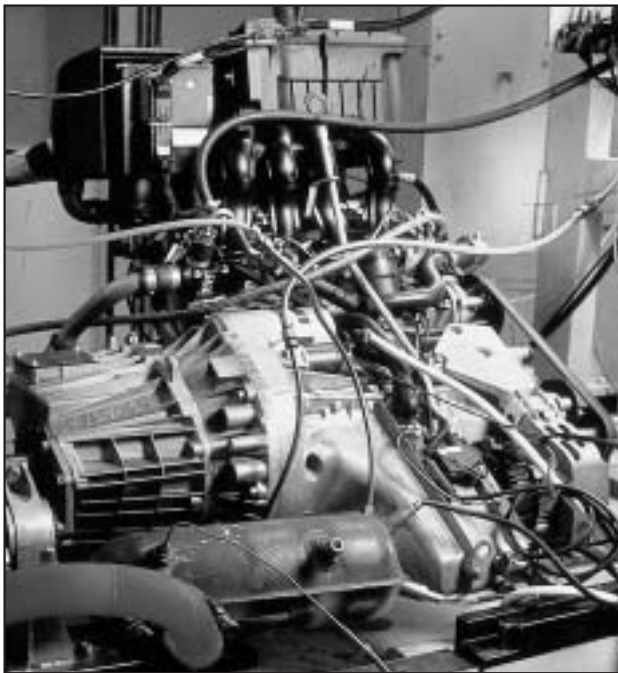


eddyNCDT

Eddy Current Displacement Sensors are Making a Major Contribution to the Development of Internal Combustion Engines

In order to improve the design of internal combustion engines and to analyse failure, it is necessary to measure the thermal and mechanical stress inside the engine. These measurements need to be made under real operating conditions in order to provide significant results. In both normal (running) and motored engines, the measuring system is exposed to the most severe environmental conditions:

- High temperature
- Environment with oil, fuel-air mixture, combustion gas or cooling water
- Vibrations
- High pressure



Non-contact displacement sensors using the eddy current principle have proven their value for measuring displacement, position and gap. Measurements which, a few years ago, were considered impossible, can now be performed successfully. The key to this is the robust and accurate eddyNCDT displacement measuring system with miniaturized sensors. We have customized the sensors in many ways and even designed the world's smallest sensor especially for this measuring task. The eddy current measuring technique, as it is used in the eddyNCDT system, measures against all electrically conductive materials (metals) with high linearity and temperature stability. The target can be non-ferromagnetic or ferromagnetic.

eddyNCDT eddy current sensors measure the internal dimensional changes inside a running engine. Picture: DaimlerChrysler AG

NON
APPLICATION

A109e

Sensors based on eddy current principle for eddyNCDT 3300/3500

The excellent immunity to severe environmental conditions of the eddy current measuring technique makes it possible to use this type of displacement sensors in running combustion engines. Lubricating oil, fuel or combustion gas in the measuring gap or next to the sensor have a negligible effect on the measuring results even under the most difficult conditions. A non-contact sensor system allows to measure very fast changes in displacement (100,000 Hz) without affecting the target and no wear.

Eddy current displacement sensors are installed at various positions in the internal combustion engine.

Sensors in stationary engine parts can be installed very easy. Routing of the sensor cable poses no great problems here. Examples of such applications are:

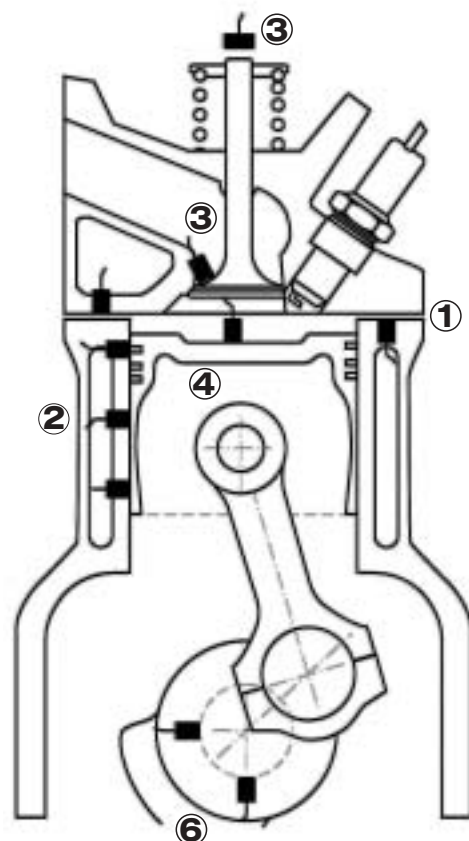
- 1 - Distance cylinder block to cylinder head
- 2 - Distance of the piston or the rings from the cylinder wall or sleeve
- 3 - Valve travel/valve seating
- 4 - Top dead centre of the piston
- 5 - Injector needle movement in the injection pump
6. Run out in the main crankshaft bearing

