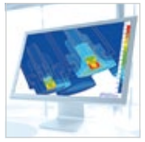
PRESSURE SENSORS FOR COMBUSTION ANALYSIS

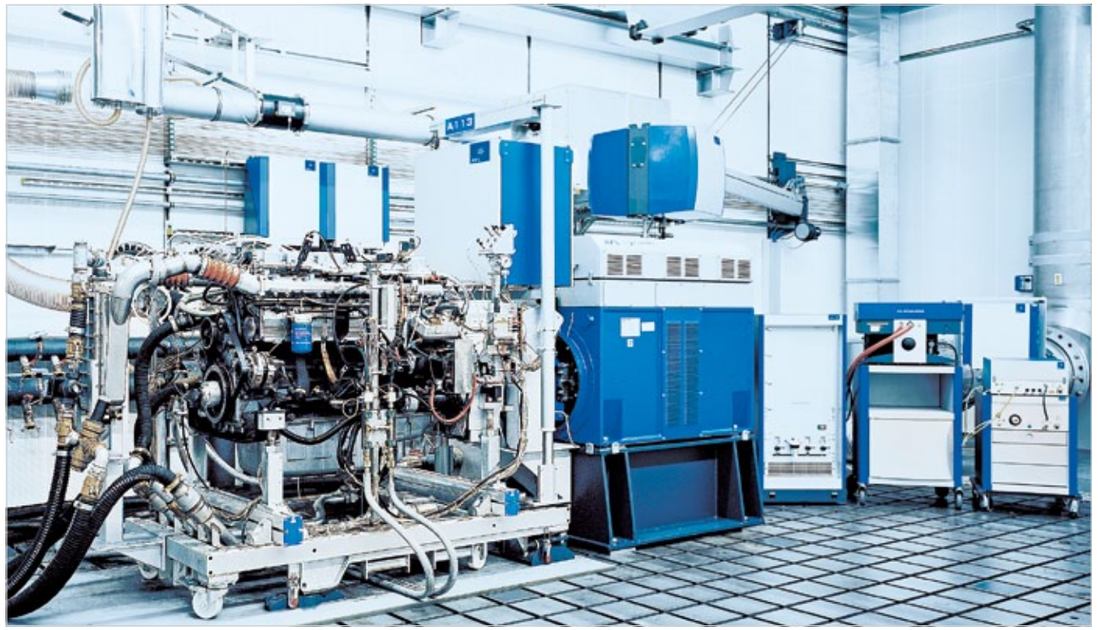
Product Catalog

CONTENTS

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.

AVL Pressure sensors

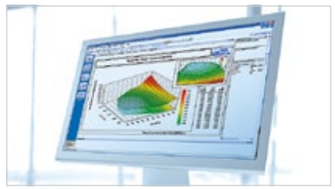
A precise, stable, and highly accurate cylinder pressure signal delivered by the pressure sensor is the basis for high quality combustion analysis. AVL provides a wide range of the sensors needed for combustion analysis tasks.

AVL Indicating charge amplifiers

Modular amplifier systems are available with different features for the signal conditioning. The portfolio goes from amplifiers with basic options to high-end solutions with intelligent signal conditioning and calculation of indicating parameters.

AVL Indicating data acquisition

Indicating systems from AVL provide data acquisition and calculated indicating parameters in real time. They allow the full integration into modern automation and application systems, which keep the flexibility for customer specific adaptations.



AVL Indicating software

AVL IndiCom™ and AVL CONCERTO™ are professional indicating and post-processing software tools from AVL. They offer powerful calculation tools, measurement automation, and professional visualization, combined with an easy-to-use interface.

Complete toolbox

AVL is worldwide the only supplier that is 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.

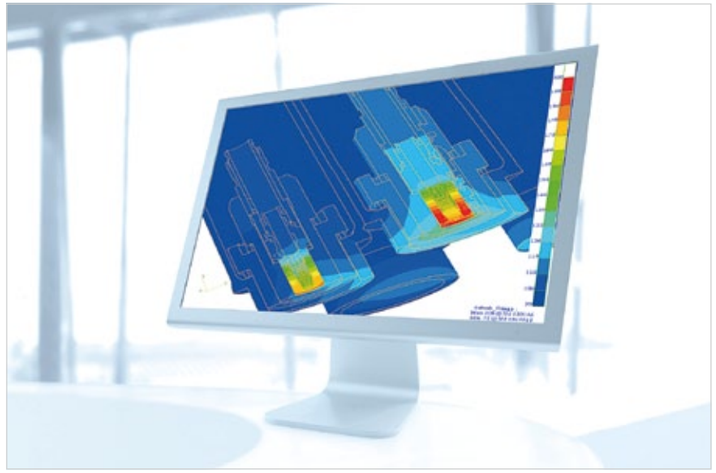
PRESSURE SENSORS FOR COMBUSTION ANALYSIS FROM AVL

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 and sensors for needle lift and valve lift can be found in the portfolio as well. The precise determination of the crankshaft position can be achieved with AVL crank angle encoders.

Quality standards and fabrication techniques

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



Research and development

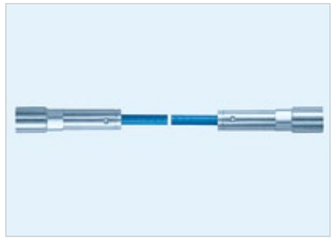
To achieve the desired precision, the design of every single part requires high-tech know-how from the development department, along with innovative computer aided modeling algorithms. One example of the unique methods AVL practices is the use of trimmed piezo elements together with the Double Shell™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

Precision manufacturing and assembly

A piezoelectric sensor consists of up to 15 parts. Some of them are just a few tenths of a millimeter in size. This requires fabrication tolerances similar to those for optical parts and assembly techniques like those used for mechanical watches. The core of every piezoelectric sensor is a set of piezoelectric crystals. Uncooled sensors from AVL use the patented crystal material $GaPO_4$ which is fabricated only at the AVL headquarters in Austria.

SETUP OF THE MEASUREMENT CHAIN

Pressure sensor:
Piezoelectric pressure sensors work on the principle of electrical charge output of certain crystals under mechanical load. Therefore they represent an active measuring element with the output charge being proportional to the pressure applied.



Measurement cable:
The high impedance measurement cable is used to transmit the electrical charge. Due to the relatively low electrical charge output of pressure sensors, the connection quality between the sensor and the charge amplifier is crucial.

Charge amplifier:
To allow effective signal processing the generated charge is converted to a voltage signal by means of a charge amplifier. The signal is then sent to the data acquisition unit.

Measuring pressure signals

The first three components of the measurement chain in a typical indicating setup consist of the pressure sensor, a connecting cable and the charge amplifier. These components are the most critical parts in the entire measurement chain. This is because the measured charge signal is still very sensitive to external influences like electromagnetic fields. Therefore the quality of signal transmission in the first three steps of the measurement chain will define the absolute achievable precision.

Processing pressure signals

After the charge is converted into a voltage by the amplifier, the analog signal is sent to a data acquisition unit like the AVL IndiSet Advanced™. It serves as the link from the analog pressure measurement into the digital domain of data processing. Together with a crank angle encoder and software like AVL IndiCom™ the unit allows real time combustion analysis. Post processing with AVL Concerto™ offers all sorts of analytical algorithms from standard processing to customized algorithms.

PRODUCT SELECTION GUIDE

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 that a customer typically faces in the decision making process when selecting a sensor. Depending on how the question is answered, a page reference within a 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 quickly classify a sensor according to its strengths and key features. There are two different types of icons. The first type, the strength, indicates how well a sensor is suited 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, the key feature, gives information about which special technical component or design features the sensor has.

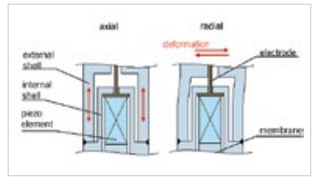
Icons of strength / measurement task

	**Toughness / knock applications** Purpose: Specially designed to withstand under extreme and harsh conditions.	Examples: Analysis of knocking combustion, operation under high engine loads, supercharged engines
	**Precision / thermodynamic analysis** Purpose: Very 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

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 suited piezoelectric material to be used in sensor 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 24.



Double Shell™ - Mechanically decouples the crystals 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 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:

- SID Sensor Identification (see picture top left)
- SIC Sensor Identification Cable (see picture top right)
- SDC Sensor Data Connector (see picture bottom left)
- SDB Sensor Data Base (see picture bottom right)

For details see also page 26.

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 families of mounts 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 possible 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.

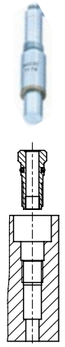
Cylinder pressure

Mechanical modifications of cylinder head

P
probe

- slim sensor design
- also for spark-/ glow-plug adaptation

C
plug



- less thermal deformation
- less influence of mounting bor

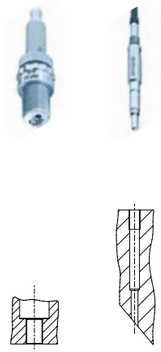
D
thread

- best heat dissipation
- simple installation

Use of existing standard bores

Z
spark-plug

G
glow-plug



- no indicating passages necessary
- custom tailored design

DECISION TREE FOR CYLINDER PRESSURE SENSORS

"Which cylinder pressure sensor is typically best suited to a certain application?"

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

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. The compatible accessories are listed on page 20.

Pressure sensor	Measurement task			Mounting type					Thread / bore diameter										Sealing type		Cable connection							
	Precision (IMEP) Thermo-dynamic analysis	Toughness Knock applications	Durability (non stop) Endurance tests	Plug type	Threaded type	Probe	Spark-plug	Glow-plug	M5 x 0.5	M7 x 0.75	M8 x 0.75	M10 x 1	M12 x 1.25	M14 x 1.25	Ø 4.25 mm	Ø 4.3 mm	Ø 6.3 mm	Ø 10 mm	Front sealed	Shoulder sealed	M3x0.35	M4x0.35	Mirco-Dot 10-32 UNF	Burklin 70F 8251	LEMO - 6 pin	M12 - 8 pin	Double Shell	$GaPO_4$
Cylinder pressure																												
GH14D	★★★	★	★★		•				•										•			•					•	•
GH14DK	★★	★★★	★★		•				•										•			•					•	•
GH15D	★★★	★	★★		•				•										•		•						•	•
GH15DK	★★	★★★	★★		•				•										•		•						•	•
GR14D	★★	★	★★		•				•										•			•					•	•
GH11C	★★★	★	★★	•											•					•		•						•
GH13P	★★	-	★★			•		○								•			•		•							•
GH14P	★★★	-	★★			•		○								•			•		•						•	•
GU21D	★★	★	★★		•					•										•		•						•
GU22C	★★★	★	★★	•													•			•		•						•
GU22CK	★★	★★★	★★	•													•			•		•						•
GG22C	★★★	★	★★	•													•			•		•						•
GU24D	★★★	★	★★		•						•									•		•					•	•
GU24DE	★★★	★	★★		•						•									•		•					•	•
GH13G	★★	-	★★					•					-								•							•
ZI21	★	★★	★				•					•								•	•							•
ZI31	★	★★	★				•						•							•	•							•
GH13Z-24	★★	★	★★			•	○							○		•			•		•							•
GH13Z-31	★★	★	★★			•	○							○		•			•		•							•
QC34C	★★★	★	★★★	•										○				•		•		•						
QC34D	★★	★	★★★		•							•								•		•						
QC43D	★★	★	★★★		•									•						•			•					
Low-pressure																												
LP11DA					•				•											•				•				
Monitoring																												
GO31D	★	★★	★★★		•							•								•		•					•	•
GO31DA	★	★★	★★★		•							•								•						•	•	•
GO41D	★	★★	★★★		•									•					○	•		•					•	•
GO41DA	★	★★	★★★		•									•					○	•						•	•	•

Pressure sensor	SDM			Pressure range										Sensitivity									Cyclic temperature drift							Natural frequency											Page
	SID	SIC	SDC	0 bar	10 bar	100 bar	200 bar	250 bar	300 bar	350 bar	2000 bar	3000 bar	Maximum temperature	8 pC/bar	12 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	50 kHz	69 kHz	85 kHz	90 kHz	96 kHz	100 kHz	115 kHz	130 kHz	160 kHz	165 kHz	170 kHz	
Cylinder pressure																																									
GH14D	•		○					•					400°C				•									•												•			30
GH14DK	•		○						•				400°C				•											•												•	32
GH15D	•		○					•					400°C				•									•												•			34
GH15DK	•		○						•				400°C				•											•												•	36
GR14D		•	○					•					400°C			•										•													•		38
GH11C	•		○					•					400°C					•							•													•			40
GH13P	•		○					•					400°C			•										•											•				42
GH14P	•		○					•					400°C			•										•											•				44
GU21D	•		○					•					400°C							•					•							•									50
GU22C	•		○					•					400°C						•						•										•						52
GU22CK	•		○							•			400°C						•							•								•							54
GG22C	•		○					•					400°C						•						•										•						56
GU24D	•		○					•					400°C								•		•										•								58
GU24DE	•		○					•					400°C								•		•										•								60
GH13G	•		○					•					400°C			•										•											•				62
ZI21			○				•						350°C	•													•										•				64
ZI31			○				•						350°C		•												•										•				66
GH13Z-24	•		○					•					400°C			•										•										•					46
GH13Z-31	•		○					•					400°C			•										•										•					48
QC34C	•		○					•					350°C				•						•								•										68
QC34D	•		○					•					350°C				•						•								•										70
QC43D			○				•						350°C									•		•						•											72
Low-pressure																																									
LP11DA					•								200°C																												74
Monitoring																																									
GO31D		○	○					•					350°C				•												•				•								76
GO31DA								•					350°C	13 mV/bar or 50 µA/bar															•				•								78
GO41D		○	○					•					350°C				•												•				•								80
GO41DA								•					350°C	13 mV/bar or 50 µA/bar															•				•								82

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

ACCESSORY CONFIGURATION CHART

"Which accessory goes best with a specific sensor?"

The chart below helps to identify the compatible accessory parts with a specific pressure sensor. It can also be used to get information about whether a tool or component for a previously obtained sensor can be used for a new sensor type as well.

Pressure sensor		Adaptors › P. 86																								› P. 98		› P. 99	› P. 96	› P. 100		
	Mounting torque [N/m]	Adaptor sets		Adaptor sleeves												Mounting sleeves			Mounting nipples		Safety ring	Spark plug adaptor	Glow plug adaptor		Cooling Adaptor	Gaskets	Gasket dismounting tool	Dummies	Removal tool	Flame arrestors		
		AS02	AS29	AH01	AH01A	AH06	AH08	AH13	AH14	AH15	AH18	AH28	AH31	AH35	AH45	AH05	AH26	AH27	AM04	AM05	AM06	ZF43	AG03	AG04	AE04					PH01	PH03	PH04
Cylinder pressure																																
GH14D	1.5			•	•																							DG01	TD01	•	•	
GH14DK	1.5			•	•																							DG01	TD01	•	•	
GH15D	1.5			•	•								•															DG24	TD13	•	•	
GH15DK	1.5			•	•								•															DG24	TD13	•	•	
GR14D	1.5			•	•																							DG01	TD01	•	•	
GH11C	1.2																															
GH13P	1.5							•							•								•	•				DG13	TD13	•	•	
GH14P	1.5							•							•								•	•				DG13	TD13	•	•	
GU21D	3					•																				SG03	TT17	DG04	TD01			
GU22C	10		•									•					•	•	•	•	•					SG02		DG10	TD01			•
GU22CK	10		•									•					•	•	•	•	•					SG02		DG10	TD01			•
GG22C	10		•									•					•	•	•	•	•					SG02		DG10	TD01			•
GU24D	6													•												SG21	TT33	DG09	TD01			
GU24DE	6																									SG21	TT33	DG25	TD01			
GH13G	4																															
ZI21	10-15																									SG23						
ZI31	15-25																									SG33						
GH13Z-24	1.5 (1)																					•				SG43 ∘				•	•	
GH13Z-31	1.5 (1)																					•				SG43 ∘				•	•	
QC34C	15	•					•									•										SG20	TT15	DG05	TD01			
QC34D	10								•		•															SG20	TT15	DG06	TD01			
QC43D	20									•																SG05	TT14	DG07	TD01			
Low-pressure																																
LP11DA	4																								•			DL01				
Monitoring																																
GO31D	15-20																									SG20	TT15	DG11	TD01			
GO31DA	15-20																									SG20	TT15	DG06	TD01			
GO41D	20-25																									SG05	TT14	DG12	TD01			
GO41DA	20-25																									SG05	TT14	DG15	TD01			

Pressure sensor	Cables & couplings › P. 101												Machining tools › P. 92															
	Couplings			Piezo-Input cable							Measuring cable		Set of machining tools					Step drills						Tap drills				
	CC31	CC41	E127M	CI31	CI3V	CI41	CI42	CI4V	CI46	CI04	E124	CS10	MS11	MS15	MS22	MS24	MS25	MD10	MD11	MD12	MD22	MD24	MD25	MT11	MT13	MT21	MT25	MT31
Cylinder pressure																												
GH14D		•				•	•	•	•		•		•		∘				•		∘			•		∘		
GH14DK		•				•	•	•	•		•		•		∘				•		∘			•		∘		
GH15D	•			•	•						•			•	∘					•	∘			•		∘		
GH15DK	•			•	•						•			•	∘					•	∘			•		∘		
GR14D		•				•	•	•	•		•		•		∘				•		∘			•		∘		
GH11C		•				•	•	•			•																	
GH13P	•			•	•						•																	
GH14P	•			•	•						•						•						•				•	
GU21D		•				•	•	•	•		•				•	∘					•	∘				•		∘
GU22C		•				•	•	•	•		•							•							•			•
GU22CK		•				•	•	•	•		•							•							•			•
GG22C		•				•	•	•	•		•							•							•			•
GU24D		•				•	•	•	•		•																	
GU24DE		•				•	•	•	•		•																	
GH13G	•			•							•																	
ZI21	•			•							•																	
ZI31	•			•							•																	
GH13Z-24	•			•							•																	
GH13Z-31	•			•							•																	
QC34C		•				•	•	•	•		•																	
QC34D		•				•	•	•	•		•																	•
QC43D			•							•	•																	
Low-pressure																												
LP11DA												•																
Monitoring																												
GO31D		•				•	•	•	•		•																	•
GO31DA																												•
GO41D		•				•	•	•	•		•																	
GO41DA																												

Pressure sensor	Mounting tools › P. 94																					Page
	Set of mounting tools	Sockets and wrenches													Pin / Polygon-Head tools	Special tools for spark-plug adaptors			Cable mounting tool			
		TT01	TT07	TT08	TT09	TT11	TT21	TT22	TT24	TT27	TT29	TT31	TA13	TA16	Z314	TA31	TT43	TT44	TC01	TC31	TT25	
Cylinder pressure																						
GH14D	TS01	•																	•			30
GH14DK	TS01	•																	•			32
GH15D	TS21						•													•	•	34
GH15DK	TS21						•													•	•	36
GR14D	TS01	•																	•			38
GH11C																			•			40
GH13P	TS21						•													•	•	42
GH14P	TS21						•													•	•	44
GU21D	TS03					•													•			50
GU22C	TS02				•								•						•			52
GU22CK	TS02				•								•						•			54
GG22C	TS02				•								•						•			56
GU24D	TS03					•													•			58
GU24DE	TS03					•													•			60
GH13G					•									•								62
ZI21								•	•			•				•	•	•		•	•	64
ZI31								•	•			•				•	•	•		•	•	66
GH13Z-24	TS21						•													•	•	46
GH13Z-31	TS21						•													•	•	48
QC34C				•															•			68
QC34D			•												•				•			70
QC43D				•															•			72
Low-pressure																						
LP11DA											•											74
Monitoring																						
GO31D														•					•			76
GO31DA										•									•			78
GO41D			•																•			80
GO41DA				•															•			82

∘ › in combination with an adaptor (1) › mounting torque to mount the spark-plug into the cylinder head is 15-20 Nm for aluminium alloys

DATASHEET INFORMATION

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

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

A

Acceleration sensitivity [bar/g]

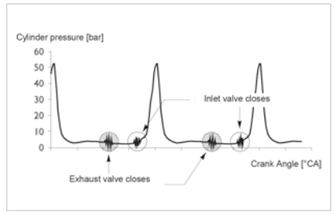


Figure 1

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. In case of specially acceleration compensated sensors, like the GR14D, additionally the radial acceleration sensitivity is stated. The 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 outlet valves on the valve seat and 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 has to be always smaller to guarantee save 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 M3x0.35 or a M4x0.35 connector. Older sensor types like, e.g. some water cooled quartz piezoelectric sensors, use so called Micro-Dot 10-32 UNF connectors. Line pressure sensors have a LEMO – 6 pin plug (FGG.0B.306.CLAD56). Monitoring sensors require either an M4x0.35 or an M12-8 pin 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 required 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 trough 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 water cooled sensors 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 quantities that are integrated over one cycle (e.g. the indicated mean effective pressure IMEP) is therefore significant. Consequently the smaller the cyclic temperature drift is the higher is the accuracy of the measurement.
It is crucial how the procedure of how 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. Additionally to the AVL standard values for Δp, Δp_{mi} and Δp_{max} are stated to ease comparison with sensors from other manufacturers. These values are 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. Spark-plugs with an integrated pressure sensor require a small eccentricity of the electrode due to the limited available space. The eccentricity should be always chosen as small as possible.

Electric strength [V]

Based on the design of the center electrode the electric strength indicates the maximum electric voltage the spark-plug can carry before unwanted flashovers occur. This value can be chosen as large as possible.

Electrode gap [mm]

The optimal Electrode Gap of a spark plug is determined by the Final Compression Pressure (FCP) from the compression stroke, as this is a convenient metric that is roughly proportional to the demand voltage required to jump the gap in the spark plug. It is necessary to match the spark-plug specifications exactly to have reliable firing of the engine and to insure that the demand voltage is not exceeding component limits to avoid permanent damage of the spark-plug sensor assembly. The tolerance limits in a spark-plug like ZI21, ZI31 and ZF43 regarding the maximum voltage is due to the nature of the design not as high as in conventional spark-plugs.
The evaluation of the final compression pressure for the desired operation point of the engine is therefore critical and has to be matched carefully to the application and operating point of the engine. For detailed instructions please refer to the document AT4370E which you can request from your technical sales support.

Excitation voltage [V]

The excitation voltage is the driver-voltage of the Wheatstone bridge circuit used for the SL31D line pressure sensors. This value is only of importance if the sensor is operated not with an AVL amplifier.

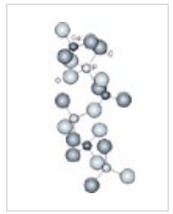
F

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 resolution 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 and 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 $GaPO_4$



Crystal structure of Gallium Orthophosphate.

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 if the hydrothermal growing process of $GaPO_4$ takes several months, AVL produces this piezoelectric material in high quantities. In numbers this means simultaneous growing of up to 300 crystals, which corresponds to almost 200 kg crystal material per year. Each crystal, having a size larger than a man's palm, gives in the cutting process thousands of thin slices and cubes which can be used with high yield for hundreds of pressure sensors.

Figure 2

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 and above that changes into the high cristobalite type.
The excellent thermal behaviour and high sensitivity of Gallium Orthophosphate have made great advances over quartz and Langasite crystals possible especially when building uncooled miniature pressure sensors. Langasite crystals tend to have higher longitudinal sensitivities than Gallium Orthophosphate. But, if measurement accuracy and precision are of importantance, terms like the sensitivity change and linearity of a sensor are more relevant. These are the areas where $GaPO_4$ performs superior. The importance of the sensitivity change becomes clear in context with the sensor housing. Designing a pressure sensor for automotive applications requires that the piezoelectric crystal needs to be packed into a rigid sensor housing. The material of the sensor housing has to be chosen in that 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 much better the optimization of the design what results in better sensors with higher measurement precision.

I

Insulation resistance [Ω]

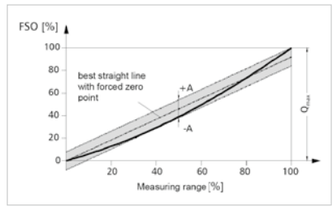
The insulation resistance is the electrical (ohmic-) resistance measured between the electrodes of the sensor (electrical contacts of the connector). Piezoelectric sensors have to have a resistance in the range of more than 10^{12} Ω to ensure proper operation.
The higher the resistivity the better the sensor performs 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

Lifetime [Number of cycles]

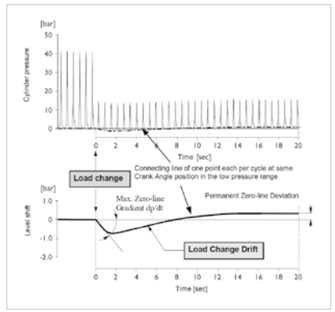
The number of cycles of alternating pressure loads up to which the pressure sensor retains its measurement performance. This value should be as large as possible.
The stated value can be only achieved under regular combustion with standard fuels. Extreme operating conditions such as combinations of very high temperature, steep pressure rises, pre-ignition events like knocking, deformation of the mounting bore and corrosive media can reduce the sensor lifetime significantly.

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 the 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 causes 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 works according to its specifications. For analysis of the cylinder pressure this range should be at least 0…200bar.
Under severe conditions like supercharged engines and under knocking the maximum pressure range becomes an issue. High pressure peaks can fatigue the membrane and can make the sensor fail. The maximum allowed pressure is mainly defined by the geometry 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 "mounting thread").

Mounting torque [Nm]

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

N

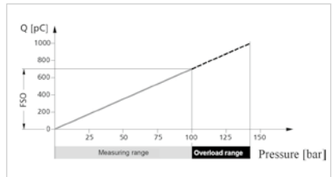
Natural frequency [Hz]

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.
By 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 within 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 average 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. This value should be chosen as high as possible.
At high pressures like this it can not be guaranteed that the sensor signal works according to the specifications but the sensor is not permanently damaged.

