Pressure Metrology.
Diaphragm- and Sensor Technology.

Absolute-, Relative- and Differential Pressure.

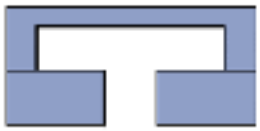
With the steam age came the demand for pressure measuring instruments. Bourdon tubes or bellows, where mechanical displacements were transfered to an indicating pointer were the first pressure instruments, and are still in use today.

Pressure metrology is the technology of transducing pressure into an electrical quantity. Normally, a diaphragm construction is used. In piezoresistive and in thin- or thick film technology, resistors are fixed onto a pressure diaphragm. Under the pressure-induced strain, the resistors change their value (strain gauges). In capacitive technology, the pressure diaphragm is one plate of a capacitor that changes its value under pressure-induced displacement.

Pressure sensing using diaphragm technology measures the difference in pressure of the two sides of the diaphragm. Depending on the reference pressure, we use the following terms:

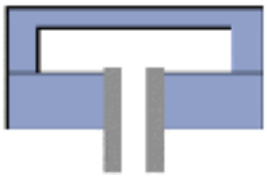
Absolute Pressure

Measurement referenced to a sealed, mostly an evacuated, volume.



Relative (Gauge) Pressure

Measurement referenced to atmospheric pressure.



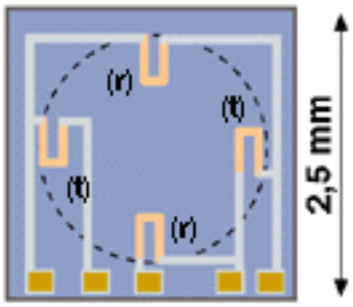
Differential Pressure

With 2 pressure ports for differential measurement of two pressures.

The Piezoresistive Pressure Sensor. The Silicon Cell.

The sensor consists of a micro-machined silicon diaphragm with piezoresistive strain gauges diffused into it, fused to a silicon or glass backplate.

The resistors have a value of approx. 3,5 kOhm. Pressure-induced strain increases the value of the radial resistors "r", and decreases the value of resistors "t" transverse to the radius. This resistance-change can be as high as 30%. The resistors are hooked up as a Wheatstone bridge. The bridge output is directly proportional to the pressure.



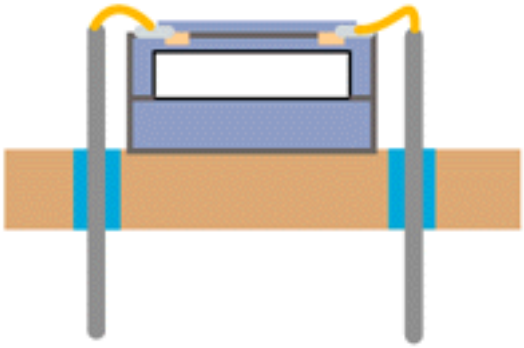
Leadouts from the Bridge

Two leadout methods are used:

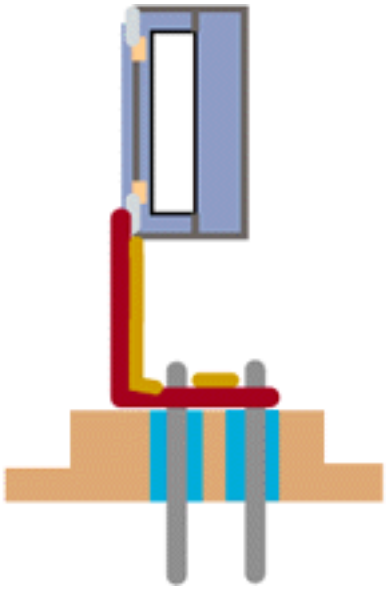
- Gold- or aluminum wires are welded to the aluminum contacts on the chip and to the glass feed-through, pins of the header.

- TAB (Tape Automated Bonding). The contacts on the chip have a gold dot. A pretinned flexible printed circuit is directly soldered to these gold dots and the other end to a PC-board or the header.

In the first method, the sensor must be fixed on the header. The TAB printed circuit, however, holds the sensor in place itself.



Cells on glass feed-through header with gold wires



Cells on glass feed-through header with TAB

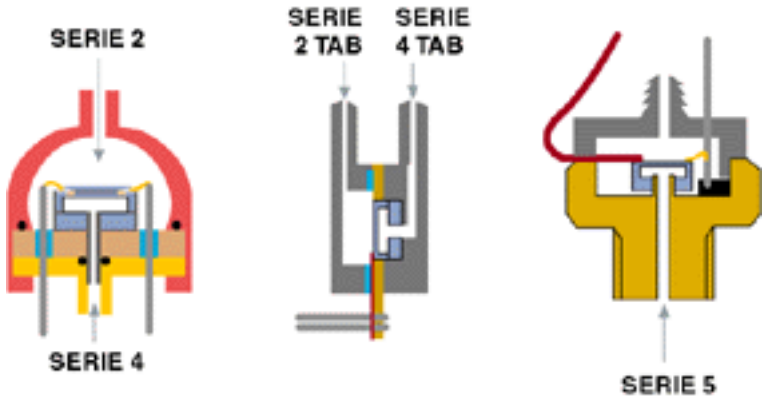
Low Cost Sensors

Low Cost Sensors are devices where the sensors are exposed to the media without protection. The Series 2, 4 and 5 are such sensors.

