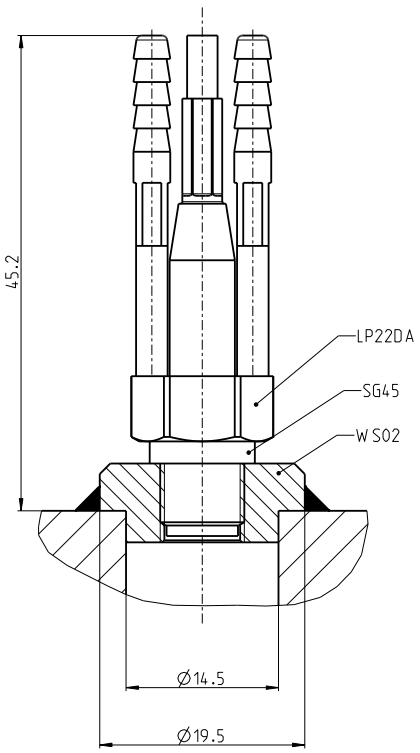


PIN	Function	
1	+ Vcc	
2	GND	Internally connected
3	n.c	
4	- OUT	
5	+ OUT	
6	RS485A	
7	RS485B	

Pin assignment



Direct installation of LP22DA



Installation using welding bung WS02

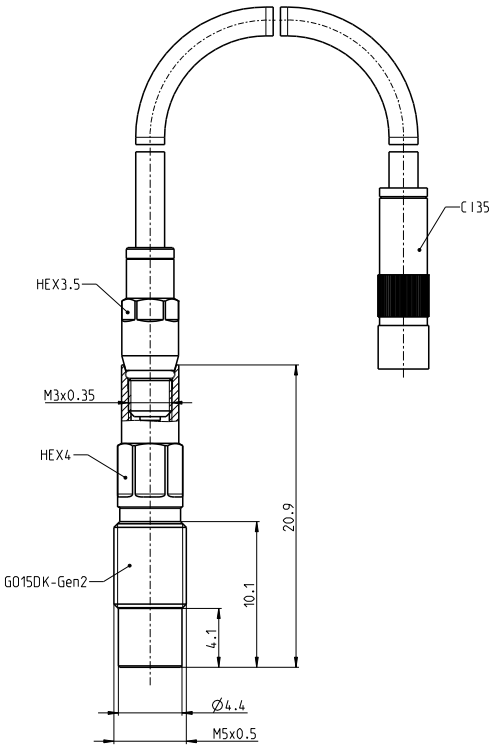
ACCESSORIES

Measurement cable extension	CS10 (5 m) CS11 (10 m)	TILPCS10A.01 TILPCS11A.01	See page 104
Power supply and cables	CX10 (connection to AVL X-ion) CY10 (connection to y-cable) PY10 (y-cable for multiple supply) PS10 (power supply 24 V)	TIBU0244A.01 TLPYS10A.01 TILPPY10A.01 TILPPS10A.01	See pages 104 to 105
Gasket	SG45	TIYS0892A.01	See page 98
Dummy	DG09	TIWG0278A.01	See page 91
Welding bung	WS02	TIYS0914A.01	See page 89
Mounting adaptor	MA10	TIWG0677A.01	See page 89
Mounting paste	SF01	TIHK0094A.01	See page 96
Cooling system	ZP91.00/1-4 (230 V version) ZP91.00/1-8 (230 V version) ZP91.00/1-4 (115 V version) ZP91.00/1-8 (120 V version) ZP93/1-8 (230 V version)	TIZP91A.04 TIZP91A.08 TIZP91A.14 TIZP91A.28 TIZP93A.08	See pages 106 to 107

GO15DK Gen2

TIGG2121A.01

The GO15DK Gen2 has the slimmest contour due to an M3 cable connector and is an M5 monitoring sensor especially suited for pmax monitoring with maximum amount of knock. The Double-Shell™ design decouples the piezoelectric elements from negative influences of mechanical stresses which can occur due to the mounting of the sensor into the engine. In addition to this it has an improved membrane material and geometry. This makes the sensor to the standard solution for monitoring with maximum levels of knock. The sensor could be equipped with SIC for SDM.



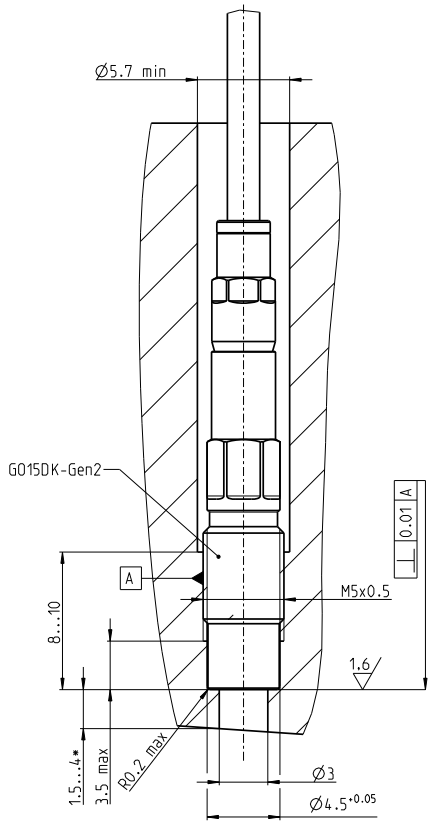
SCOPE OF SUPPLY

Sensor GO15DK Gen2
Piezo-input cable CI35-1
Coupling CC31
Accessory kit (protection cap + 2 o-rings)
Calibration sheet
Documentation

SPECIFICATIONS

Measuring range			0 … 1,000 bar	
Overload			1,000 bar	
Sensitivity			1.5 pC/bar	nominal
Linearity	≤	±	0.5 %	200 °C 0 … 150 bar FSO
Calibrated ranges			0 … 150 bar 0 … 300 bar	
Natural frequency	>		400 kHz	
Acceleration sensitivity	≤		0.0005 bar/g	axial
Shock resistance	≥		2,000 g	
Insulation resistance	≥		$1*10^{13}$ Ω	
Capacitance			7 pF	
Sensor operating temperature range [1]			- 40 … 350 °C	
Thermal sensitivity change	≤		4 %	20 … 250 °C and 0 … 300 bar
Load change drift			4 mbar/ms	max. gradient typ.
Cyclic temperature drift [2]	≤	±	1.5 bar	
Thermo shock error Δp [3]	≤	±	0.8 bar	typ.
Thread diameter			M5×0.5	front sealed
Cable Connection			M3×0.35	negative
Weight			1.6 grams	without cable
Mounting torque			1.5 Nm	using SF01

[1] surface temperature around the HEX < 200 °C
[2] at 7 bar IMEP and 1,300 rpm, diesel
[3] at 9 bar IMEP and 1,500 rpm, gasoline



Front sealed direct installation.
*) 1.5 mm for steel, 4 mm for cast iron and aluminium alloys.

ACCESSORIES

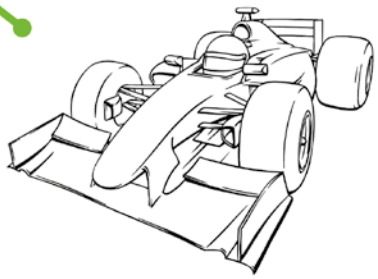
Cables & couplings	CI35, CC31, E124		See pages 100 to 105
Cable mounting tool	TC02	TIWG0613A.01	See page 95
Dummy removal tool	TD13	TIWG0224A.01	See page 96
Adaptor sleeves	AH01, AH01A, AH91, MA01, MA02, MA03, MA07		See pages 87
Mounting tool	Toolset TS21 (TT21, TT02) Mounting socket TT21 Torque wrench TT02	TIWG0213A.01 TIWG0214A.01 TIWG0117A.01	See pages 94 to 97
Machining tool	Toolset MS15 (MD12, MT12) Step drill MD12 Tap drill MT12 Seat dressing tool MR01-85 Seat dressing tool MR01-160	TIWG0337A.01 TIWG0335A.01 TIWG0346A.01 TIWG0346A.01 TIWG0616A.01	See pages 92 to 93
Mounting paste	SF01	TIHK0094A.01	See pages 96
Racing Amplifier	MiniAmp R3 – 1.5 MiniAmp R4 – 1.5	TIGG2200A.01 TIGG2086A.01	See pages 84 to 85

3 Accessories for Pressure Sensors

Racing amplifier

AMPLIFIER – FOR ON-BOARD COMBUSTION ANALYSIS

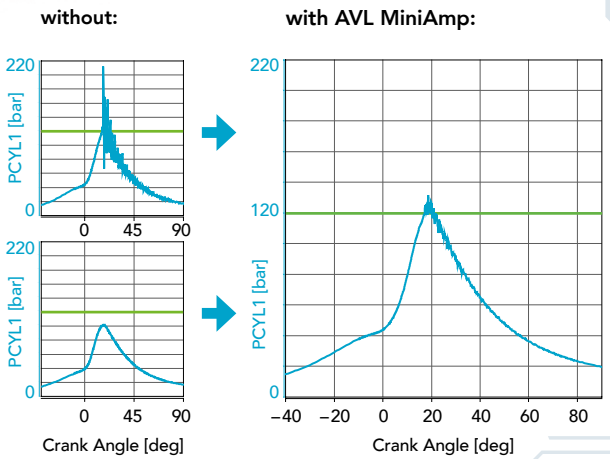
The AVL MiniAmp is a miniaturized charge amplifier for combustion monitoring and control tasks in racing applications.Benefiting from the well known experience with amplifiers for research and development tasks, the MiniAmp R4 has a tailored design, especially compact dimension and low weight in racing environments.

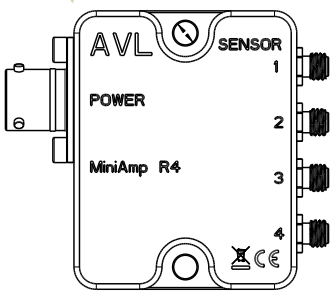


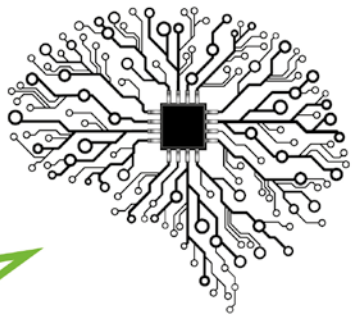
AVL MiniAmp

GAIN MAXIMUM POWER by going to the limit – without going into extreme knocking!

- Miniature design
- Precise onboard measurement
- Continuous drift compensation
- Galvanic isolated signal and power lines







TECHNICAL DATA

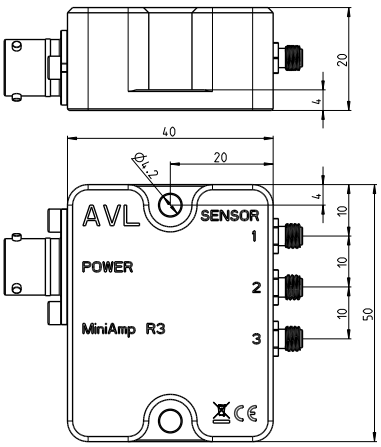
General		
Input channels		3 or 4
Dimension W × H × D		40 × 20 × 50 mm (without plugs)
Weight	~	80 g
Power supply		8 … 60 V DC
Input Current @ 12 V DC	<	150 mA over the complete temperature range (typically 50 mA)
Temperature range		–20 … 115 °C –20 … 80 °C best accuracy 80 … 115 °C reduced accuracy
Shock resistance		500 g / 1 ms (according to IEC60068-2-27)
Degree of protection		IP67
Parametrization		Via PC interface
Charge Amplifier		
Input range per channel		900 pC (1.5 pC/bar type) 6,000 pC (10 pC/bar type)
Frequency range	<	50 kHz
Drift compensation		Continuous compensation
Time constant	~	1,6 sec (1,5 pC/bar) 1 sec (10 pC/bar)
Output signal complete range		0 … 4.97 V
Zero level (@ 0 RPM and room temperature)		0.5 V
Output signal typically		Δ1 bar ≙ Δ6.5 mV
Connectors		
ECU (signals, power supply, parametrization)		DEUTSCH ASDD006-09-PN-HE
Piezo cable to the sensors		10/32 UNF

SCOPE OF SUPPLY

Amplifier – MiniAmp R3 or R4
Documentation

MiniAmp R3

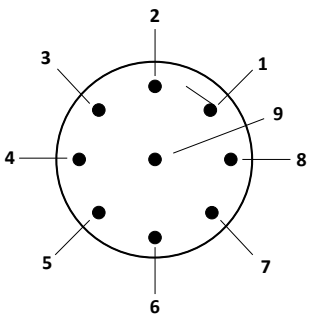
TIGG2200A.01 MiniAmp R3 – 1.5
TIGG2201A.01 MiniAmp R3 – 10



Dimensions of MiniAmp R3

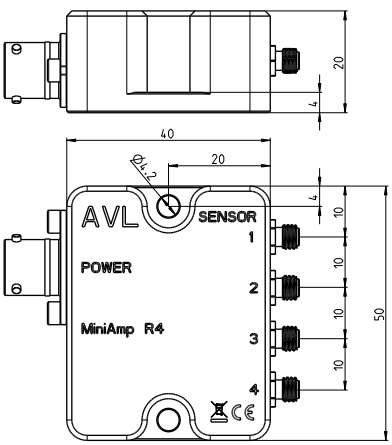
PIN ASSIGNMENT

Pin	Function
1	Power supply pos. +
2	Power GND –
3	–
4	Signal 3
5	Signal 2
6	Signal 1
7	Configuration SCL
8	Configuration SDA
9	Signal GND



MiniAmp R4

TIGG2086A.01 MiniAmp R4 – 1.5
TIGG2087A.01 MiniAmp R4 – 10



Dimensions of a MiniAmp R4

PIN ASSIGNMENT

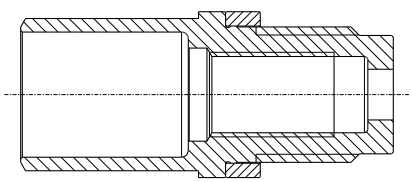
Pin	Function
1	Power supply pos. +
2	Power GND –
3	Signal 4
4	Signal 3
5	Signal 2
6	Signal 1
7	Configuration SCL
8	Configuration SDA
9	Signal GND

Adaptors and dummy plugs

MOUNTING ADAPTOR

Mounting adaptors are used to install a smaller sensor into a larger mounting bore. The mounting adapter should be chosen with the inner dimensions of the new sensor and the outer dimensions of the bore.