P

Pipe oscillations [Hz]

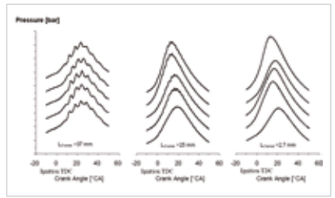


Figure 3

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 and is a 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 and is a 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 [C/bar]
DIN1319 defines sensitivity in this context as the ratio how much electrical charge is generated per pressure unit (bar). This value should be at least 10 pC/bar to generate good data.
The electrical charge is measured in Coulomb (1 C = 10^9 pC). The line pressure sensors (SL31D) are based on a Wheatstone bridge and give therefore a change in resistivity of the measurement element instead of a generated charge.
The nominal sensitivity is the measured sensitivity at 23°C.
It might seem that it is 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 is 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. AVL developed for this area of application an acceleration compensated sensor, the GR14D on page 38.
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 and is a part of the SDM Sensor Data Management system.
The SIC fulfills the same purpose as an SID. It carries like the SID a unique identification number which allows the amplifiers from AVL to recognize and identify the sensor which is 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 that 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 and is a part of the SDM Sensor Data Management system.
A sensor with SID electronics has a built-in electronic component with a 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 and is measuring. 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. TEDS formats are defined in the IEEE1451 interface standards developed by a 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 22.

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

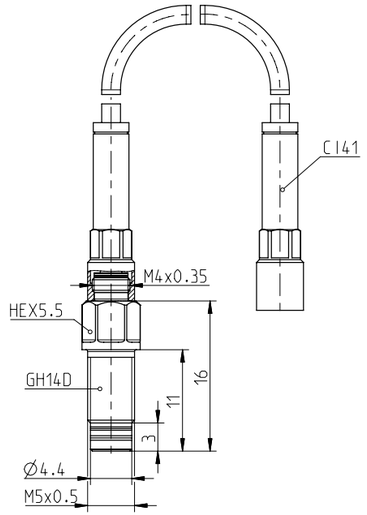
W

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

PRESSURE SENSORS

GH14D

TIGG1321A.01



The GH14D 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 thermal expansion, and other 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.
A thermo protection can improve the accuracy even further, see also page 100.

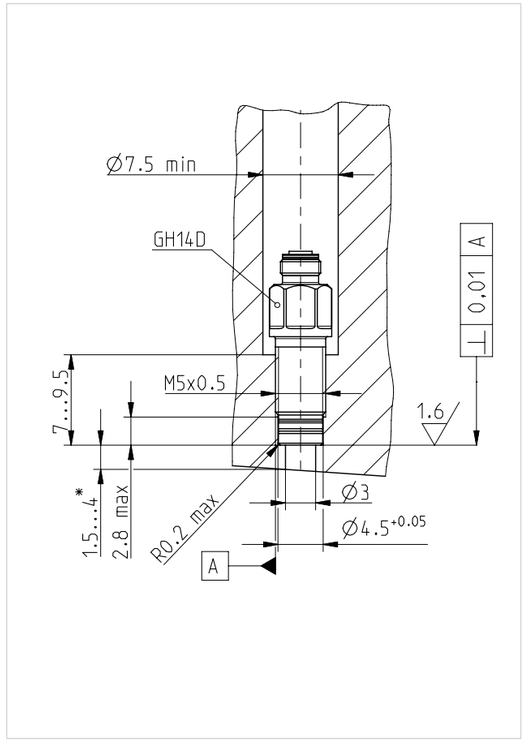
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			19 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	160 kHz	
Acceleration sensitivity		≤	0.0005 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7.5 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	1%	20… 400°C
		≤ ±	0.25%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.5 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.3 bar	
	Δp_{mi}	≤ ±	1.5%	
	Δp_{max}	≤ ±	1%	
Thread diameter			M5x0.5	front sealed
Cable connection			M4x0.35	negative
Weight			2.2 grams	without cable
Mounting torque			1.5 Nm	

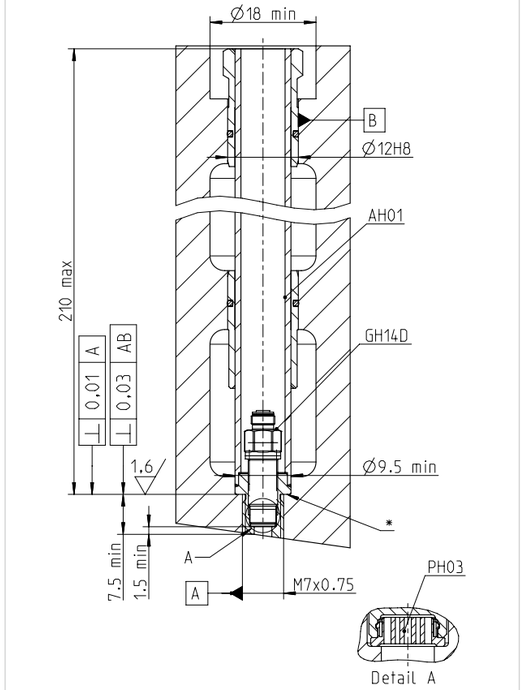
[1]) at 7 bar IMEP and 1300 rpm, diesel
[2]) at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

- Sensor GH14D
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41
- Calibration sheet and documentation



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



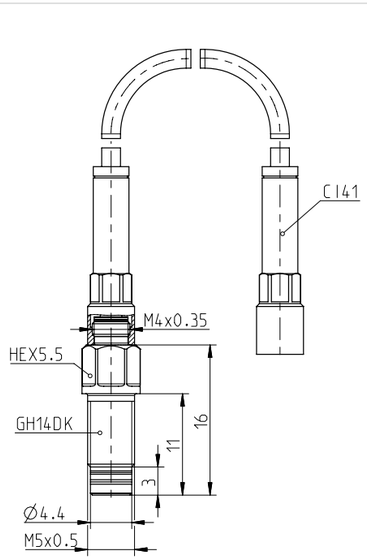
Installation with an AH01 adaptor and the PH03.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Dummy	DG01	Art.No. TIWG0113A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Adaptor sleeves	AH01, AH01A		see page 86
Mounting tool set	TS01 (TT01, TT02)		see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Machining tool set	MS11 (MD11, MT11)		see page 92
Thermo protection	PH01, PH03		see page 100

GH14DK

TIGG1322A.01



The GH14DK is an accurate and robust M5 sensor especially suited for supercharged engines with very high specific output. It has thermally optimized piezoelectric elements and the special Double Shell™ design. In addition to this, it has an improved membrane material and geometry. This makes the sensor even more durable and the first choice for e.g. knock analysis. The sensor is equipped with built in SID for SDM.
A thermo protection can improve the accuracy even further, see also page 100.

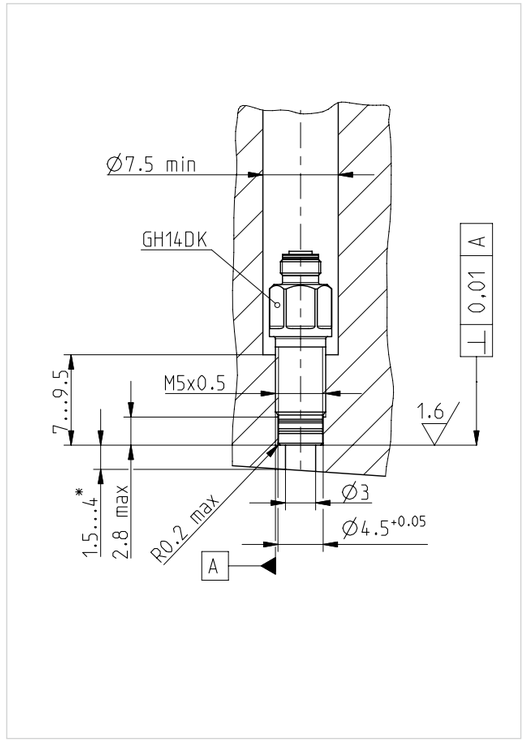
Specifications

Measuring range			0…300 bar	
Overload			350 bar	
Lifetime [1]		≥	10^8	load cycles
Sensitivity			19 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	170 kHz	
Acceleration sensitivity		≤	0.0005 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7.5 pF	
Operating temperature range			-40°C … 400°C	
Thermal sensitivity change		≤	2%	20… 400°C
		≤ ±	0.5%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [2]		≤ ±	0.7 bar	
Thermo shock error [3]				
	Δp	≤ ±	0.4 bar	
	Δp_{mi}	≤ ±	2%	
	Δp_{max}	≤ ±	1.5%	
Thread diameter			M5x0.5	front sealed
Cable connection			M4x0.35	negative
Weight			2.2 grams	without cable
Mounting torque			1.5 Nm	

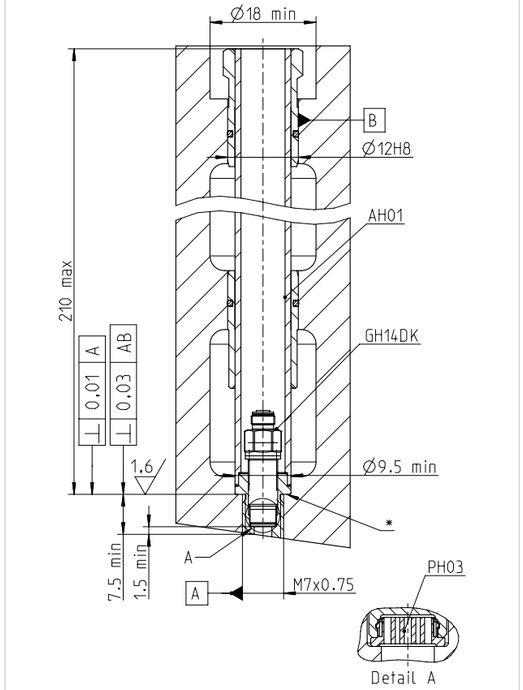
[1] pre-ignition and knocking reduces the lifetime significantly
[2] at 7 bar IMEP and 1300 rpm, diesel
[3] at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

- Sensor GH14DK
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41
- Calibration sheet and documentation



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



Installation with an AH01 adaptor and the PH03.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

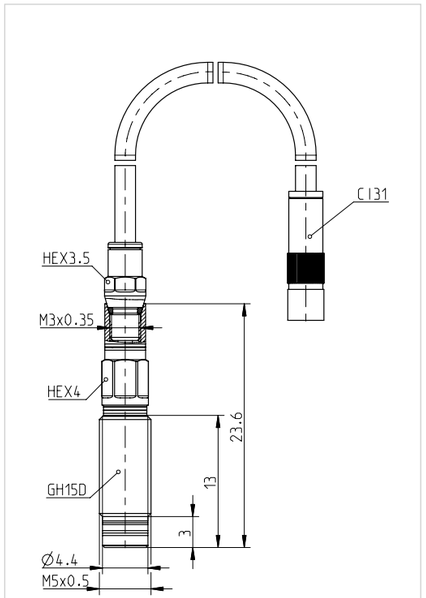
Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Dummy	DG01	Art.No. TIWG0113A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Adaptor sleeves	AH01, AH01A		see page 86
Mounting tool set	TS01 (TT01, TT02)		see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Machining tool set	MS11 (MD11, MT11)		see page 92
Thermo protection	PH01, PH03		see page 100

GH15D

TIGG1349A.01

★ ★★★ ★★ GaPO4 SDM double shell



The GH15D has the slimmest contour due to a M3 cable connector and allows very precise thermodynamic measurements with a sensor of size M5. The good performance is realized by thermally optimized piezoelectric crystal elements and the special Double Shell™ design. It decouples the piezoelectric elements from negative influences of thermal expansion, and other 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.
A thermo protection can improve the accuracy even further, see also page 100.

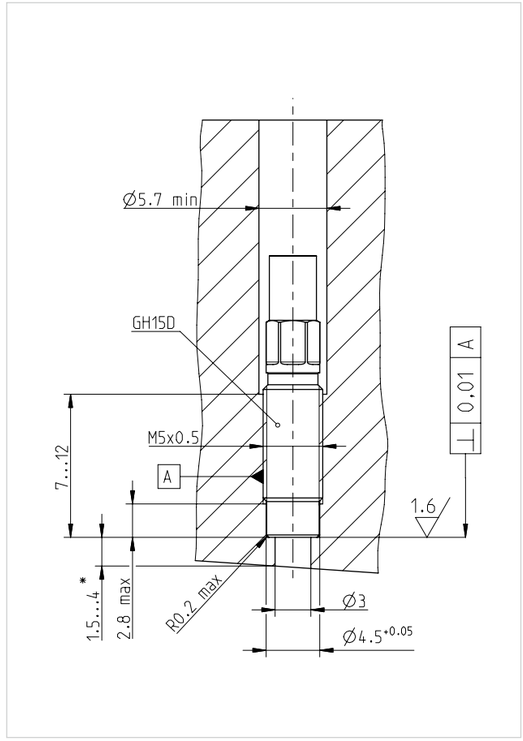
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			19 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	160 kHz	
Acceleration sensitivity		≤	0.0005 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7.5 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	1%	20… 400°C
		≤ ±	0.25%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.5 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.3 bar	
	Δp_{mi}	≤ ±	1.5%	
	Δp_{max}	≤ ±	1%	
Thread diameter			M5x0.5	front sealed
Cable connection			M3x0.35	negative
Weight			2.2 grams	without cable
Mounting torque			1.5 Nm	

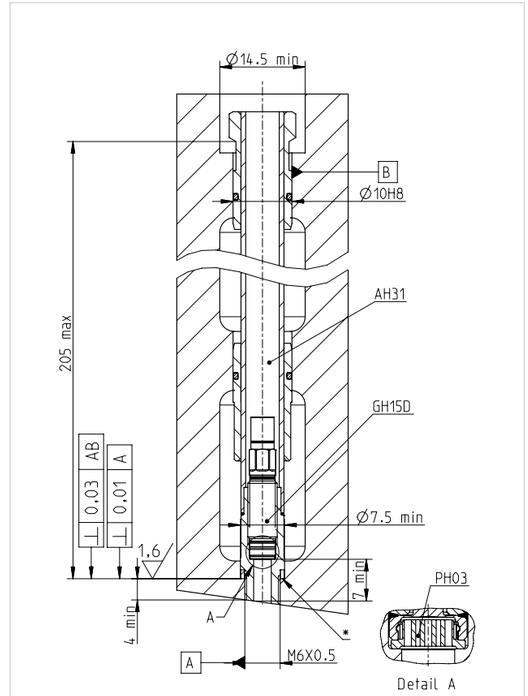
[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

- Sensor GH15D
- Protection cap
- Piezo-input cable CI31-1 and 2 spare O-rings
- Fitted coupling CC31
- Calibration sheet and documentation



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



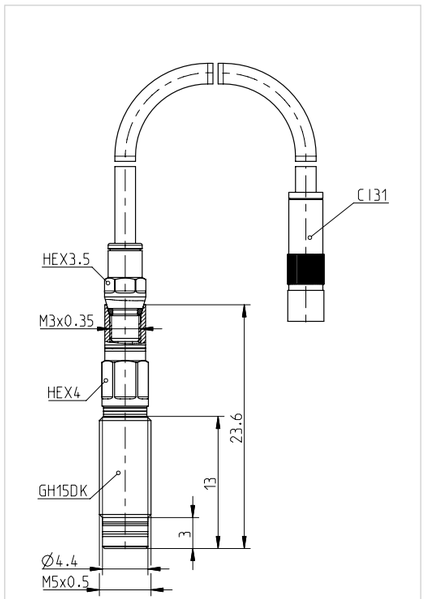
Installation with an AH31 adaptor and the PH03.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

Accessories

Cables & couplings	CI31, CI3V, CC31, E124		see page 101
Cable-mounting tool	TC31, TT25		see page 95
Dummy	DG24	Art.No. TIWG0334A.01	see page 99
Dummy removal tool	TD13	Art.No. TIWG0224A.01	see page 96
Adaptor sleeves	AH01, AH01A, AH31		see page 86
Mounting tool set	TS21 (TT21, TT02)		see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Machining tool set	MS15 (MD12, MT12)		see page 92
Thermo protection	PH01, PH03		see page 100

GH15DK

TIGG1383A.01



The GH15DK has the slimmest outer dimensions due to a M3 cable connector and allows for thermodynamic measurements in compact supercharged engines with demanding mounting environments. The strong thermodynamic performance is realized by thermally optimized GaPO4 elements and the special Double Shell™ design. The GH15DK is equipped with SID Sensor Identification to support SDM Sensor Data Management.

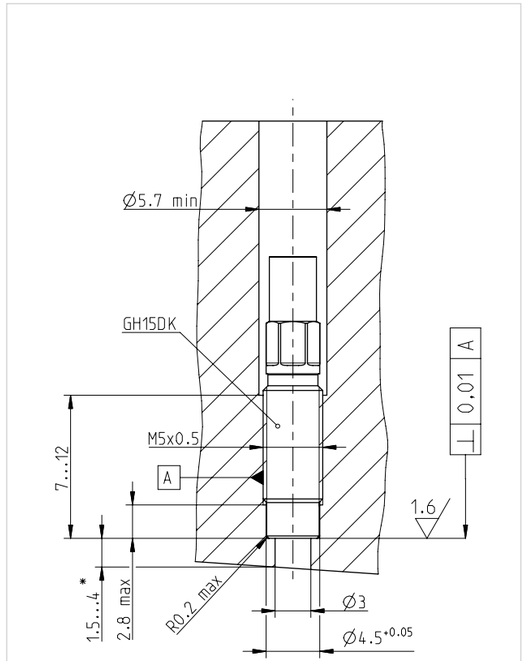
Scope of supply

- Sensor GH15DK
- Protection cap
- Piezo-input cable CI31-1 and 2 spare O-rings
- Fitted coupling CC31
- Calibration sheet and documentation

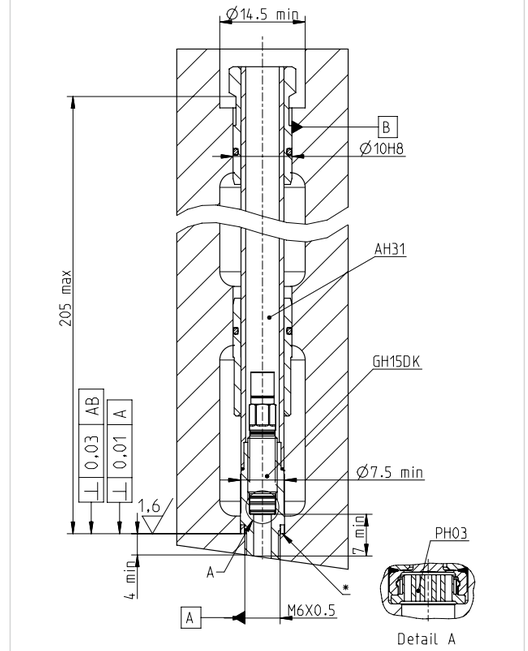
Specifications

Measuring range			0…300 bar	
Overload			350 bar	
Lifetime [1]		≥	10^8	load cycles
Sensitivity			19 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	170 kHz	
Acceleration sensitivity		≤	0.0005 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20 °C
Capacitance			7.5 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	2%	20… 400 °C
		≤ ±	0.5%	250 ±100 °C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [2]		≤ ±	0.7 bar	
Thermo shock error [3]				
	Δp	≤ ±	0.4 bar	
	Δp_{mi}	≤ ±	2%	
	Δp_{max}	≤ ±	1.5%	
Thread diameter			M5x0.5	front sealed
Cable connection			M3x0.35	negative
Weight			2.2 grams	without cable
Mounting torque			1.5 Nm	

[1]) pre-ignition and knocking reduces the lifetime significantly
[2]) at 7 bar IMEP and 1300 rpm, diesel
[3]) at 9 bar IMEP and 1500 rpm, gasoline



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



Installation with an AH31 adaptor and the PH03.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

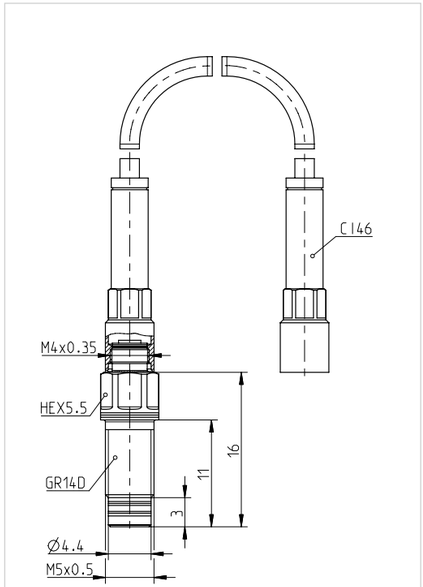
Accessories

Cables & couplings	CI31, CI3V, CC31, E124		see page 101
Cable-mounting tool	TC31, TT25		see page 95
Dummy	DG24	Art.No. TIWG0334A.01	see page 99
Dummy removal tool	TD13	Art.No. TIWG0224A.01	see page 96
Adaptor sleeves	AH01, AH01A, AH31		see page 86
Mounting tool set	TS21 (TT21, TT02)		see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Machining tool set	MS15 (MD12, MT12)		see page 92
Thermo protection	PH01, PH03		see page 100

GR14D

TIGG1072A.01

★ ★★ ★★ GaPO4 double shell



The GR14D fulfills the highest requirements for racing applications. This M5 sensor comes with Double Shell™ and has built-in axial acceleration compensation that reduces the influence of mechanical noise as it can appear in combustion engines during e.g. valve closing. In order to reduce mechanically induced electrical noise the GR14D is shipped with a durable super low-noise piezo-input cable. The SDM Sensor Data Management is realized by a SIC Sensor Identification Cable.
A thermo protection can improve the accuracy even further, see also page 100.

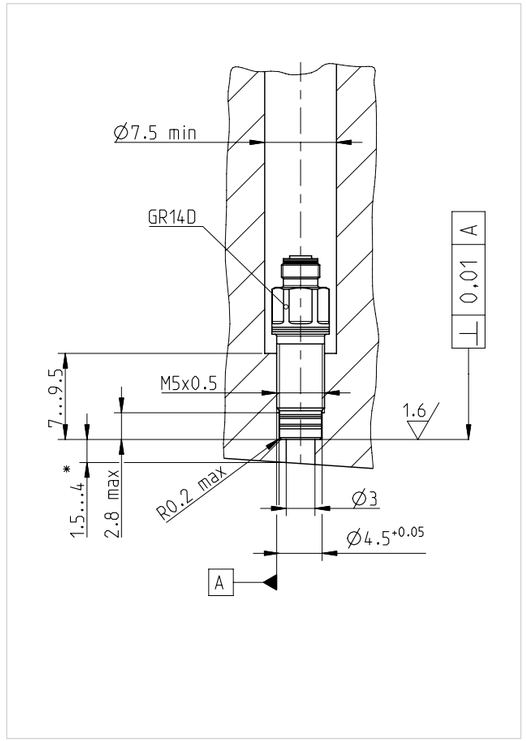
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			16 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	165 kHz	
Acceleration sensitivity		≤	0.00005 bar/g	axial
		≤	0.00015 bar/g	radial
Shock resistance		≥	7000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			8.5 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	2%	20… 400°C
		≤ ±	0.5%	250 ±100°C
Load change drift			1 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.5 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.3 bar	
	Δp_{mi}	≤ ±	1.5%	
	Δp_{max}	≤ ±	1%	
Thread diameter			M5x0.5	front sealed
Cable connection			M4x0.35	negative
Weight			2.5 grams	without cable
Mounting torque			1.5 Nm	

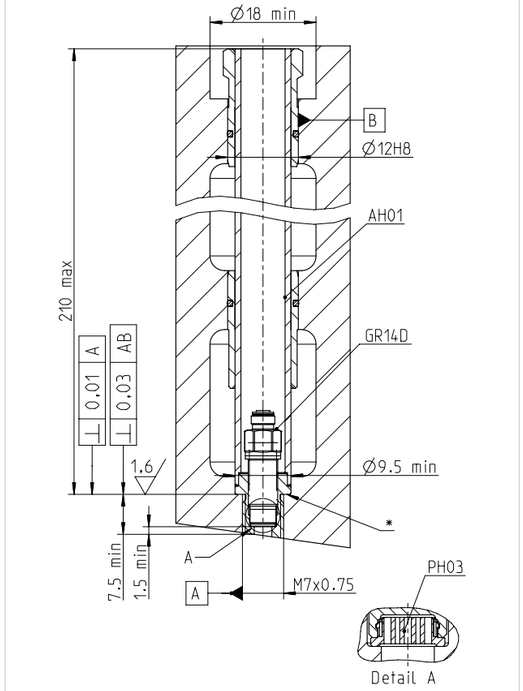
[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

- Sensor GR14D
- Protection cap
- Cable CI46-1 with SIC and 2 spare O-rings
- Fitted coupling CC41
- Calibration sheet and documentation



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



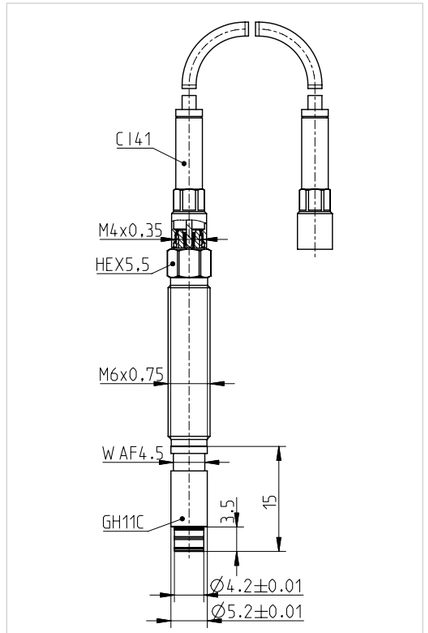
Installation with an AH01 adaptor and the PH03.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

Accessories

Cables & couplings	CI41, CI42, CI43, CI4V, CI46, CC41, E124		see page 102
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Dummy	DG01	Art.No. TIWG0113A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Adaptor sleeves	AH01, AH01A		see page 86
Mounting tool set	TS01 (TT01, TT02)		see page 95
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Machining tool set	MS11 (MD11, MT11)		see page 92
Thermo protection	PH01, PH03		see page 100

GH11C

TIGGGH11CA.01



The GH11C is in combination with a custom tailored extension rod a very slim and versatile solution for gasoline engines. The design allows to place the sensor membrane very close to the combustion chamber and to suppress any pipe oscillations. The mounting bore close to the membrane is just 5.5 mm in diameter. The sensor has an integrated flame arrestor which allows very precise thermodynamic measurements. The sensor is equipped with built in Sensor Identification SID for SDM.