The installation of miniaturized eddy current displacement sensors in internal combustion engines takes know-how, skill and time. But it's worth the effort because these sensors provide reliable data on the mechanical conditions of the engine. Renowned international companies put their trust in MICRO-EPSILON eddy current sensors:

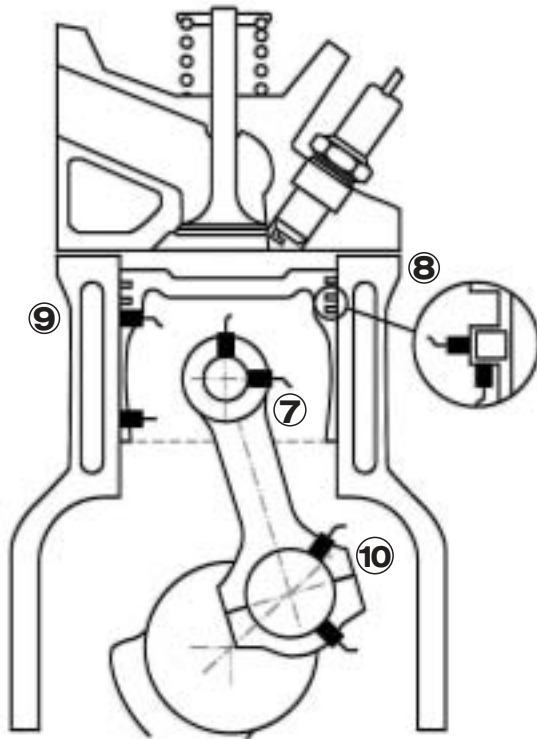
- | | |
|-------------------|--------------------------------|
| - DaimlerChrysler | - GM |
| - Detroit Diesel | - IAV Chemnitz |
| - Dr. Schrick | - John Deere |
| - FEV | - Technical University München |
| - Ford | - Victor Reinz |



Miniaturized version of the eddy current sensor



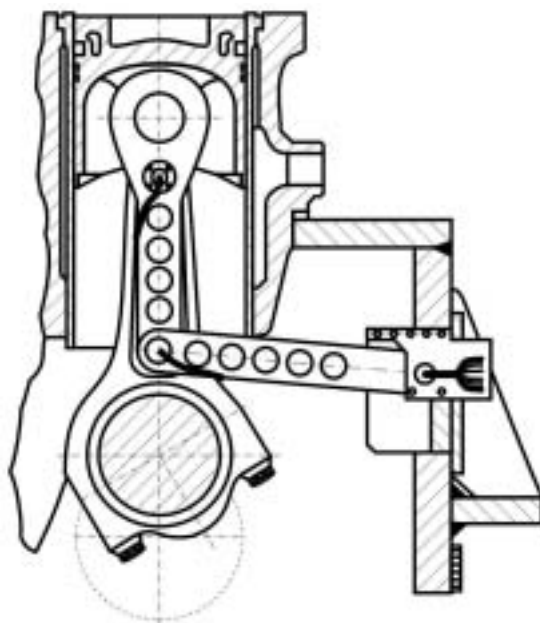
Sensors in stationary engine parts



Sensors in moving engine parts

Examples of application for moving sensors:

- 7 - Orbit tracing of the gudgeon pin in the upper con-rod bearing
- 8 - Axial and radial movement of the piston rings in the piston groove
- 9 - Position of the piston relative to the cylinder wall during the whole stroke of the piston (piston secondary movement)
- 10 - Orbit tracing and vibrations in the bottom con-rod bearing



Cable routing with crank arm

Installation of displacement sensors in moving engine parts (pistons, con-rod, crankshaft) is a little bit more difficult. The problem is the transmission of signal from the moving part to the stationary engine block. Transmission by slip rings or RC can not be used because of dimensional problems. Such a device requires modifications of the sensor cable. This will affect the measurement results as the sensor cable is a part of the sensor circuit. A suitable solution for the cable routing is the use of a special crank arm. One end of the crank arm is attached to the piston rod or at the upper con-rod eye and moves up and down. The other end is fixed to the engine block. From there it is easy to continue routing the cable to the amplifiers. The critical point for cable routing and for the cable stressing is in the central joint of the crank. At the joints the cable are led through the centre axle eye and therefore only exposed to torsional movement. Special Teflon-insulated coax cables with an extreme small outer diameter are used for routing along the crank arm. A crank arm designed in this way and carefully installed increases the life cycle of the cable and is therefore suitable for extensive series of measurements.

eddyNCDT: Non-contact eddy current sensors for applications in combustion engines

- Wear and maintenance free
- Sensors are resistant to severe industrial environments
- Accurate and stable operation:
- Non-Linearity $\pm 0.2\%$
- Reliable results even from very fast events: frequency response 100 kHz (-3 dB)

Features of the series eddyNCDT.



