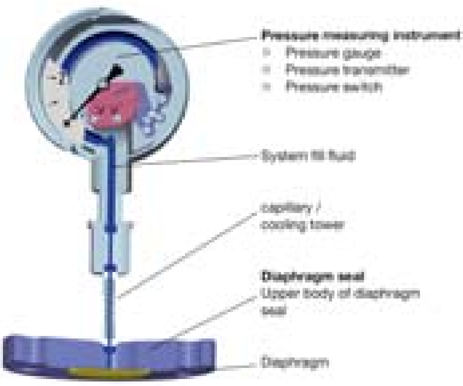
Diaphragm seal systems for safety applications

Reduced risk

Diaphragm seals enable measuring instruments for pressure, differential pressure and absolute pressure to be adapted to even the harshest of tasks. They come in many designs, are compatible with the majority of pressure measuring instruments and can be made of various highly resilient materials. Although a SIL classification is not possible for diaphragm seals, since they only contain mechanical components, safety values are available for Wika seals.

Using components of excellent quality is a prerequisite for preventing risks to persons, the environment and property. Reliable components in instrumentation and control technology (I&C) safeguard critical processes in the chemical industry. Such components are generally referred to as protective circuits, safety circuits or safety functions.

The required safety-relevant characteristics of the components used are currently specified, for example, in the IEC 61508 (Functional safety – General) and IEC 61511 (Functional safety in the process industry) standards. Amongst other things, these standards define the term Safety Integrity Level (SIL). The failure rates of a component are determined by the manufacturer and made available to the user. An essential tool in this context is FMEDA (Failure Modes, Effects and Diagnostic Analysis). It facilitates a joint assessment of the statistical values of individual components and their functional correlations. The results are quantified data on the reliability and probability of failure of the components. In order to describe this data with respect to diaphragm seal assembly, an explanation of the functional principle is needed.



Diaphragm seal mounted to a pressure gauge via a capillary

Principle of a diaphragm seal system

By using diaphragm seals, pressure measuring instruments can be adapted to even the harshest of conditions within process industries. A diaphragm made of the appropriate material separates the pressure medium from the pressure instrument, while a suitable liquid (chosen to suit the particular application) transmits the pressure to the instrument's sensing element. The process side of the seal is isolated by a flexible diaphragm. The space between the diaphragm and the pressure measuring instrument is completely filled with a system fill fluid. The process pressure is transmitted by the elastic diaphragm into the system fill fluid and from there, hydraulically, to the measuring element of the pressure measuring instrument, such as a pressure gauge, transmitter or pressure switch. The pressure can be reliably determined in this way. The diaphragm seal can be mounted to the measuring instrument via a rigid connection or

IPT-10 process pressure transmitter with a diaphragm seal. The diaphragm is made of tantalum.

Diaphragm seal with extended diaphragm

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Characteristic safety values

Diaphragm seal design	*l_{DU} FIT*
Standard design, such as diaphragm seal with flange or threaded connection	*26*
Special design, such as diaphragm seal with extended diaphagm or diaphragm in-line seal	*45*
Special diaphragm seal with internal diaphragm	*100*

** l_{DU} = Failure rate dangerous undetected; FIT = Failure in Time*

a flexible capillary. A cooling element can be fitted between the seal and the instrument for high temperatures.

Diaphragm materials

Corrosion-resistant 316L stainless steel (1.4404 / 1.4435) is used as the standard diaphragm material. If this material does not have sufficient resistance against attack from specific media, all wetted parts can either be covered or coated with plastic, e.g. PTFE, ECTFE, etc. A further option would be to use the Wikaramic ceramic coating as lasting protection against abrasion.
For particularly critical applications, diaphragms can be manufactured from special materials such as tantalum or Hastelloy C. There is then no problem using such a measuring assembly at extremely high permanent temperatures up to +400 °C. The only limitation comes from the maximum operating temperature of either the system fill fluid or the special material. Users have more than twenty different special materials to choose from. The most common special materials for diaphragm seals in chemical and petrochemical applications are Hastelloy C4, Hastelloy C276, tantalum and Monel 400.

Safety values

IEC 61508 applies to all applications of electronic systems whose malfunction could have a massive influence on the safety of persons, the environment and equipment. The safety requirement is calculated in accordance with the probability of occurrence of a damaging event and its potential impact. The higher the expected extent of the damage and the higher its probability of occurrence, the higher the classification from SIL 1 to SIL 4. This classification is established by the plant operator using a risk graph. In accordance with IEC 61508, the entire safety circuit – i.e. all components used in the circuit (sensors, logic processors, actuators) – must be considered.
A detailed knowledge of the construction of each individual component – in this case, the diaphragm seal – is needed in order to carry out the calculation and risk assessment. This results in a relatively low expected probability of failure, for example, for a standard design consisting of a diaphragm seal body and diaphragm (which only have a connecting point between the diaphragm and body of the diaphragm seal as well as between the diaphragm seal and the measuring instrument).
If a more complex design is necessary owing to the material or the type of construction, for example a diaphragm seal with an extended diaphragm, the sum of the failure rates increases with each additional component or connection point. This is understandable bearing in mind that a random failure can occur with a specific probability for each component and each connection.
A greatly simplified seal categorisation with the relevant safety parameters for assessing a complete safety-related system is shown in the table. Detailed characteristic values for the different diaphragm seal variants are available and can be provided for evaluations if required.
Based on these safety-related characteristics and taking into account all components, the plant operator must perform a calculation for the entire system with the aim of minimising the associated risks. This calculation is also deemed to count as proof of risk reduction for the safety system.

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