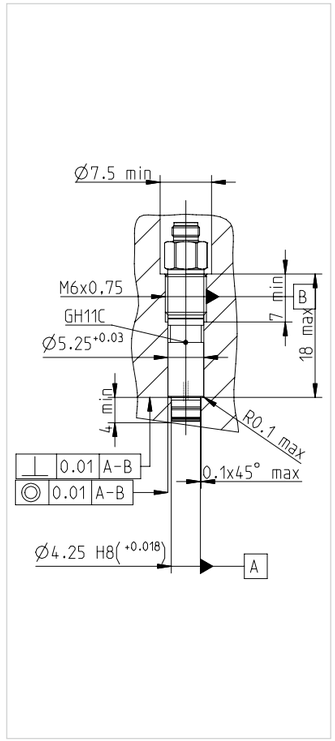
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			20 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	160 kHz	
Acceleration sensitivity		≤	0.0005 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20 °C
Capacitance			8.3 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	1%	20… 400 °C
		≤ ±	0.5%	250 ±100 °C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.4 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.3 bar	
	Δp_{mi}	≤ ±	1.5%	
	Δp_{max}	≤ ±	1%	
Thread diameter			M6x0.75	without O-ring
Cable connection			M4x0.35	negative
Weight			2.2 grams	without extension
Mounting torque			1.5 Nm	at 25°C
			1.2 Nm	at 90°C

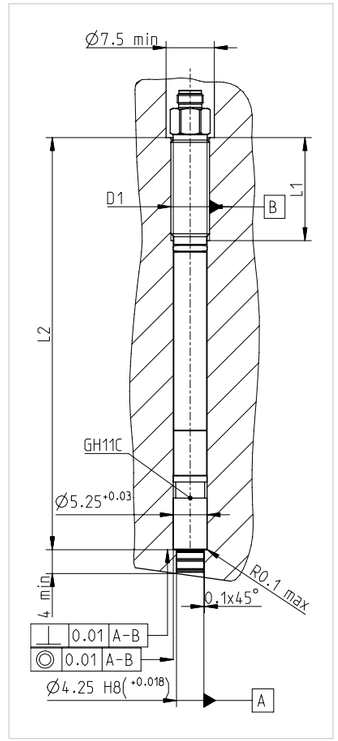
[1] at 7 bar IMEP and 1300 rpm, diesel; this sensor has a build in flame arrestor and is not recommended for the use in diesel engines.
[2] at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

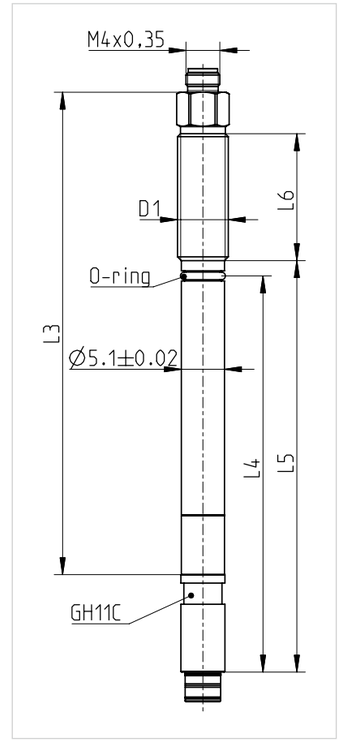
- Sensor GH11C
- Customer-specific extension rod
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41
- Calibration sheet and documentation



Example of direct installation with shortest possible extension rod.



Dimensions of the mounting bore. To allow a custom specific design please specify the variable parameters. Note: The version with O-ring has a D_1 = M7 x 0.75.



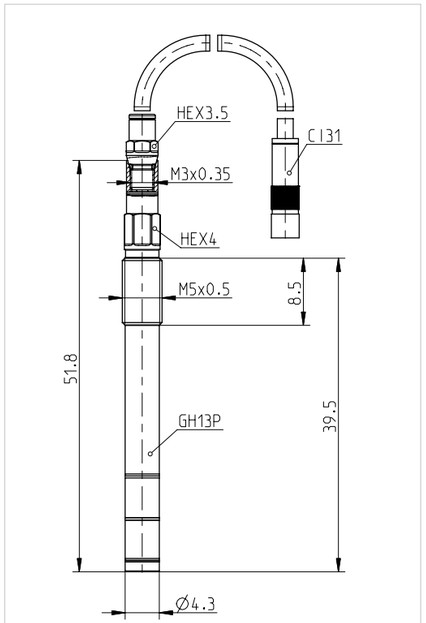
Dimensions of the extension rod. To allow a custom specific design please specify the variable parameters.

Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01, TT25		see page 95
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96

GH13P

TIGG0931A.01



The GH13P is in combination with the M8 glow-plug adaptor AG04 a nearly flush mounted solution for diesel engines. It allows measurements without pipe oscillations and pressures of up to 250 bar. The GH13P comes with an M3 connector which allows the smallest installation tool clearance diameters. The adaptor dimensions are custom tailored to the requirements of the customer. The sensor is equipped with SID Sensor Identification for the use of SDM Sensor Data Management.

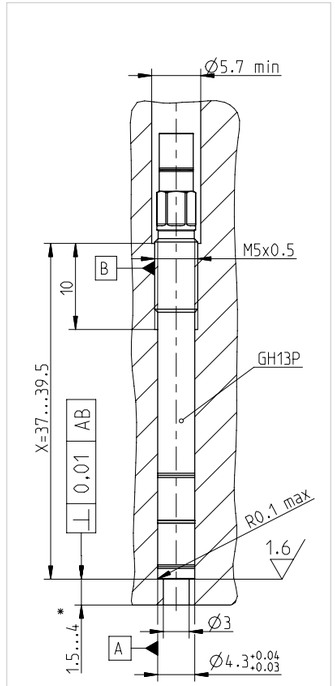
Scope of supply

- Sensor GH13P
- Protection cap
- Piezo-input cable CI31-1 and 2 spare O-rings
- Fitted coupling CC31
- Calibration sheet and documentation

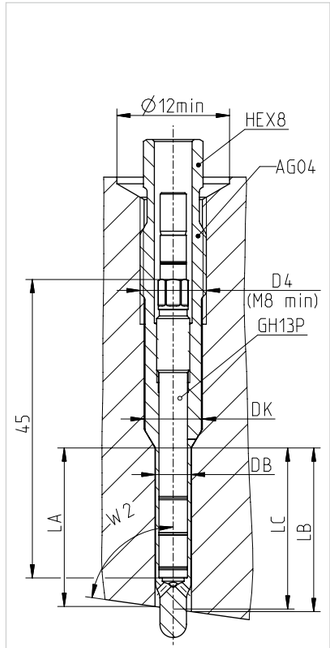
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			16 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	130 kHz	
Acceleration sensitivity		≤	0.001 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	2%	20… 400°C
		≤ ±	0.5%	250 ±100°C
Load change drift			1 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.5 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.3 bar	
	Δp_{mi}	≤ ±	1.5%	
	Δp_{max}	≤ ±	1%	
Mounting bore			Ø 4.3 mm	front sealed
Cable connection			M3x0.35	negative
Weight			4.7 grams	without cable
Mounting torque			1.5 Nm	

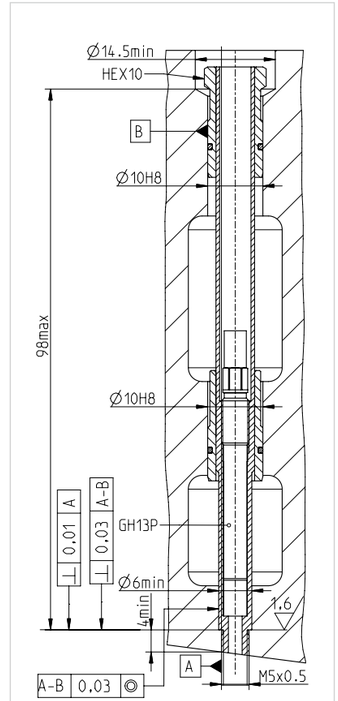
[1]) at 7 bar IMEP and 1300 rpm, diesel
[2]) at 9 bar IMEP and 1500 rpm, gasoline



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



Installation with glow-plug adaptor AG04.



Installation with adaptor AH13.

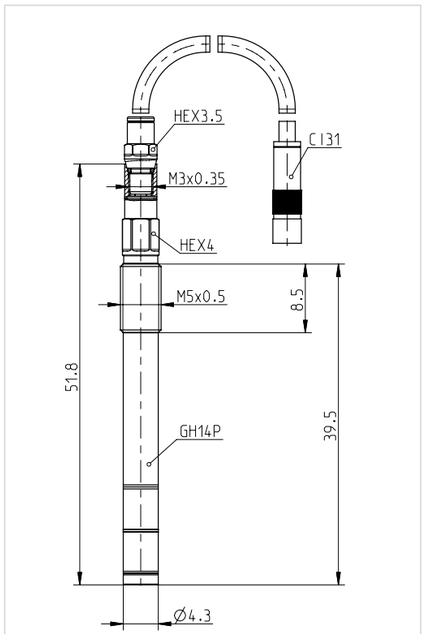
Accessories

Cables & couplings	CI31, CI3V, CC31, E124		see page 101
Cable-mounting tool	TC31, TT25		see page 95
Dummy	DG13	Art.No. TIWG0219A.01	see page 99
Dummy removal tool	TD13	Art.No. TIWG0224A.01	see page 96
Adaptors	AG03, AG04, AH13, AH45		see page 89
Mounting tool set	TS21 (TT21, TT02)	Art.No. TIWG0213A.01	see page 95
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Thermo protection [3]	PH01, PH03		see page 100

[3]) The thermo protection is not recommended for engines with diesel combustion.

GH14P

TIGG1323A.01



The GH14P is in combination with the M8 glow-plug adaptor AG04 a nearly flush mounted solution for diesel engines. It allows measurements without pipe oscillations and pressures of up to 250 bar. The sensor has the special Double Shell™ design which isolates the piezo elements from thermal expansion and other mechanical stresses caused by mounting the sensor into the cylinder. The GH14P comes with an M3 connector which allows the smallest installation tool clearance diameters. The adaptor dimensions are custom tailored to the requirements of the customer. The sensor is equipped with SID Sensor Identification for the use of SDM.

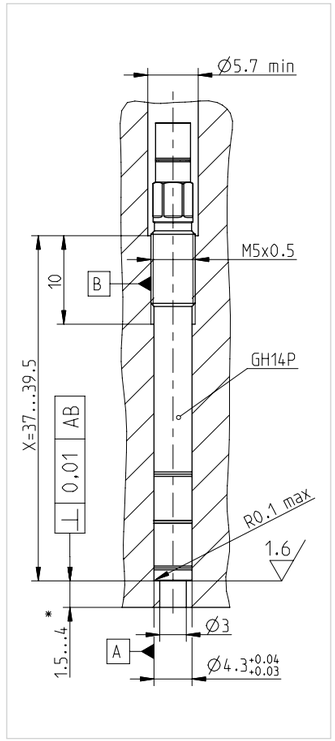
Scope of supply

- Sensor GH14P
- Protection cap
- Piezo-input cable CI31-1 and 2 spare O-rings
- Fitted coupling CC31
- Calibration sheet and documentation

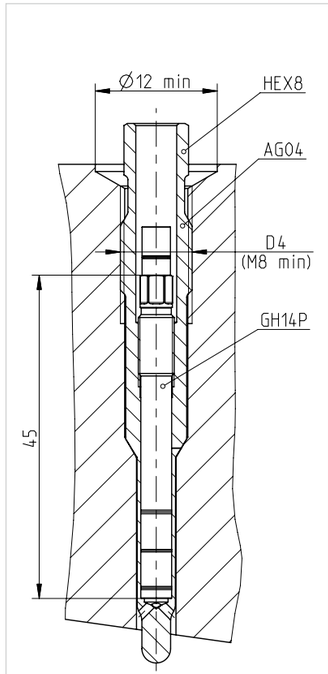
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			16 pC/bar	nominal
Linearity		≤	± 0.3%	FSO
Natural frequency		~	130 kHz	
Acceleration sensitivity		≤	0.001 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	2%	20… 400°C
		≤	± 0.5%	250 ±100°C
Load change drift			1 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤	± 0.5 bar	
Thermo shock error [2]				
	Δp	≤	± 0.3 bar	
	Δp_{mi}	≤	± 1.5%	
	Δp_{max}	≤	± 1%	
Mounting bore			Ø 4.3 mm	front sealed
Cable connection			M3x0.35	negative
Weight			4.7 grams	without cable
Mounting torque			1.5 Nm	

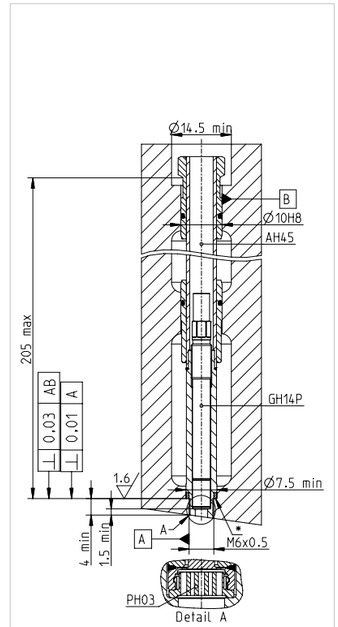
[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline



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



Installation with glow-plug adaptor AG04.



Installation with adaptor AH45.

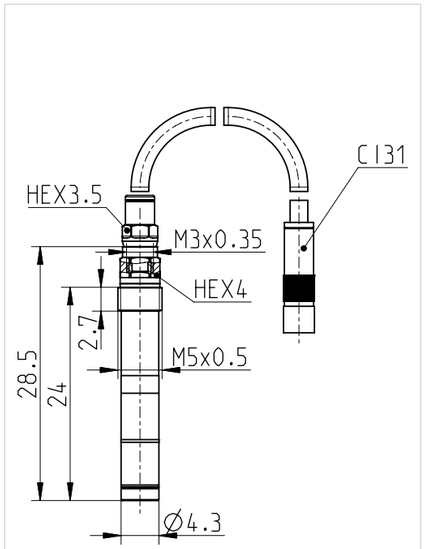
Accessories

Cables & couplings	CI31, CI3V, CC31, E124		see page 101
Cable-mounting tool	TC31, TT25		see page 95
Dummy	DG13	Art.No. TIWG0219A.01	see page 99
Dummy removal tool	TD13	Art.No. TIWG0224A.01	see page 96
Adaptors	AG03, AG04, AH13, AH45		see page 89
Mounting tool set	TS21 (TT21, TT02)	Art.No. TIWG0213A.01	see page 95
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Thermo protection [3]	PH01, PH03		see page 100

[3] The thermo protection is not recommended for engines with diesel combustion.

GH13Z-24

TIGG0929A.01



The GH13Z-24 is a M5 sensor dedicated for use in combination with the short version of the ZF43 spark-plug adaptor. The design is based on the construction techniques of M5 sensors and shows similar outstanding measurement performance. The sensor is equipped with SID (Sensor Identification) to allow the use of SDM Sensor Data Management.
Please refer to page 90 for the specifications of the ZF43 spark-plug adaptor.

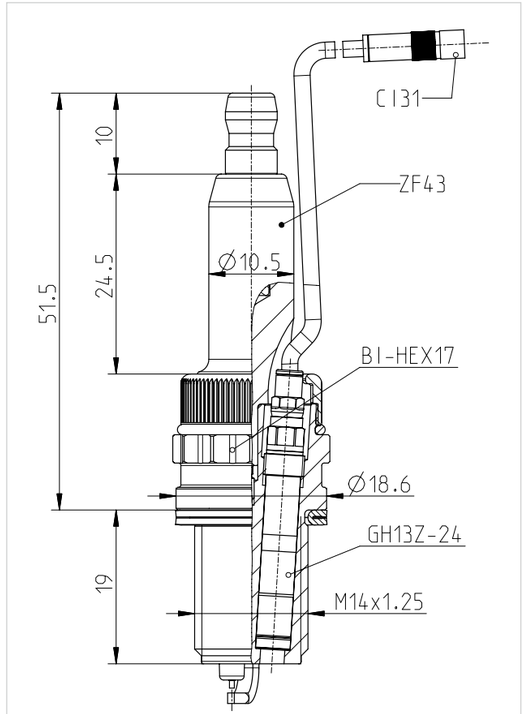
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			16 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	115 kHz	
Acceleration sensitivity		≤	0.001 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	2%	20… 400°C
		≤ ±	0.5%	250 ±100°C
Load change drift			1 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.5 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.3 bar	
	Δp_{mi}	≤ ±	1.5%	
	Δp_{max}	≤ ±	1%	
Mounting bore			Ø 4.3 mm	front sealed
Cable connection			M3x0.35	negative
Weight			2.5 grams	without cable
Mounting torque			1.5 Nm	

[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

- Sensor GH13Z-24
- Protection cap
- Piezo-input cable CI31-1 and 2 spare O-rings
- Fitted coupling CC31
- Calibration sheet and documentation



Installation with a ZF43 spark-plug adaptor flat seat, thread length 19 mm.
See also page 90.

Accessories

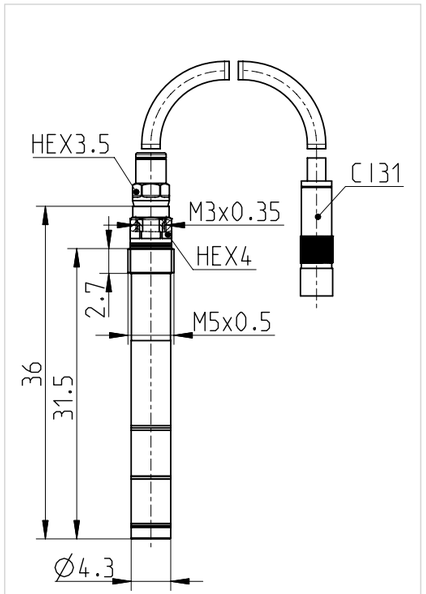
Cables & couplings	CI31, CI3V, CC31, E124		see page 101
Cable-mounting tool	TC31, TT25		see page 95
Spark-plug adaptor	ZF43		see page 90
Mounting tool set	TS21 (TT21, TT02)	Art.No. TIWG0213A.01	see page 95
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Thermo protection	PH01, PH03		see page 100

GH13Z-31

TIGG0930A.01

★ ★★ ★★

The GH13Z-31 is a M5 sensor dedicated for use in combination with the long version of the ZF43 spark-plug adaptor. The design is based on the construction techniques of M5 sensors and shows similar outstanding measurement performance. The sensor is equipped with SID (Sensor Identification) to allow the use of SDM Sensor Data Management.
Please refer to page 90 for the specifications of the ZF43 spark-plug adaptor.



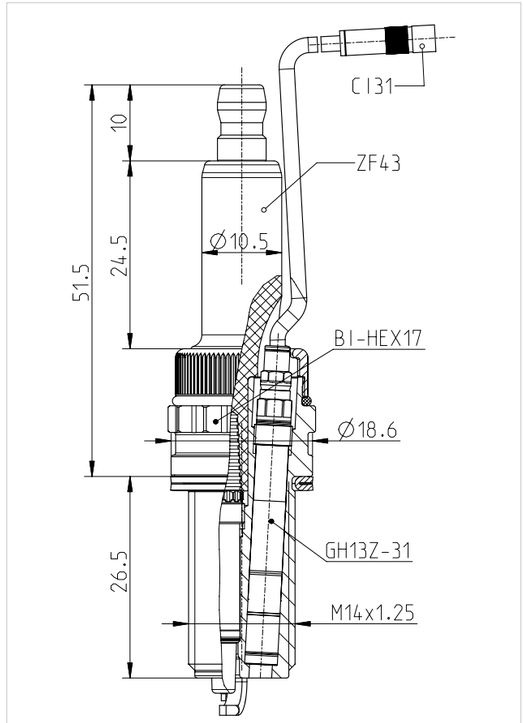
Scope of supply

- Sensor GH13Z-31
- Protection cap
- Piezo-input cable CI31-1 and 2 spare O-rings
- Fitted coupling CC31
- Calibration sheet and documentation

Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			16 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	115 kHz	
Acceleration sensitivity		≤	0.001 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	2%	20… 400°C
		≤ ±	0.5%	250 ±100°C
Load change drift			1 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.5 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.3 bar	
	Δp_{mi}	≤ ±	1.5%	
	Δp_{max}	≤ ±	1%	
Mounting bore			Ø 4.3 mm	front sealed
Cable connection			M3x0.35	negative
Weight			2.5 grams	without cable
Mounting torque			1.5 Nm	

[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline



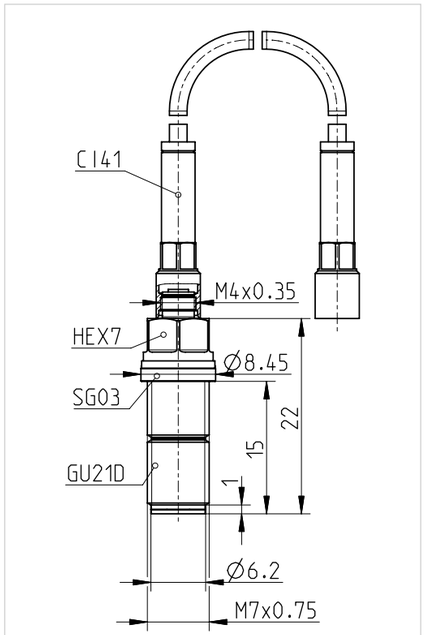
Installation with a ZF43 spark-plug adaptor flat seat, thread length 26.5mm.
See also page 90.

Accessories

Cables & couplings	CI31, CI3V, CC31, E124		see page 101
Cable-mounting tool	TC31, TT25		see page 95
Spark-plug adaptor	ZF43		see page 90
Mounting tool set	TS21 (TT21, TT02)	Art.No. TIWG0213A.01	see page 95
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Thermo protection	PH01, PH03		see page 100

GU21D

TIGG0558A.01



The GU21D is a M7 solution for precise thermodynamic analysis especially where 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 comes with integrated SID Sensor Identification electronics for the use of SDM.

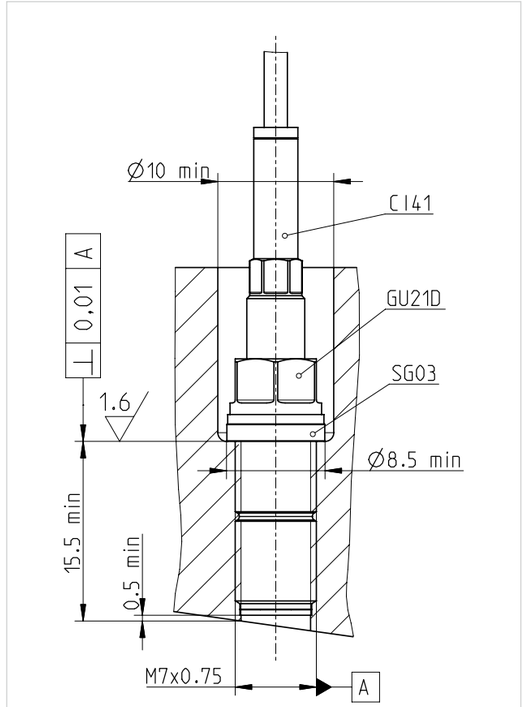
Scope of supply

- Sensor GU21D
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41 and gasket SG03
- 1 Spare gasket SG03
- Calibration sheet and documentation

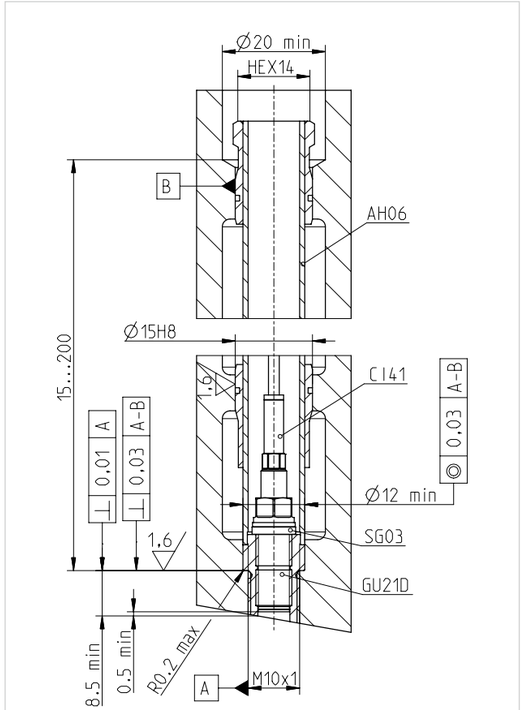
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			35 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	85 kHz	
Acceleration sensitivity		≤	0.002 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			8 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	2%	20… 400°C
		≤ ±	0.5%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.4 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.2 bar	
	Δp_{mi}	≤ ±	1%	
	Δp_{max}	≤ ±	1%	
Thread diameter			M7x0.75	shoulder sealed
Cable connection			M4x0.35	negative
Weight			6 grams	without cable
Mounting torque			3 Nm	

[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline



Direct installation.



Installation with adaptor sleeve AH06.