Type	Art. No.	Recommended mounting torque	Sensor type	Mounting bore type
MA01	TIWG0364A.01	6 Nm	M5×0.5: GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2	M8×0.75: GU24D, GU24DK, GC24D, GC24DK
MA02	TIWG0427A.01	10 Nm	M5×0.5: GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2	M10×1: QC34D, GU31D
MA03	TIWG0399A.01	20 Nm	M5×0.5: GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2	M14×1.25: GU41D, QC43D
MA04	TIWG0356A.01	20 Nm	M8×0.75: GU24D, GU24DK	M14×1.25: GU41D, QC43D
MA05	TIWG0413A.01	20 Nm	Ø 6,3 mm: GU22C + PH04, GU22CK + PH04	M14×1.25: GU41D, QC43D
MA06	TIWG0428A.01	20 Nm	Ø 6,3 mm: GU22C, GU22CK	M14×1.25: GU41D, QC43D
MA07	TIWG0535A.01	15 Nm	M5×0.5: GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2	Ø 10 mm: QC34C



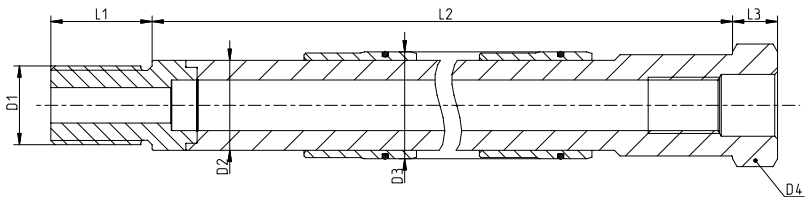
Principle section of a standard mounting adapter

ADAPTOR SLEEVES

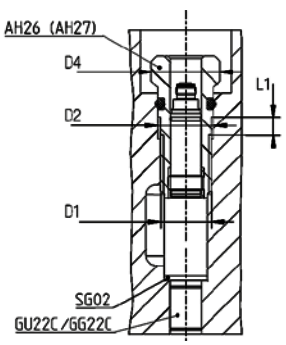
Adaptor sleeves are used where a direct installation of the sensor is not possible and wherever a cooling jacket or oil gallery has to be crossed by the indicating channel. The adaptor (type and dimensions) should be chosen as small as possible in order to fulfill the measurement task with a minimum of interference to the cylinder head. Specially developed machining and mounting tools are available for installation of these adaptors, refer to pages 92–97 for further information.

Type	Art. No	Rec. mounting torque	D1	D2	D3	D4	L1	L2	L3	For sensors
AH01	TIWG0115A.01	3	M7×0.75	9.5	12	HEX12	12	15 to 205	5	GH14D, GH14DK, GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2
AH01A	TIWG0252A.01	8	M7×0.75	9.5	12	HEX12	12	15 to 205	5	GH14D, GH14DK, GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2
AH05	TIWG0174A.01	10	–	–	–	HEX14	–	–	–	QC34C
AH06	TIWG0175A.01	10	M10×1	12	15	HEX14	17.5	15 to 200	5	GU21D
AH08	TIWG0183A.01	20	M14×1.25	16	19	HEX19	18	140	11	QC34C
AH13	TIWG0218A.01	5	M5×0.5	6	7	HEX10	10	max. 98	4	GH14P
AH14	TIWG0193A.01	20	M14×1.25	16	19	HEX19	18	max. 15 to 140	8	QC34D
AH15	TIWG0194A.01	20	M18×1	23	26	HEX27	25	15 to 240	8	QC43D
AH18	TIWG0197A.01	20	M14×1.25	19	22	HEX22	18	15 to 223	8	QC34D
AH26	TIYG1520A.01	10	M10×1	11	–	HEX12	1 to 133	–	–	GU22C, GU22CK
AH27	TIYG1521A.01	10	3/8"×24 UNF	11	–	HEX12	1 to 133	–	–	GU22C, GU22CK
AH28	TIWG0255A.01	10	M14×1.25	16	19	HEX19	18	132	8	GU22C, GU22CK
AH35	TIWG0333A.01	15	M12×1.25	14	14	HEX17	22	max. 186	8	GU24D, GU24DK
AH45	TIWG0397A.01	5	M6×0.5	7.5	10	HEX10	12	max. 205	5	GH14P
AH91	TIWG0691A.01	3	M7×0.75	9.5	10	HEX10	12	15 to 205	5	GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2

Standard socket mounting tool is sufficient and no special tool is required to mount the adaptor sleeve into the cylinder head.



Dimensions of a standard adaptor sleeve



Installation with the mounting sleeve AH26 (AH27).

Adaptors and dummy plugs

ADAPTOR SET

An adaptor set is available if more than one adapter is typically needed for the mounting of a sensor.

Type	Art. No.	For sensor	Consists of
AS02	TIWG0184A.01	QC34C	AH05 + AH08

MOUNTING NIPPLES

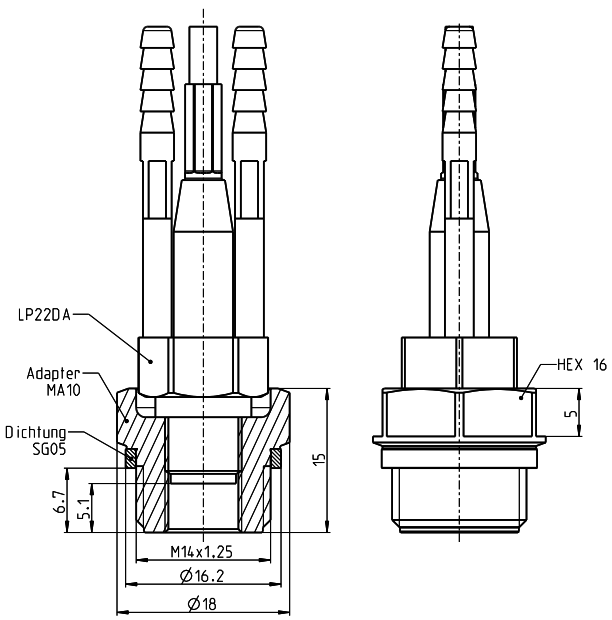
Plug type sensors require specific mounting screws or so called mounting nipples. To fix an AM04 or AM05 with the sensor the AM06 safety ring (Art. No. TIWG0417A.01) is required.

Type	Art. No.	For sensor	Mounting tool	Mounting thread
AM04	TIWG0240A.01	GU22C GU22CK	TT09	M10×1
AM05	TIWG0253A.01	GU22C GU22CK	TT09	3/8″×24 UNF

ADAPTORS FOR LOW-PRESSURE INDICATING

The AE04 is a cooling adaptor and the AI01 is a mounting adapter for the piezoresistive sensor LP12DA. Please refer also to page 76 for more information about this sensor.

Adaptor type	Art. No.	Description	For pressure sensor	Mounting thread
AI01	TILPIA01A.01	Mounting adaptor for the intake manifold	LP12DA	M14
AE04	TILPEA01A.01	Cooling adaptor for the exhaust manifold	LP12DA	M14
WS01	TIYF0821A.01	Used for mounting AI01 or AE04	LP12DA	M14
WS02	TIYS0914A.01	Welding bung for M8×0.75 sensors	LP22DA	M8
MA10	TIWG0677A.01	Used for mounting M8×0.75 sensor into M14×1.25 bore	LP22DA	M14



Adaptors and dummy plugs

GLOW-PLUG ADAPTORS

AVL glow-plug adaptors allow the use of probe-type sensors in standard and custom tailored glow-plug bores. AG03 and AG04 can be customized down to 5 mm tip diameters. The selection of the adaptor type depends on the thread diameter of the glow-plug bore of the engine: For threads down to M10 AG03 adaptor is recommended. For threads of sizes between M10 and M8 AG04 is the right choice. For smaller diameters down to 4.3 mm please refer to the integrated glow-plug solution GH13G on pages 58–59.

Adaptor type	Art. No.	Thread diameter D4 [1]	Tip bore diameter DB	For sensor	Mounting torque [2] [Nm]
AG03	TIAG03A.01	≥ M10	≥ 5 mm	GH14P	4.0
AG04	TIAG04A.01	≥ M8	≥ 5 mm	GH14P	4.0

[1] Drawing available on page 131
[2] Higher mounting torque could be calculated depending on type

A new design of a glow plug adaptor must be ordered separately with the article TIAGDESA.01.

Glow-plug adaptor order form

To customize the adaptor to your specific application a detailed description of the glow-plug bore is required. To ensure the best performance and durability of the delivered sensor especially the bore dimensions and length are important for optimum design. AVL requires a full description of the custom tailored adaptor. The glow-plug order form allows a clear specification of all required dimensions. Based on this data AVL can design the adaptor to the customer needs. The data is stored in the AVL database for further orders. The input as well as forwarding the form can be carried out electronically. Please see page 130 for drawings with the required dimensions. The order form is also available as download at **www.avl.com/sensors**.

DUMMY PLUGS

A sensor dummy plug seals the indicating bore of the engine in a save way. It is recommended to replace the sensor with a dummy plug if it is not used for measurements. This replacement helps to extend the usage time of the sensors. For easy and convenient removal of the dummy from the engine a dummy removal tool is available.

Dummy	Art. No.	Fits into sensor	Mounting tool	Removal tool
DG04	TIWG0170A.01	GU21D	TT11	TD01
DG05	TIWG0187A.01	QC34C	TT08	TD01
DG06	TIWG0188A.01	QC34D	TT07	TD01
DG07	TIWG0189A.01	QC43D	TT08	TD01
DG09	TIWG0278A.01	GU24D, GU24DK, GC24D, GC24DK	TT11	TD01
DG10	TIWG0336A.01	GU22C, GU22CK	TT09	TD01
DG11	TIWG0339A.01	GU31D	TA16	TD01
DG12	TIWG0340A.01	GU41D	TT07	TD01
DG13	TIWG0219A.01	GH14P	TT21	TD13
DG14	TIWG0367A.01	GU22C + PH04, GU22CK + PH04	TT09	TD01
DG24	TIWG0334A.01	GH15D, GH15DK, GR15D	TT21	TD13
DG25	TIWG0405A.01	GU24DE	TT11	TD01
DG39	TIWG0593A.01	GP15DK, GO15DK Gen2	TT21	TD13
DG41	TIWG0668A.01	GH01D	TT66	TD41
DL01	TIDL01A.01	LP12DA	TT29	–

[1] For shoulder sealed installation with minimum thread length of 14 mm and minimum distance between combustion chamber and sealing of 17 mm

Machining tools

For appropriate preparation and machining of the indicating bore an assorted collection of machining tools is available. These tools are designed to machine the bores and threads of AVL sensors for several sizes. Especially for the M5 sensors it is very important to machine the seat for the sensor (front-sealing) in high quality to guarantee correct operation up to maximum pressure and the exact mounting torque.
A set of machining tools consists of one step drill, one tap drill and if needed one guiding tool to keep the tap drill aligned inside long bores.

SET OF MACHINING TOOLS

Type	Art. No.	To machine bore for	The set consists of
MS15	TIWG0337A.01	GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2, GH15DKE	MD12 + MT12
MS22	TIWG0165A.01	AH01, AH01A, AH91, GU21D	MD22 + MT21 + MG22
MS24	TIWG0167A.01	AH06, GU21D	MD24 + MT31 + MG24
MS25	TIWG0394A.01	AH45	MD25 + MT25

Sensors or adaptors which are not listed do not require any machining or any special AVL tools to machine the indicating bore. Machining of adapter bores might need an additional standard tool (see table standard tools). In this case please refer to your standard tool supplier.

SEAT DRESSING TOOLS

Type	Art. No.	To machine bore for
MR01-85	TIWG0616A.01	GH15D, GH15DK, GR15D, GH15DKE, GP15DK, GO15DK Gen2
MR01-180	TIWG0632A.01	GH15D, GR15D, GH15DK, GH15DKE, GP15DK, GO15DK Gen2
MR05	TIWG0575A.01	GH14P

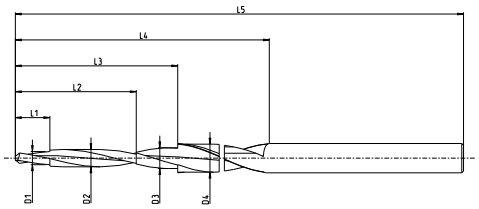
Sensors or adaptors which are not listed do not require any machining or any special AVL tools to machine the indicating bore. Machining of adapter bores might need an additional standard tool (see table standard tools). In this case please refer to your standard tool supplier.

STANDARD TOOLS

Additional standard drills are needed in order to finalize the bore for adapter sleeves. These tools could be taken from a standard tool supplier.

D1	To machine bore for
10 mm	AH91, AH45
12 mm	AH01, AH01A
15 mm	AH06

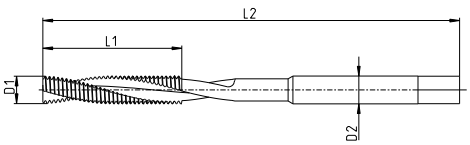
STEP DRILLS



Type	Art. No.	For sensor or adaptor	D1	D2	D3	D4	L1	L2	L3	L4	L5
MD10	TIWG0257A.01	GU22C, GU22CK with thread 3/8"×24 UNF	6.3	–	8.5	–	20	–	215	270	–
MD12	TIWG0335A.01	GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2, GH15DKE	3	4.5	5.7	–	10	19	134	190	–
MD16	TIWG0418A.01	GU22C, GU22CK with thread M10×1	6.3	8.5	8.9	–	20	34	215	270	–
MD22	TIWG0151A.01	AH01, AH01A, AH91, GU21D	6.2	–	10	–	20	–	215	270	–
MD24	TIWG0153A.01	AH06, GU21D	9	–	12	–	20	–	215	270	–
MD25	TIWG0391A.01	AH45	5.5	–	7.5	–	20	–	225	270	–
MD26	TIWG0574A.01	GH14P	3	4.2	4.5	5.7	10	35	47	134	190
MD27	TIWG0665A.01	GH01D	2	3.13	4.5	–	10	16	134	190	–

Sensors or adaptors which are not listed do not require any machining or any special AVL tools to machine the indicating bore. Machining of adapter bores might need an additional standard tool (see table standard tools). In this case please refer to your standard tool supplier.