In Series 2 and 4, the glass feed-through and the silicon cell is mounted in a plastic housing with pressure ports for positive pressure (Series 2); and positive and negative pressure (Series 4).

In Series 2 TAB and Series 4 TAB, the silicon sensor with the TAB print is fixed between two plastic mouldings with pressure ports.

In the Series 5, the silicon sensor is bonded to a brass pressure port. The contacts are made either by gold wires to soldering pins, or by TAB flexible printed circuit.



Series 2: Pressure acting on front of chip: for dry media only.
Series 4, Series 5: Pressure acting on back of chip: suitable for wet media also.

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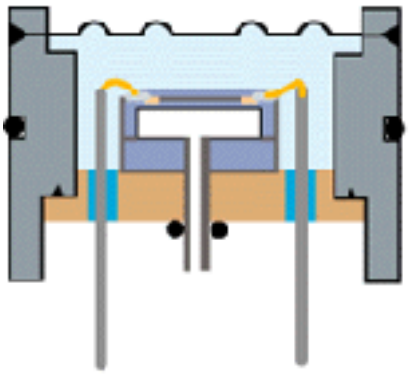
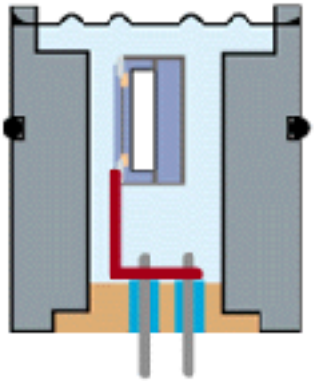
Pressure Sensor Technology and -Terminology.

The Piezoresistive OEM Pressure Transducer

The silicon sensor on the glass feed-through is mounted in a stainless steel housing, isolated by a thin stainless steel diaphragm and filled with silicone oil. The pressure acts on the diaphragm and is transfered through the oil onto the sensor. The OEM transducers are fully tested for temperature and linearity and the compensation resistor values given on the individual test sheets.



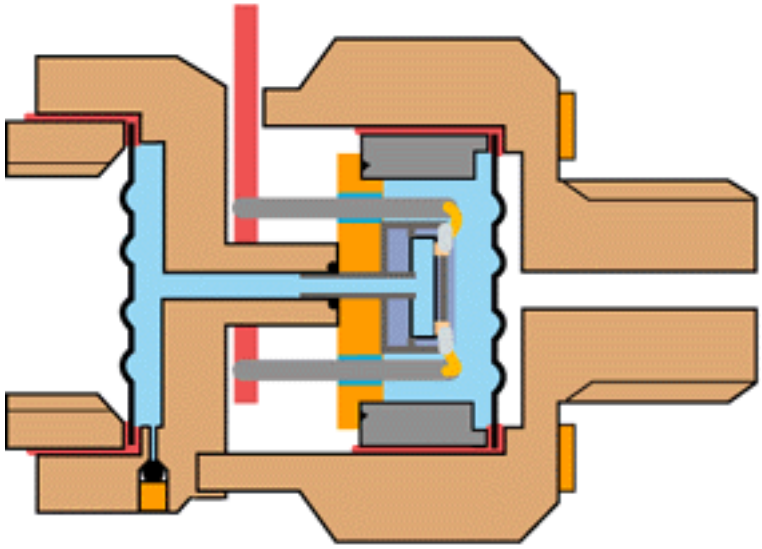
Series 9
(ø 19 mm)



Series 8
(ø 15 mm TAB)

Low Cost Transducers

Nickel diaphragms in brass housings brazed under high temperature (Series 6 M) or brazed steel diaphragms in steel housings (Series 6 S) nowadays allow the fabrication of isolated pressure sensors with low production costs, without substantially limiting the applications.