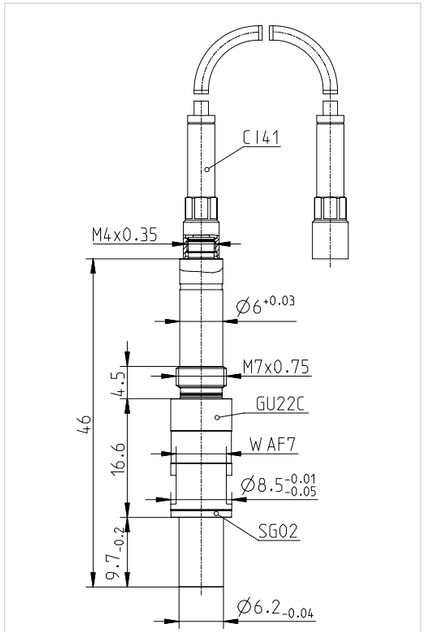
Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG03	Art.No. TIBQ0228A.01	see page 98
Gasket dismounting tool	TT17	Art.No. TIWG0185A.01	see page 98
Dummy	DG04	Art.No. TIWG0170A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Adaptor	AH06	Art.No. TIWG0175A.01	see page 86
Mounting tool set	TS03 (TT11, TT02)	Art.No. TIWG0181A.01	see page 95
Machining tool set	MS22 (MD22, MT21)		see page 92
Machining tool set for AH06	MS24 (MD24, MT31)	Art.No. TIWG0167A.01	see page 92
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96

GU22C

TIGG1073A.01

★ ★★★ ★★ 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. There is no influence of the mounting bore on the pressure signal due to minimized mechanical contact between the mounting bore and the sensor housing. The GU22C is equipped with built in SID for SDM. A thermo protection can improve the accuracy even further, see also page 100.

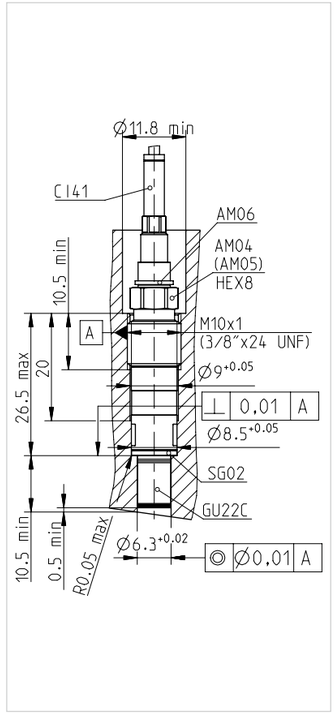
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			34 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	100 kHz	
Acceleration sensitivity		≤	0.001 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			8 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	1%	20… 400°C
		≤ ±	0.25%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.4 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.2 bar	
	Δp_{mi}	≤ ±	1%	
	Δp_{max}	≤ ±	1%	
Mounting bore			Ø 6.3 mm +0.02	shoulder sealed
Cable connection			M4x0.35	negative
Weight			12.5 grams	without cable
Mounting torque			10 Nm	

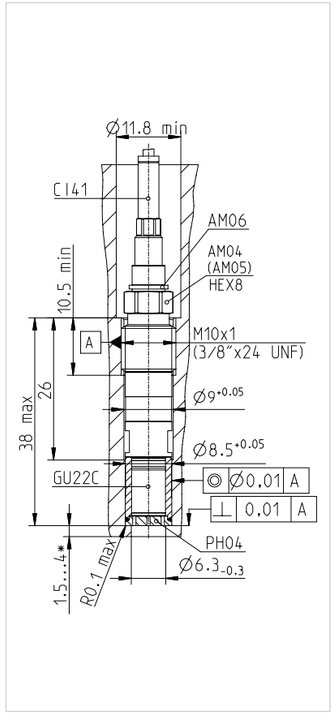
[1]) at 7 bar IMEP and 1300 rpm, diesel
[2]) at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

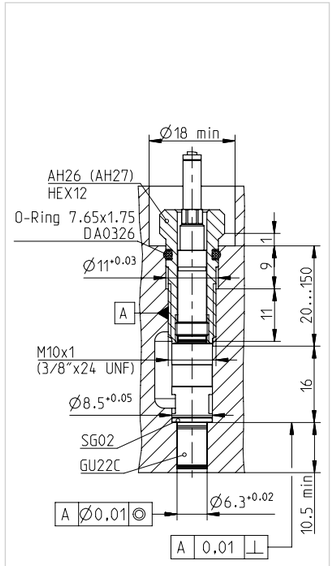
- Sensor GU22C
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41
- Gasket SG02
- Calibration sheet and documentation



Direct installation with the mounting nipple AM04 (AM05).



Direct installation with AM04 (AM05) and PH04.
*) 4 mm for cast iron, aluminium alloys



Direct installation with the mounting sleeve AH26 (AH27).

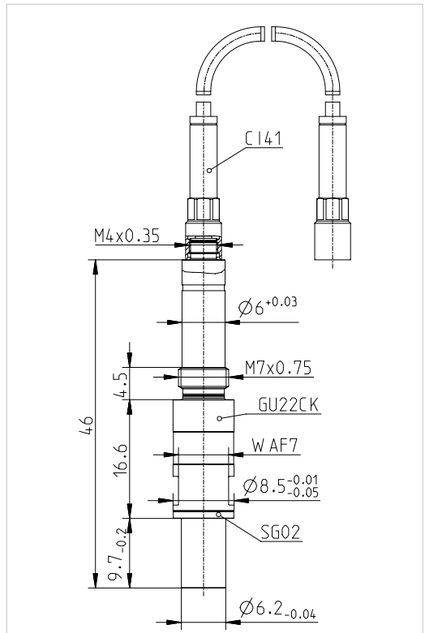
Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG02	Art.No. TIBQ0227A.01	see page 98
Mounting nipples	AM04, AM05		see page 87
Safety ring for mounting nipple	AM06	Art.No. TIWG0417A.01	see page 87
Dummy (M10x1), Dummy (3/8"x24 UNF)	DG10, DG14		see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Machining tool (step drill)	MD10, MD16		see page 93
Tap drill (M10x1), Tap drill (3/8"x24 UNF)	MT31, MT13		see page 93
Mounting tools	TS02 (TT09, TT18), TA13		see page 94
Mounting sleeves	AH26 [3], AH27 [3], AH28 [4]		see page 86
Thermo protection	PH04	Art.No. TIYF0760A.01	see page 100

[3]) Specify sleeve length (28 mm to 160 mm) and refer to page 86 for additional information.
[4]) See also page 55 for the specification of the installation with AH28.

GU22CK

TIGG1355A.01



The GU22CK is a 6.2 mm plug-type sensor for precise thermodynamic analysis with a very durable membrane. This makes the sensor applicable for measurements of knocking combustions. The sensor is based on a well established design concept that allows high accuracy. There is no influence of the mounting bore on the pressure signal due to minimized mechanical contact between the mounting bore and the sensor housing. The GU22CK is equipped with SID Sensor Identification to support SDM Sensor Data Management.

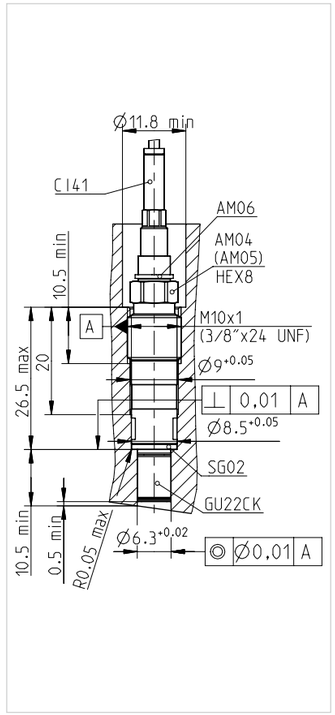
Scope of supply

- Sensor GU22CK
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41
- Gasket SG02
- Calibration sheet and documentation

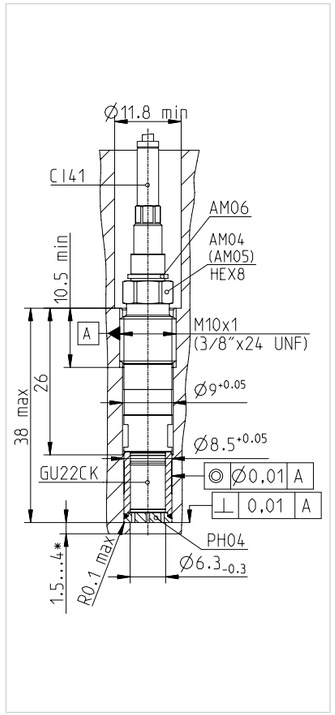
Specifications

Measuring range			0…350 bar	
Overload			400 bar	
Lifetime [1]		≥	10^8	load cycles
Sensitivity			34 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	96 kHz	
Acceleration sensitivity		≤	0.001 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			8 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	1%	20… 400 °C
		≤ ±	0.25%	250 ±100 °C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [2]		≤ ±	0.6 bar	
Thermo shock error [3]				
	Δp	≤ ±	0.3 bar	
	Δp_{mi}	≤ ±	2%	
	Δp_{max}	≤ ±	2%	
Mounting bore			Ø 6.3 mm +0.02	shoulder sealed
Cable connection			M4x0.35	negative
Weight			12.5 grams	without cable
Mounting torque			10 Nm	

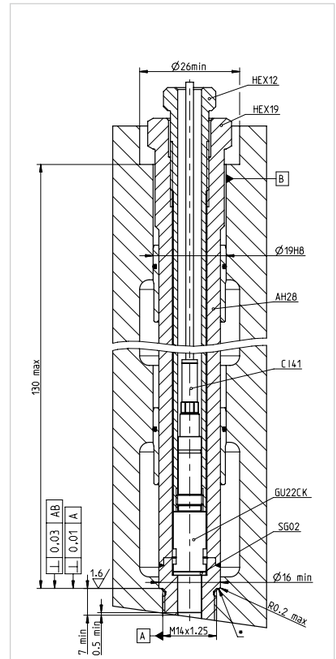
[1] pre-ignition and knocking reduces the lifetime significantly
[2] at 7 bar IMEP and 1300 rpm, diesel
[3] at 9 bar IMEP and 1500 rpm, gasoline



Direct installation with the mounting nipple AM04 (AM05).



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



Installation with the adaptor sleeve AH28.

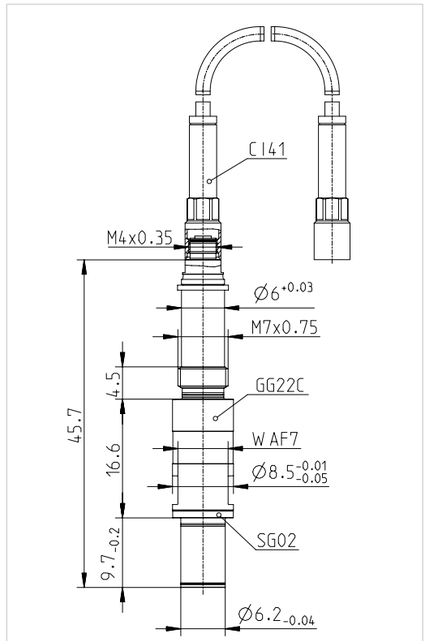
Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG02	Art.No. TIBQ0227A.01	see page 98
Mounting nipples	AM04, AM05		see page 87
Safety ring for mounting nipple	AM06	Art.No. TIWG0417A.01	see page 87
Dummy (M10x1), Dummy (3/8"x24 UNF)	DG10, DG14		see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Machining tool (step drill)	MD10, MD16		see page 93
Tap drill (M10x1), Tap drill (3/8"x24 UNF)	MT31, MT13		see page 93
Mounting tool	TS02 (TT09, TT18), TA13		see page 94
Mounting sleeves	AH26 [4], AH27 [4], AH28		see page 86
Thermo protection	PH04	Art.No. TIYF0760A.01	see page 100

[4] Specify sleeve length (28 mm to 160 mm) and refer to page 86 for additional information. See also page 53 for the specification of the installation with AH26 or AH27.

GG22C

TIGG1074A.01



Scope of supply

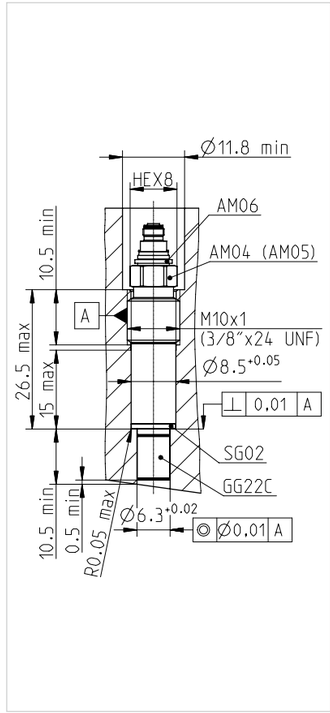
- Sensor GG22C
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41
- Gasket SG02
- Calibration sheet and documentation

The GG22C is an electrically ground isolated 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. There is no influence of the mounting bore on the pressure signal due to minimized mechanical contact between the mounting bore and the sensor housing. The GG22C is equipped with built in SID for SDM.
A thermo protection can improve the accuracy even further, see also page 100.

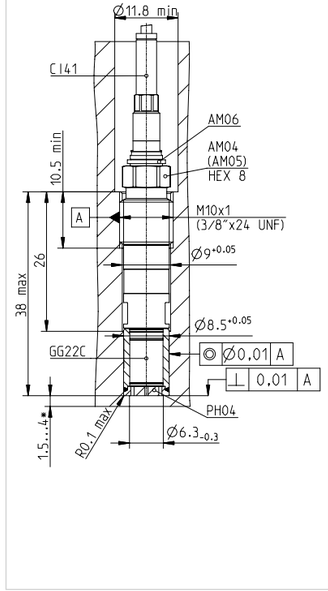
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			34 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	100 kHz	
Acceleration sensitivity		≤	0.001 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			8 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	1%	20… 400°C
		≤ ±	0.25%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.4 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.2 bar	
	Δp_{mi}	≤ ±	1%	
	Δp_{max}	≤ ±	1%	
Mounting bore			Ø 6.3 mm +0.02	shoulder sealed
Cable connection			M4x0.35	negative
Weight			12.5 grams	without cable
Mounting torque			10 Nm	

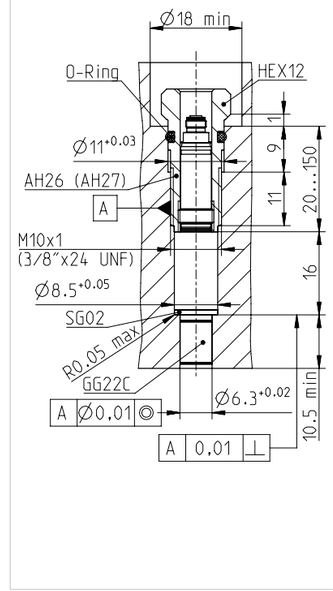
[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline



Direct installation with the mounting nipple AM04 (AM05).



Direct installation with AM04 (AM05) and PH04.
*) 4 mm for cast iron, aluminium alloys



Direct installation with the mounting sleeve AH26 (AH27).

Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG02	Art.No. TIBQ0227A.01	see page 98
Mounting nipples	AM04, AM05		see page 87
Safety ring for mounting nipple	AM06	Art.No. TIWG0417A.01	see page 87
Dummy (M10x1), Dummy (3/8"x24 UNF)	DG10, DG14		see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Machining tool (step drill)	MD10, MD16		see page 93
Tap drill (M10x1), Tap drill (3/8"x24 UNF)	MT31, MT13		see page 93
Mounting tool	TS02 (TT09, TT18), TA13		see page 94
Mounting sleeves	AH26 [3], AH27 [3], AH28 [4]		see page 86
Thermo protection	PH04	Art.No. TIYF0760A.01	see page 100

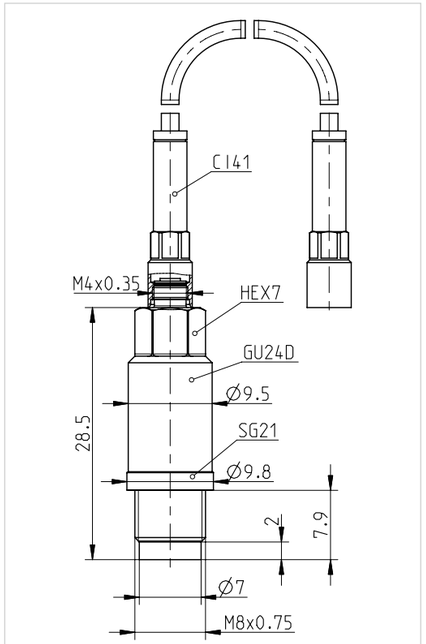
[3] Specify sleeve length (28 mm to 160 mm) and refer to page 86 for additional information.
[4] See also page 55 for the specification of the installation with AH28.

GU24D

TIGG1329A.01

★ ★★★ ★★

The GU24D 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 Double Shell™ design gives high mechanical isolation from the influences of the mounting bore. Specially trimmed piezo-elements are used to achieve excellent linearity of the output signal. The GU24D is equipped with SID Sensor Identification to support SDM Sensor Data Management.



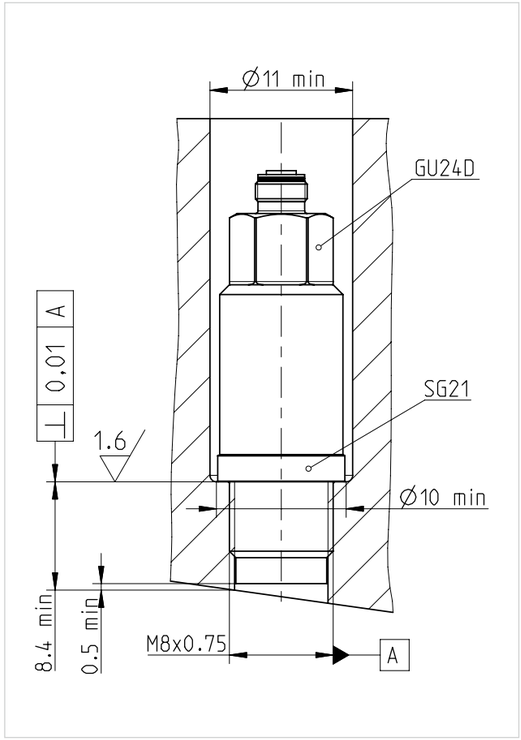
Scope of supply

- Sensor GU24D
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41 and gasket SG21
- 1 Spare gasket SG21
- Calibration sheet and documentation

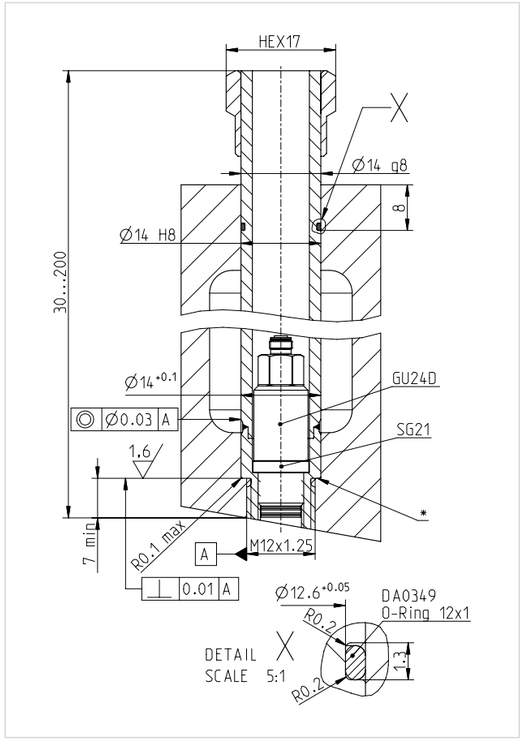
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			45 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	92 kHz	
Acceleration sensitivity		≤	0.002 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			8 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	1%	20… 400°C
		≤ ±	0.25%	250 ±100°C
Load change drift		<	4 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.3 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.2 bar	
	Δp_{mi}	≤ ±	1%	
	Δp_{max}	≤ ±	1%	
Thread diameter			M8x0.75	shoulder sealed
Cable connection			M4x0.35	negative
Weight			14 grams	without cable
Mounting torque			6 Nm	

[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline



Shoulder sealed direct installation into the cylinder head.



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

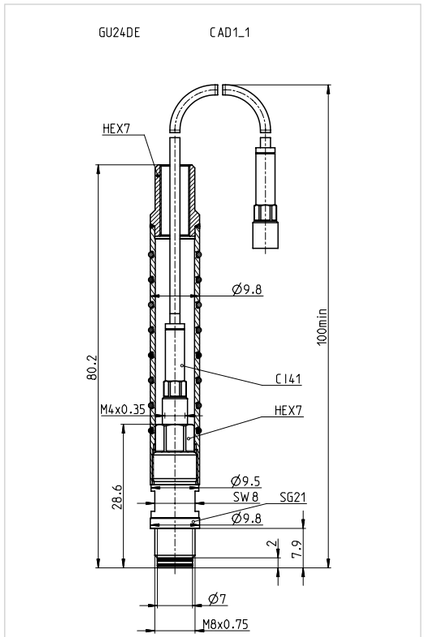
Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG21	Art.No. TIYF0718A.01	see page 98
Gasket removal tool	TT33	Art.No. TIWG0281A.01	see page 98
Dummy	DG09	Art.No. TIWG0278A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Adaptor	AH35	Art.No. TIWG0333A.01	see page 86
Mounting tools	TT11, TT18		see page 94
Mounting paste	SF01	Art.No. 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 Double Shell™ design gives high mechanical isolation from the influences of the mounting bore. Specially trimmed piezo-elements are used to achieve excellent linearity of the output signal. The GU24DE is equipped with SID Sensor Identification to support SDM Sensor Data Management.



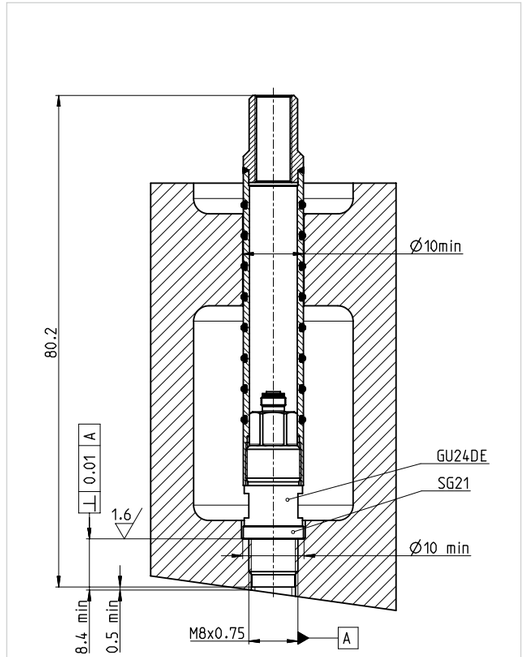
Scope of supply

- Sensor GU24DE
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41 and gasket SG21
- 1 Spare gasket SG21
- Calibration sheet and documentation

Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			45 pC/bar	nominal
Linearity		≤ ±	0.3%	FSO
Natural frequency		~	92 kHz	
Acceleration sensitivity		≤	0.002 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			8 pF	
Operating temperature range			-40°C…400°C	
Thermal sensitivity change		≤	1%	20… 400°C
		≤ ±	0.25%	250 ±100°C
Load change drift		<	4 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.3 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.2 bar	
	Δp_{mi}	≤ ±	1%	
	Δp_{max}	≤ ±	1%	
Thread diameter			M8x0.75	shoulder sealed
Cable connection			M4x0.35	negative
Weight			14 grams	without cable
Mounting torque			6 Nm	

[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline



Shoulder sealed direct installation into the cylinder head.

Accessories

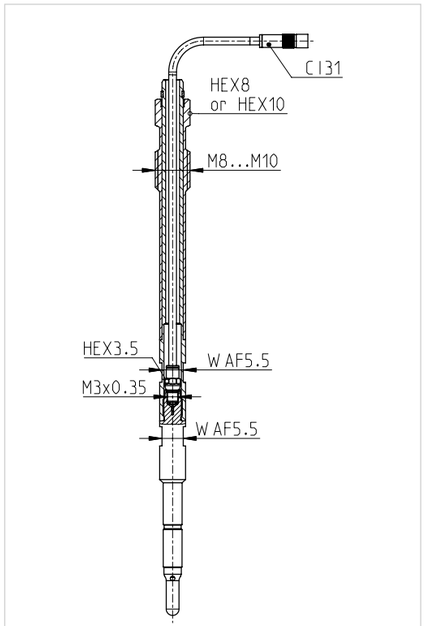
Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG21	Art.No. TIYF0718A.01	see page 98
Gasket removal tool	TT33	Art.No. TIWG0281A.01	see page 98
Dummy	DG25	Art.No. TIBX4170A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Adaptor	AH35	Art.No. TIWG0333A.01	see page 86
Mounting tools	TT11, TT18		see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96

GH13G

TIGH13GPA.01

IMEP ★★ non stop ★★ GaPO4 SDM

The GH13G is a glow-plug sensor for diesel applications where the cylinder head design requires glow-plug diameters as small as 4.3 mm. The membrane of this glow-plug sensor is almost 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 has integrated SID Sensor Identification electronics for the use of SDM Sensor Data Management.



Specifications

Measuring range		0…250 bar	
Overload		300 bar	
Lifetime	≥	10^8	load cycles
Sensitivity		16 pC/bar	nominal
Linearity	≤ ±	0.3%	FSO
Natural frequency	~	130 kHz	
Acceleration sensitivity	≤	0.001 bar/g	axial
Shock resistance	≥	2000 g	
Insulation resistance	≥	10^{13} Ω	at 20°C
Capacitance		7 pF	
Operating temperature range		-40°C … 400°C	
Thermal sensitivity change	≤	2%	20… 400°C
	≤ ±	0.5%	250 ±100°C
Load change drift		1.5 mbar/ms	max. gradient
Cyclic temperature drift [1]	≤ ±	0.5 bar	
Cable connection		M3x0.35	negative
Weight		5 grams	without cable
Mounting torque		4 Nm	

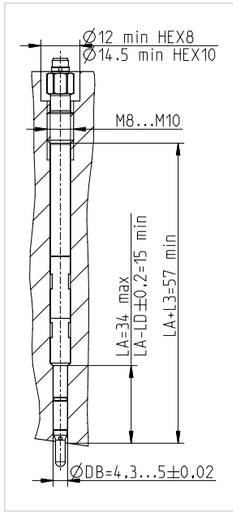
[1] at 7 bar IMEP and 1300 rpm, diesel

Scope of supply

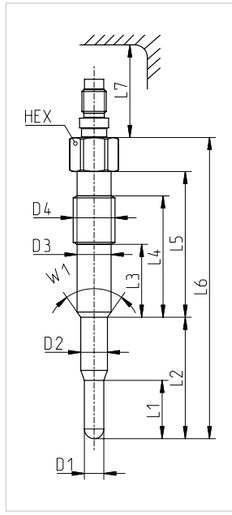
- Sensor GH13G
- Protection cap
- Piezo-input cable CI31-1 and 2 spare O-rings
- Fitted coupling CC31
- Calibration sheet and documentation

Glow-plug sensor and glow-plug adaptor order form

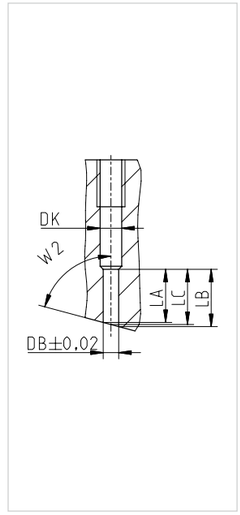
To customize the adaptors to your specific application a detailed description of the glow-plug bore is required. Especially the bore dimension in the flame deck is important for optimum design to ensure the best performance and durability of the delivered senor. The glow-plug adaptor order form allows the customer to give AVL a full description of the required adaptor. 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.
The order form AT4197E_Glow-Plug_Design_Specifications.pdf is available as download at www.avl.com/sensors.



