



Media-compatible differential pressure transmitters - D5100 - construction and applications

With a large variety of possible measurement media and their diverse chemical reactivity, media-compatible pressure sensors make great demands of materials and construction. For many years, sensors made of stainless steel have proved effective where the measurement medium is separated from the silicon pressure sensing element by an oil seal. As a rule, these sensors are only suitable for the measurement of absolute and relative pressure. Taking D5100 as an example, this article aims to illustrate that media-compatible differential pressure sensors can also be made on the basis of this construction.



Double sided media-compatible differential pressure transmitter D5100 for measurement of liquids and critical medias e.g. for level control in chemical and pharmaceutical applications

Figure 1: D5100 Differential pressure transmitter

Media-compatible pressure transmitters for the measurement of relative and absolute pressure

Most modern pressure sensors are based on a silicon sensing element (silicon pressure die) which is mounted on a substrate (Figure 2). For the purpose of substrate bonding the



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upper membrane surface of the silicon sensing element has several small metal surfaces (bonding pads) made of refined aluminum that is not corrosion resistant. After very thin gold wires (wire bonding) have been attached, these contact pads are covered with soft silicone gel for protection. There are gels that provide relatively sufficient protection against water, oil- or alcohol-emulsive liquids for example, but there is no gel that guarantees universal protection against all kinds of media.

Another disadvantage of gel material is its hygroscopic behavior, for instance. Through direct contact with liquids or through condensation moisture can be stored in the gel that in time diffuses through to the silicon layer. When it does, this moisture not only causes corrosion but also a high impedance between the wires connected at various potentials. This can distort measurement values.

For the reasons given above, sensing elements with a gel cover thus cannot be used to measure liquids or aggressive gases – or if they can, then only under very limited conditions.

This obvious disadvantage of the pressure die can be avoided to achieve the required media compatibility by mounting the sensing element in a pressure-sensitive chamber filled with oil (*Figure 3*).

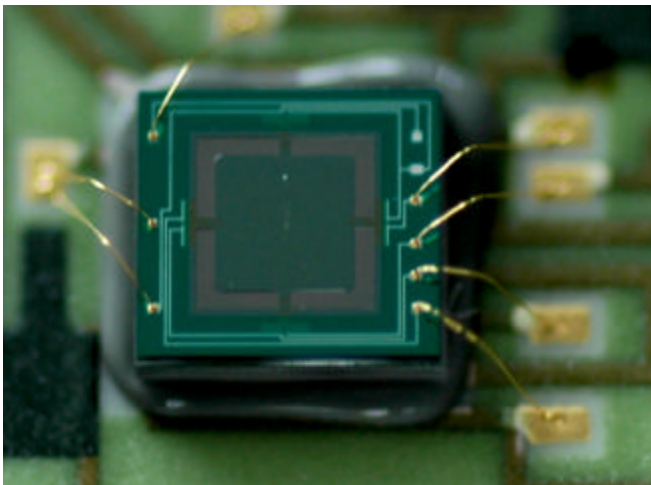


Figure 2: silicon pressure sensing element bonded with gold wire

The stainless steel chamber (e.g. 316L) is sealed by a thin separating diaphragm, which is also made of stainless steel. This is deformed when pressure is applied. As the space between the pressure die and the separating diaphragm is filled with oil the induced pressure on the membrane is transferred and inside the sensing element converted into an electrical signal. The oil in the metal chamber has been selected so that it is inert to the silicon sensing element. No chemical reaction thus takes place.

As most media - from water, oils and solvents through alcohols, fuels and caustics to moderately aggressive liquids - do not corrode the chamber with the separating diaphragm, sensors with oil seals can be used in all applications where the pressure is measured in media that are compatible with such stainless steel.



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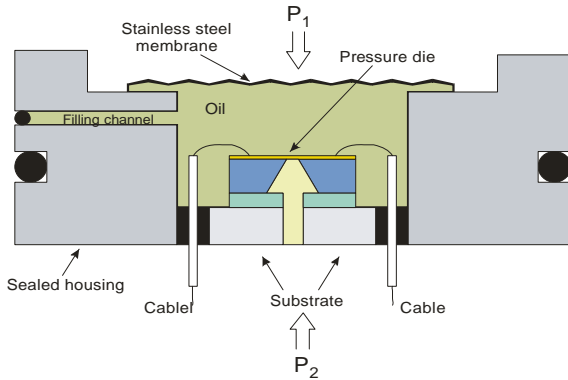


Figure 3: pressure sensor with an oil seal for the measurement of relative pressure

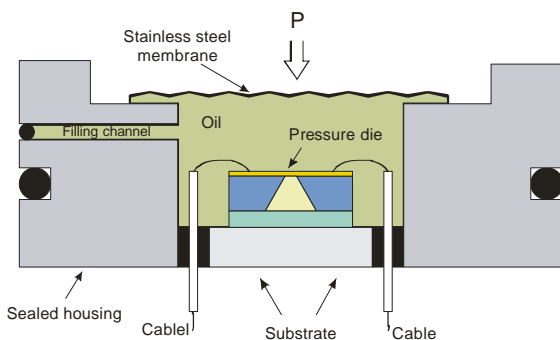


Figure 4: pressure sensor with an oil seal for the measurement of absolute pressure