TAP DRILLS



Type	Art. No.	For sensor or adaptor	D1	D2	L1	L2
MT11	TIWG0154A.01	GH14P	M5×0.5	6	14	200
MT12	TIWG0346A.01	GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2, GH15DKE	M5×0.5	5.7	14	200
MT13	TIWG0369A.01	GU22C, GU22CK	3/8"×24 UNF	10	20	250
MT21	TIWG0155A.01	GU21D, AH01, AH01A, AH91	M7×0.75	8	19	250
MT25	TIWG0392A.01	AH45	M6×0.5	7	20	250
MT31	TIWG0156A.01	QC34D, GU31D, GU22C, GU22CK, AH06, GU21D	M10×1	10	20	250
MT32	TIWG0667A.01	GH01D	M3.5×0.35	4.5	15	200

Sensors or adaptors which are not listed do not require any machining or any special AVL tools to machine the indicating bore. Machining of adapter bores might need an additional standard tool (see table standard tools). In this case please refer to your standard tool supplier.

Mounting tools

The limited space that is given inside the mounting bores requires special tools to allow convenient and correct installation of sensors and adaptors into the engine. To ensure appropriate installation of sensors and adaptors a collection of mounting tools is available. These tools are matched to the different dimensions and applications of the sensors and adaptors. Sensors and adaptors which are not listed here do not require any special AVL mounting tools. In this case please refer to your standard tool supplier.

SOCKETS AND WRENCHES

	Type	Art. No.	D1	D2	D3	L	to mount	into
	TT07	TIWG0133A.01	HEX12	15.8	HEX16	250	QC34D GU41D GU22C, GU22CK	indicating bore, AH18 indicating bore indicating bore with AH26, AH27, AH28
	TT08	TIWG0132A.01	HEX14	18.2	HEX19	250	AH05 QC43D	AH08 indicating bore, AH15
	TT09	TIWG0140A.01	HEX8	11.5	HEX12	70	GH13G, AG04 GU22C, GU22CK	M8 glow-plug bore indicating bore with AM04 or AM05
	TT11	TIWG0180A.01	HEX7	9.5	HEX8	250	GU21D GU24D, GU24DK GU24DE	indicating bore, AH06 indicating bore, AH35 indicating bore
	TT21	TIWG0214A.01	HEX4	5.6	HEX8	220	GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2 GH15DKE GH14P	indicating bore, AH01, AH01A, AH91 indicating bore i.b., AG03, AG04, AH13, AH45 glow plug adaptor
	TT22 [1]	TIWG0233A.01	HEX16	19	SQR 3/8"	73	ZI33	spark-plug bore
	TT23	TIWG0548A.01	HEX9	12	HEX14	250	GU24DK, GC24D, GC24DK	indicating bore
	TT24	TIWG0234A.01	HEX16	20.2	SQR 3/8"	60	ZI33	spark-plug bore
	TT26	TIWG0247A.01	HEX4	7.4	HEX8	215	GH15D, GH15DK, GR15D, GP15DK, GO15DK Gen2, GH15DKE, GH14P, GA16P	indicating bore
	TT29 [2]	TIWG0371A.01	HEX5.5	–	–	–	LP12DA	direct installation, AI01, AE04
	TT30	TIWG0598A.01	HEX12	17	SQR 1/4"	65	ZI22, (ZI33)	spark plug bore
	TT34	TIWG0606A.01	HEX12	19.9	SQR 1/4"	65	ZI22, (ZI33)	spark plug bore
	TT42	TIYG1024A.01	HEX17	21.8	SQR 3/8"	70	ZI45	spark-plug bore
	TT57 [1]	TIWG0585A.01	HEX16	19.9	SQR 3/8"	73	ZI33	spark-plug bore
	TT64	TIWG0631A.01	HEX5.5	8.5	SQR 1/4"	50	LP12DA	direct installation, AI01, AE04
	TT66	TIWG0664A.01	HEX3	4.5	HEX8	220	GH01D	indicating bore
	TA13	TIWG0136A.01	HEX8	11.5	HEX12	200	GU22C, GU22CK	indicating bore with AM04 or AM05
	TA16	TIWG0200A.01	HEX10	13.8	HEX14	139	GH13G, AG03 GU31D	M10 glow-plug bore indicating bore

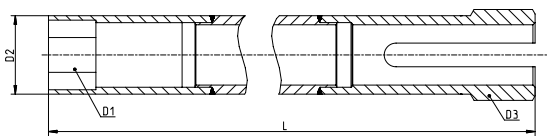
[1] narrow spark-plug bore
[2] flat wrench

PIN TOOLS / POLYGON-HEAD SPANNERS

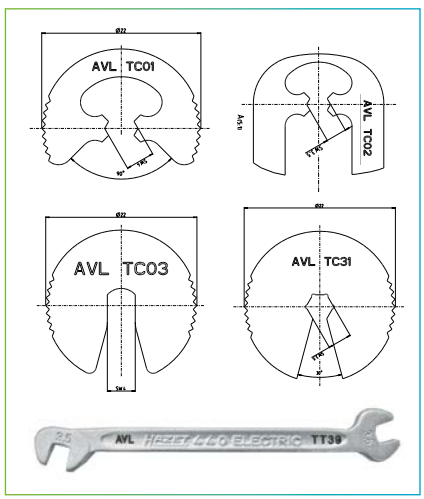
Type	Art. No.	to mount	into	D1	D2	D3	L
Z314	TIWG0103A.01	QC34D	indicating bore, AH14	pins	13.8	HEX12	140

SET OF MOUNTING TOOLS

Type	Art. No.	to mount	into	Scope of supply
TS02	TIWG0128A.01	GU22C, GU22CK	indicating bore with AM04, AM05	socket TT09, torque wrench TT18
TS03	TIWG0181A.01	GU21D	indicating bore, AH06	socket TT11, torque wrench TT02
TS21	TIWG0213A.01	GH15D, GH15DK, GH15DKE, GR15D, GP15DK GH14P, GA16P, GO15DK Gen2	indicating bore, AH01, AH01A, AG03, AG04, AH13, AH45, AH91	socket TT21, torque wrench TT02
TS43	TIWG0211A.01	ZI45	spark-plug bore	socket TT42, elongation TT43, t-handle TT44



Specifications of socket mounting tools



CABLE MOUNTING TOOLS

Type	Art. No.	For cable connector type
TC01	TIWG0131A.01	M4×0.35 with HEX4
TC02	TIWG0613A.01	M3×0.35 with HEX3.5
TC03	TIWG0653A.01	M3×0.35 with HEX3.5
TC21	TIWG0690A.01	M2×0.25 without HEX
TC31	TIWG0215A.01	M3×0.35 with HEX3.5
TT39	TIWG0510A.01	M3×0.35 with HEX3.5

Please refer to the accessories list of a specific sensor in order to get information which specific tool is needed for which sensor. Usability depends on sensor type and mounting bore.

Mounting tools

MOUNTING PASTE

Type	Art. No.	Purpose
SF01	TIHK0094A.01	Ensures easy removal of the sensor after long engine operation

ADAPTOR MOUNTING ADHESIVE SET

Type	Art. No.	Purpose
AMA01	TI0600ZB.01	For secure fixing and waterproof sealing of adaptors in cylinder heads. Consists of one thin and one thick high temperature resistant component cement Loctite 648 and Loctite 290

SPARK-PLUG ISOLATION GREASE

Type	Art. No.	Purpose
ZKF01	TIHS0060A.01	To ensure best isolation this highly resistive grease needs to be applied between the insulator and the spark-plug socket. For further information refer to the instruction manuals of your spark plug pressure sensor.

GASKET AND DUMMY REMOVAL TOOL

Type	Art. No.	Purpose
TT14	TIWG0178A.01	to remove gasket SG05 from QC43D/GU41D
TT15	TIWG0179A.01	to remove gasket SG20 from QC34C/QC34D/GU31D
TT17	TIWG0185A.01	to remove gasket SG03 from GU21D
TT33	TIWG0281A.01	to remove gasket SG21 from GU24D/GU24DE/GU24DK
TT54	TIWG0560A.01	to remove gasket SG21 from GC24D/GC24DK
TD01	TIWG0122A.01	to take a dummy plug out of the mounting bore which has a M4×0.35 connector
TD13	TIWG0224A.01	to take a dummy plug out of the mounting bore which has a M3×0.35 connector
TD41	TIWG0669A.01	to take a dummy plug out of the mounting bore which has a M2×0.25 connector

SPECIAL TOOLS FOR SPARK-PLUG SENSORS

Type	Art. No.	Purpose
TT25A	TIYM5782A.01	cable mounting tool
TT48	TIWG0469A.01	for insulator exchange with 9×12 mm drive
TA32	TIWG0387A.01	adjustment tool set for electrode gap

STANDARD TOOLS

To ensure accurate measurements and safe operation sensors and accessories have to be fixed with a certain mounting torque. This can be done with our torque wrenches.

Type	Art. No.	Remarks
TT02	TIWG0117A.01	1/4" socket incl. 1/4" SQR drive TT36 (DIN3120), Torque range: 0.5 … 4.5 Nm
TT18	TIWG0209A.01	9x12 mm socket incl. 3/8" SQR drive TT35 (DIN 3120), Torque range: 4 … 40 Nm
TT32	TIWG0236A.01	1/4" socket incl. 1/4" SQR drive TT36 (DIN3120), Torque range: 1 … 6 Nm
TT35	TIWH0093A.01	insert-reversible ratchet, 3/8" SQR drive (DIN3120) 9×12 mm for TT18
TT43	TIYG1026A.01	elongation between the torque wrench or T-handle and mounting socket
TT44	TIYG1027A.01	T-handle to ease mounting of spark plugs into the spark-plug bore
TT47	TIWG0395A.01	plug insert, 3/8" SQR drive (DIN3120) 9×12 mm for TT18
TT50	TIWG0473A.01	torque wrench for insulator exchange with 1/4" drive

Gaskets and flame arrestors

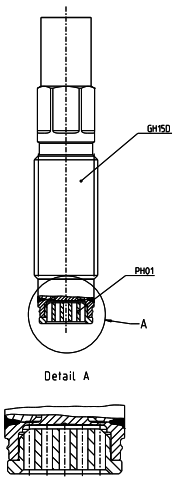
GASKETS & GASKET DISMOUNTING TOOLS

Gaskets are used as sealing between the sensor and the cylinder head or adaptor. Due to usage of optimized gasket material there is no additional temperature stress to be expected during operation. All sensors with shoulder sealing (all types except the M5 types) need an appropriate gasket for correct installation. For exchange of the gasket a dismounting tool has to be used.

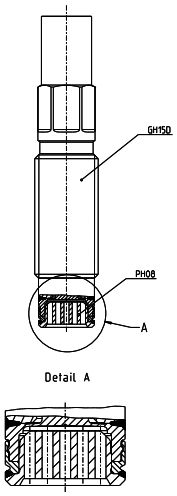
Gasket	Art. No.	For sensor / adaptor	Quantity	Dismounting tool
SG02	TIBQ0227A.01	GU22C, GU22CK	5 pcs.	–
SG03	TIBQ0228A.01	GU21D	5 pcs. incl. TT17	TT17
SG05	TIBQ0230A.01	QC43D, GU41D	5 pcs. incl. TT14	TT14
SG06	TIYF0629A.01	ZI45	5 pcs.	–
SG08	TIYF0640A.01	ZI33	5 pcs.	–
SG20	TIBQ0231A.01	QC34C, QC34D, GU31D	5 pcs. incl. TT15	TT15
SG21	TIYF0718A.01	GU24D, GU24DE, GU24DK, GC24D, GC24DK	1 pc.	TT33 (GU24D, GU24DE, GU24DK) TT54 (GC24D, GC24DK)
SG30	TIYG2513A.01	spark plug insulator	10 pcs.	–
SG32	TIYG2767A.01	ZI22	5 pcs.	–
SG44	TIYG3136A.01	LP12DA	10 pcs.	–
SG45	TIYS0892A.01	LP22DA	10 pcs.	–

FLAME ARRESTORS

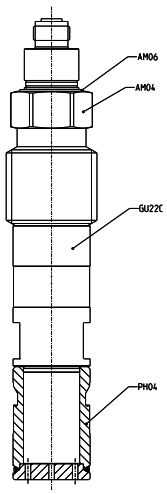
For highly accurate measurements we recommend the use of a flame arrestor or a so called thermo protection. A significant reduction of the cyclic drift and protection of the sensor in case of operation at extremely high temperatures can be achieved. Due to small holes at the front flame arrestors are in principal not recommended for the use in engine with a high density of soot particles.



Installation of the PH01 together with GH15D.



Installation of the PH08 together with GH15D.



Installation of the PH04 together with GU22C.

Thermo protection	Art. No.	Recommended for	Cyclic temperature drift without flame arrestor	Typical cyclic temperature drift with flame arrestor
PH01	TIYF0592A.01	GH15D GH15DK GH15DKE GR15D GP15DK GH14P	0.5 bar 0.7 bar 0.7 bar 0.7 bar – 0.5 bar	0.3 bar 0.4 bar 0.4 bar 0.4 bar 1.5 bar 0.3 bar
PH08 [1]	TIBY3882A.01	GH15D GH15DK GH15DKE GR15D GP15DK	0.5 bar 0.7 bar 0.7 bar 0.7 bar –	0.3 bar 0.4 bar 0.4 bar 0.4 bar 1.5 bar
PH04	TIYF0760A.01	GU22C GU22CK	0.4 bar 0.5 bar	0.3 bar 0.3 bar

[1] Dismounting tool TT51 (TIWG0532A.01) is needed for maintenance

Cables and couplings

PIEZO-INPUT CABLES

CI21-1 Art. No. TICI21/1A.02
CI21-2 Art. No. TICI21/2A.02

SPECIFICATIONS	
Connection	M2×0.25 neg. – M2×0.25 neg.
Cable material	Teflon™ coated
Maximum temperature	200 °C
Cable diameter	2 mm
Mounting torque	0.35 Nm
HEX at sensor	friction-type connection
Cable mounting tool	TC21
Length	1 m … CI21-1 2 m … CI21-2

Note: To connect a sensor to the amplifiere with this cable the BNC Coupling CC21 is additionally necessary. Minimum bending radius 20 mm.