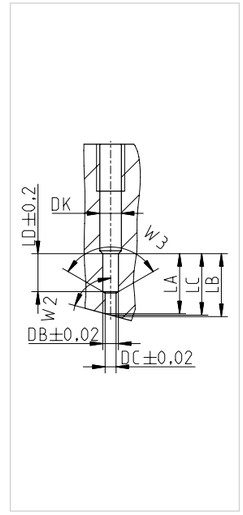
Example of direct installation.



Dimensions of the glow-plug.



Glow plug bore Type A.



Glow plug bore Type B.

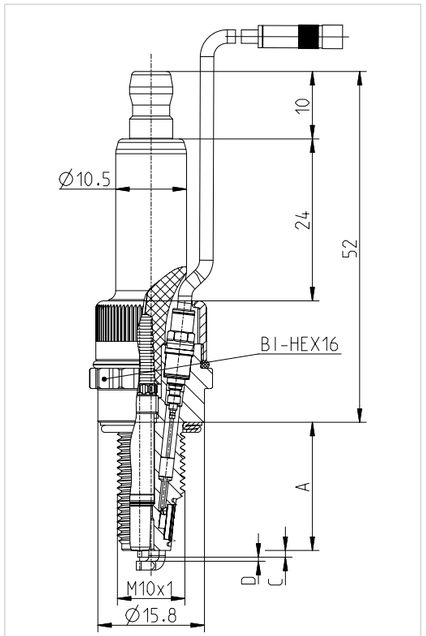
Accessories

GH13G design costs		Art.No. TIAGDESA.01	
Cables & couplings	CI31, CI3V, CC31, E124		see page 101
Mounting tool for M8	TT09	Art.No. TIWG0140A.01	see page 94
Mounting tool for M10	TA16	Art.No. TIWG0200A.01	see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96

ZI21

BOSCH
in collaboration with AVL

★★ ★ ★ GaPO4



The ZI21 is the smallest spark-plug with integrated pressure sensor. The M10 design has very small eccentricity of the center electrode. This and the high sensitivity of the sensor elements combined with the high stiffness of the spark plug body guarantees excellent measurement performance. The insulator of the spark-plug is developed and manufactured by Bosch. The sensor can be equipped with SDC or SIC to make it ready for SDM Sensor Data Management.

Scope of supply

- Sensor ZI21
- Protection cap
- Piezo-input cable CI31-1 and 2 spare O-rings
- Fitted coupling CC31
- Calibration sheet and documentation
- Operating instructions

Specifications

Measuring range		0…200 bar	
Overload		250 bar	
Lifetime	≥	10^8	load cycles
Sensitivity		8 pC/bar	nominal
Linearity	≤ ±	0.5%	FSO
Natural frequency	~	130 kHz	
Acceleration sensitivity	≤	0.001 bar/g	axial
Shock resistance	≥	2000 g	
Insulation resistance	≥	10^{13} Ω	at 20°C
Capacitance		5 pF	
Operating temperature range		-40°C…350°C	
Thermal sensitivity change	≤ ±	0.6%	200 ±50°C
Load change drift		5 mbar/ms	max. gradient
Cyclic temperature drift [1]	≤ ±	0.6 bar	
Thermo shock error [2]			
Δp	≤ ±	0.5 bar	
Δp_{mi}	≤ ±	1.5%	
Δp_{max}	≤ ±	1%	
Temperature of plug-seat	≤	230°C	permanent
Spark-plug insulator resistivity	≥	$10 \cdot 10^6$ Ω	at 20°C
Burn off resistance		6 kΩ	at 20°C
Electric strength	≤	30 kV	permanent
Eccentricity of insulator		1.7 mm	
Thread diameter		M10x1	
Cable connection		M3x0.35	negative
Weight		35 grams	without cable
Mounting torque for the spark-plug		10… 15 Nm	

[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline

Specification of the spark-plug function

Type	Article	Sealing type	Thread length A [3]	Heat value	Spark protrusion C	Electrode gap D [4]	Spare insulator (inner part)
ZI21 U07CPRT	TIGG1448A.01	flat	12.7 … 19	07	1	0.6	TIBX2459A.01
ZI21 U3CPRT	TIGG0980A.01	flat	12.7 … 19	3	1	0.6	TIBO7350A.01
ZI21 U3DPRT	TIGG1400A.01	flat	12.7 … 19	3	3	0.6	TIBW6142A.01
ZI21 U5DPRT	TIGG0981A.01	flat	12.7 … 19	5	3	0.6	TIBO7351A.01
ZI21 U7DPRT	TIGG0982A.01	flat	12.7 … 19	7	3	0.6	TIBO7352A.01
ZI21 U7LPRT	TIGG0983A.01	flat	12.7 … 19	7	5	0.6	TIBO7353A.01
ZI21 U3MPRT	TIGG1320A.01	flat	20.2 … 26.5	3	3	0.6	TIBW6142A.01

[3] Shorter thread length than 19 mm down to 12.7 mm and 26.5 mm down to 20.2 mm is realized by special distance rings on customer request.
[4] Customer specific adaptations may be performed with aid of TA32. The value has to match exactly to the recommendations described in the document AT4370E.

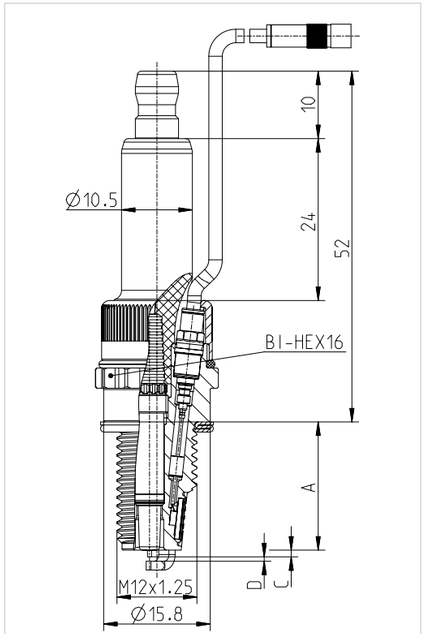
Accessories

Cables & couplings	CI31, CI3V, CC31, E124		see page 101
Cable-mounting tool	TC31, TT25		see page 95
Socket for insulator (inner part)	TT31	Art.No. TIWG0232A.01	see page 97
Mounting tool for insulator (upper part)	TA31	Art.No. TIWG0231A.01	see page 97
Socket standard version	TT24	Art.No. TIWG0234A.01	see page 94
Socket thin version	TT22	Art.No. TIWG0233A.01	see page 94
Torque wrench for cable	TT02	Art.No. TIWG0117A.01	see page 97
Torque wrench for sensor	TT18	Art.No. TIWG0209A.01	see page 97
Sealing gasket	SG23	Art.No. TI0YF0725A.01	see page 98
T-handle	TT44	Art.No. TIYG1027A.01	see page 97
Elongation for sockets	TT43	Art.No. TIYG1026A.01	see page 97
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Electrode gap adjustment tool	TA32	Art.No. TIWG0387A.01	see page 97

ZI31

BOSCH
in collaboration with AVL

★★ ★ ★ GaPO4



The ZI31 is a spark-plug with integrated pressure sensor. The M12 design has very small eccentricity of the center electrode. This and the high sensitivity of the sensor elements combined with the high stiffness of the spark plug body guarantees excellent measurement performance. The insulator of the spark-plug is developed and manufactured by Bosch. The sensor can be equipped with SDC or SIC to make it ready for SDM Sensor Data Management.

Scope of supply

- Sensor ZI31
- Protection cap
- Piezo-input cable CI31-1 and 2 spare O-rings
- Fitted coupling CC31
- Calibration sheet and documentation
- Operating instructions

Specifications

Measuring range			0…200 bar	
Overload			250 bar	
Lifetime	≥		10^8	load cycles
Sensitivity			12 pC/bar	nominal
Linearity	≤	±	0.5%	FSO
Natural frequency	~		130 kHz	
Acceleration sensitivity	≤		0.001 bar/g	axial
Shock resistance	≥		2000 g	
Insulation resistance	≥		10^{13} Ω	at 20°C
Capacitance			5 pF	
Operating temperature range			-40°C…350°C	
Thermal sensitivity change	≤	±	0.6%	200 ±50°C
Load change drift			5 mbar/ms	max. gradient
Cyclic temperature drift [1]	≤	±	0.6 bar	
Thermo shock error [2]				
Δp	≤	±	0.5 bar	
Δp_{mi}	≤	±	1.5%	
Δp_{max}	≤	±	1%	
Temperature of plug-seat	≤		230°C	permanent
Spark-plug insulator resistivity	≥		$10 \cdot 10^6$ Ω	at 20°C
Burn off resistance			6 kΩ	at 20°C
Electric strength	≤		30 kV	permanent
Eccentricity of insulator			1.1 mm	
Thread diameter			M12x1,25	
Cable connection			M3x0.35	negative
Weight			38 grams	without cable
Mounting torque for the spark-plug			15… 25 Nm	

[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline

Specification of the spark-plug function

Type	Article	Sealing	Thread length A [3]	Heat value	Spark protrusion C	Electrode gap D [4]	Spare insulator (inner part)
ZI31 YO7CPRT	TIGG1201A.01	flat	12.7 … 19	07	1	0.6	TIBW3591A.01
ZI31 Y3CPRT	TIGG0984A.01	flat	12.7 … 19	3	1	0.6	TIBO7350A.01
ZI31 Y3DPRT	TIGG1252A.01	flat	12.7 … 19	3	3	0.6	TIBW6142A.01
ZI31 Y5DPRT	TIGG0985A.01	flat	12.7 … 19	5	3	0.6	TIBO7351A.01
ZI31 Y5LPRT	TIGG1232A.01	flat	12.7 … 19	5	5	0.6	TIBW6141A.01
ZI31 Y7DPRT	TIGG0986A.01	flat	12.7 … 19	7	3	0.6	TIBO7352A.01
ZI31 Y7LPRT	TIGG0987A.01	flat	12.7 … 19	7	5	0.6	TIBO7353A.01
ZI31 Y3RPRT	TIGG1028A.01	flat	20.2 … 26.5	3	1	0.6	TIBO7350A.01
ZI31 Y3MPRT	TIGG1253A.01	flat	20.2 … 26.5	3	3	0.6	TIBW6142A.01
ZI31 Y5MPRT	TIGG1029A.01	flat	20.2 … 26.5	5	3	0.6	TIBO7351A.01
ZI31 Y5SPRT	TIGG1233A.01	flat	20.2 … 26.5	5	5	0.6	TIBW6141A.01
ZI31 Y7MPRT	TIGG1030A.01	flat	20.2 … 26.5	7	3	0.6	TIBO7352A.01
ZI31 Y7SPRT	TIGG1031A.01	flat	20.2 … 26.5	7	5	0.6	TIBO7353A.01

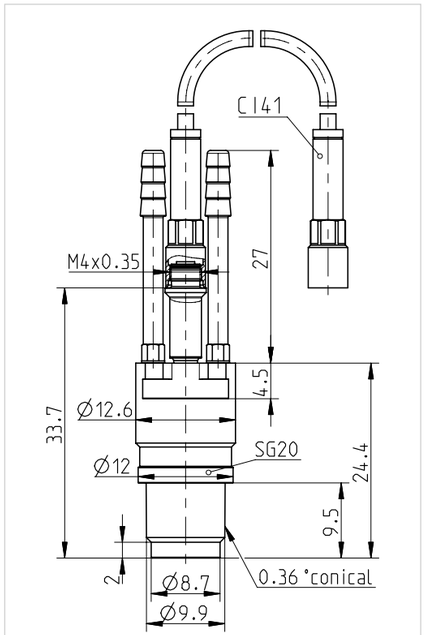
[3] Shorter thread length than 19 mm down to 12.7 mm and 26.5 mm down to 20.2 mm is realized by special distance rings on customer request.
[4] Customer specific adaptations may be performed with aid of TA32. The value has to match exactly to the recommendations described in the document AT4370E

Accessories

Cables & couplings	CI31, CI3V, CC31, E124		see page 101
Cable-mounting tool	TC31, TT25		see page 95
Socket for insulator (inner part)	TT31	Art.No. TIWG0232A.01	see page 97
Mounting tool for insulator (upper part)	TA31	Art.No. TIWG0231A.01	see page 97
Socket standard version	TT24	Art.No. TIWG0234A.01	see page 94
Socket thin version	TT22	Art.No. TIWG0233A.01	see page 94
Torque wrench for cable	TT02	Art.No. TIWG0117A.01	see page 97
Torque wrench for sensor	TT18	Art.No. TIWG0209A.01	see page 97
Sealing gasket	SG33	Art.No. TIOYF0726A.01	see page 98
T-handle	TT44	Art.No. TIYG1027A.01	see page 97
Elongation for sockets	TT43	Art.No. TIYG1026A.01	see page 97
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Electrode gap adjustment tool	TA32	Art.No. TIWG0387A.01	see page 97

QC34C

TIGG1364A.01



The QC34C is a water-cooled pressure sensor for engines with cylinder bores of typically less than 100 mm, and if a quartz sensor is desired. An active water cooling system is required to ensure long lifetimes and excellent thermodynamic behavior. The plug-in design decouples the sensor from the negative influences like thermal expansion and mechanical effects. The sensor is equipped with SID Sensor Identification for the use of SDM.

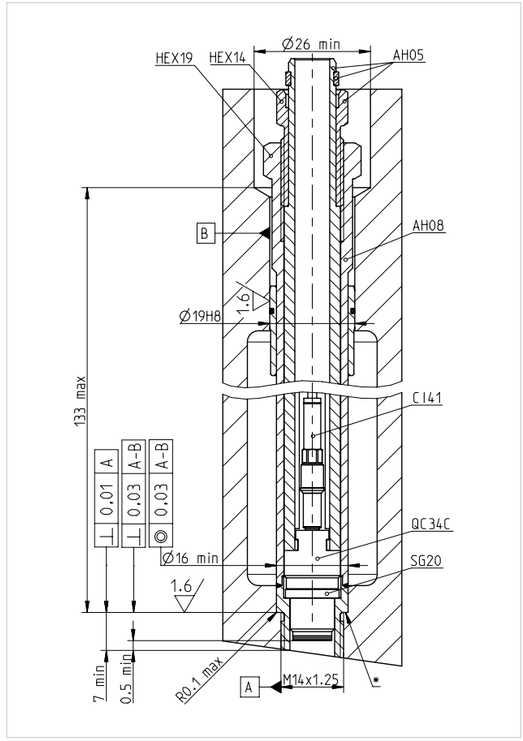
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			19 pC/bar	nominal
Linearity		≤ ±	0.2%	FSO
Natural frequency		~	69 kHz	
Acceleration sensitivity		≤	0.013 bar/g	axial water cooled
		≤	0.003 bar/g	axial uncooled
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			10 pF	
Thermal sensitivity				
change (cooled)		≤	0.003%/°C	20… 80°C
Load change drift			5.5 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.3 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.2 bar	
	Δp_{mi}	≤ ±	1%	
	Δp_{max}	≤ ±	0.5%	
Mounting bore			Ø 10 mm	shoulder sealed
Cable connection			M4x0.35	negative
Cooling rate		≥	20 l/h	at max. 2 bar
Weight			15 grams	without cable
Mounting torque for AH05			15 Nm	

[1]) at 7 bar IMEP and 1300 rpm, diesel
[2]) at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

- Sensor QC34C
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41 and gasket SG20
- 1 Spare gasket SG20
- Calibration sheet and documentation



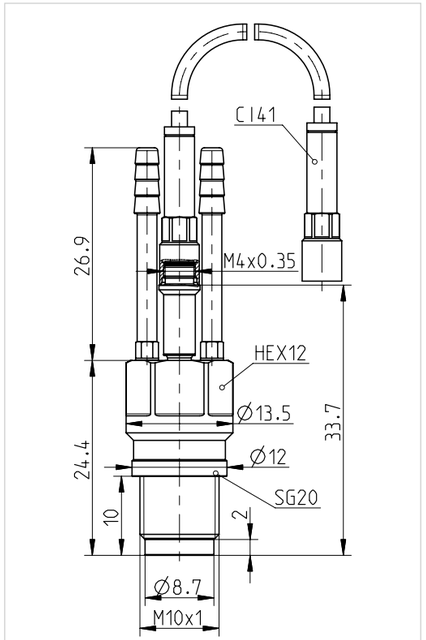
Installation with an AS02 adaptor set.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG20	Art.No. TIBQ0231A.01	see page 98
Gasket dismounting tool	TT15	Art.No. TIWG0179A.01	see page 98
Dummy	DG05	Art.No. TIWG0187A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Adaptor-Set	AS02 (AH05, AH08)		see page 87
Mounting tool for AH05	TT08	Art.No. TIWG0132A.01	see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Cooling system	ZP91.00		see page 104
Cooling tube	ZP90.40	Art.No. TIZP9040A.01	see page 105

QC34D

TIGG1367A.01



Scope of supply

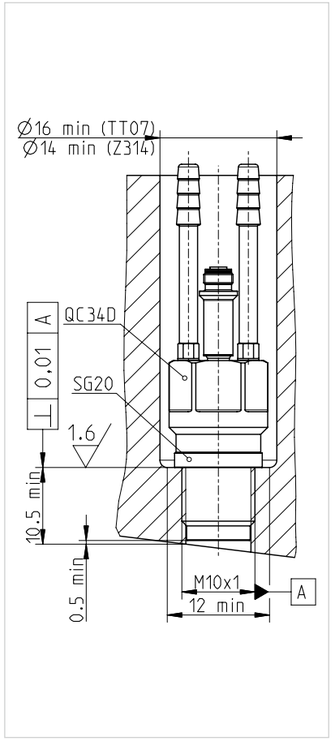
- Sensor QC34D
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41 and gasket SG20
- 1 Spare gasket SG20
- Calibration sheet and documentation

The QC34D is a cooled quartz sensor with a mounting thread of M10 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 SID Sensor Identification for the use of SDM Sensor Data Management.

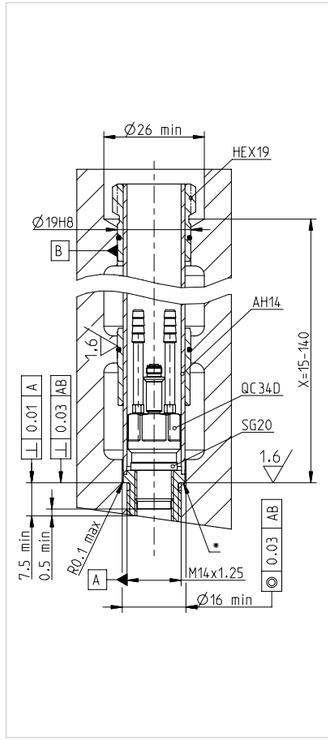
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^8	load cycles
Sensitivity			19 pC/bar	nominal
Linearity		≤ ±	0.2%	FSO
Natural frequency		~	69 kHz	
Acceleration sensitivity		≤	0.013 bar/g	axial water cooled
		≤	0.003 bar/g	axial uncooled
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			10 pF	
Thermal sensitivity change (cooled)		≤	0.003%/°C	20… 80°C
Load change drift			4.5 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤ ±	0.3 bar	
Thermo shock error [2]				
	Δp	≤ ±	0.2 bar	
	Δp_{mi}	≤ ±	1%	
	Δp_{max}	≤ ±	1%	
Mounting bore			M10x1	shoulder sealed
Cable connection			M4x0.35	negative
Cooling rate		≥	20 l/h	at max. 2 bar
Weight			15 grams	without cable
Mounting torque for sensor			10 Nm	

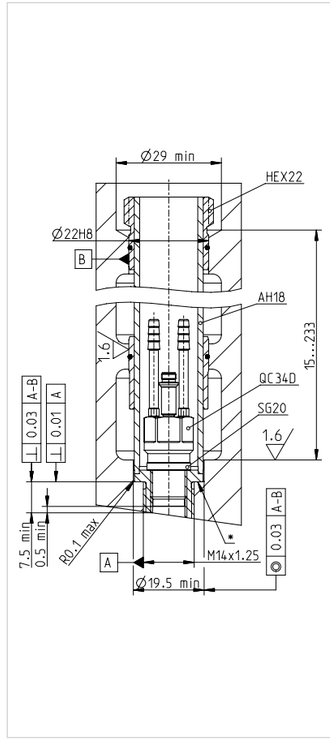
[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline



Direct installation.



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



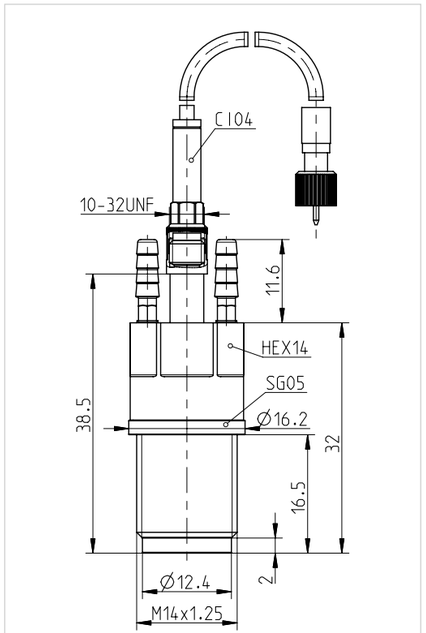
Installation with adaptor AH18 and socket TT07. *) Rigid adhesive, e.g. LOCTITE 648.

Accessories

Cables & couplings	CI41, CI42, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG20	Art.No. TIBQ0231A.01	see page 98
Gasket dismounting tool	TT15	Art.No. TIWG0179A.01	see page 98
Dummy	DG06	Art.No. TIWG0188A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Adaptors	AH14, AH18		see page 86
Machining tool	MT31	Art.No. TIWG0156A.01	see page 94
Mounting tool	TT07, Z314		see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Cooling system	ZP91.00		see page 104

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 to ensure long lifetimes and excellent data reproducibility. The sensor can be equiped with a SDC Sensor Data Connector to allow the use of SDM Sensor Data Management.

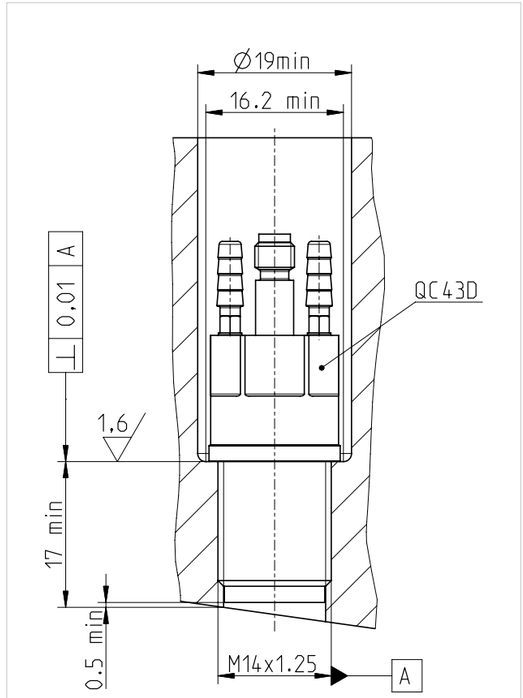
Specifications

Measuring range			0…200 bar	
Overload			250 bar	
Lifetime		≥	10^7	load cycles
Sensitivity			68 pC/bar	nominal
Linearity		≤	± 0.2%	FSO
Natural frequency		~	50 kHz	
Acceleration sensitivity		≤	0.02 bar/g	axial water cooled
		≤	0.003 bar/g	axial uncooled
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			18 pF	
Thermal sensitivity change (cooled)		≤	0.02%/°C	20… 80°C
Load change drift			4 mbar/ms	max. gradient
Cyclic temperature drift [1]		≤	± 0.35 bar	
Thermo shock error [2]				
	Δp	≤	± 0.2 bar	
	Δp_{mi}	≤	± 1%	
	Δp_{max}	≤	± 1%	
Mounting bore			M14x1.25	shoulder sealed
Cable connection			10-32 UNF	Micro-Dot
Cooling rate		≥	20 l/h	at max. 2 bar
Weight			34 grams	without cable
Mounting torque for sensor			20 Nm	

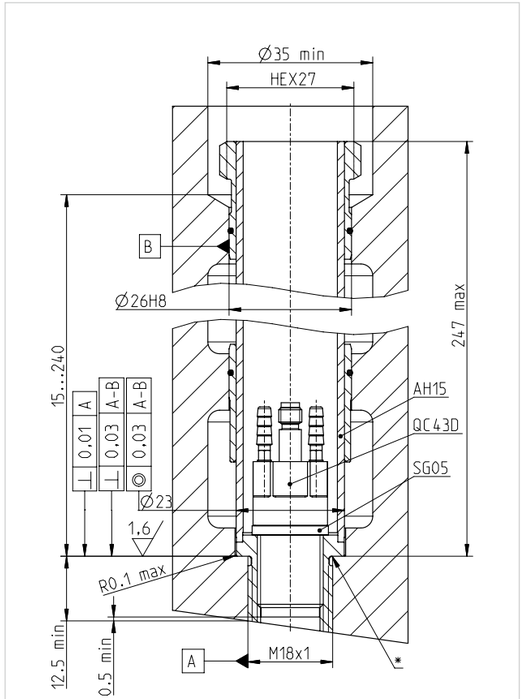
[1] at 7 bar IMEP and 1300 rpm, diesel
[2] at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

- Sensor QC43D
- Protection cap
- Piezo-input cable CI04-1 and 2 spare O-rings
- Fitted coupling E127M and gasket SG05
- 1 Spare gasket SG05
- Calibration sheet and documentation



Shoulder sealed direct installation.