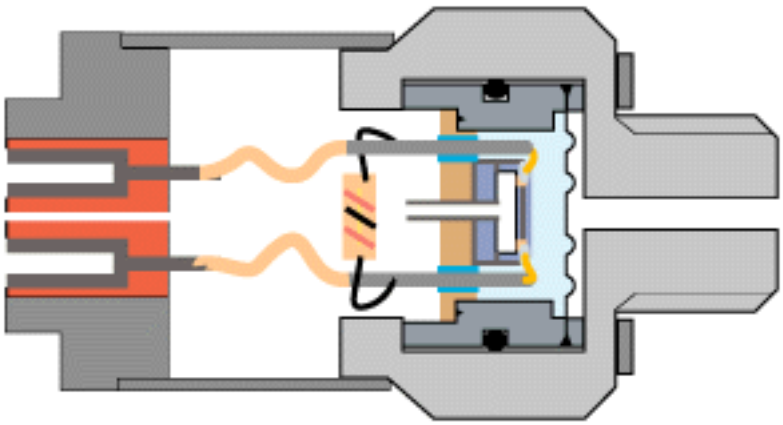


Isolated Pressure Sensor in Brass Housing
Differential Pressure Transducer wet/wet

Pressure Transducers

Pressure transducers are pressure measuring instruments, ready to use. It is an OEM transducer with pressure port, integrated compensation resistors and a cable or plug.

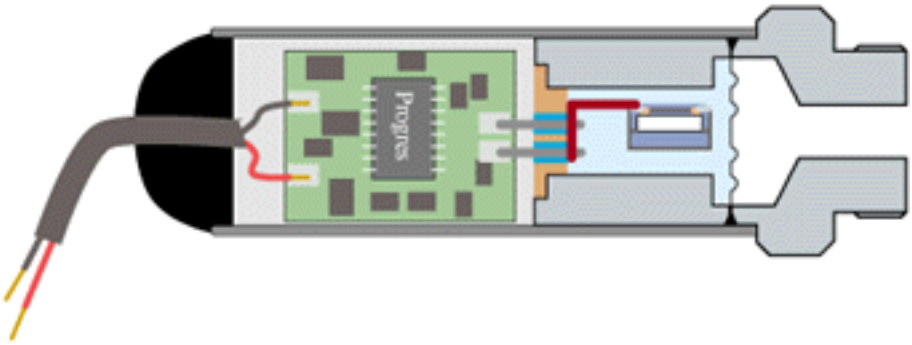
Transducers give an unamplified signal into a seperate instrumentation amplifier or indicator. They can be considered as passive bridges, interchangeable between different manufacturers.



Series 11 Transducer (relative)
Compensated, with Plug

Pressure Transmitters

In pressure transmitters, the full signal conditioning is integrated in the housing. The sensor signal is conditioned into standard output signals of 0...100 mV, 0...10 V, 0,5...4,5 V, 4...20 mA. Normally, the signal is independent from the excitation (i.e. 8...28 V), but in ratiometric transmitters, the signal is proportional to the excitation.



Series 21 Transmitter
Absolute, sealed, with Cable

The accuracy of a transmitter is best described by an error band. The error band covers all errors over the full pressure and temperature range. Typical errors are also given. The typical error describes the accuracy which one can normally expect in a measurement.

Instruments are classified by the error band at room temperature, which includes zero and span offsets, linearity and repeatability.
KELLER has three basic classes of transmitters. The error bands and typical errors for the three classes are listed in the table (below).

For EMC-protection, an additional circuit is included in the housing.

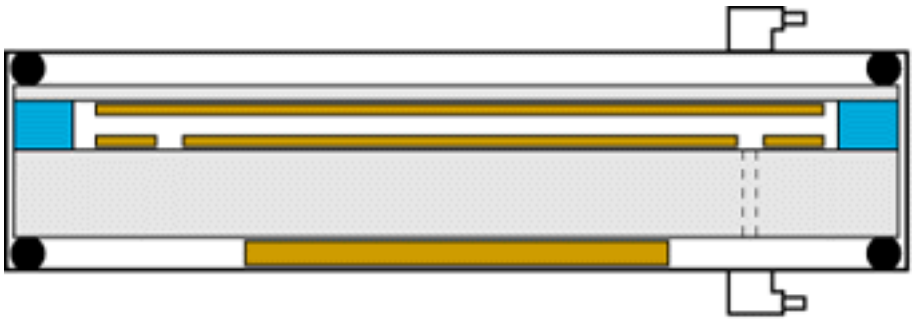
CLASSE		1,0%	0,5%	0,1%
SERIES		21R/21M	21/23/25/26	53/55/56
18...22°C	max.	1,0 %	0,5 %	0,10 %
	typ.	0,5 %	0,3 %	0,05 %
0...50°C	max.	2,0 %	1,0 %	0,10 %
	typ.	1,0 %	0,6 %	0,05 %
-20...80°C	max.	4,0 %	2,5 %	0,20 %
	typ.	2,5 %	1,5 %	0,10 %

Capacitive Transmitters

For pressure in the mbar ranges, a strain gauge diaphragm sensor is technically unsuitable. A large diameter capacitive sensor solves this problem.

KAVLICO / USA is a manufacturer of such sensors in very large numbers for automotive applications, where class 2% accuracy is sufficient.

KELLER utilises this very stable sensor and is manufacturing pressure transmitters of very high accuracy for industrial applications.



Construction of a Capacitive Ceramic Cell

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