CI31-1 Art. No. TICI31/1A.02
CI31-2 Art. No. TICI31/2A.02
CI31-3 Art. No. TICI31/3A.02
CI31-5 Art. No. TICI31/5A.01

Connection	M3×0.35 pos. – M3×0.35 pos.
Cable material	Teflon™ coated
Maximum temperature	200 °C
Cable diameter	2 mm
Mounting torque	0.5 Nm
HEX at sensor side	3.5
Cable mounting tool	TC02, TC31, TT39
Length	1 m … CI31-1 2 m … CI31-2 3 m … CI31-3 5 m … CI31-5

Note: To connect a sensor to the amplifier with this cable the BNC Coupling CC31 is additionally necessary. Minimum bending radius 20 mm.

CI32-1 Art. No. TICI32/1A.02
CI32-2 Art. No. TICI32/2A.02
CI32-3 Art. No. TICI32/3A.02

Connection	M3×0.35 pos. – M3×0.35 pos.
Cable material	Metal shielded – Viton™ coated
Maximum temperature	200 °C
Cable diameter	2.4 mm
Mounting torque	0.5 Nm
HEX at sensor	3.5
Cable mounting tool	TT39
Length	1 m … CI32-1 2 m … CI32-2 3 m … CI32-3

Note: To connect a sensor to the amplifier with this cable the BNC Coupling CC31 is additionally necessary. Minimum bending radius 20 mm.

PIEZO-INPUT CABLES

CI33-1 Art. No. TICI33/1A.02
CI33-2 Art. No. TICI33/2A.02

SPECIFICATIONS	
Connection	M3×0.35 pos. – M4 ×0.35 pos.
Cable material	Teflon™ coated
Maximum temperature	200 °C
Cable diameter	2 mm
Mounting torque	0.5 Nm
HEX at sensor	3.5
Cable mounting tool	TC02, TC31, TT39
Length	1 m ... CI33-1 2 m ... CI33-2

Note: To connect a sensor to the amplifier with this cable the BNC Coupling CC41 is additionally necessary. Minimum bending radius 20 mm.

CI35-1 Art. No. TICI35/1A.02
CI35-2 Art. No. TICI35/2A.02
CI35-3 Art. No. TICI35/3A.02
CI35-3 Art. No. TICI35/3A.03
CI35-3 90° Art. No. TICI35/3A.04

Connection	M3×0.35 pos. – M3 ×0.35 pos.
Cable material	Teflon™ coated
Maximum temperature	200 °C
Cable diameter	2 mm
Mounting torque	0.5 Nm
HEX at sensor	3.5
Cable mounting tool	TC02, TC31, TT39
Length	1m ... CI35-1 2m ... CI35-2 3m ... CI35-3 3m ... CI35-3 3m ... CI35-3 90°

Note: This cable has a different cable connection to be more resistent against strucural vibration. To connect a sensor to the amplifier with this cable the BNC Coupling CC31 is additionally necessary. Minimum bending radius 20 mm.

CI37-1 Art. No. TICI37/1A.02
CI37-2 Art. No. TICI37/2A.02
CI37-3 Art. No. TICI37/3A.02

Connection	M3×0.35 pos. – M4×0.35 pos.
Cable material	Metal shielded – Viton™ coated
Maximum temperature	200 °C
Cable diameter	2.4 mm
Mounting torque	0.5 Nm
HEX at sensor	3.5
Cable mounting tool	TT39
Length	1 m … CI37-1 2 m … CI37-2 3 m … CI37-3

Note: Metal shielded cable. To connect a sensor to the amplifier with this cable the BNC Coupling CC41 is additionally necessary. Minimum bending radius 20 mm.

Cables and couplings

PIEZO-INPUT CABLES

CI38-1 Art. No. TICI38/1A.02
CI38-2 Art. No. TICI38/2A.02
CI38-3 Art. No. TICI38/3A.02

SPECIFICATIONS	
Connection	M3×0.35 pos. – Microdot pos.*
Cable material	Metal shielded – Viton™ coated
Maximum temperature	200 °C
Cable diameter	2.4 mm
Mounting torque	0.5 Nm
HEX at sensor	3.5
Cable mounting tool	TT39
Length	1 m … CI38-1 2 m … CI38-2 3 m … CI38-3

Note: Metal shielded cable. To connect a sensor to the amplifier with this cable the BNC Coupling CC41 is additionally necessary. Minimum bending radius 20 mm.
*) 10-32UNF.

CI3V-1 Art. No. TICI3V/1A.01
CI3V-2 Art. No. TICI3V/2A.01
CI3V-3 Art. No. TICI3V/3A.01

Connection	M3×0.35 pos. – M3×0.35 pos.
Cable material	Viton™ oil proof
Maximum temperature	200 °C
Cable diameter	2 mm
Mounting torque	0.5 Nm
HEX at sensor	3.5
Cable mounting tool	TT39
Length	1 m … CI3V-1 2 m … CI3V-2 3 m … CI3V-3

Note: Metal shielded cable. To connect a sensor to the amplifier with this cable the BNC Coupling CC31 is additionally necessary. Minimum bending radius 20 mm.

CI41-1 Art. No. TICI41/1A.02
CI41-2 Art. No. TICI41/2A.02
CI41-3 Art. No. TICI41/3A.02

Connection	M4×0.35 pos. – M4×0.35 pos.
Cable material	Teflon™ coated
Maximum temperature	200 °C
Cable diameter	2 mm
Mounting torque	0.5 Nm
HEX at sensor	4
Cable mounting tool	TC01
Length	1 m … CI41-1 2 m … CI41-2 3 m … CI41-3

Note: To connect a sensor to the amplifier with this cable the BNC Coupling CC41 is additionally necessary. This cable has a very good signal to noise ratio. Minimum bending radius 20 mm.

PIEZO-INPUT CABLES

CI42-1 Art. No. TICI42/1A.02
CI42-2 Art. No. TICI42/2A.02
CI42-3 Art. No. TICI42/3A.02

SPECIFICATIONS	
Connection	M4×0.35 pos. – M4×0.35 pos.
Cable material	Metal shielded – Teflon™ coated
Maximum temperature	200 °C
Cable diameter	2.4 mm
Mounting torque	0.5 Nm
HEX at sensor	4
Cable mounting tool	TC01
Length	1 m … CI42-1 2 m … CI42-2 3 m … CI42-3

Note: Metal shielded cable. To connect a sensor to the amplifier with this cable the BNC Coupling CC41 is additionally necessary. Minimum bending radius 20 mm.

CI4V-1 Art. No. TICI4V/1A.01
CI4V-2 Art. No. TICI4V/2A.01
CI4V-3 Art. No. TICI4V/3A.01

Connection	M4×0.35 pos. – M4×0.35 pos.
Cable material	Viton™ oil proof
Maximum temperature	200 °C
Cable diameter	2 mm
Mounting torque	0.5 Nm
HEX at sensor	4
Length	1 m … CI4V-1 2 m … CI4V-2 3 m … CI4V-3

Note: Oil proof cable. To connect a sensor to the amplifier with this cable the BNC Coupling CC41 is additionally necessary. Minimum bending radius 20 mm.

CI52-1 Art. No. TICI52/1A.02
CI52-2 Art. No. TICI52/2A.02
CI52-3 Art. No. TICI52/3A.02

Connection	Microdot pos. – Microdot pos.*
Cable material	Metal covered – Teflon™ coated
Maximum temperature	200 °C
Cable diameter	2.4 mm
Mounting torque	0.5 Nm
HEX at sensor	4
Cable mounting tool	TC01
Length	1 m … CI52-1 2 m … CI52-2 3 m … CI52-3

Note: To connect a sensor to the amplifier with this cable the BNC Coupling E127M is additionally necessary. Metal shield cable. Minimum bending radius 20 mm.
*) 10-32UNF

CI04-1 Art. No. TICI04/1A.02
CI04-2 Art. No. TICI04/2A.02

Connection	Microdot pos. – Microdot pos.*
Cable material	Teflon™ coated
Maximum temperature	200 °C
Cable diameter	2 mm
Mounting torque	0.5 Nm
HEX at sensor	4
Cable mounting tool	TC01
Length	1 m … CI04-1 2 m … CI04-2

Note: To connect a sensor to the amplifier with this cable the BNC Coupling E127M is additionally necessary. Minimum bending radius 20mm. *) 10-32 UNF

Cables and couplings

MEASURING CABLES

CX10 Art. No. TIBU0244A.01

SPECIFICATIONS	
Connection	DIN 7-pin neg. – LEMO 6-pin
Cable material	PVC
Maximum temperature	80 °C
Cable diameter	5 mm
Length	1 m

Note: Measuring cable for connecting low pressure sensors to AVL X-ion™.

CY10 Art. No. TILPYS10A.01

Connection	DIN 7-pin neg. – D-SUB 9-pin pos. / BNC pos.
Cable material	PVC
Maximum temperature	80 °C
Cable diameter	5.8 + 2.8 mm
Length	1 m

Note: Measurement Y-cable which seperates signal path and power supply.

E124-1.5 Art. No. TIBV2480A.01
E124-5 Art. No. TIBV0055A.01
E124-10 Art. No. TIBV0056A.01
E124-25 Art. No. TIBV4995A.01

Connection	BNC pos. – BNC neg.
Cable material	PVC
Maximum temperature	70 °C
Cable diameter	5 mm
Length	1.5 m… E124-1.5 5 m … E124-5 10 m … E124-10 25 m … E124-25

Note: Extension cable for the connection of the piezo-input cable to the amplifier.

CS10 Art. No. TILPCS10A.01
CS11 Art. No. TILPCS11A.01

Connection	DIN 7-pin neg. – DIN 7-pin pos.
Cable material	PVC
Maximum temperature	70 °C
Cable diameter	5 mm
Length	5 m … CS10 10 m … CS11

Note: Extension cable for low pressure sensors and line pressure sensors.

COUPLINGS

CC21
Art. No.
TIEG0908A.01

SPECIFICATIONS	
Connection	M2×0.25 pos. – BNC pos.

Note: Coupling for the connection of the piezo-input cable CI21 to the amplifier of the measuring cable.

CC31
Art. No.
TIEU2085A.01

SPECIFICATIONS	
Connection	M3×0.35 neg. – BNC pos.

Note: Coupling for the connection of the piezo – input cables CI31, CI32, CI35, CI3V to the amplifier or the measuring cable.

CC41
Art. No.
TIEU2077A.01

SPECIFICATIONS	
Connection	M4×0.35 neg. – BNC pos.

Note: Coupling for the connection of the piezo – input cables CI33, CI37, CI41, CI42, CI4V to the amplifier or the measuring cable.

E127M
Art. No.
TIEU0861A.01

SPECIFICATIONS	
Connection	Micro Dot neg. – BNC pos.

Note: Coupling for the connection of the piezo – input cable CI04 to the amplifier or measuring cable.

CC42
Art. No.
TIEU4137A.01

SPECIFICATIONS	
Connection	M4×0.35 neg. – M4×0.35 neg.

Note: Coupling to connect two piezo-input cables of size M4. This allows to extend the distance between sensor and CC41.

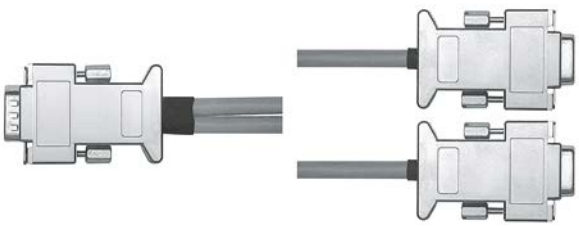
CC43
Art. No.
TIEU3385A.01

SPECIFICATIONS	
Connection	M4×0.35 neg. – M4×0.35 pos.

Note: Coupling includes an SID element and enables the automated usage of sensor within AVL Sensor Data Management.

POWER SUPPLY AND CABLES

PY10 Art. No. TILPPY10A.01



SPECIFICATIONS	
Connection	D-SUB 9-pin pos. – 2 times D-SUB 9-pin neg.
Cable material	PVC
Maximum temperature	80 °C
Cable diameter	5 mm
Length	0.3 m

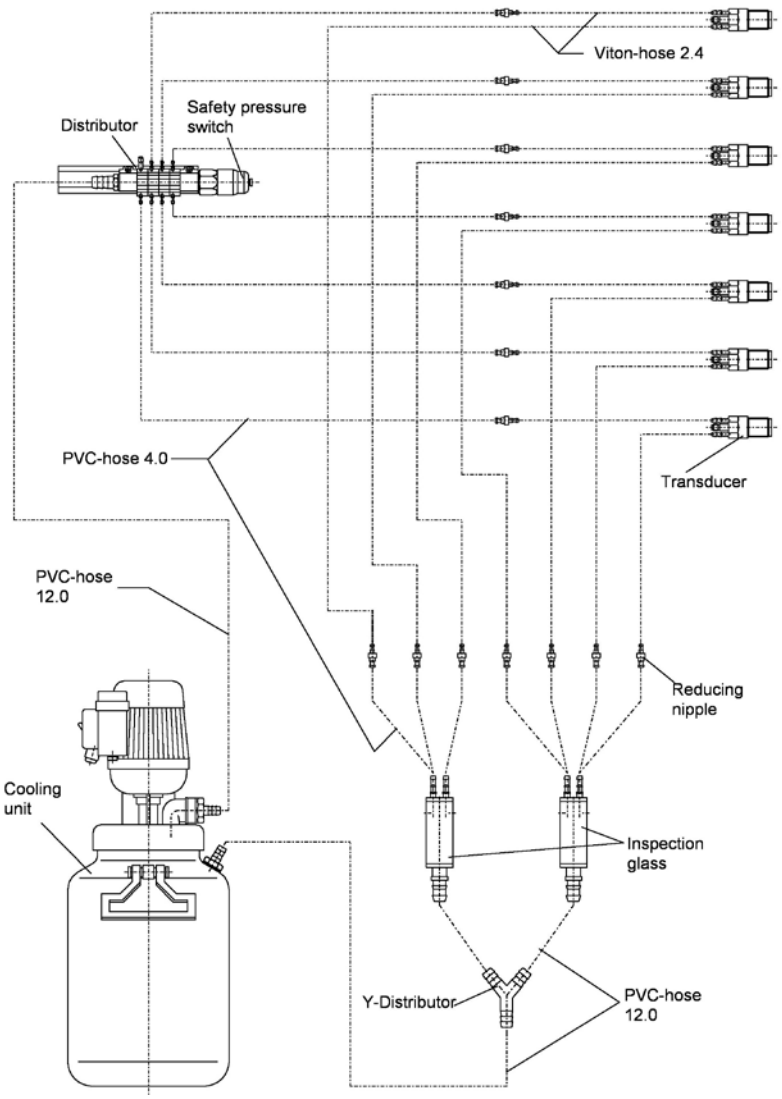
Note: Y-cable for multiple power supply.