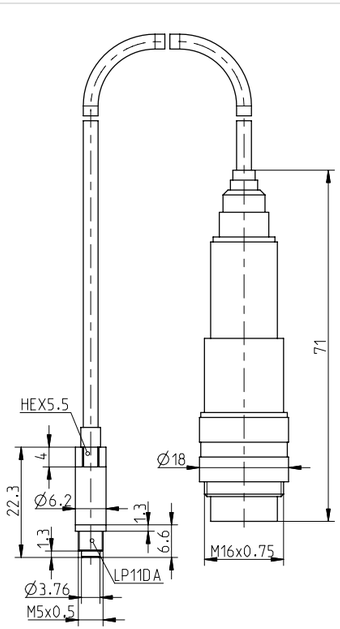
Installation with an AH15 adaptor.
*) Rigid adhesive, e.g. LOCTITE 648 or Henkel omniFIT.

Accessories

Cables & couplings	CI04, E127M, E124		see page 102
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG05	Art.No. TIBQ0230A.01	see page 98
Gasket dismounting tool	TT14	Art.No. TIWG0178A.01	see page 98
Dummy	DG07	Art.No. TIWG0189A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Adaptor	AH15	Art.No. TIWG0194A.01	see page 86
Mounting tool	TT08	Art.No. TIWG0132A.01	see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Cooling system	ZP91.00		see page 104
Cooling tube	ZP90.40	Art.No. TIZP9040A.01	see page 105

LP11DA

TILP1101A.01



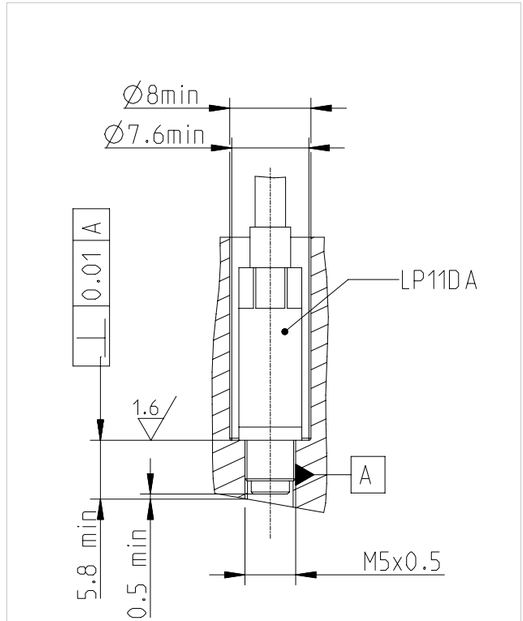
Low Pressure Indicating Sensor LP11DA measures the absolute pressure in intake and exhaust manifold of combustion engines. The piezoresistive sensor is used for precise measurement of static and dynamic pressure variations. The sensor is equipped with an integrated amplifier. For measurements in the exhaust manifold a cooling adapter is necessary. Typical applications are gas-exchange analysis, precise friction analysis, or turbo charger development.

Scope of supply

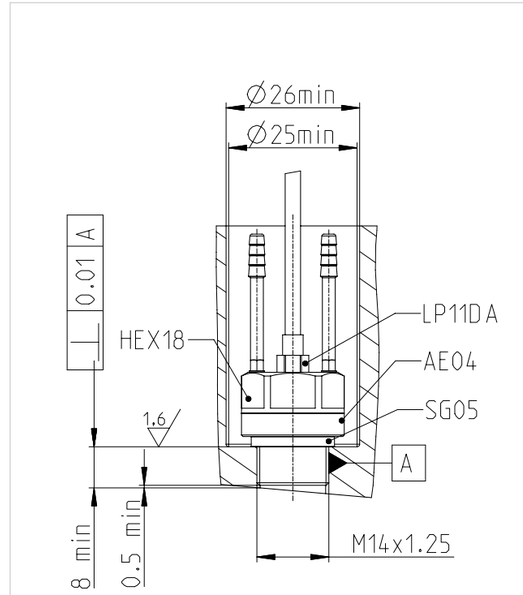
- LP11DA Sensor with 2m cable
- Integrated amplifier
- Connection cable with CY10
- Calibration sheet and documentation

Specifications

Measuring range		0…10 bar	FSO
Thread diameter		M5 x 0.5	
Sensitivity		930 mV/bar	
Overload		20 bar	
Linearity	<	0.1%	FSO
Operating temperature		-55°C…232°C	
Compensated temperature range		-20°C…200°C	
Frequency response	>	50 kHz	
Weight		15 grams	Sensor only
Mounting torque		4 Nm	
Amplifier output		0.2…9.5V	±150mV
Power supply		24 ±4 VDC 10 mA	



Direct installation of LP11DA.



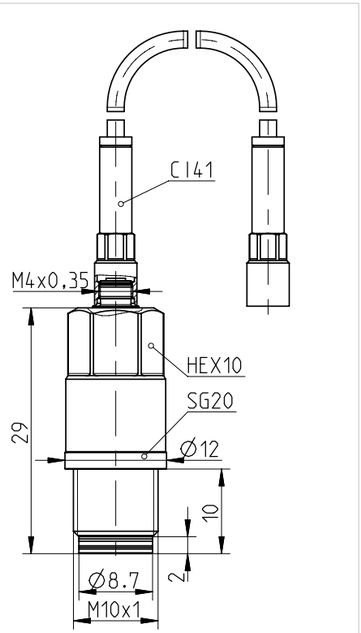
Low pressure sensor LP11DA mounted into cooling adaptor AE04.

Accessories

Cooling Adapter for the exhaust manifold	AE04	Art.No. TILPEA01A.01	see page 88
Adapter for the intake manifold	AI01	Art.No. TILPIA01A.01	
Extension cable 5m	CS10	Art.No. TILPCS10A.01	
Extension cable 10 m	CS11	Art.No. TILPCS11A.01	
Dummy for LP11DA	DL01	Art.No. TIDL01A.01	see page 99
Spare gaskets for LP11DA	SG11	Art.No. TIBQ0242A.01	see page 98
Mounting wrench HEX5.5	TT29	Art.No. TIWG0371A.01	see page 94
Power supply 24V	PS10	Art.No. TILPPS10A.01	
Y-Cable to provide multiple power supply	PY10	Art.No. TILPPY10A.01	
Cooling system	ZP91.00		see page 104

GO31D

TIGG1245A.01



GO31D is a durable M10 cylinder pressure sensor for monitoring or closed loop control in large-bore engines. The sensor can be used with various fuels such as diesel, heavy fuel oil and 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.

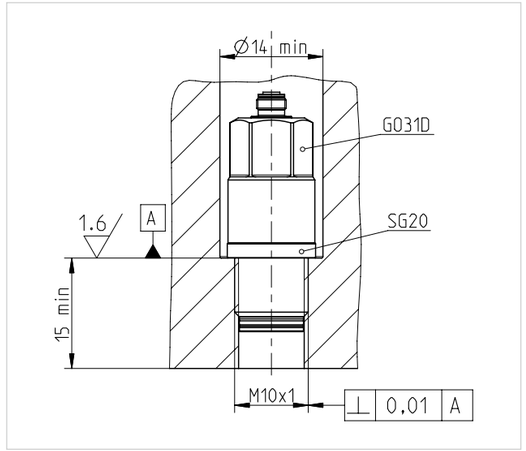
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^9	load cycles
Sensitivity			20 pC/bar	nominal
Linearity		≤ ±	0.5%	FSO
Natural frequency		~	90 kHz	
Acceleration sensitivity		≤	0.002 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7 pF	
Operating temperature range [1]			-50°C…350°C	
Thermal sensitivity change		≤	0.5%	20… 350°C
		≤ ±	0.2%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [2]		≤ ±	0.8 bar	
Thermo shock error [3]				
	Δp	≤ ±	0.4 bar	
	Δp_{mi}	≤ ±	2%	
	Δp_{max}	≤ ±	1%	
Thread diameter			M10x1	shoulder sealed
Cable connection			M4x0.35	negative
Weight			22 grams	without cable
Mounting torque			15… 20 Nm	

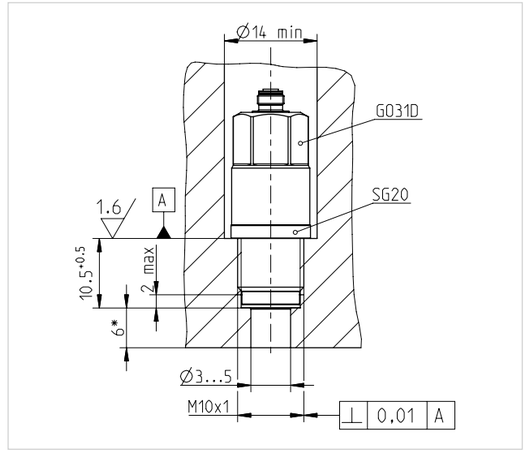
[1] surface temperature around the HEX < 200°C
[2] at 7 bar IMEP and 1300 rpm, diesel
[3] at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

- Sensor GO31D
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41 and gasket SG20
- 1 Spare gasket SG20
- Calibration sheet and documentation



Shoulder sealed direct installation.



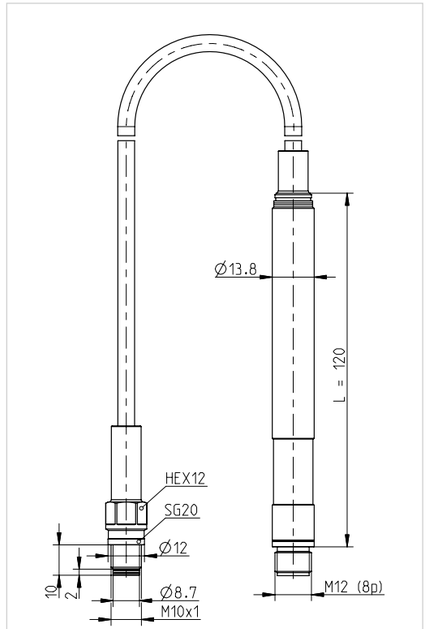
Recessed shoulder sealed direct installation.
*) recommended

Accessories

Cables & couplings	CI41, CI42, CI43, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG20	Art.No. TIBQ0231A.01	see page 98
Gasket dismounting tool	TT15	Art.No. TIWG0179A.01	see page 98
Dummy	DG11	Art.No. TIWG0339A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Machining tool (tap drill)	MT31	Art.No. TIWG0156A.01	see page 93
Mounting tool	TA16	Art.No. TIWG0200A.01	see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
In-Line amplifier voltage output	M4-V	Art.No. TIGG1271A.01	see page 107
In-Line amplifier current output	M4-C	Art.No. TIGG1269A.01	see page 107

GO31DA

TIGG1247A.01 C-Type
TIGG1248A.01 V-Type



GO31DA is a durable M10 cylinder pressure sensor with integrated charge amplifier for monitoring large-bore engines. The sensor can be used with various fuels such as diesel, heavy fuel oil and 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.

Approved environmental and safety standards

Safety CE-approval	EMV EN61236 IEC 61010-1/EN 61010-1
Protection aigainst media	IP67 AVL VP04
Environmental standard	ROHS lead free

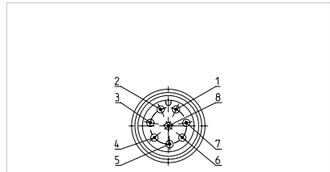
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^9	load cycles
Linearity		≤ ±	0.5%	FSO
Natural frequency		~	90 kHz	
Acceleration sensitivity		≤	0.002 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7 pF	
Operating temperature range [1]			-40°C…350°C	
Thermal sensitivity change		≤	0.5%	20… 350°C
		≤ ±	0.2%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [2]		≤ ±	0.8 bar	
Thermo shock error [3]				
	Δp	≤ ±	0.4 bar	
	Δp_{mi}	≤ ±	1.5%	
	Δp_{max}	≤ ±	0.5%	
Thread diameter			M10x1	shoulder sealed
Cable connection			M12 – 8pin	
Weight			22 grams	without cable
Mounting torque			15… 20 Nm	

[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

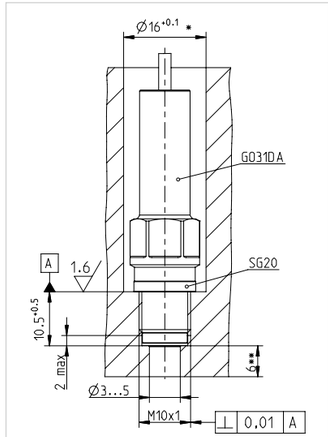
Scope of supply

- Sensor GO31DA
- Protection cap
- 3m cable with integrated charge amplifier
- Fitted gasket SG20
- 1 Spare gasket SG20
- Calibration sheet and documentation

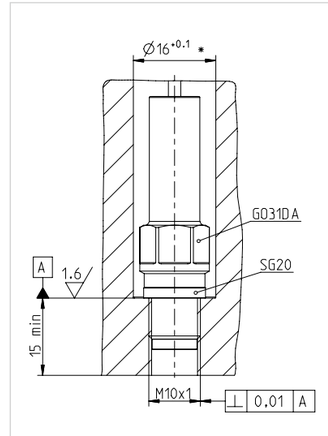


Pin	GO31DAV	GO31DAC
1	GND	GND
2	-	-
3	-	Current output
4	(Com. Input)*	(Com. Output)*
5	Voltage output	-
6	(Com. Output)*	(Com. Output)*
7	(Drift Comp. Off)*	(Drift Comp. Off)*
8	Power supply	Power supply

Pin layout of the in-line amplifier.
*) for programming purposes at factory site only.



Recessed shoulder sealed direct installation. *) minimal diameter. Keep diameter and tolerance to maintain functionality of the mounting tool. **) recommended



Shoulder sealed direct installation. *) Keep diameter and tolerance to maintain functionality of the mounting tool.

Amplifier specification

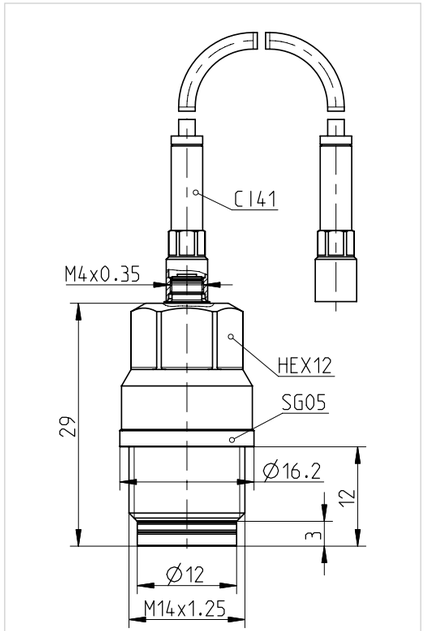
Bandwidth	20 kHz	at -3 dB
Engine speed range for drift compensation	15 ... 3000 rpm	higher engine speeds on request
Drift compensation	cyclic	active above 13 bar, can be switched off
Time delay	none	analog between signal input and output
Shock resistance	200 g	
	V-type voltage out	C-type current out
Power supply	8 ... 32 VDC, ≤ 6 mA at 24V	12 ... 32 VDC, ≤ 26 mA at 24V
Nominal output signal	0.5 ... 4.5V	4 ... 20mA
Sensitivity	13 mV/bar	50 µA/bar
Zero level	0.5 V	4 mA
Load resistor, ≤ 26 mA at 24V		500 Ω max.
Operating temperature range	-10 … 110°C	-50 … 80°C

Accessories

Gasket	SG20	Art.No. TIBQ0231A.01	see page 98
Gasket dismounting tool	TT15	Art.No. TIWG0179A.01	see page 98
Dummy	DG06	Art.No. TIWG0188A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Machining tool (tap drill)	MT31	Art.No. TIWG0156A.01	see page 93
Mounting tool	TT27	Art.No. TIWG0277A.01	see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96

GO41D

TIGG1239A.01



GO41D is a durable M14 cylinder pressure sensor for monitoring large-bore engines. The sensor can be used with various fuels such as diesel, heavy fuel oil and 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.

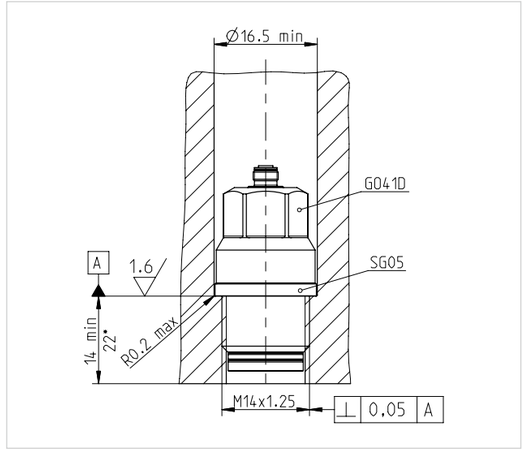
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^9	load cycles
Sensitivity			20 pC/bar	nominal
Linearity		≤ ±	0.5%	FSO
Natural frequency		~	90 kHz	
Acceleration sensitivity		≤	0.002 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7 pF	
Operating temperature range [1]			-40°C…350°C	
Thermal sensitivity change		≤	0.5%	20… 350°C
		≤ ±	0.2%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [2]		≤ ±	0.8 bar	
Thermo shock error [3]				
	Δp	≤ ±	0.4 bar	
	Δp_{mi}	≤ ±	2%	
	Δp_{max}	≤ ±	1%	
Thread diameter			M14x1.25	shoulder sealed
Cable connection			M4x0.35	negative
Weight			34 grams	without cable
Mounting torque			20… 25 Nm	

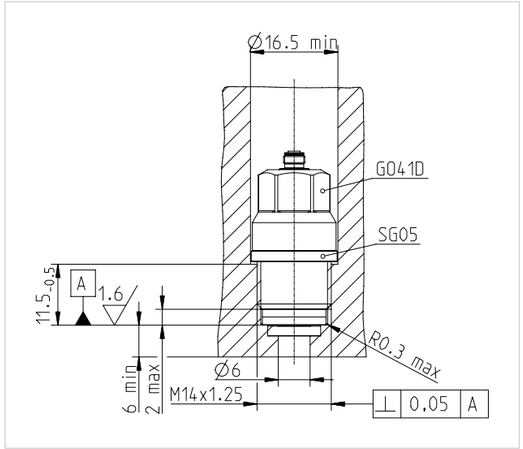
[1] surface temperature around the HEX < 200°C
[2] at 7 bar IMEP and 1300 rpm, diesel
[3] at 9 bar IMEP and 1500 rpm, gasoline

Scope of supply

- Sensor GO41D
- Protection cap
- Piezo-input cable CI41-1 and 2 spare O-rings
- Fitted coupling CC41 and gasket SG05
- 1 Spare gasket SG05
- Calibration sheet and documentation



Shoulder sealed direct installation.
*) recommended



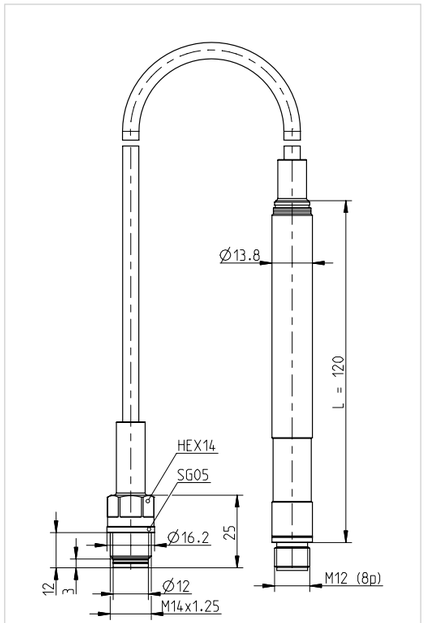
Front sealed direct installation.

Accessories

Cables & couplings	CI41, CI42, CI43, CI4V, CC41, E124		see page 101
Cable-mounting tool	TC01	Art.No. TIWG0131A.01	see page 95
Gasket	SG05	Art.No. TIBQ0230A.01	see page 98
Gasket dismounting tool	TT14	Art.No. TIWG0178A.01	see page 98
Dummy	DG12	Art.No. TIWG0340A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Mounting tool	TT07	Art.No. TIWG0133A.01	see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
In-Line amplifier voltage output	M4-V	Art.No. TIGG1271A.01	see page 107
In-Line amplifier current output	M4-C	Art.No. TIGG1269A.01	see page 107

GO41DA

TIGG1241A.01 C-Type
TIGG1242A.01 V-Type



GO41DA is a durable M14 cylinder pressure sensor with integrated charge amplifier for monitoring large-bore engines. The sensor can be used with various fuels such as diesel, heavy fuel oil and 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.

Approved environmental and safety standards

Safety CE-approval	EMV EN61236 IEC 61010-1/EN 61010-1
Protection against media.	IP67 AVL VP04
Environmental standard	ROHS lead free

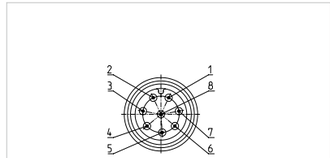
Specifications

Measuring range			0…250 bar	
Overload			300 bar	
Lifetime		≥	10^9	load cycles
Linearity		≤ ±	0.5%	FSO
Natural frequency		~	90 kHz	
Acceleration sensitivity		≤	0.002 bar/g	axial
Shock resistance		≥	2000 g	
Insulation resistance		≥	10^{13} Ω	at 20°C
Capacitance			7 pF	
Operating temperature range [1]			-40°C…350°C	
Thermal sensitivity change		≤	0.5%	20… 350°C
		≤ ±	0.2%	250 ±100°C
Load change drift			1.5 mbar/ms	max. gradient
Cyclic temperature drift [2]		≤ ±	0.8 bar	
Thermo shock error [3]				
	Δp	≤ ±	0.4bar	
	Δp_{mi}	≤ ±	1.5%	
	Δp_{max}	≤ ±	0.5%	
Thread diameter			M14x1.25	shoulder sealed
Cable connection			M12 – 8pin	
Weight			34 grams	without cable
Mounting torque			20… 25 Nm	

[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

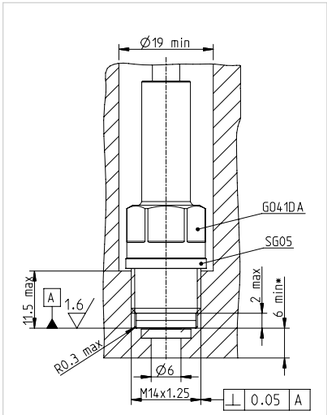
Scope of supply

- Sensor GO41DA
- Protection cap
- 3m cable with integrated charge amplifier
- Fitted gasket SG05
- 1 Spare gasket SG05
- Calibration sheet and documentation

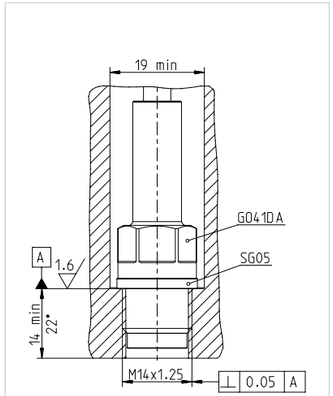


Pin	GO41DAV	GO41DAC
1	GND	GND
2	-	-
3	-	Current output
4	(Com. Input)*	(Com. Output)*
5	Voltage output	-
6	(Com. Output)*	(Com. Output)*
7	(Drift Comp. Off)*	(Drift Comp. Off)*
8	Power supply	Power supply

Pin layout of the in-line amplifier.
*) for programming purposes at factory site only.



Front sealed direct installation.
*) recommended



Shoulder sealed direct installation.
*) recommended

Amplifier specification

Bandwidth	20 kHz	at -3 dB
Engine speed range for drift compensation	15 ... 3000 rpm	higher engine speeds on request
Drift compensation	cyclic	active above 13 bar, can be switched off
Time delay	none	analog between signal input and output
Shock resistance	200 g	
	V-type voltage out	C-type current out
Power supply	8 ... 32 VDC, ≤ 6 mA at 24V	12 ... 32 VDC, ≤ 26 mA at 24V
Nominal output signal	0.5 ... 4.5V	4 ... 20mA
Sensitivity	13 mV/bar	50 µA/bar
Zero level	0.5 V	4 mA
Load resistor		500 Ω max.
Operating temperature range	-10 … 110°C	-50 … 80°C

Accessories

Gasket	SG05	Art.No. TIBQ0230A.01	see page 98
Gasket dismounting tool	TT14	Art.No. TIWG0178A.01	see page 98
Dummy [4]	DG15	Art.No. TIWG0415A.01	see page 99
Dummy removal tool	TD01	Art.No. TIWG0122A.01	see page 96
Mounting tool	TT08	Art.No. TIWG0132A.01	see page 94
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96

[4] for shoulder sealed installation only.