Piston installed with displacement sensors with con-rod and "crank-arm" for guiding the cable.

System Structure Series 3500

The series 3500 multi channel displacement measuring system is modular. All plug-ins are euro-size cards.

A measuring system with n channels includes:

- 1 Eurocard cabinet with power supply
- 1 Display /Interface-plug-in (optional)
- 1 Oscillator plug-in
- n Demodulator plug-ins with matching board
- n Sensors with cable



eddyNCDT: Non-contact displacement measuring systems using the eddy current principle.

System Structure Series 3300

The series 3300 non-contact displacement measuring system is a single-channel system with an electronics in a compact aluminium housing.

It consists of:

- 1 Oscillator plug-in
- 1 Demodulator plug-in
- 1 Matching board
- 1 Sensor
- 1 Interconnecting cable

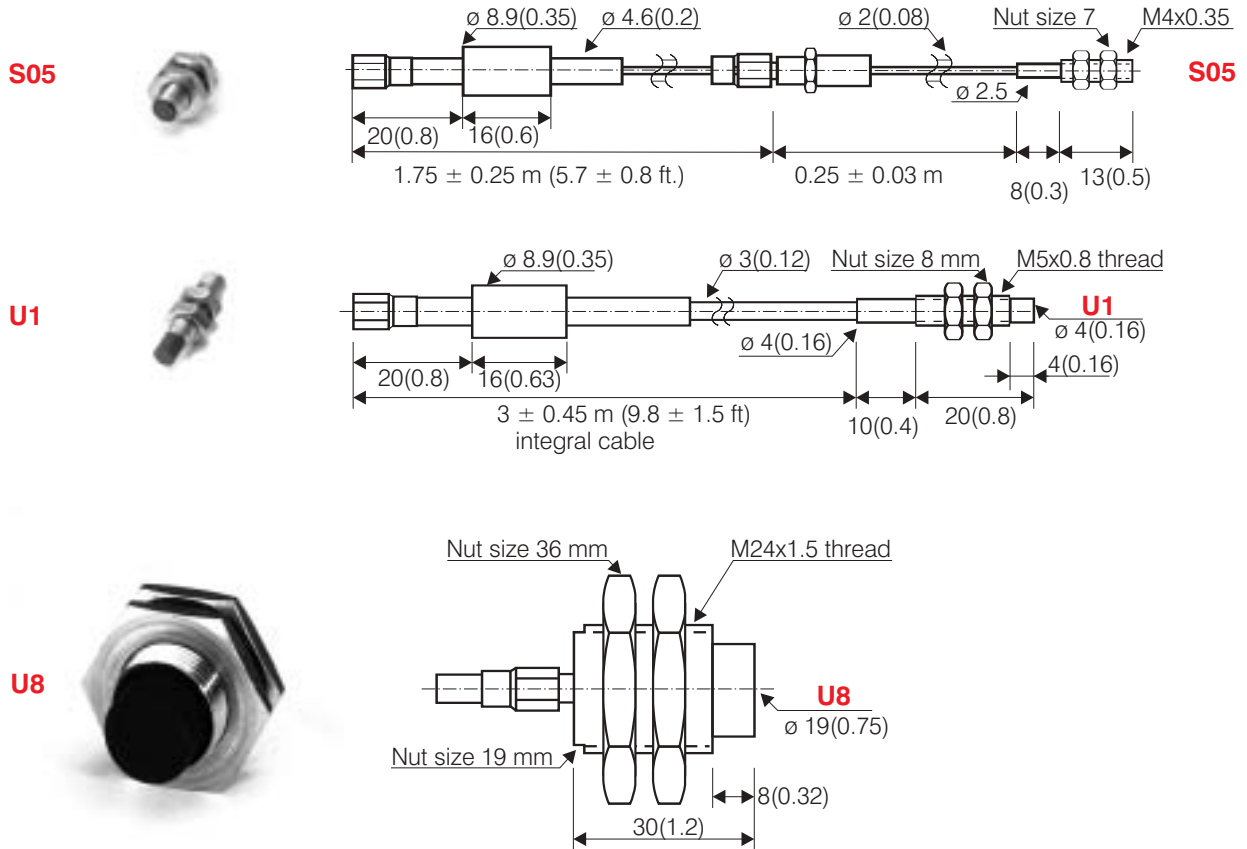
For more information about our product range, technical data visit our web site:

www.micro-epsilon.com

Certified acc. to
DIN EN ISO 9001: 1994



Sensor dimensions in mm (inch)