PS10 Art. No. TILPPS10A.01

Connection	D-SUB 9-pin neg. – power plug CEE7-16A
Cable material	PVC
Maximum temperature	80 °C
Cable diameter	5 mm
Length	2.5 m

Note: Low-pressure sensor power supply for non AVL X-ion™ units.

Cooling system



This cooling system provides direct water cooling of the sensor diaphragm and the measurement cell for sensors which require active cooling. This is only necessary for sensors with piezoelectric quartz material or piezoresistive sensors.

The advantages can be summarized to:

- Prevention of overheating of quartz measuring elements and piezoresistive measurement cells
- Reduction of load change drift
- Minimum change of sensitivity due to almost constant temperature of quartz measuring elements

SCOPE OF SUPPLY

- 1 Cooling water tank incl. immersion pump
- 1 Distributor
- 1(2) Inspection glass(es) (depending on type)
- 1 Set of hoses
- Documentation

GENERAL PROPERTIES

The Cooling system provides supply of cooling water to the sensor by means of constant pressure (preventing pressure/signal fluctuations). This unit allows monitoring of the coolant flow through the engine to prevent overheating of the sensor.

SPECIFICATIONS	
Tank capacity	ZP91: approx. 20 l ZP93: approx. 50 l
Immersion pump	6 l/min at 0.6 bar pressure difference
Electric pump	230 V, 50/60 Hz (115 V, 50/60 Hz), 0.25 kW, power cable 3m
Dimensions	ZP91: 275×235×600 mm ZP93: Ø 360×805 mm
Weight	approx. 12 kg

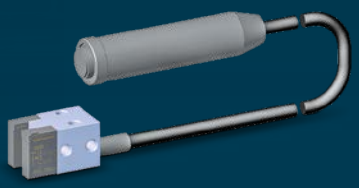
ACCESSORIES	Art. No.
Pump unit 230V	TIGH0086A.01
Pump 230 V – 50/60 Hz	TIMV0076A.01
Pump unit 115V	TIGH0116A.01
Tank ZP91	TIBO0196A.01
Tank ZP93	TIHY0316A.01
Distributor	TIBO0183A.01
Inspection glass	TIBO3364A.01
Reducing nipple	TIBO0187A.01
Y- Distributor	TIBO0188A.01
PVC-tube 4.0 (4 mm inner radius) [1]	TIZP9145A.01
PVC-tube 12.0 (12 mm inner radius) [1]	TIZP9142A.01
Cooling tube (Viton-hose 2.4)	TIZP9140A.01
Level switch ZP93	TIEZ1815A.01

[1] minimum quantity 10 m

AVAILABLE VERSIONS		Art. No.
Cooling system ZP91.00/1-4	230 V, for 1 to 4 cooling ports	TIZP91A.04
Cooling system ZP91.00/1-8	230 V, for 1 to 8 cooling ports	TIZP91A.08
Cooling system ZP91.00/1-4	115 V, for 1 to 4 cooling ports	TIZP91A.14
Cooling system ZP91.00/1-8	120 V, for 1 to 8 cooling ports	TIZP91A.28
Cooling system ZP93/1-8 [2]	230 V, for 1 to 8 cooling ports	TIZP93A.08

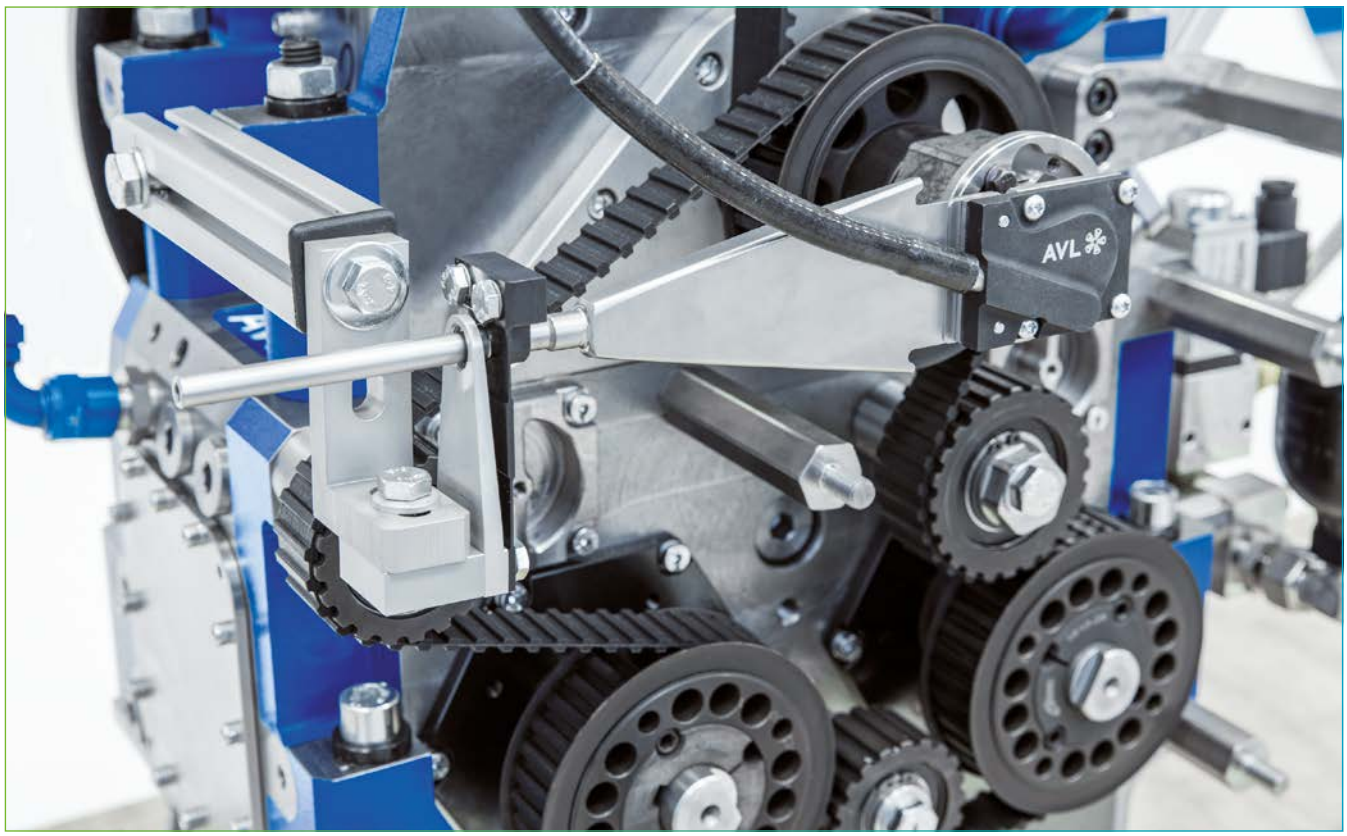
[2] Tank re-filling possible during operation.

4 Other Sensors



366C angle encoder

TI366C.01



Know exactely where you are

Angle Encoder Unit suitable for mounting to a free shaft end for flange mounting. The angle encoder is hardly sensitive against high temperature, electrical interference and vibration of the engine.

The integrated marker disc is equipped with 720 marks therefore the encoder provides a live resolution of ½ deg Crank angle. Additionally to CDM and Trigger the electronics provide the information about rotation direction – right – left. In combination with AVL X-ion™ for example when Stop-Start-operation is performed, the actual angle position is available.

Your benefits at a glance

- 720 crank degree marks (CDM) plus 1 trigger information (TRG) per revolution as LVDS-signal
- Precise measurement from n = 0 rpm to n = 20,000 rpm
- Additional information about direction of rotation: revolving right–left, evaluation via AVL X-ion™
- small height of the body, less volume and less mass and therefore less inertia, fits perfectly for in vehicle operation
- Additional signal-out-plug integrated in electronics for CDM transfer e.g. to the test cell (PUMA)

Customer requirements

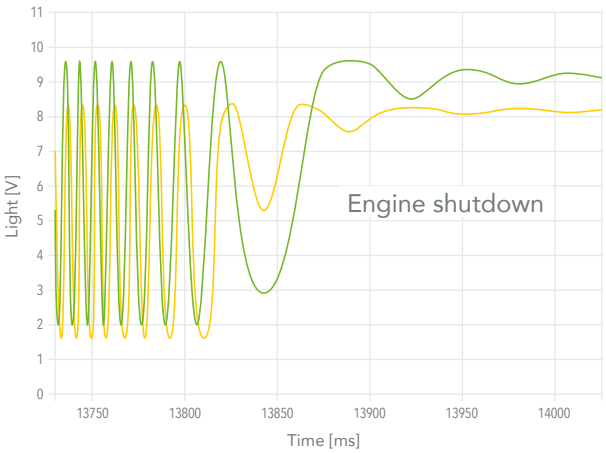
Usage of angle encoder at the test cell is a standard application. Today customer expectation is "plug and play": Easy installation of the encoder and precise and save measurement of many different values in parallel, highly resolved and reliable data acquisition.

Application

But expectations rise. Engine tests expand to even in vehicle testing on the road (RDE). AVL has developed a new optical encoder 366C that is very small and light with little inertia. It can be installed and operated in the vehicle.

Beyond this the new encoder provides the information of rotation direction – either left or right. For this reason the absolute position of the crank shaft is known at any time and in combination with X-ion™ the shaft can be positioned at any desired crank angle when the engine is shut down, useful e.g. for start-stop application.

Crank Angle Encoder 366C



Shaft positon, known at any time

TECHNICAL DATA	
Type	Optical encoder 366C
Preferred acquisition	AVL X-ion™ (Gigabit possible)
Detection rotation direction	Yes, absolute angle available
Speed range	0 rpm to 20,000 rpm
Vibration resistance	500 × 9.81 m/s² (500 g)
Short term load	1000 g
Temperature range (mechanics)	–40 °C to 120 °C
Life time	10^7 revs at 500 g load
Signal type	LVDS, RS422
Compatibility	365C mounting situation
Article number to order	TI366C.01

365X angle encoder set

TI0365XC.08

365X: SUITABLE FOR ANY SHAFT POSITION

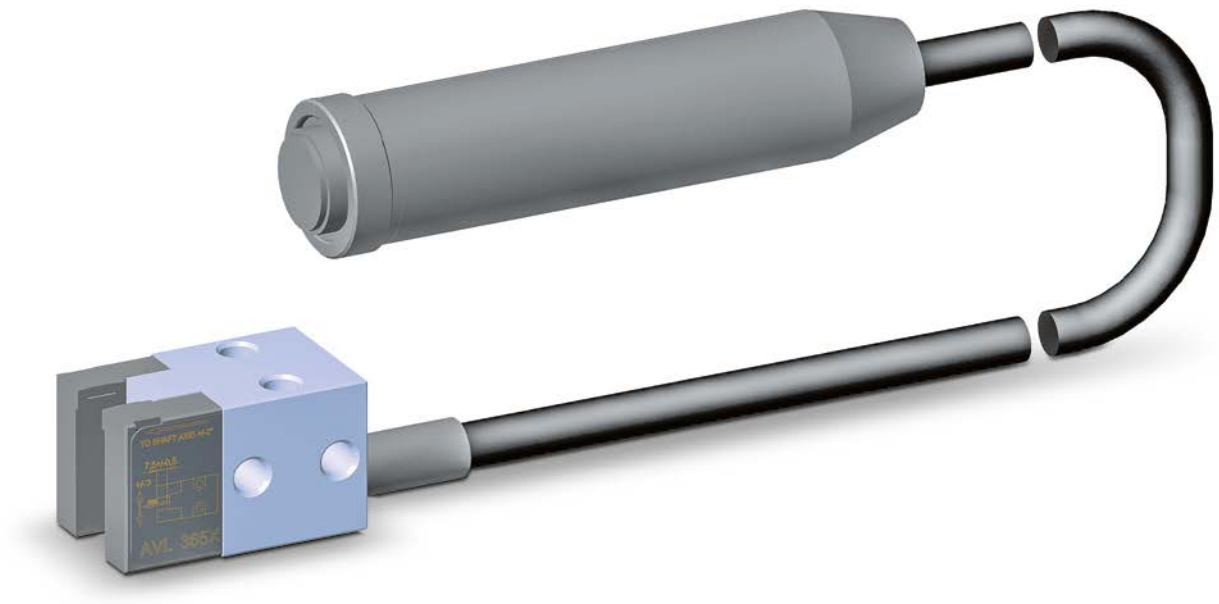
365X Angle Encoder Set is a high precision sensor for angle-related measurements mainly for indicating purposes. The encoder can be mounted between the engine and the dynamometer. The high tensile steel disk is manufactured to customer's specification.

Your benefits at a glance

- High precision
- High resolution
- High mechanical resistance
- Output: LVDS, TTL, RS422

Technical insight

The optical function of the encoder is based on a slot mark disk, utilizes the reflection light principle and provides one Trigger and 720 CDM-signals per revolution. It is the most commonly used system in engine indicating technology. The electronic components are mounted separately off the sensor head at the crank shaft to minimize the influence of vibration, temperature and electrical interference to the electronics.