ACCESSORIES

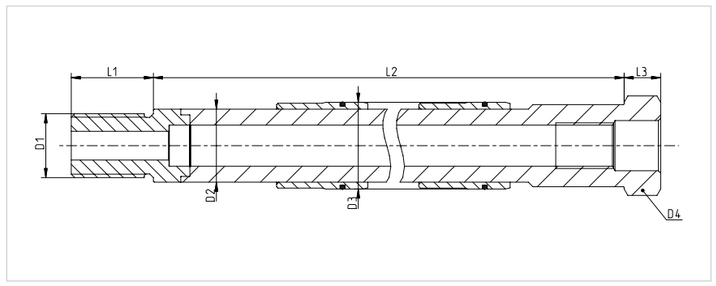
ADAPTORS

Adaptor sleeves

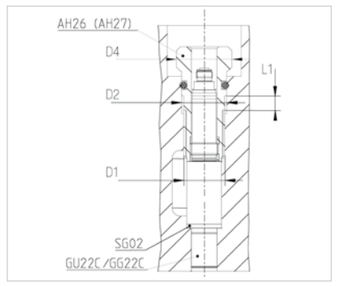
Adaptor sleeves are used where a direct installation of the sensor is not possible and wherever a cooling jacket or oil gallery has to be crossed by the indicating channel. The adaptor (type and dimensions) should be chosen as small as possible in order to fulfill the measurement task with a minimum of interference to the cylinder head. The accessory configuration chart on pages 20 - 21 gives an overview which adapter is suited for a specific sensor. Specially developed machining and mounting tools are available for installation of these adaptors, refer to pages 92 - 97 for further information.

Type	Art.No	Recommend-ed mounting torque [Nm]	D1	D2	D3	D4	L1	L2	L3	For sensor
AH01	TIWG0115A.01	3	M7x0.75	9.5	12	HEX12	12	15 to 205	5	GH14D / GH14DK GH15D / GR14D / GH15DK
AH01A	TIWG0252A.01	8	M7x0.75	9.5	12	HEX12	12	15 to 205	5	GH14D / GH14DK GH15D / GR14D / GH15DK
AH05	TIWG0174A.01	10	-	-	-	HEX14	-	-	-	QC34C
AH06	TIWG0175A.01	10	M10x1	12	15	HEX14	17.5	15 to 200	5	GU21D
AH08	TIWG0183A.01	20	M14x1.25	16	19	HEX19	18	140	11	QC34C
AH13	TIWG0218A.01	5	M5x0.5	6	7	HEX10	10	max. 98	4	GH13P / GH14P
AH14	TIWG0193A.01	20	M14x1.25	16	19	HEX19	18	max. 15 to 140	8	QC34D
AH15	TIWG0194A.01	20	M18x1	23	26	HEX27	25	15 to 240	8	QC43D
AH18	TIWG0197A.01	20	M14x1.25	19	22	HEX22	18	15 to 223	8	QC34D
AH26	TIYG1520A.01	10	M10x1	11	-	HEX12	1 to 133	-	-	GU22C / GG22C / GU22CK
AH27	TIYG1521A.01	10	3/8"x 24 UNF	11	-	HEX12	1 to 133	-	-	GU22C / GG22C / GU22CK
AH28	TIWG0255A.01	10	M14x1.25	16	19	HEX19	18	132	8	GU22C / GU22CK GG22C
AH31	TIWG0284A.01	5	M6x0.5	7.5	10	HEX10	12	max. 205	5	GH15D / GH15DK
AH35	TIWG0333A.01	15	M12x1.25	14	14	HEX17	22	max. 186	8	GU24D
AH45	TIWG0397A.01	5	M6x0.5	7.5	10	HEX10	12	max 205	5	GH13P / GH14P

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).

Adaptor sets

For common combinations of adaptors and mounting nipples the following sets are available.

Type	Art.No.	For sensor	Consists of
AS02	TIWG0184A.01	QC34C	AH05 + AH08
AS29 [1]	TIWG0256A.01	GU22C GG22C, GU22CK	AH29 + AM29

[1] To mount GU22C, GG22C and GU22CK into AH08

Mounting nipples

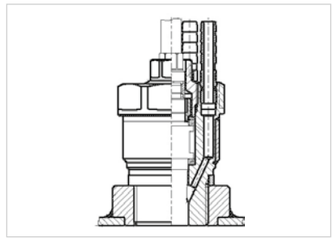
Several sensors require specific mounting screws or so called mounting nipples. To fix a AM04 or AM05 with the sensor the AM06 safety ring (Art.No. TIWG0417A.01) is required. The accessory configuration guide on pages 20 - 21 gives additionally an overview for which sensor which mounting accessory is available.

Type	Art.No.	For sensor	Mounting tool	Mounting thread
AM04	TIWG0240A.01	GU22C GG22C, GU22CK	TT09	M10x1
AM05	TIWG0253A.01	GU22C GG22C, GU22CK	TT09	3/8“ x 24 UNF

ADAPTORS

Adaptors for Low-Pressure indicating

The damping adaptor AE02 is recommended for low pressure measurement of the gas exchange at intake and exhaust line with the sensor GU21C. The AE04 is a cooling adaptor for the piezoresistive LP11DA. Please refer also to page 74 for more information about this sensor.

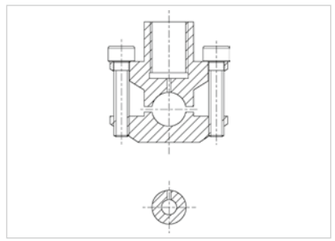


Adaptor type	Adaptor Art.No.	Description	For pressure sensor	Sensor Art.No.	Mounting thread
AE02	TIWG0191A.01	Cooling adaptor for the exhaust manifold	GU21C [1]	TIGG0498A.01	M14
AE04	TILPEA01A.01	Cooling adaptor for the exhaust manifold	LP11DA see page 74	TILP1101A.01	M14
AI01	TILPIA01A.01	Adaptor for the intake manifold	LP11DA	TILP1101A.01	M14

[1]) Art.No. TIGG0498A.01 is a discontinued product. Please contact AVL for equivalent substitute.

Briden adaptors

The Briden adaptors are recommended for easy installation of the line-pressure sensor series SL31D.
There are several standard types for different line diameters available.



Type	Art.No.	For sensor	For line diameter	Mounting torque of adaptor screws [Nm]
AK01	TIWG0238A.01	SL31D	6 mm	4.0 Nm
AK02	TIWG0241A.01	SL31D	8 mm	4.0 Nm
AK03	TIWG0242A.01	SL31D	9 mm	4.0 Nm
AK04	TIWG0290A.01	SL31D	¼ inch	4.0 Nm
AK05	TIWG0352A.01	SL31D	6.5 mm	4.0 Nm

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 the AG03 adaptor is recommended. Between M10 and M8 the AG04. For slimmer diameters down to 4.3 mm please refer to the integrated glow-plug solution GH13G on pages 62 - 63.

Adaptor type	Art. No.	Thread diameter D4	Tip bore diameter DB	For sensor	Mounting torque [Nm]
AG03	TIAG03A.01	≥ M10	≥ 5 mm	GH12P GH13P, GH14P	4.0
AG04	TIAG04A.01	≥ M8	≥ 5 mm	GH13P, GH14P	4.0

Along with the first order of a new glow-plug type the article TIAGDESA.01 needs to be ordered additionally.

Accessories				
Mounting tool for AG03	TA16	HEX10	Art.No. TIWG0200A.01	see page 94
Mounting tool for AG04	TT09	HEX8	Art.No. TIWG0140A.01	see page 94

Glow-plug adaptor order form

To customize the adaptors to your specific application a detailed description of the glow-plug bore is required. To ensure the best performance and durability of the delivered senor especially the bore dimension and length is important for optimum design. AVL requires a full description of the required 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 63 for drawings with the required dimensions. The order form AT4197E_Glow-Plug_Design_Specifications.pdf is available as download at www.avl.com/sensors.

ADAPTORS

ZF43 Spark-plug adaptors

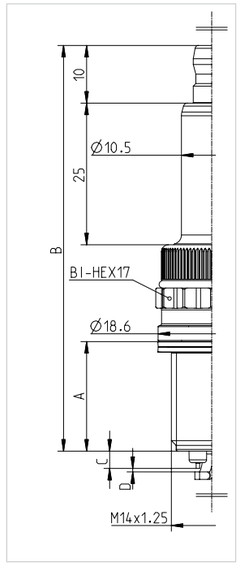
BOSCH
in collaboration with AVL

The high sensitivity of the piezoelectric sensor in combination with the high stiffness of the housing of the spark plug adaptor ZF43 guarantees an excellent signal quality. The outer shape of the ZF43 corresponds to the design of a standard spark plug of size M14 based on ISO 8470. This enables the use of the spark plug adaptor in combination with single coils and ignition rails as well as in vehicle indicating without limits. The ZF43 is equipped with a specifically designed insulator which is supplied by Bosch. Furthermore the ZF43 is equipped with a platinum reinforced ground electrode. The modular design permits dismounting and service of all relevant components like the sensor, insulator, adaptor.

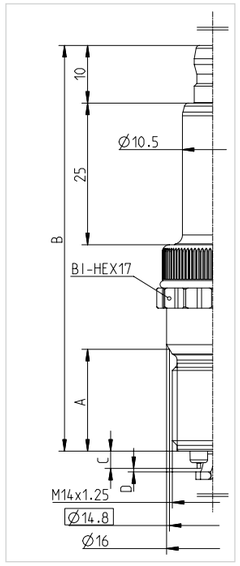
Applicable for the following sensors

Sensors	Art.No.	
GH13Z-24 for “short”	TIGG0929A.01	see page 46
GH13Z-31 for “long”	TIGG0930A.01	see page 48

The required mounting torque for mounting the sensor into the spark-plug adaptor is 1.5 Nm. To mount the spark-plug into the cylinder head a mounting torque of 20-25 Nm is necessary. For cylinder heads made from aluminium alloys a mounting torque between 15-20 Nm is recommended.



Example of ZF43 with GH13Z-24 and flat sealing.



Example of ZF43 with GH13Z-31 and conical sealing.

Specifications		
Temperature of plug-seat	≤ 230°C	permanent
Spark-plug insulator resistivity	≥ $10 \cdot 10^6 \Omega$	at 20°C
Burn off resistance	6 kΩ	
Electric strength	≤ 30kV	permanent
Eccenticity of insulator	2.4 mm	
Thread diameter	M14x1.25	
Cable connection	M3x0.35	negative
Weight	52 g	without sensor
Adaptor mounting torque	15...20 Nm	cast iron, aluminium
	20...25 Nm	steel

Type	Art. No.	For sensor type	Sealing type	Thread length A [1]	Heat value	Spark protrusion C	Electrode gap D [2]	Spare insulator (inner part) [3]
ZF43 F07CPRT	TIGG1071A.01	GH13Z-24	flat	19	07	1	0.6	TIBW3591A.01
ZF43 F3CPRT	TIGG0966A.01	GH13Z-24	flat	19	3	1	0.6	TIBO7350A.01
ZF43 F3DPRT	TIGG1256A.01	GH13Z-24	flat	19	3	3	0.6	TIBW6142A.01
ZF43 F5DPRT	TIGG0967A.01	GH13Z-24	flat	19	5	3	0.6	TIBO7351A.01
ZF43 F5LPRT	TIGG1254A.01	GH13Z-24	flat	19	5	5	0.6	TIBW6141A.01
ZF43 F7DPRT	TIGG0968A.01	GH13Z-24	flat	19	7	3	0.6	TIBO7352A.01
ZF43 F7LPRT	TIGG0969A.01	GH13Z-24	flat	19	7	5	0.6	TIBO7353A.01
ZF43 F3MPRT	TIGG1257A.01	GH13Z-31	flat	26.5	3	3	0.6	TIBW6142A.01
ZF43 F5MPRT	TIGG0970A.01	GH13Z-31	flat	26.5	5	3	0.6	TIBO7351A.01
ZF43 F5SPRT	TIGG1255A.01	GH13Z-31	flat	26.5	5	5	0.6	TIBW6141A.01
ZF43 F7MPRT	TIGG0971A.01	GH13Z-31	flat	26.5	7	3	0.6	TIBO7352A.01
ZF43 F7SPRT	TIGG0972A.01	GH13Z-31	flat	26.5	7	5	0.6	TIBO7353A.01
ZF43 H07CPRT	TIGG1180A.01	GH13Z-24	conical	17.5	07	1	0.6	TIBW3591A.01
ZF43 H7DPRT	TIGG0973A.01	GH13Z-24	conical	17.5	7	3	0.6	TIBO7352A.01
ZF43 H7LPRT	TIGG0974A.01	GH13Z-24	conical	17.5	7	5	0.6	TIBO7353A.01
ZF43 HO7RPRT	TIGG1202A.01	GH13Z-31	conical	25	07	1	0.6	TIBW3591A.01
ZF43 H3CPRT	TIGG1147A.01	GH13Z-31	conical	25	3	1	0.6	TIBO7350A.01
ZF43 H5MPRT	TIGG0975A.01	GH13Z-31	conical	25	5	3	0.6	TIBO7351A.01
ZF43 H7MPRT	TIGG0976A.01	GH13Z-31	conical	25	7	3	0.6	TIBO7352A.01
ZF43 H7SPRT	TIGG0977A.01	GH13Z-31	conical	25	7	5	0.6	TIBO7353A.01

[1] Shorter thread length than 19mm down to 12.7mm and 26.5mm down to 20.2mm is realised by special distance rings on customer request.
[2] Customer specific adaptations may be performed with aid of TA32. The value has to match exactly to the recommendations described in the document AT4370E.
[3] Set consists of one isolator, one isolator gasket and one isolation grease ZKF01.

Accessories			
Set of mounting tools for adaptor	TS43 (TT42 + TT43 + TT44)	Art.No. TIWG0211A.01	see page 95
Set of mounting tools for sensor	TS21 (TT21 + TT02)	Art.No. TIWG0213A.01	see page 95
Mounting tool for insulator (upper part)	TA42	Art.No. TIWG0212A.01	see page 97
Socket for insulator (inner part)	TT31	Art.No. TIWG0232A.01	see page 97
T-Handle	TT44	Art.No. TIYG1027A.01	see page 97
Elongation	TT43	Art.No. TIYG1026A.01	see page 97
Sealing gasket	SG43	Art.No. TI0YF0722A.0	see page 98
Mounting paste	SF01	Art.No. TIHK0094A.01	see page 96
Electrode gap adjustment tool	TA32	Art.No. TIWG0387A.01	see page 97

MACHINING TOOLS

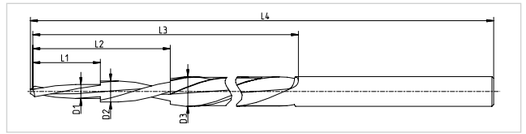
For appropriate preparation and machining of the indicating bore an assorted collection of machining tools is available. These tools are designed to machine the bores and threads of AVL sensors for several sizes. Especially for the M5 sensors it is very important to machine the seat for the sensor (front-sealing) in high quality to guarantee correct operation at pressures up to 250 bar and the exact mounting torque.

A set of machining tools consists of one step drill, one tap drill and eventually of 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
MS11	TIWG0161A.01	GH14D GH14DK GR14D	MD11 + MT11 + MG11
MS15	TIWG0337A.01	GH15D GH15DK	MD12 + MT12
MS22	TIWG0165A.01	AH01 AH01A GU21D	MD22 + MT21 + MG22
MS24	TIWG0167A.01	AH06 AH16	MD24 + MT31 + MG24
MS25	TIWG0394A.01	AH31 AH45	MD25 + MT25

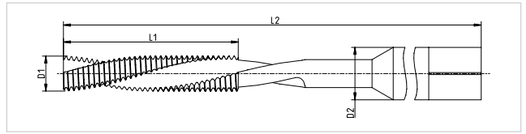
Step drills



Type	Art.No. L4	For sensor or adaptor	D1	D2	D3	L1	L2	L3	L4
MD10	TIWG0257A.01	GU22C GG22C, GU22CK	6.3	-	8.5	20	-	215	270
MD16	TIWG0418A.01	GU22C, GG22C GU22CK	6.3	8.5	8.9	20	34	215	270
MD11	TIWG0148A.01	GH14D GH14DK, GR14D	3	4.5	7.5	10	19	134	190
MD12	TIWG0335A.01	GH15D, GH15DK	3	4.5	5.7	10	19	134	190
MD22	TIWG0151A.01	AH01, AH01A GU21D	6.2	-	10	20	-	215	270
MD24	TIWG0153A.01	AH06, AH04	9	-	12	20	-	215	270
MD25	TIWG0391A.01	AH31, AH45	5.5	-	7.5	20	-	225	270

Sensors or adaptors which are not listed here either do not require any machining or do not require special AVL tools to machine the indicating bore. Please refer to your standard tool supplier.

Tap drills



Type	Art.No.	For sensor or adaptor	D1	D2	L1	L2
MT11	TIWG0154A.01	GH14D GH14DK, GR14D	M5x0.5	6	14	200
MT12	TIWG0346A.01	GH15D, GH15DK	M5x0.5	5	14	200
MT13	TIWG0369A.01	GU22C, GG22C GU22CK	3/8“ x 24 UNF	10	20	250
MT21	TIWG0155A.01	GU21D AH01	M7x0.75	8	19	250
MT25	TIWG0392A.01	AH31, AH45	M6x0.5	7	20	250
MT31	TIWG0156A.01	QC34D GO31D, GO31DA GU22C, GU22CK, GG22C AH06	M10x1	10	20	250

Sensors or adaptors which are not listed here either do not require any machining or do not require special AVL tools to machine the indicating bore. 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 inside 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. Please refer to your standard tool supplier.

Sockets and wrenches

Type	Art.No.	D1	D2	D3	L	to mount	into
TT01	TIWG0112A.01	HEX5.5	7.3	HEX8	220	GH14D GH14DK GR14D	indicating bore, AH01, AH01A indicating bore, AH01, AH01A indicating bore, AH01, AH01A
TT07	TIWG0133A.01	HEX12	15.8	HEX16	250	QC34D GO41D, GO31DA	indicating bore, AH18 indicating bore
TT08	TIWG0132A.01	HEX14	18.2	HEX19	250	AH05 QC43D GO41DA	AH08 indicating bore, AH15 indicating bore
TT09	TIWG0140A.01	HEX8	11.5	HEX12	70	GH13G GU22C GG22C, GU22CK AG04	M8 glow-plug bore indicating bore with AM04 or AM05 indicating bore with AM04 or AM05 M8 glow-plug bore
TT11	TIWG0180A.01	HEX7	9.5	HEX8	250	GU21D GU24D GU24DE	indicating bore, AH06 indicating bore, AH35 indicating bore
TT21	TIWG0214A.01	HEX4	5.6	HEX8	220	GH15D GH13P GH13Z-24/31	indicating bore, AH01, AH01A, AH31 AG03, AG04, AH13 ZF43
TT22	TIWG0233A.01	HEX16	19	SQR 3/8“	73	ZI21/31	spark-plug bore [1]
TT24	TIWG0234A.01	HEX16	20.2	SQR 3/8“	60	ZI21/31	spark-plug bore
TT27	TIWG0227A.01	HEX12	15.9	SQR 3/8“	350	GO31DA	indicating bore
TT29	TIWG0371A.01	HEX5.5	-	-	-	LP11DA	AE04
TT31	TIWG0232A.01	HEX4.5	6.3	SQR 1/4“	42	inner insulator inner insulator	ZI21/31 ZF43
TT42	TIYG1024A.01	HEX17	21.8	SQR 1/2“	70	ZF43	M14 spark-plug bore
TA13	TIWG0136A.01	HEX8	11.5	HEX12	200	GU22C GG22C, GU22CK	indicating bore with AH26/27 indicating bore with AH26/27
TA16	TIWG0200A.01	HEX10	13.8	HEX14	139	GH13G SL31D AG03 GO31D	M10 glow-plug bore Briden adaptor AK01/02/03/04 M10 glow-plug bore indicating bore

[1] narrow spark-plug bore

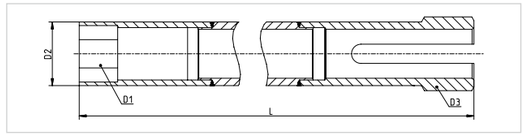
Pin tools / Polygon-Head spanners

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
TS01	TIWG0121A.01	GH14D GH14DK GR14D	indicating bore, AH01, AH01A indicating bore, AH01, AH01A indicating bore, AH01, AH01A	Socket TT01, Torque Wrench TT02
TS02	TIWG0128A.01	GU22C GG22C, GU22CK	indicating bore with AM04/05 indicating bore with AM04/05	Socket TT09, Torque Wrench TT18
TS03	TIWG0181A.01	GU21D	indicating bore, AH06	Socket TT11, Torque Wrench TT02
TS21	TIWG0213A.01	GH15D GH13P GH13Z-24/31	indicating bore, AH01, AH01A, AH13 indicating bore, AG04, AH13 ZF43	Socket TT21, Torque Wrench TT02
TS43	TIWG0211A.01	ZF43	spark-plug bore	Socket TT42, Elongation TT43 T-handle TT44

If no specific tools are recommended, no special AVL mounting tools are required. In this case standard mounting tools can be used which can be acquired from conventional tool suppliers.



Specifications of socket mounting tools.

Cable mounting tools

Type	Art.No.	For cable connector type
TC01	TIWG0131A.01	M4 x 0.35 with HEX4
TC31	TIWG0215A.01	M3 x 0.35 with HEX3.5
TT25	TIYM5782A.01	M3 x 0.35 with HEX3.5

Please refer to pages 20 - 21 with the accessory configuration guide to get a listing of which cable mounting tool is required for a specific sensor. The TC01 can be used together with TC31 to counter-back the sensor with a HEX4 while removing a M3 cable with HEX3.5 .

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. Consisits 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 inner insulator and the spark-plug body as well as between the upper insulator and the spark-plug socket. For further information refer to the instruction manuals of spark-plug pressure sensors and adaptors AT2191E00_ZI21_ZI31_Spark_Plug_Sensor.pdf.

Gasket and Dummy removal tool

Type	Art.No.	Purpose
TT14	TIWG0178A.01	to remove gasket SG05 from QC43D/GO41D/GO41DA
TT15	TIWG0179A.01	to remove gasket SG20 from QC34C/QC34D/GO31D/GO31DA
TT17	TIWG0185A.01	to remove gasket SG03 from the sensor GU21D
TT33	TIWG0281A.01	to remove gasket SG21 from the sensor GU24D or GU24DE
TD01	TIWG0122A.01	to take a dummy plug out of the mounting bore which has a M4x0.35 connector
TD13	TIWG0224A.01	to take a dummy plug out of the mounting bore which has a M3x0.35 connector

Special tools for spark-plug sensors and adaptors

Type	Art.No.	To be used with	Purpose
TA31	TIWG0231A.01	ZI21, ZI31	mounting tool for the upper part of insulator
TA32	TIWG0387A.01	ZI21, ZI31 ZF43	adjustment tool to set the correct electrode gap according to the final compression pressure
TA42	TIWG0212A.01	ZF43	mounting tool for the fix the upper part of the insulator
TT03	TIWG0114A.01		Converts a 1/4“ SQR drive to a HEX8 socket
TT19	TIWG0210A.01	ZI21, ZI31 ZF43	to connect a TT18 with a HEX12 socket of e.g. TT09 and TA13
TT31	TIWG0232A.01	ZI21, ZI31 ZF43	mounting socket for the inner insulator part into the spark-plug body. See also page 94.
TT35	TIWH0093A.01	TT18	offers for the TT18 a 3/8“ SQR drive (DIN3120)
TT36	TIWH0108A.01	TT02	converts a 1/4“ HEX socket to a 1/4“ SQR drive (DIN3120)
TT43	TIYG1026A.01	ZI21, ZI31 ZF43	elongation between the torque wrench or T-handle and socket
TT44	TIYG1027A.01	ZI21/31 ZF43	T-handle to ease mounting the ZI21 or ZI31 into the spark-plug bore
TT47	TIWG0395A.01	ZI21, ZI31 ZF43	to connect a TT18 with a 3/8“ socket of e.g. TT43, TT22, TT24 and TT27

Torque wrenches

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.	Torque range	Remarks
TT02	TIWG0117A.01	0.5 – 4.5 Nm	Provides a 1/4“ SQR drive (DIN3120), includes TT36
TT18	TIWG0209A.01	4 – 40 Nm	Provides a 3/8“ SQR drive (DIN3120), includes TT35
TT32	TIWG0236A.01	1 – 6 Nm	offers a 1/4“ HEX drive

GASKETS, DUMMY PLUGS 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 GG22C, GU22CK	5 pcs.	-
SG03	TIBQ0228A.01	GU21D	5 pcs. incl. TT17	TT17
SG05	TIBQ0230A.01	QC43D GO41D/DA	5 pcs. incl. TT14	TT14
SG11	TIBQ0242A.01	LP11DA	20 pcs.	-
SG13	TIB04282A.01	SL31D-200 SL31D-2000 SL31D-3000	5 pcs.	-
SG20	TIBQ0231A.01	QC34C QC34D GO31D/DA	5 pcs. incl. TT15	TT15
SG21	TIYF0718A.01	GU24D, GU24DE	1 pc.	TT33
SG23	TI0YF0725A.01	ZI21	100 pcs.	-
SG33	TI0YF0726A.01	ZI31	100 pcs.	-
SG43	TI0YF0722A.01	ZF43	100 pcs.	-

Dummy plugs

A sensor dummy plug seals the indicating bore of the engine in a save way. It is recommended to replace the sensor if it is not used for measurements. This replacement allows prolonging the useful life time of the sensor. For easy and convenient removal of the dummy out of the engine a so called dummy removal tool can be used.