Technical data

Sensor model		S05	U1	U8
Measuring range	mm	.5	1	8
	inch	.020	.039	.315
Extended measuring range	mm	.7	2	13
	inch	.028	.079	.512
Offset distance non-ferromagnetic	mm	.025	.1	.8
	inch	.001	.004	.032
Offset distance ferromagnetic	mm	.05	.2	1.6
	inch	.002	.008	.064
Linearity 0.2 %FSO	$\pm \mu\text{m}$	1	2	16
Static resolution 0.01%FSO	μm	.05	.1	.8
Dynamic resolution 0.2 %FSO	μm	1	2	16
Temperature range Sensors and cables		-50 to 150 °C / -60 to 300 °F		
Signal output		Demodulator DL 500/ DL504: 0-10 V Demodulator DL 501/ DL505: 4-20 mA		

Special sensor options

Sub-Miniature pressure resistant displacement sensor U05(65)

The displacement sensor U05(65) offers high precision in severe environment. Its measuring coil is integrated into a sub-miniature ceramics housing. A O-ring sealing enables pressure proof operation. At static pressure tests to the sensor front face, up to 2000 bar have been successfully applied for short term. Cable routing is very simple due to miniature cable with just 0.5 mm outer diameter.



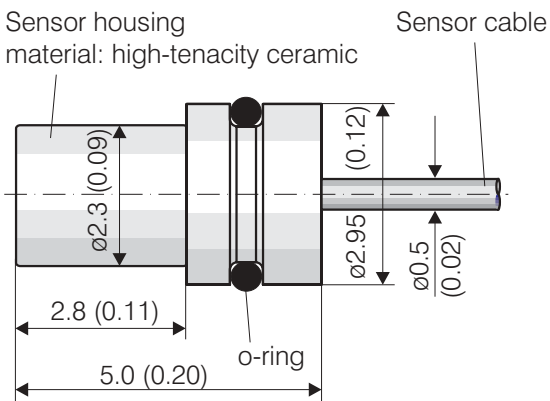
- Sub-miniature design
- Pressure proof housing
- Operation in severe environment
- High precision measurement
- Measuring range 0.5 mm
- Linearity $\pm 0.2\%$ FSO
- Resolution 0.01 % FSO

Sensor U05(65) features with series 300 or 500 electronics

Areas of use

The environmental stable eddy current principle offers a wide variety of applications, especially in combustion engines

- Measurement of fuel injection needle movement



Sensor dimensions in mm(inch)

Shielded non-contact displacement sensor S 05/180(17)

The special design of the eddy current displacement sensor is suitable for a flush installation in metal surfaces. The maximum operating temperature is increased up to +180 °C (356 °F). Because of the small size, this sensor can be used under restricted installation conditions without sacrificing reliability and accuracy. The sensor is connected via a miniature coaxial cable to a small transition pc-board with standard coaxial cable extension. The front part of the sensor consists of ceramics which is potted in a cylindrical steel housing (M4 x 0.35) with epoxy resin. The small size doesn't allow to build a complete cable relief at the sensor. Therefore it is necessary to provide mechanical support for the cable immediately behind the sensor.



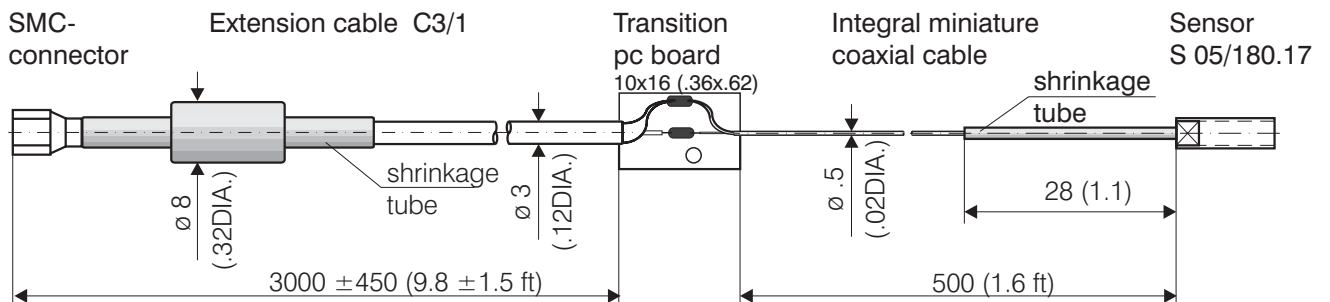
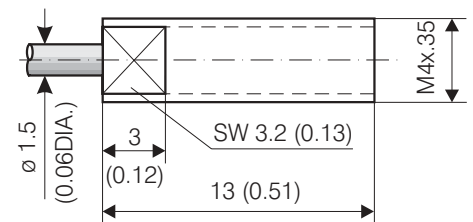
Areas of use