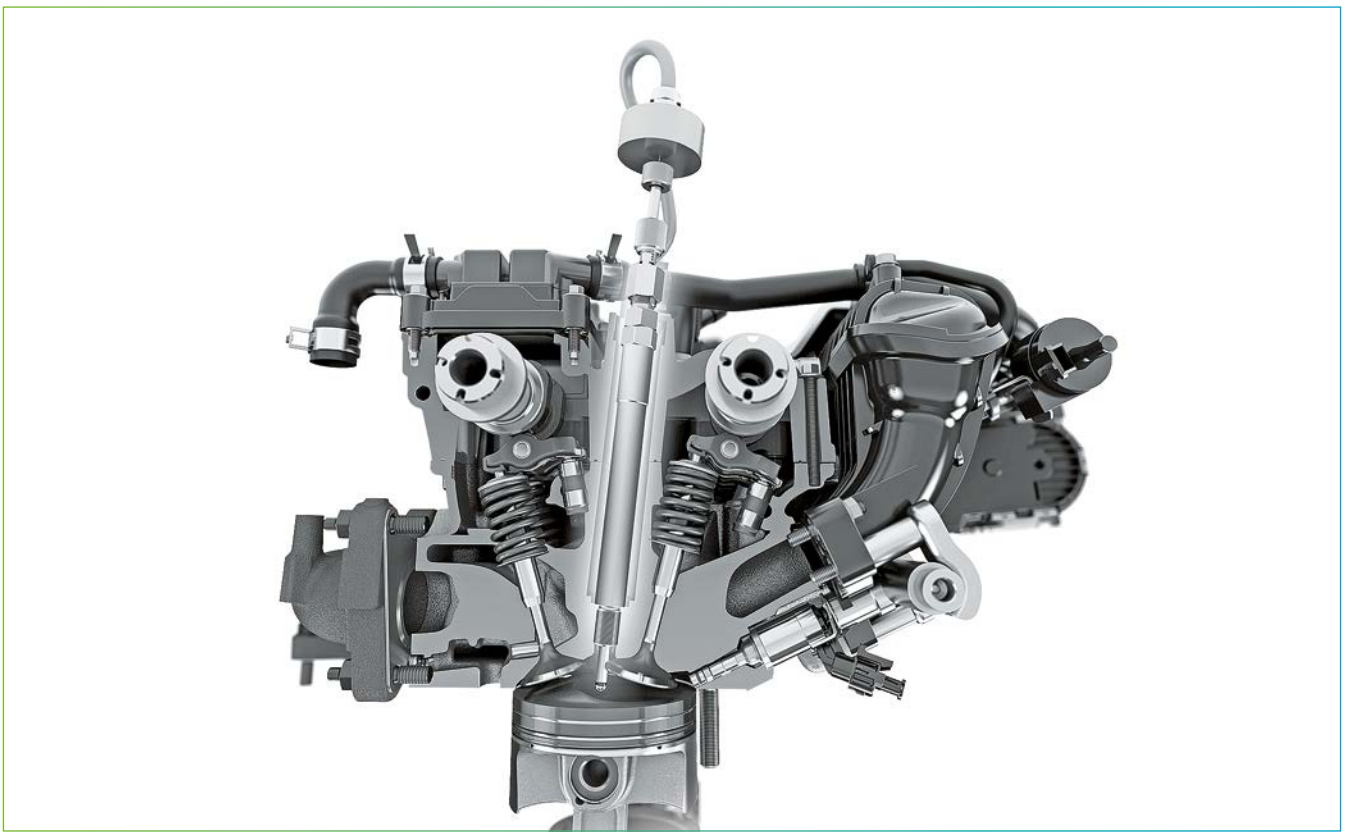


Crank Angle Encoder 365X

TECHNICAL DATA	
Type	Optical Angle Encoder 365X
Speed Range	50 min^{-1} to 28,000 min^{-1}
Vibration durability	500 × 9.81 m/s^2 (500 g)
Short time max. load	1,000 g
Temperature range	–40 °C to 120 °C, mechanics –40 °C to +70 °C, electronics
Article number to order	TI0365XC.08

TDC sensor 428

TI0428SETA.01



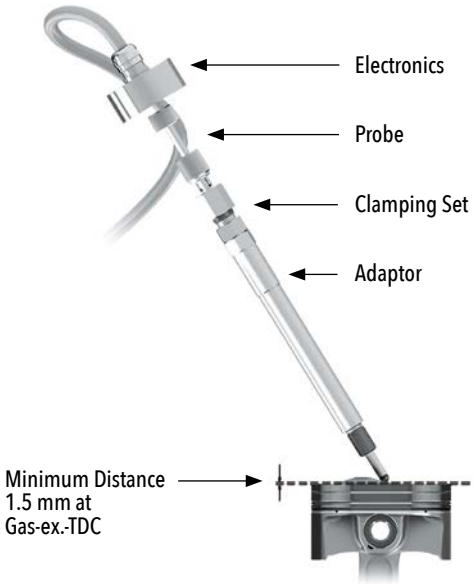
THE MOST IMPORTANT CRANK ANGLE: TDC – WE MEASURE IT!

When performing thermodynamic calculations on pressure curves measured in internal combustion engines, the exact determination of the TDC position is of great importance (e.g. IMEP calculation). Due to the not ideally rigid construction of the engine, the static determination of the TDC can lead to uncertainties at calculation. The capacitive TDC Sensor 428 is a precise measuring instrument for determination of the TDC of a motored or non-fired cylinder of internal combustion engines.

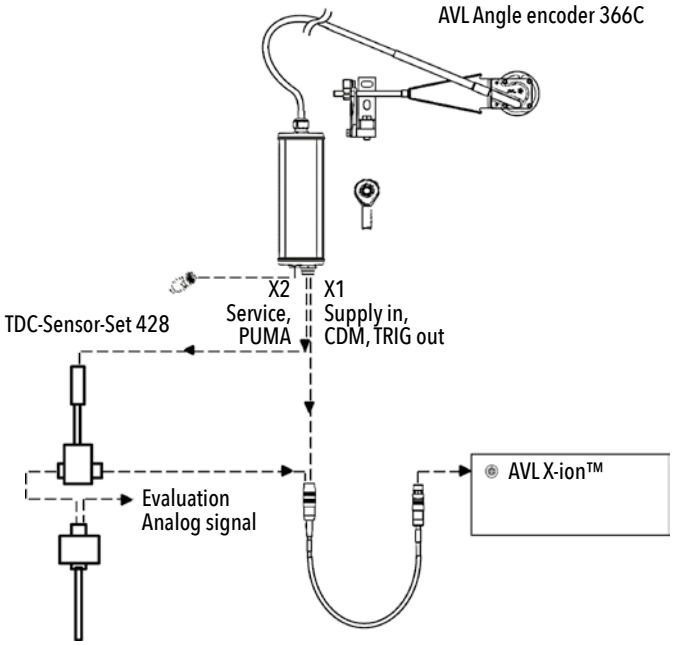
A specially developed electronic circuit delivers an analogue signal, it's maximum value corresponds to the engine's TDC position. The AVL Indicating Systems are able to process this signal in conjunction with an angle encoder directly. The necessary power for the TDC-sensor is supplied by means of AVL's angle encoder.

Your benefits at a glance

- Dynamic determination of the angular TDC position under motored or non-fired operating conditions better than ± 0.1 deg. CA
- AVL Indicating Software IndiCom recognizes the compression TDC and calculates the TDC symmetry angle.
- Simple installation of the sensor via the pressure sensor bore, spark bore plug or injector bore.
- Comparison of the TDC-sensor and the cylinder pressure signals



Sensor mounted in cylinder head



Measurement set-up

Technical information

The TDC-Sensor is installed in the cylinder head via already existing bores using suitable adapters. Due to the high variety of injectors or spark plugs and engine types in use, the necessary adapter will usually be manufactured by the user. For applying the standard probe Length = 260 mm the „TDC-Sensor-Set 428" consists of three suitable adaptors (M10, M12, M14).

SENSOR	
Operating Temperature Range	Sensor Probe: 0 °C to 250 °C (Cycle average) Sensor Electronic: 0 °C to 80 °C
Speed Range	600 rpm to 2000 rpm, non-fired
Power Supply	AVL angle encoder
Analogue Output Signal	±10 V
Weight	TDC-Sensor 428: 780g
Article number to order	TI0428SETA.01

Optical sensors

TI366C.01

THE CHALLENGE

Stringent emissions targets force our industry into ever more complex combustion technologies. The combination of electrification and advanced combustion solutions provides key ingredients for clean and efficient propulsion. As this results in increased efforts in powertrain development, robust and thorough analysis methods become mandatory.

Beside the classic pressure sensors for combustion analysis AVL offers optical spark plug sensors based on fiber optic technology for advanced combustion analysis. This solution in combination with the X-FEM Visio data acquisition module represents the perfect completion to the data acquition platform X-ion for the detailed analysis of combustion phenomena.

THE SOLUTION

M10 VisioKnock SPARK PLUG SENSOR

Due to the increasing complexity of today's combustion engines the available space for spark plugs is reduced already. The mounting size M10×1 becomes more and more popular.

AVL covers this demand already with the brand new M10 VisioKnock Spark Plug Sensor for optical investigation of knocking combustion for performance optimization. Five optical elements provide the functionality of VisioKnock measurements with fifteen cones of view. One optical element provides one further cone of view towards the piston to identify the diffusion flame radiation from the piston surface.

SPECIFICATIONS	
Mounting thread	M10×1
Thread length	26.5 mm
Heat value (BOSCH)	HV3
Spark position	3 mm
Electrode gap	0.7 mm
Temperature of the plug seat	230 °C permanent
Spark plug insulator resistivity	10^8 Ω at 20 °C, 1 kV
Burn-off resistence	6 kΩ at 20 °C, 1 kV
Electric strength (ISO11565, 3.7.2)	40 kV
Eccentricity of the insulator	1.15 mm

M12 VISIO SPARK PLUG SOLUTIONS

Most of the engine designs today use a spark plug of size M12×1.25. In order to perform advanced combustion analysis based on optical investigation the AVL product spectrum of optical spark plug solutions of size M12×1.25 covers a broad range of crank angle based flame measurement applications from in IC engine cylinders to enable the identification of premixed flames versus versus diffusion flames for the root cause analysis of particulate formation in stationary and transient operation, flame kernal propagation, knock starting locations analysis and the identification of irregular combustion. Beside the available standard solutions customized solutions can be built up on request.

Mounting thread	M12×1.25
Thread length	26.5 mm
Heat value (BOSCH)	HV3, HV5
Available spark position	3 mm, 5 mm
Electrode gap	0.7 mm
Temperature of the plug seat	230 °C permanent
Spark plug insulator resistivity	10^8 Ω at 20 °C, 1 kV
Burn-off resistence	6 kΩ at 20 °C, 1 kV
Electric strength (ISO11565, 3.7.2)	40 kV
Eccentricity of the insulator	0 mm

Available solutions

- VisioFlame Spark Plug Sensor (7 channels)
- VisioKnock Spark Plug Sensor (8 channels)
- VisioVolume Spark Plug Sensor (8 channels, for soot investigations)
- VisioKnock Advanced Spark Plug Sensor (35 channels, for knock studies)
- VisioHighRes Spark Plug Sensor (70 channels, for pre-ignition and high resolution soot investigations)

M10 VisioKnock Spark Plug Sensor

M12 HighRes Spark Plug Sensor as an example

VISIO SPARK PLUG SOLUTIONS

Many of the engine designs today use a spark plug of size M14×1.25. In order to perform advanced combustion analysis based on optical investigation the AVL product spectrum of optical spark plug solutions of size M14×1.25 covers a broad range of crank angle based flame measurement applications in IC engine cylinders to enable the identification of premixed flames versus versus diffusion flames for the root cause analysis of particulate formation in stationary and transient operation, flame kernal propagation, knock starting locations analysis and the identification of irregular combustion. Beside the available standard solutions customized solutions can be built up on request.

Available solutions

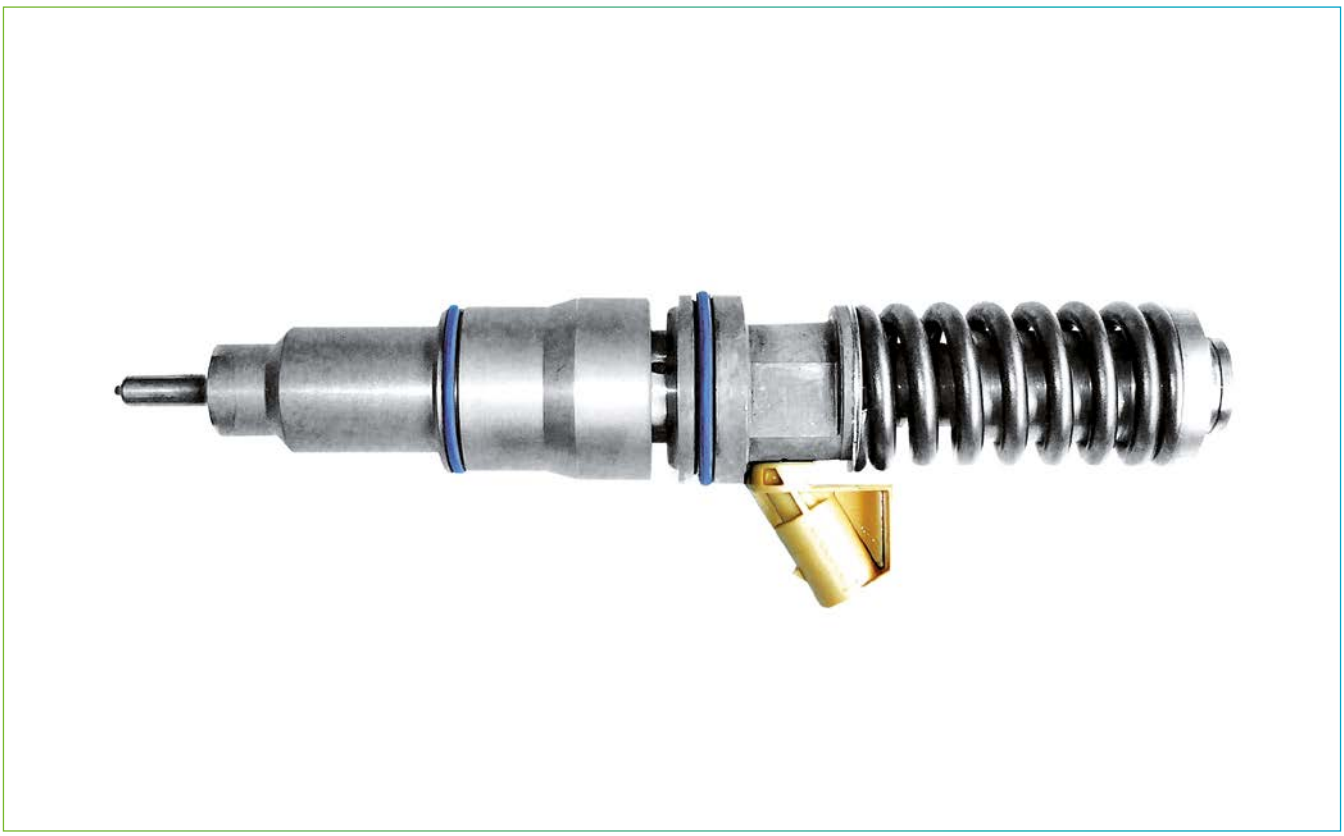
- VisioFlame Spark Plug Sensor (8 channels)
- VisioKnock Spark Plug Sensor (8 channels)
- VisioVolume Spark Plug Sensor (8 channels, for soot investigations)
- VisioKnock Advanced Spark Plug Sensor (40 channels, for knock studies)
- VisioHighRes Spark Plug Sensor (80 channels, for pre-ignition and high-res soot studies)

SPECIFICATIONS	
Mounting thread	M14×1.25
Thread length	26.5 mm
Heat value (BOSCH)	HV3, HV5
Available spark position	3 mm, 5 mm
Electrode gap	0.7 mm
Temperature of the plug seat	230 °C permanent
Spark plug insulator resistivity	10^8 Ω at 20 °C, 1 kV
Burn-off resistence	6 kΩ at 20 °C, 1 kV
Electric strength (ISO11565, 3.7.2)	40 kV
Eccentricity of the insulator	0 mm

M14 VisioFlame Spark Plug Sensor with 8 Channel as an example

Needle lift sensor

TI0600DNA.02



The nozzle needle lift indicating sensor enables the customer to measure the movement of the injector nozzle needle in diesel fuel injectors. This allows a precise determination of the beginning, the end and the duration of the injection pulse. This specially developed sensor is installed within the customer's original R&D injector. The adaptation is available for small and medium size injectors used in cars or light duty engines. It is also available for large injectors in heavy duty or marine engines.