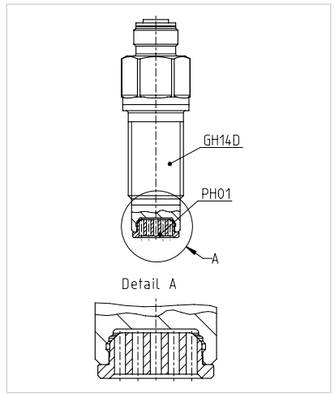
Dummy	Art.No.	Fits into sensor bore of	Mounting tool	Removal tool
DG01	TIWG0113A.01	GH14D GH14DK GR14D	TT01	TD01
DG04	TIWG0170A.01	GU21D	TT11	TD01
DG05	TIWG0187A.01	QC34C	TT08 via AS02	
DG06	TIWG0188A.01	QC34D GO31DA	TT07	TD01
DG07	TIWG0189A.01	QC43D	TT08	TD01
DG09	TIWG0278A.01	GU24D	TT11	TD01
DG10 (1)	TIWG0336A.01	GU22C GG22C GU22CK	TT09	TD01
DG11	TIWG0339A.01	GO31D	TA16	TD01
DG12	TIWG0340A.01	GO41D	TT07	TD01
DG13	TIWG0219A.01	GH13P GH14P	TT21	TD13
DG14 (2)	TIWG0367A.01	GU22C GG22C GU22CK	TT09	TD01
DG15	TIWG0415A.01	GO41DA	TT08	TD01
DG24	TIWG0334A.01	GH15D GH15DK	TT21	TD13
DG25	TIBX4170A.01	GU24DE	TT11	-
DS01	TIWG0198A.01	SL31D-200 SL31D-2000 SL31D-3000	-	-
DL01	TIDL01A.01	LP11DA	-	-

[1]) with M10x1 thread
[2]) with 3/8“x24 UNF thread

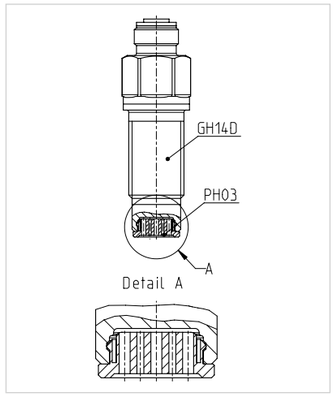
GASKETS, DUMMIES AND FLAME ARRESTORS

Flame arrestors

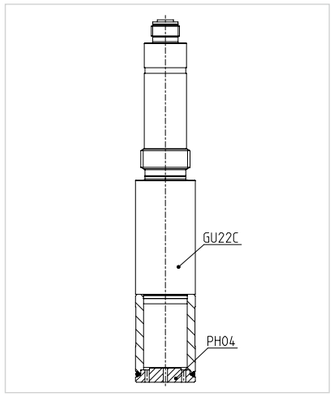
For highly accurate measurements we recommend the use of a flame arrestor or a so called thermo protection. A reduction of the cyclic drift by 50% and protection of the sensor in case of operation at extremely high temperatures can be achieved. Due to the high density of soot particles flame arrestors are in principal not recommended for the use in diesel engines.



Installation of the PH01 together with GH14D.



Installation of the PH03 together with GH14D.



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	GH14D GH14DK GR14D GH15D GH15DK GH13Z	0.5 bar 0.7 bar 0.5 bar 0.5 bar 0.7 bar 0.5 bar	0.3 bar 0.4 bar 0.3 bar 0.3 bar 0.4 bar 0.3 bar
PH03	TIYF0734A.01	GH14D GH14DK GR14D GH15D GH15DK GH13Z	0.5 bar 0.7 bar 0.5 bar 0.5 bar 0.7 bar 0.5 bar	0.3 bar 0.4 bar 0.3 bar 0.3 bar 0.4 bar 0.3 bar
PH04	TIBW7172A.01	GU22C GU22CK GG22C	0.4 bar 0.5 bar 0.4 bar	0.3 bar 0.3 bar 0.3 bar

CABLES AND COUPLINGS

Piezo-Input cables

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

Specifications	
Connection	M3x0.35 pos. – M3x0.35 pos.
Cable material	Teflon™ coated
Maximum temperature	200°C
Cable diameter	2 mm
Mounting torque	0.5 Nm
Length	1m … CI31-1 2m … CI31-2 3m … CI31-3

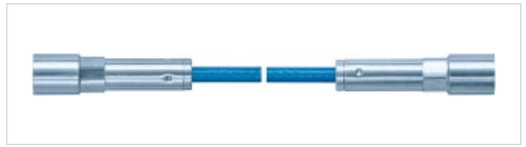
Note: To connect a sensor to the amplifier with this cable the BNC Coupling CC31 is additionally necessary. Minimum bending radius 20 mm.

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

Connection	M3x0.35 pos. – M3x0.35 pos.
Cable material	Viton™ oil proof
Maximum temperature	200°C
Cable diameter	2 mm
Mounting torque	0.5 Nm
Length	1m … CI3V-1 2m … CI3V-2

Note: Oil proof 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	M4x0.35 pos. – M4x0.35 pos.
Cable material	Teflon™ coated
Maximum temperature	200°C
Cable diameter	2 mm
Mounting torque	0.5 Nm
Length	1m … CI41-1 2m … CI41-2 3m … CI41-3

Note: 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

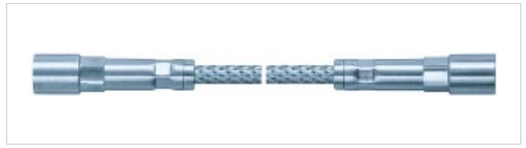
Connection	M4x0.35 pos. – M4x0.35 pos.
Cable material	Viton™ oil proof
Maximum temperature	200°C
Cable diameter	2 mm
Mounting torque	0.5 Nm
Length	1m … CI4V-1 2m … CI4V-2

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.

CABLES AND COUPLINGS

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	M4x0.35 pos. – M4x0.35 pos.
Cable material	Metal sheath -Teflon™ coated
Maximum temperature	200°C
Cable diameter	2.4 mm
Mounting torque	0.5 Nm
Length	1m … CI42-1 2m … CI42-2 3m … CI42-3

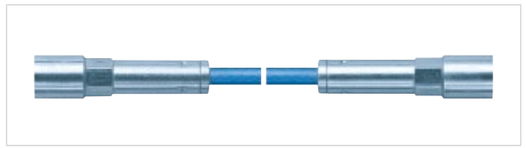
Note: Metal sheath cable. To connect a sensor to the amplifier with this cable the BNC Coupling CC41 is additionally necessary. Minimum bending radius 20 mm.

CI43-1 Art.No.: TICI43/1A.02 with SIC
CI43-2 Art.No.: TICI43/2A.02 with SIC

Connection	M4x0.35 pos. – M4x0.35 pos.
Cable material	Teflon™ coated
Maximum temperature	200°C
Cable diameter	2 mm
Mounting torque	0.5 Nm
Length	1m … CI43-1 2m … CI43-2

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

CI46-1 Art.No.: TICI46/1A.02



Connection	M4x0.35 pos. – M4x0.35 pos.
Cable material	Teflon™ coated
Maximum temperature	200°C
Cable diameter	2 mm
Mounting torque	0.5 Nm
Length	1m … CI46-1

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.

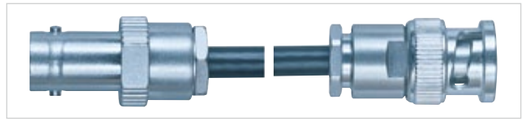
CI04-1 Art.No.: TICI04/1A.02
CI04-2 Art.No.: TICI04/2A.02

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

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

Measuring cables

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



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

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

CS01 Art.No.: TIBV2397A.01

Connection	Lemo pos. – Amphenol 7-pin pos.
Cable material	PVC
Maximum temperature	70°C
Cable diameter	4 mm
Length	10m … CS01

Note: Serves as a connection of the strain gauge sensors, e.g. SL31D, to an AVL Amplifier 3009A03/A04 or IFEM 3FM. Please refer to datasheet of SL31D-type sensors.

CS02 Art.No.: TIBV2398A.01

Connection Amphenol	Amph. 7-pin neg. - Amph. 7-pin pos.
Cable material	PVC
Maximum temperature	70°C
Cable diameter	4 mm
Length	5 m … CS02

Note: Extension cable for strain gauge sensors like SL31D.

Couplings

CC31
Art.No.: TIEU2085A.01

Specifications	
Connection	M3x0.35 neg. – BNC pos.

Note: Coupling for the connection of the piezo – input cables CI31-1, CI31-2 to the amplifier or the measuring cable.

CC41
Art.No.: TIEU2077A.01

Specifications	
Connection	M4x0.35 neg. – BNC pos.

Note: Coupling for the connection of the piezo – input cables CI41-1, CI41-2 to the amplifier or the measuring cable.

E127M
Art.No.: TIEU0861A.01

Connection	Micro Dot neg. – BNC pos.

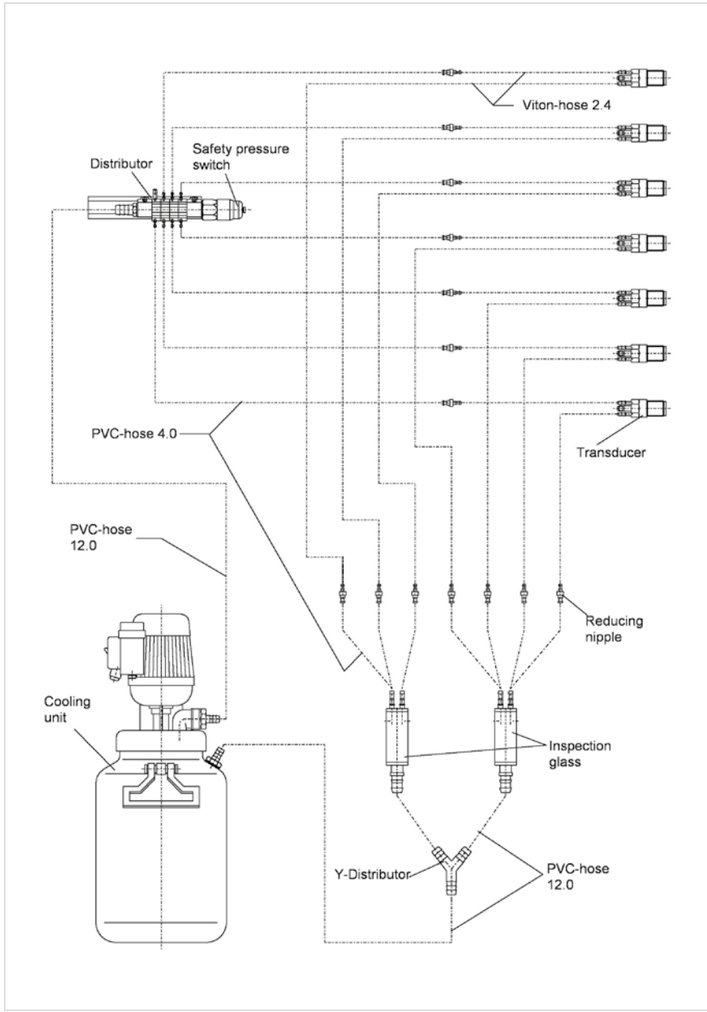
Note: Coupling for the connection of the piezo – input cable CI04 (Microdot) to the Measuring Cable E124 or the Piezo Amplifier (BNC).

CC4-4
Art.No.: TI41-CCA.01

Connection	M4x0.35 neg. – M4x0.35 neg.

Note: Coupling to connect two CI4 piezo-input cables. This allows to extend the distance between a sensor and the CC41.

COOLING SYSTEM



This cooling system provides direct water cooling of the sensor diaphragm and the piezo elements for sensors which require active cooling. This is only necessary for sensor with piezoelectric quartz material. With this system the piezoelectric sensing material is kept below 250°C to prevent twin-formation and to maintain the piezoelectric property.

The advantages can be summarized to:

- Prevention of overheating of quartz measuring elements
- Reduction of cyclic temperature drift and load change drift
- Minimum change of sensitivity due to almost constant temperature of quartz measuring element

Scope of supply
1 Cooling water tank incl. immersion pump ZP91.01
1 Distributor ZP91.11-4(8) 1(2) Inspection glass(es) ZP91.21A
1 Set of hoses 1 Handling instructions
The numbers in () are valid for cooling system ZP91.00/5-8

General properties

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	approx. 20 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	275 x 235 x 600 mm
Weight	approx. 12 kg (for ZP 91.00/1-4)

Accessories		Art. No.
Pump unit 230V	ZP91.01	TIGH0086A.01
Pump unit 115V	ZP91.01C	TIGH0116A.01
Tank	ZP91.01.05	TIBO0196A.01
Distributor	ZP91.11-04	TIBO0183A.01
Distributor	ZP91.11-08	TIBO0184A.01
Inspection glass	ZP91.21A	TIBO3364A.01
Reducing nipple	ZP91.25	TIBO0187A.01
Y- Distributor	ZP91.27	TIBO0188A.01
PVC-tube 4.0 [1]	ZP91.45	TIZP9145A.01
PVC-tube 12.0 [1]	ZP91.42	TIZP9142A.01
Cooling tube	ZP91.40	TIZP9140A.01

[1] minimum quantity 10 m

Available versions		
Cooling system ZP 91.00/1–4	230V, for 1 to 4 cooling ports	Art. No. TIZP91A.04
Cooling system ZP 91.00/5–8	230V, for 1 to 8 cooling ports	Art. No. TIZP91A.08
Cooling system ZP 91.00/1–4	115V, for 1 to 4 cooling ports	Art. No. TIZP91A.14

SPECIAL ACCESSORIES

Top-Dead-Center sensor TDC428

When performing thermodynamic calculations on pressure curves measured in internal combustion engines, the exact determination of top-dead-center (TDC) position is of great importance. The AVL Capacitive TDC Sensor 428 is a precise measuring instrument for dynamic determination of TDC in a non fired cylinder of internal combustion engines. An electronic circuit, as well as special TDC evaluation software (horizontal cut principle), provides an analog signal whose maximum value corresponds to the engine's TDC position.
www.avl.com/other-sensors

Valve-Lift sensor VL426

The AVL Type 426 Valve Lift Transducer allows measurements of the valve lift in engines with valve controlled intake/exhaust systems. It may also be applied to any other static or dynamic lift measurements of a similar nature. The transducer housing is mounted to the valve cover by means of an adjustment plate. The lift movement of the valve is transmitted by means of a magnetic core with extension rod. The extension rod is provided with extra length and may be shortened by the user as necessary for the individual application.
www.avl.com/other-sensors

Needle-Lift adaptation

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 car, or light duty engines. It is also available for large injectors in heavy duty or marine engines.
www.avl.com/other-sensors

Angle encoder

The 365 Angle Encoder series consists of high precision sensors for angle-related measurements used mainly for indicating purposes. The optical function is based on a marker disk and utilizes the transmission or reflection of light principle, with a maximum angle resolution of 0.025 degrees of crank angle. The electronic components are mounted separately from the crankshaft to minimize the influence of electrical interference, temperature and vibration. The angle information is transmitted by light pulses from the encoder through an optical cable to an emitter-receiver electronics module. The electrical connection to the pulse converter is of plug-in type; therefore the pulse converter can remain permanently in the test cell.
www.avl.com/other-sensors

Signal conditioning

From simple utilization of strain-gauge, piezo-resistive or inductive sensors, to the intelligent amplification of piezoelectric signals - AVL's flexible indicating amplifiers of the MicroIFEM and the FlexIFEM families, are suited for all test environments. AVL's amplifiers provide the most flexibility; from stand-alone usage at mobile testbeds or in the vehicle, to stationary usage fully integrated into the test cell environment. This portfolio can be combined, expanded by cascading multiple units, and further extended by adding the stand-alone conditioning unit for optical signals, the AVL VisioFEM.
www.avl.com/indicating_systems

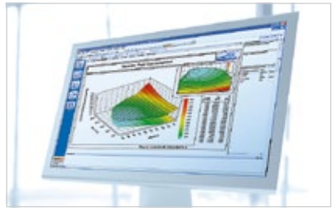
Data acquisition

Providing calculated indicating parameters in real time, full integration into modern automation or application systems, and still keeping the flexibility for customer specific adaptations are some main requirements that are fully supported by all of AVL's market-leading indicating systems. Due to their integrated amplifiers and very small-sized design, all-in-One indicating devices such as AVL FlexIFEM Advanced, AVL IndiMicro and AVL IndiSmart are best suited for mobile applications. The compactly designed AVL IndiModul, AVL IndiSet and highly modular AVL IndiMaster series offer solutions for all fields of high-end combustion analysis.
www.avl.com/combustion-measurement

Indicating software AVL INDICOM™

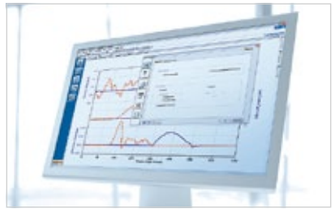
Increasing complexity and shorter development times require more and more intelligence from software tools with the possibility to easily turn the volume of acquired data into meaningful information. AVL IndiCom™ is particularly focused on meeting these demands. AVL IndiCom™ is available in several standard configurations for the corresponding indicating system families. Application oriented packages and functional extensions allow a modular configuration custom tailored to the specific application needs.
www.avl.com/indicom2

Postprocessing software AVL CONCERTO™



With continuously growing data volumes, increasing channel numbers, longer test duration or archiving of raw data, AVL CONCERTO™ is data evaluation software that supports the user to find the relevant data parts and turn them into useful results. Application oriented configuration packages allow modular post processing of data from engine, drivetrain, hybrid, component testbeds, emission benches, indicating devices, and more. Due to its open interfaces, AVL CONCERTO™ is the ideal tool for central data correlation, no matter what the origins of the data are.
www.avl.com/concerto

Gas exchange analysis software GCA



AVL GCA is a tool for thermodynamic process analysis of internal combustion engines. It can be seen as both “virtual sensor” and design tool for optimizing the entire process. First, combustion analysis is performed and subsequently gas exchange analysis is done, whose result is in turn supplied back to the combustion analysis. This analysis is then recalculated a second time for higher accuracy. Due to the reduction of interfaces, AVL GCA™ is fully integrated into AVL´s indicating software IndiCom, as well as the post-processing software AVL CONCERTO™. AVL GCA™ helps to provide a greater understanding of the entire engine gas exchange process.
www.avl.com/combustion-measurement

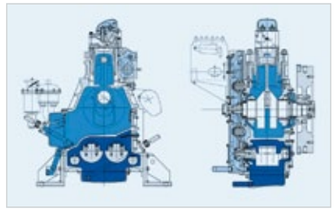
Monitoring software AVL EPOS™

Close to the end of the engine development process and during the productive life of the engine, the interest in combustion characteristics and especially indicating results is very high. Therefore the main focus is on long lifetime and robust design of the equipment, in order to offer stable and reliable result values. 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.
www.avl.com/epos

Optical indicating AVL VISIO™

Whenever the results of traditional pressure indicating methods are insufficient, optical measuring methods can offer additional information. The AVL Visiolution technology provides the right tools and services to improve performance regarding fuel consumption, mixture formation, exhaust emission, and engine power. A wide portfolio of optical measurement systems is offered by AVL, starting with the small VisioFEM system, in combination with the VisioPressure Sparkplug. More capable systems are also offered ranging from the Visio-Knock and VisioFlame systems, to the VisioTomo system with up to 160 optical channels for high-end analysis of processes within the combustion chamber.
www.avl.com/visiolution

Single cylinder research engines



Working with single cylinder research engines offers the significant advantage that the prospects for success of a concept can be tested under realistic engine conditions long before these new concepts are translated to the full production engine. AVL’s single cylinder engines cover everything from small car engines up to large truck engines. Engines equipped with optical top sets offer transparent access to the combustion chamber. The AVL single cylinder compact testbeds are the ideal combination of engine and testbed for professional operation of single cylinder engines. They are best suited for basic research and investigation of fuel injection and combustion phenomena.
www.avl.com/single-cylinder-research-engines-and-testbeds

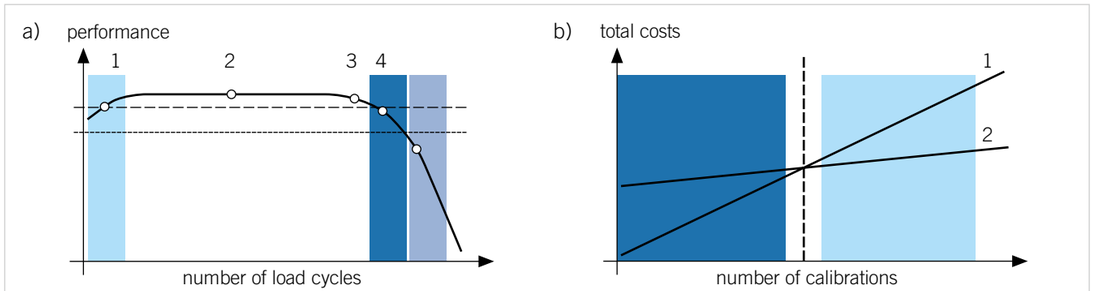
SERVICE & CALIBRATION

SENSOR CALIBRATION

About the importance of calibrating sensors

Calibration is the process of checking and adjusting precisely a sensor. Piezoelectric sensors are very stable over their long lifetime if used under regular combustion conditions. AVL gives a standard criterion for R&D sensors of maximum 0.3% linearity error.
All piezoelectric sensors go through a lifetime cycle, see Figure (a).

1) It starts with a settling phase where normally an improvement of linearity happens. The settling of the sensors occurs during the standard run-in procedure on the test engine at the AVL headquarters.
2) A further minor settling 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) Calibrations 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.



Options to calibrate a sensor

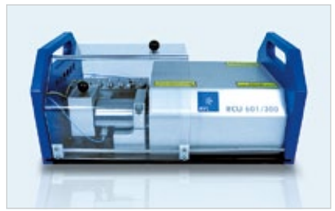
Pressure sensors can be calibrated upon request directly at AVL. Another possibility is the in-house calibration with an own calibration device. The main criterion for an internal or external calibration depends on the expected number of calibrations per year. The situation is for every customer very individual. A calibration directly at AVL has the advantage that the customer does not have to spend any manpower and investment for calibration equipment. On the other hand the in-house solution allows the customer independent calibrations at any time, instantly. Regarding costs, Figure (b) shows the total costs over the number of calibrations. (1) Developing costs in the case of sending the sensors to AVL for calibration. For every single calibration a fixed price will be charged. (2) Scenario of buying a calibration unit for calibrating sensors in-house. The inertial costs are high due to the investment in the calibration unit. After this the costs per calibration are much less. The point where these two graphs cross each other represents a number which can be taken as an orientation when an in-house calibration system becomes more economical than using a calibration service.

Repair of pressure sensors

A typical repair procedure contains optical control, insulation check and calibration. Eventually single parts as piezoelectric cable or cooling nipple are exchanged. If necessary a dynamic test on the engine is done.

RAMP CALIBRATION UNIT

RCU 601/300



Three main factors are important for choosing a calibration process:

- How much time is consumed until a non calibrated sensor can be used again?
- 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?

These factors define the demand for a calibration unit which:

- allows to calibrate and check quickly within a few minutes
- gives fixed costs per year independent from the number of calibrations needed
- guarantees permanent optimum performance due to certified calibrations

To cover all these requirements AVL developed an automated system for certified heated calibrations up to 250 °C and pressures up to 300 bar. It is called Ramp Calibration Unit RCU 601/300. To increase the speed of the calibration process this new system has the option to measure up to six different sensors simultaneously. A computer controlled spindle generates a changing hydraulic pressure to the sensors under test and 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 entry in the SDB Sensor Database. This ensures a quick and organized calibration procedure which guarantees that calibration data are not mixed up between different sensors.

Benefits at a glance

- The system allows fully automatic operation - no manual spindle operation is needed to apply the pressure
- Up to 6 sensors can be calibrated at once which reduces the necessary time of calibration procedures
- Cold and hot calibration is possible with one system
- Temperature isolated 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

Recommended configuration	
RCU 601/300 (230V)	Art.No. TI0SDMRCUA.01
RCU 601/300 (110V)	Art.No. TI0SDMRCUA.02
Adaptor to mount sensor (max. 6)	Art.No. TI0SDMADAP.01
NIDAQ-USB 6210	Art.No. TI0SDMDATA.01
MicroIFEM	Art.No. TI04PIEZA.03
Notebook with installation	Art.No. TI0620PCB.01
Reference sensor GU21C Select	Art.No. TIGG1492A.01
Mounting tool for the reference sensor	Art.No. TIWG0128A.01
RCU Comissioning	Art.No. TI0SDMCOMA.01

Accessories	
Adaptor to mount one sensor	Art.No. TI0SDMADAP.01
Upgrade to a hot calibration system	Art.No. TI0SDMOHCA.01
Commissioning of the system	Art.No. TI0SDMCOMA.01
NIDAQ-USB 6210	Art.No. TI0SDMDATA.01
MicroIFEM	Art.No. TI04PIEZA.03
Notebook with installation	Art.No. TI0620PCB.01
Mobile cabinet for RCU	Art.No. TI0600TROB.01

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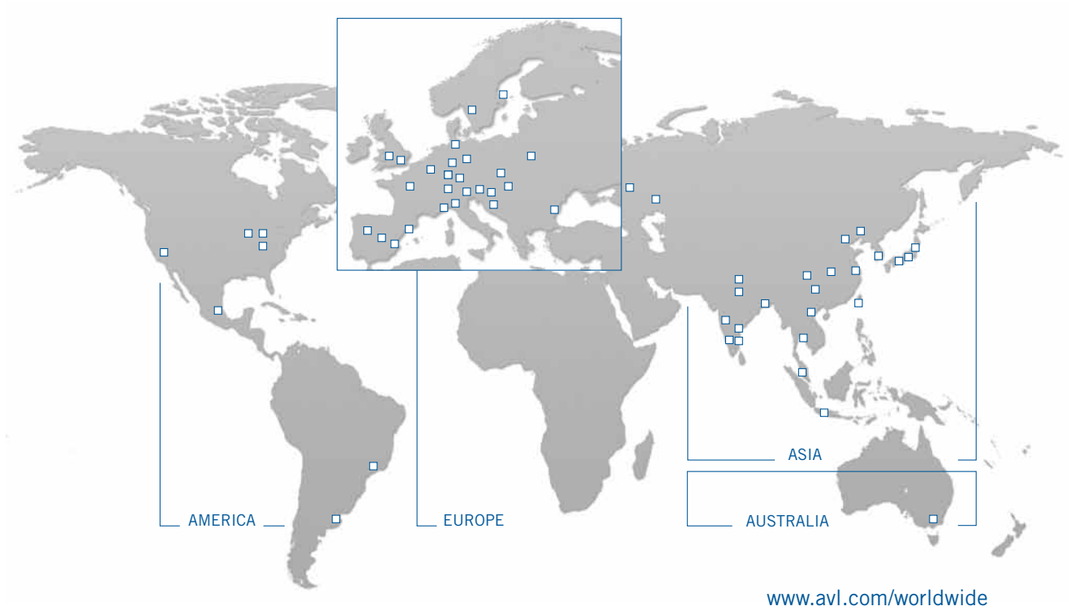

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