- Measurement of radial and axial motion of shafts
- Piston motion in the cylinder
- Measurements of gasket gap and lubricating gap
- Acquisition of valve movements
- Nozzle needle stroke in injection pumps

- Non-contact measurement under operating conditions
- Flush installation in a metal surfaces
- Environmental stable
- μm -accuracy
- High measuring speed
- Temperature stability up to +180 °C (356 °F)

Sensor
S 05/180(17)
features

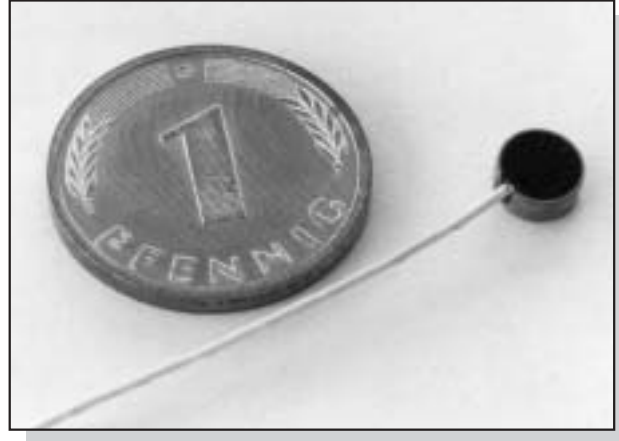
Sensor S05/180(17)
not to scale, mm(inch)



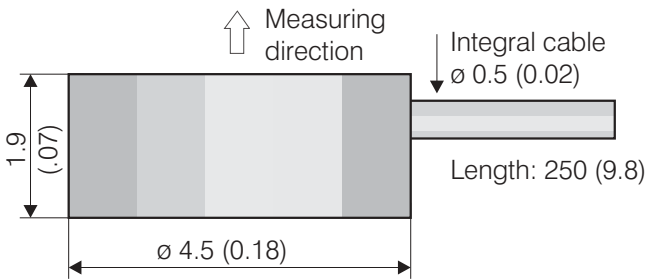
Shielded non-contact displacement sensor S 05/180(16)

Application example

Gap measuring in an operating combustion engine between cylinder block and cylinder head. Mounting in the cylinder head or engine block.



Sensor dimensions in mm (inch)



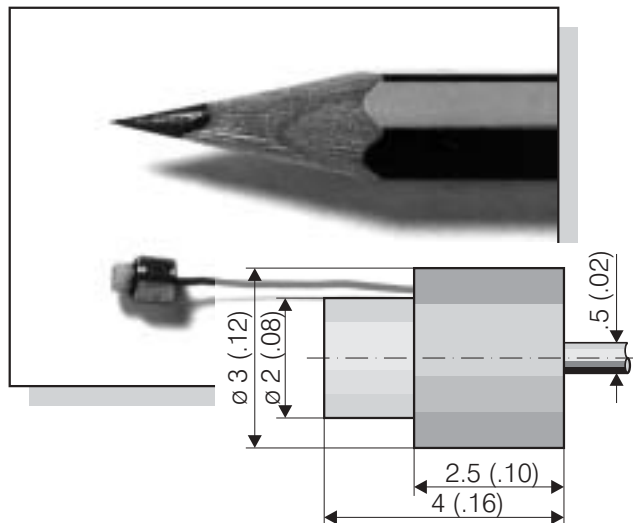
The special features of the sensor S 05/180(16)

- Non-contact measurement under operating conditions
- Flush installation in metal surfaces
- Environmental stable
- μm -accuracy
- High measuring speed
- Temperature stability up to $+180\text{ }^{\circ}\text{C}$ ($356\text{ }^{\circ}\text{F}$)

Unshielded non-contact displacement sensor U 05(08)

Areas of use

- Piston motion in the cylinder
- Acquisition of piston ring motion
- Measurement of gasket gap and lubricating gap
- Acquisition of valve movement
- Nozzle needle stroke in injection pumps
- Measuring radial and axial motion of shafts



MICRO-EPSILON MESSTECHNIK GmbH & CO. KG