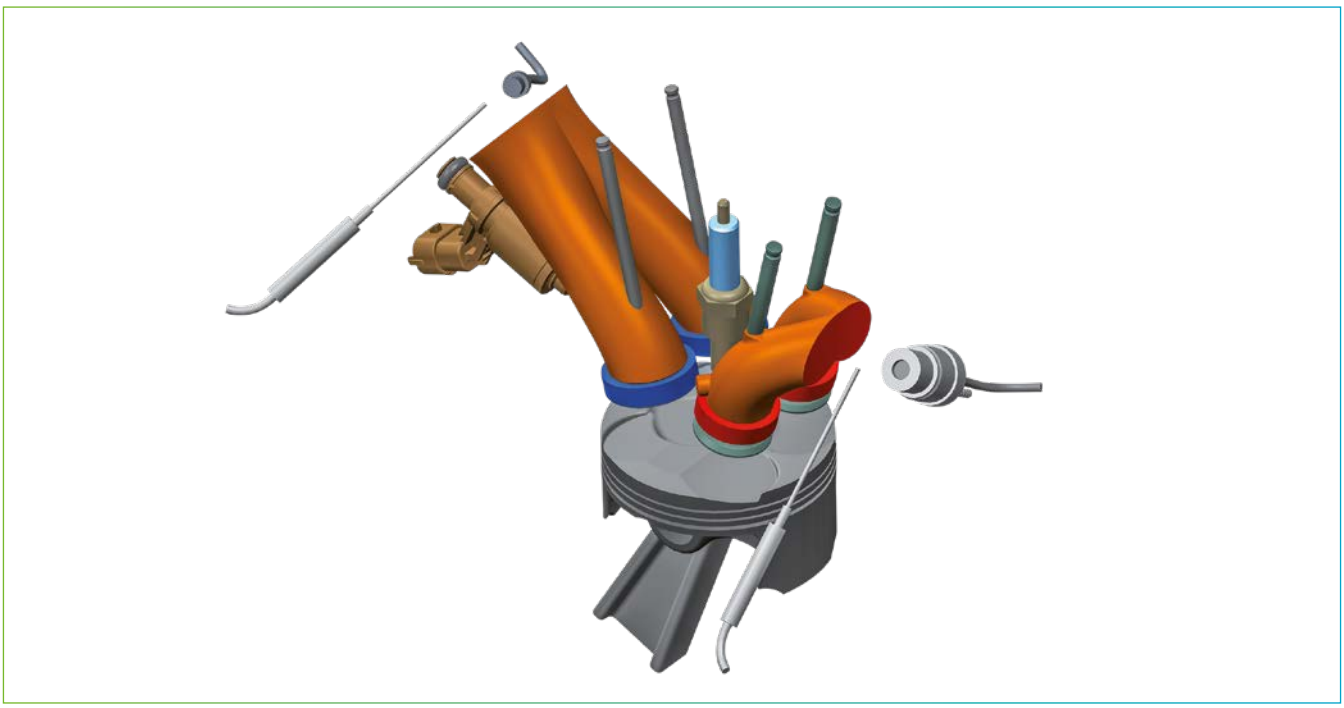
The needle lift sensor uses the eddy current principle to measure the movement of the nozzle needle. The eddy current principle is based on the extraction of energy from an oscillating circuit. The change of the impedance is calculated by the AVL Bridge Amplifier 3010 (incl. Oscillator box 3077) by looking at the change of the amplitude and phase position of the magnetic field. Moreover one available data acquisition channel is required.

Your benefits at a glance

- Direct measurement of needle lift for precise determination of beginning and duration of injection
- Design of custom tailored solutions

Gas exchange and combustion analysis (GCA)

TI0GCAADDB.01



THE VIRTUAL SENSOR

Accurate combustion analysis can help with engine design, efficiency improvements or pollutants reduction by providing instantaneous feedback on the combustion process. It can also convey detailed combustion information to help speed up the engine calibration process.

AVL GCA is a thermodynamic analysis tool based on measured data. The engine's intake, cylinder and exhaust are considered in detail. GCA calculates the complete cycle in an iterative matter, firstly " combustion" then "gas exchange". By using the measured pressure traces, values can be determined that otherwise can only be acquired with a lot of effort, or even not at all e.g. residual gas content or volumetric efficiency.

Therefor GCA is called "The Virtual Sensor"

Calibration of a simulation model by measurement is mandatory in case high accuracy is required. The calibration process requires data exchange between BOOST and GCA, therefore the consistency of these two calculation programs is necessary. Both use the same calculation core, therefore consistency is guaranteed.

Your benefits at a glance

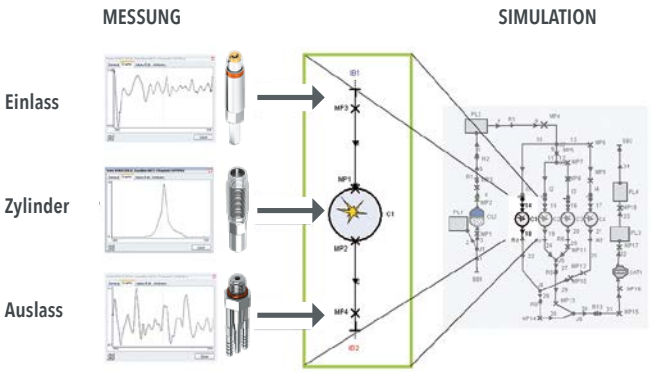
- Deep insight into the phenomena connected with the combustion chamber provides understanding of the combustion process
- Acquisition of values that cannot be measured. Verified results by plausibility checks
- Full integration of AVL indicating software and post-processing software leads to reduction of interfaces

Mastering complexity – rating plausibility

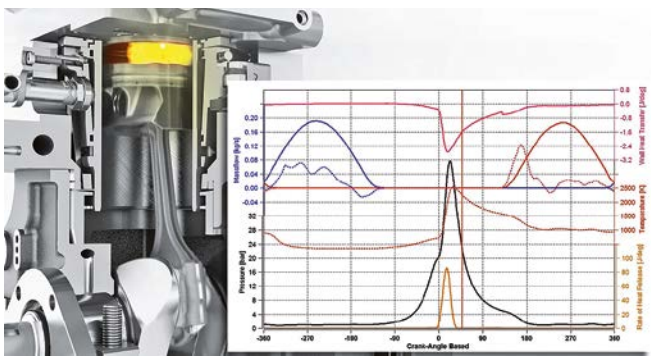
Gasoline engines use a broad range of different technologies such as the highly flexible valve-train system. This requires detailed knowledge of the thermodynamic processes in the combustion chamber – especially regarding the relationship between mixture preparation, charge motion, combustion stability and wall heat loss as it is crucial for reducing fuel consumption.

The measurement equipment at many test cells is set up with a low pressure sensor in the intake manifold and another in the exhaust. GCA provides a complete gas dynamics evaluation considering not only gas mass propagation, but also effects like natural charging.

AVL GCA is the result of continuous effort by a development team involving AVL's three main columns.



AVL GCA – consistent with AVL BOOST



Calculation of non-measureable parameters

AVL offers the following consulting services in thermodynamic analysis:

SERVICES
Quantitative assessment of thermodynamic proficiency of current combustion system design including comparison with relevant AVL pattern
Troubleshooting of process anomalies
Performance improvement
Measurement execution, application support
Technical AVL GCA Support
Article number to order: TI0GCAADDB.01

5 Service & Calibration

Maintenance for piezoelectric sensors

COMPONENTS OF SENSOR MAINTENANCE

The maintenance of sensors contains typically a visual inspection, a cleaning, once again a visual inspection after cleaning, an insulation check and a calibration. In some cases it might be necessary to exchange single components as piezoelectric cables or cooling nipples.

Additionally a dynamic test on the engine might be performed in order to control the dynamic behaviour of the sensor. Spark plug sensor maintenance contains as well a verification of the spark function.

ABOUT THE IMPORTANCE OF SENSOR CALIBRATION

Calibration means the process of checking precisely the status of the sensor. Piezoelectric sensors are stable over their lifetime if used under regular combustion conditions. All piezoelectric sensors go through a lifetime cycle, see Figure (a).

1) It starts with an improvement of linearity. The performance improvement based on linearity happens already during the run-in procedure on the test engine at the AVL headquarter.
2) A further minor improvement occurs during operation in the field. Now the sensor operates with highest performance. It lasts for a certain number of cycles of operation depending on the intensity of use.
3) Calibration in regular time intervals is recommended to ensure that the measurements are always performed with the correct sensitivity of the sensor.
4) At the end a sensor falls below the required accuracy level. Calibration is absolutely essential.

Figure a)

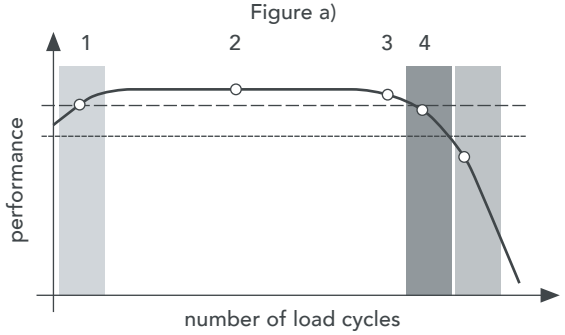
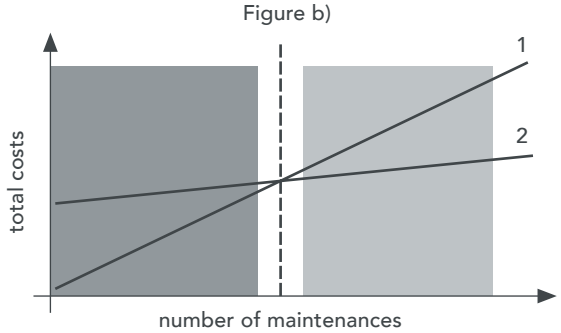


Figure b)



OPTIONS OF SENSOR MAINTENANCE

Pressure sensors can be maintained upon request directly at AVL (factory service). Another possibility is the in-house maintenance based on above-mentioned steps with an own calibration device. The main criterion for an internal or external maintenance is the expected number of maintenances per year. A maintenance directly at AVL offers the advantage that the customer does not have to spend any manpower and investment for equipment. On the other hand the in-house solution allows the customer ndependent maintenance at any time, instantly.

Regarding costs, Figure (b) shows the total costs over the number of maintenances. (1) For every single maintenance a fixed price will be charged (excluded exchange parts) in case of factory service. (2) The inertial costs are high due to the investment for maintenance devices (incl. calibration unit). After this the costs per maintenance are much less. The point where these two lines cross each other represents an orientation when an in-house maintenance becomes more economical than a factory service.

THREE MAIN QUESTIONS FOR THE DECISION OF A MAINTENANCE PROCESS:

- How long is the maintenance allowed to take?
- How much does it cost per year to calibrate all sensors on a scheduled basis externally?
- How accurate is the system and how reliable are the resulting data?

Ramp calibration unit

IN-HOUSE MAINTENANCE

The most important part of in-house maintenance is the calibration of the cylinder pressure sensor.

These factors define the demand for a calibration unit

- Request for instant calibration within a short time
- The charge for the calibrations needed inside one year exceeds the annual costs for in-house maintenance
- Use of optimum performance based on continuous calibration

RCU 601/300

To cover these requirements AVL developed an automated system for calibrations for temperatures up to 250 °C and pressures up to 300 bar. In the Ramp Calibration Unit RCU 601/300 a computer controlled spindle generates an increasing hydraulic pressure to the sensors under test. The signals are related to the response of the build in reference sensor. The calibration software allows customized documentation and the connection to the SDB Sensor Database which enables central management and coordination of calibration schedules. By using AVL charge amplifiers the system is able to identify the sensors under test automatically via the SID Sensor Identification system and link it with the corresponding information in the SDB Sensor Database. It is also possible to verify measurement chains (sensor + amplifier) and low pressure sensors from 0 to 4 bar up to 0 to 30 bar.

BENEFITS AT A GLANCE

- Fully automated operation – no manual spindle operation is needed to apply the pressure
- Up to 6 sensors can be calibrated at once which reduces the time of the calibration procedure
- Cold and hot calibrations are possible with one system
- Temperature isolated absolute reference pressure sensor ensures reproducible and accurate calibrations
- Standardized calibration sheets can be generated by the software
- A sensor history is build up and stored in the SDB Sensor Database to track and monitor the sensor performance
- Clear step by step guidance due to the user friendly software interface

MINIMUM CONFIGURATION		OPTIONS AND ACCESSORIES	
RCU 601/300 cold	TI0SDMABSA.01	Mounting adapter (per piece)	TI0SDMADAP.01
RCU 601/300 hot (230 V) (alternative)	TI0SDMABSA.03	Upgrade to hot calibration 230 V (for existing device)	TI0SDMOHCA.01
RCU 601/300 hot (120 V) (alternative)	TI0SDMABSA.04	Upgrade to hot calibration 120 V (for existing device)	TI0SDMOHCA.02
Mounting adapters (per piece)	TI0SDMADAP.01	Retrofit kit to absolute pressure reference sensor (for existing device with GU21C)	TI0SDMABSA.05
NI-USB 6210	TI0SDMDATA.01	Absolute reference sensor	TIEZ1155A.01
Microlfem Piezo 4th Generation	TI04PIEZA.04	Mobile cabinet for RCU	TI0600TROB.01
Notebook with installation	TI0620PCB.01	Software for measurement chain + low pressure verification	TI0SDMCHAA.01
Commissioning	TI0SDMCOMA.01	Hardware for low pressure verification	TI0SDMCHLA.01

Factory service

AVL is offering a factory service for cylinder pressure sensors on request which is an important part of the service of the complete indicating equipment. AVL recommends to service the piezoelectric sensors latest every 400 hours or annually including a calibration which checks the sensitivity and linearity values for room temperature and 250 °C.
The service contains inspection, cleaning, calibration and repair of cylinder pressure sensors. Repairs are performed only on demand.