Description of D5100

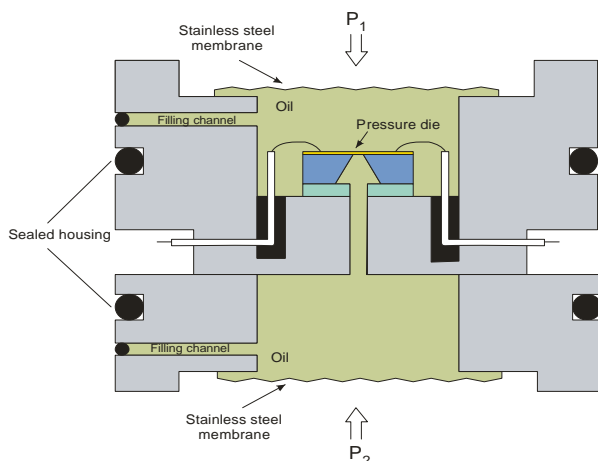


Figure 5: Double-chamber differential pressure transmitter D5100

Most media-compatible pressure transmitters for relative pressure measurement are designed as shown in *Figure 3*. (measurement pressure = P_1 , ambient pressure = P_2 .) The topside of the pressure die is protected by the chamber with the oil seal, the underside not. As the materials on the underside are uncritical to air or even humidity, sensors like these can be used to measure relative pressure in relation to saturated ambient air, for example, without any media problems.

The sensing element design and downstream electronics stipulate that in most cases $P_1 = P_2$ must apply.

Measurement of absolute pressure (see *Figure 4*) is also not critical for sensors filled with oil as the reverse side of the sensing element is sealed in a vacuum and not exposed to any medium.

Media-critical measurements of differential pressure cannot be made with single-chamber sensors such as these, however.

Using a relative pressure sensor with one oil-filled chamber as a basis (*Figure 3*), in the D5100 series the reverse side of the pressure die is also protected by a chamber with steel membrane. This second chamber is exposed to pressure on the reverse. This means that the pressure-sensitive silicone membrane sits between the two chambers and measures the difference between the oil pressures applied on both sides. (*Figure 5*)



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The suitable design leads the voltage signal of the resistance bridge of the pressure die out of the device, where it is processed electronically.

The devices in the D5100 series have been designed as genuine double-chamber transmitters where all media-relevant areas are made of stainless steel. They can therefore measure the differential pressure in all liquids or gases which are compatible with this metal.

This double-chamber pressure transmitter is beside many industrial applications suitable for the food industry, for chemical and pharmaceutical measurements, for medical engineering and for applications in the field of energy supply.

Thanks to the double-chamber construction the transmitter are able to measure the liquid level in closed tanks (see *Figure 6*). If there is a gas and a liquid in the tank and the gas should have no contact with the environment the difference between the pressure of the gas and the pressure of the liquid will correspond to the liquid level.

What's remarkable about this type of stainless steel transmitter is the low pressure range of 1 psi (\sim 70 mbar), which makes special demands of the stainless steel membrane and oil filling. This permits level measurement in closed tanks with a fill level of 70 cm, for instance. The system pressure may equal 70bar in all models in the D5100 series (line pressure versus atmospheric pressure).

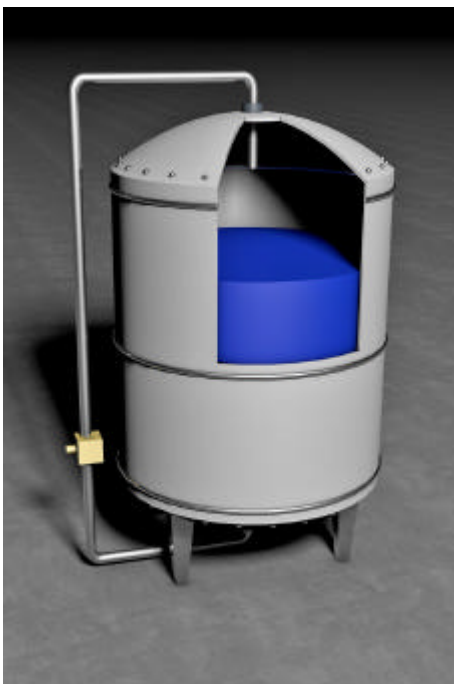


Figure 6: level measurement in closed tanks

The calibrated sensors in the D5100 series surpass the CE directives for heavy industry and are certified accordingly (IEC 61000). They are supplied in a number of models for the following pressure ranges: 0–1, 0–5, 0–15, 0–30, 0–50, 0–100, 0–300 and 0–500 psi (alternatively also in bar).

These robust transmitters can withstand shocks of up to 50 g and vibrations of up to 20 g. They are designed for an extended temperature range of -40°C to $+125^{\circ}\text{C}$ and can thus be used in extreme temperature areas.

D5100 differential pressure sensors come with a large number of different pressure ports and different electrical connections. They are offered with various industrial analog outputs (not amplified: 80mV and amplified: 0.5–4.5V (ratio metric), 1–5V and 4–20mA (for two-wire operation)).



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CONCLUSION

The devices in the D5100 series are genuine, double-chamber, differential pressure transmitters with a compact design which are largely media compatible and can be used for critical pressure measurements. Possible applications for the D5100 range from filter control and flow metering to level measurement in liquid and gaseous media (pressure tanks). The many variations and compact design of this device allow D5100 sensors to be utilized in most industrial plants.

Further reading

[1] D5100 datasheet: http://www.amsys.de/sheets/amsys_d5100.pdf