THE CONTENT OF THE FACTORY SERVICE IS (DEPENDING ON TYPE):

- Optical inspection of the pressure sensor
- Insulation check for pressure sensor and piezo input cable
- Cleaning of the pressure sensor
- Cleaning and heating of electrical connection on demand
- Cold and hot calibration with a ramp calibration system
- Exchange of a defective piezo input cable on demand
- Check of spark functionality with a pressurized ignition system
- Exchange of a defect insulator (or all insulator components) on demand
- Exchange of a defect mass electrode on demand
- Exchange of cooling water nipples on demand

FACTORY SERVICE DEPENDING ON TYPE	
Service for uncooled cylinder pressure sensor	TI0SERVICU.01
Service for cooled cylinder pressure sensor	TI0SERVICC.01
Service for spark plug sensor	TI0SERVICS.01
Service for sensor and spark plug adapter	TI0SERVICE.01
Service for spark plug adapter	TI0SERVICA.01
Service for reference sensor GU21C	TI0SERVICR.01
Service for low pressure sensor	TI0SERVICL.01

FAQ for spark plug sensors

The spark plug sensors from AVL have two functions in parallel. The spark plug sensor measures the combustion pressure and in addition ignites the gas mixture in the combustion chamber. The expansion of the combustion in the chamber is depending on many influences like the spark energy, position of the spark etc. AVL offers a state of the art generation of spark plugs in line with the original spark plugs. This FAQ list should help to find answers to frequently asked questions.

Why isn't it always possible to determine a suitable measurement spark plug with information like engine type, OEM part number or manufacturer code?

AVL doesn't have information about the recommended original spark plug for every engine type and the OEM part number. The engine type itself doesn't define spark plug. The manufacturer helps together with conversion tables to get most information but information like spark protrusion, customized adaptions or heat range conversion aren't totally clear due to missing information or a high uncertainty. In worst case AVL would need an original spark plug to define the correct type.

The measurement spark plugs from AVL are only available in dedicated heat ranges and spark protrusions. Which values should be taken if there is no matching AVL solution compared to the original spark plug?

Additionally heat ranges like 4 and 6 (Bosch) and adjusted spark protrusions are possible based on customization of standard types. Recommendation of AVL is to choose a colder heat range if the conversion of the heat range means a high uncertainty.

Could the electrode gap be adjusted without limits?

The electrode gap could be adjusted to the value of the original spark plug for measurement spark plugs of generation ZI22, ZI33 and ZI45 due to the electrical strength. The measurement spark plugs of the new generation are delivered standard wise with a gap of 0.8 mm.

Does it make sense to check the electrode gap before every usage as well as during operation and how could this be done?

AVL recommends to check the electrode gap before every usage and also during operation (every 50 to 100 h depending on fuel). The check should be done with the tool TA32 from AVL.

Is it possible to use AVL spark plug sensor as well without sealing ring?

The sealing surface of the AVL spark plug sensor is manufactured with a high accuracy and less roughness in comparison to the original spark plug. Based on this AVL measurement spark plug sensors could be used without sealing ring if needed due to the specification.

How could you mount an already existing spark plug in an oriented position?

AVL offers sealing rings (used as indexing washers) with different thicknesses to reach the oriented position with a minimum impact to the spark potrusion.

Design specification – spark plug sensor

TO CUSTOMIZE THE SPARK PLUG SENSOR TO YOUR SPECIFIC APPLICATION A DETAILED DESCRIPTION OF THE ORIGINAL SPARK PLUG AND BORE IS REQUIRED.

A proper analysis of the original spark plug is needed in order to ensure the best performance and durability of the sensor solution and a comparable spark initiation in the cylinder. Based on these data AVL can design the sensor according to the customer needs. The data is stored for further orders. The input as well as forwarding the form can be carried out electronically. The order form is also available as download at **www.avl.com/sensors.**

BASE INFORMATION:

Customer name / contact	Affiliate name / contact	Date

ENGINE INFORMATION:

Engine manufacturer / code	Spark plug manufacturer / part number

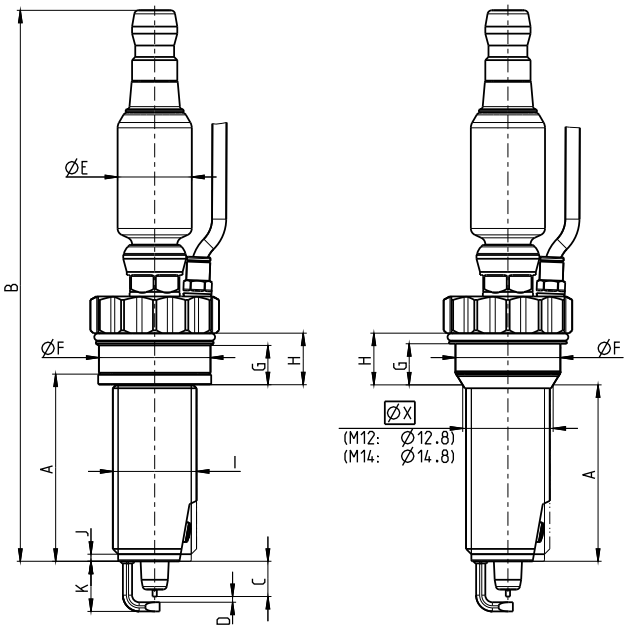
SPARK PLUG SENSOR SOLUTIONS:

(Type selection via checkbox)

Sensor	Thread diameter [l]	Selection
ZI22	M10 × 1	☐
ZI33	M12 × 1.25	☐
ZI45	M14 × 1.25	☐

SPECIFICATION OF SHAPE AND DIMENSION OF THE ORIGINAL SPARK PLUG:

Dimension



Dimension

Reach [A] = _____ mm

Total length [B] = _____ mm

Spark protrusion [C] = _____ mm

Electrode gap [D] = _____ mm

Insulator diameter [E] = _____ mm

Shaft diameter [F] = _____ mm

Length [G] = _____ mm

Length [H] = _____ mm

Thread return [J] = _____ mm

Maximum depth [K] = _____ mm

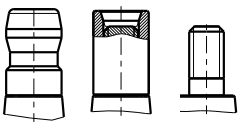
Length of insulator [L] = _____ mm

Connector (type selection via checkbox)

SAE ☐ NAPF ☐ M4 thread ☐

Connector

SAE NAPF M4



Sealing (type selection via checkbox)

Flat ☐ Conical ☐

Heat range

Scale type _____

Heat range _____

Mounting hexagon

Mounting hexagon = HEX _____

Ground electrode specification

Indexed mounting ☐

Number of electrodes ____

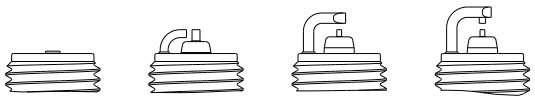
Electrode type (type selection via checkbox)

Surface gap ☐ Side ☐

Top ☐ Pin-Pin ☐

Ground electrodes specification

Surface gap Side Top Pin-Pin



INSTALLATION SOCKET INFORMATION (necessary for conical sealing and HEX <16):

Dimension

Outer diameter mounting tool = _____ mm

Diameter spark plug bore = _____ mm

Design specification – glow plug sensor/adaptor

A DETAILED DESCRIPTION OF THE ORIGINAL GLOW PLUG AND BORE IS REQUIRED IN ORDER TO CUSTOMIZE THE GLOW PLUG SENSOR / ADAPTOR ACCORDING TO YOUR SPECIFIC APPLICATION.

To ensure the best performance and durability of the sensor / adaptor solution the bore dimensions in the flame deck are particularly critical. Based on this data AVL can design the adaptor according to the customer's needs. The data is stored in the AVL database for further orders. The input as well as forwarding of the form can be carried out electronically. The order form is also available as download at **www.avl.com/sensors.**

BASE INFORMATION:

Customer name / contact	Affiliate name / contact	Date

ENGINE INFORMATION:

Engine manufacturer / code	Spark plug manufacturer / part number

SELECTION OF GLOW PLUG SENSOR / ADAPTOR:

(Type selection via checkbox)

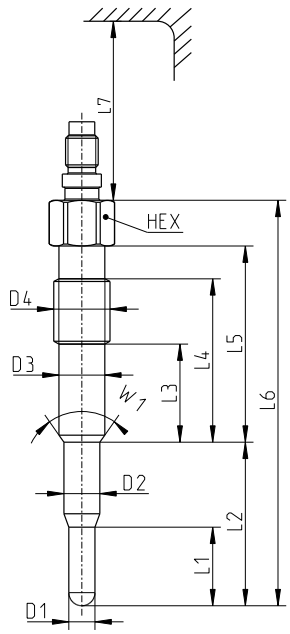
Sensor	Sensor / adapter	Thread diameter D4	Tip bore diameter DB	Selection
TIGH13GPA.01	GH13G	≥ M8	4.3 mm ≤ DB ≤ 5.0 mm	☐
TIGG1323A.01 TIAG04A.01	GH14P AG04	≥ M8	≥ 5.0 mm	☐
TIGG1323A.01 TIAG03A.01	GH14P AG03	≥ M10	≥ 5.0 mm	☐

NEW GLOW PLUG DESIGN (Definition by AVL):

A new design needs to be done, if the glow plug of interest isn't available in the AVL adapter data base. Customer understands the need for this article.

Article number	Article	Selection
TIAGDESA.01	Glow plug sensor / adaptor design	☐

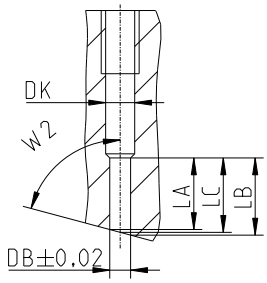
SPECIFY SHAPE AND DIMENSION OF THE ORIGINAL GLOW PLUG:



D1 = _____ mm
D2 = _____ mm
D3 = _____ mm
D4 = M ____ x ____
L1 = _____ mm
L2 = _____ mm
L3 = _____ mm
L4 = _____ mm
L5 = _____ mm
L6 = _____ mm
L7 = _____ mm
W1 = _____ °
HEX = _____ mm

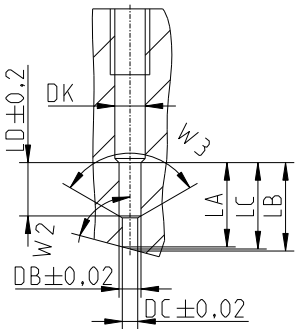
SPECIFY TYPE, SHAPE AND DIMENSION OF THE GLOW PLUG BORE:

☐



LA = _____ mm
LB = _____ mm
LC = _____ mm
DB = _____ ± _____ mm
DK = _____ ± _____ mm
W2 = _____ °

☐



Final check (with bore type B):
LA – LD ≥ 15 mm
LA + L3 ≥ 57 mm

LA = _____ mm
LB = _____ mm
LC = _____ mm
LD = _____ ± _____ mm
DB = _____ ± _____ mm
DC = _____ ± _____ mm
DK = _____ ± _____ mm
W2 = _____ °
W3 = _____ °

FAQ for glow plug sensors

AVL has made a list of frequently asked questions and tricks in order to avoid typical problems occurring while defining a glow plug adapter.

What is the difference between an original glow plug and a measurement glow plug?

The original glow plug is supporting the engine start especially with low ambient temperatures (cold start). Due to this the tip of the glow plug is designed to bring as much heat as possible into the fuel / air mixture in the combustion chamber. One factor that influences the heat contribution is the gap between the glow plug and the glow plug bore in the cylinder head.

The glow plug adaptors and sensors are used for the pressure measurement in the combustion chamber without the glow function. It is necessary to have a minimum gap between the glow plug adaptor / sensor and the bore in the cylinder head in order to ensure the best possible lifetime of the sensor. With this design, the heat transfer from combustion to the adaptor and sensor is reduced to a minimum. Based on this, the diameter and shape of the tip has to be aligned with the glow plug bore in the cylinder head. The diameter DB, DK and DC (if applicable) have to be determined with the best possible precision in order to allow the design department the smallest tolerances.

Beside the lifetime the measurement accuracy is most important. The adapter construction allows a positioning of the pressure sensor membrane close to the combustion chamber with a minimum of pipe oscillation.

To ensure a safe and damage-free dismounting a minimum wall thickness is needed. The pressure sensor GH14P has an outer diameter of 4.3 mm, therefore the minimum diameter for the usage of a sensor with glow plug adaptor (modular approach) is a DB of 5 mm. For bore diameters smaller than 5 mm, AVL can provide a glow plug sensor GH13G. This glow plug sensor will then be supplication specific and can't be used in engines with different bore dimensions.

Which dimensions are needed minimum in order to make a proper design proposal?

It is possible to make a design proposal, if:

a) the dimension of the original glow plug is available (but this is a recessed solution with pipe oszillation)
b) the dimension of the original glow plug and the diameter DB, DK and DC (if applicable) and the length LA respectively LD are available
c) all dimension / the construction drawing of the glow plug bore and the tip geometry of the original glow plug (D1 and L2) are available

Why is the information of the engine type, original part number or manufacturer code not enough?

The engine type normally only leads to a part number of the spare part. With this spare part number (or manufacturer part number) the dimension of the glow plug is normally not available and the dimensions of the bore in the cylinder head cannot be judged. Most of the time it is impossible to judge the bore diameter DB and DC. Depending on the tolerances of the glow plug bore it could be necessary to define different adapters for each bore or to ream the bore to a defined value.

For most requests no engine code or part number is given, although AVL has manufactured more than 500 different types of glow plug adapters. In addition, it is possible that due to some of the required changes, the cylinder head has to be changed slightly as well. Based on this the dimension must be checked even with known engine type information in the data base.

Published in 01/2019 by AVL List GmbH, Hans-List-Platz 1, 8020 Graz, Austria
Responsible for the contents: AVL List GmbH, Graz, Email: info@avl.com, www.avl.com
Layout: SCOOP & SPOON GmbH, Vienna
PA4044E, Subject to modifications and amendments. Printed in Austria by AVL