Diaphragm seals
Application - operating principle - designs

WIKA data sheet IN 00.06

Definition

Diaphragm seals, also known as chemical seals or remote seals, are used for pressure measurements when the process medium should not come into contact with the pressurised parts of the measuring instrument.
A diaphragm seal has two primary tasks:

1. Separation of the measuring instrument from the process medium
2. Transfer of the pressure to the measuring instrument

Operating principle of a diaphragm seal

The operating principle of a diaphragm seal is shown in the picture on the right.

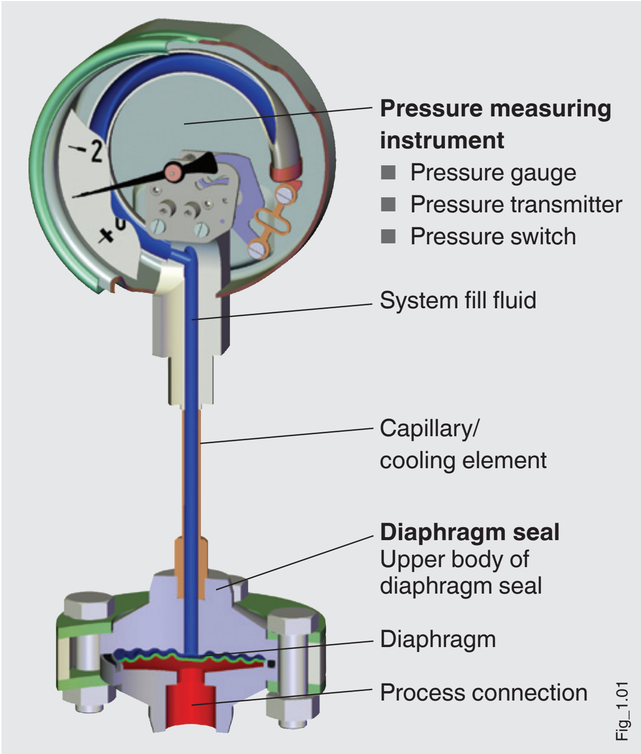
Principle
The process side of the seal is isolated by a flexible diaphragm. The internal space between this diaphragm and the pressure measuring instrument is completely filled with a system fill fluid. The pressure is transmitted from the measured medium by the elastic diaphragm into the fluid and from there to the measuring element, i.e. to the pressure measuring instrument or the transmitter.

In many cases, between the diaphragm seal and pressure measuring instrument, a capillary is connected in order (for example) to eliminate or to minimise temperature effects from the hot fluid to the measuring instrument. The capillary affects the response time of the overall system.

Diaphragm seal, capillary and measuring instrument form a closed system. The sealed filling screws on the diaphragm seal and the measuring instrument must therefore never be opened, since the function of the system is affected following any escape of filling liquid!

The diaphragm and the connecting flange are the elements of the system which come into contact with the medium. Therefore, the material from which they are made must meet the relevant requirements in terms of temperature and corrosion resistance.

Pressure measuring instrument with diaphragm seal



If the diaphragm is leaking, the system fill fluid can enter the medium. For food processing applications, it must be approved for contact with food. In selecting the fill fluid, the factors of compatibility, temperature and pressure conditions in the medium are of crucial importance. A variety of fluids are available which can cover the temperature range from -90 °C to +400 °C (see table "System fill fluids").

Fields of application

For the user, diaphragm seals make pressure measuring instruments of all sorts able to be used also for the harshest of applications.

Examples

- The medium is corrosive and the pressure measuring element itself (e.g. the interior of a Bourdon tube) cannot be sufficiently protected against it.
- The medium is highly viscous and fibrous, thus causing measuring problems due to dead spaces and constrictions in the bores of the pressure measuring instrument (pressure channels, Bourdon tubes).
- The medium has a tendency towards crystallisation or polymerisation.
- The medium has a very high temperature. As a result, the pressure measuring instrument is strongly heated. The heating leads to a high temperature error in the pressure measurement (i.e. in the display of the measured pressure on the measuring instrument). It can also exceed the upper limits for the thermal loading of the instrument components.
- The pressure measuring point is in an awkward location. For space reasons, the pressure measuring instrument either cannot be installed or can only be read poorly. By installing a diaphragm seal and using a longer capillary, the pressure measuring instrument can be installed in a location where it can be easily viewed.
- In the manufacture of the process product, and in the production plant, hygienic requirements must be followed. For these reasons, dead-space in the measuring instrument and fittings must be avoided.
- The medium is toxic or harmful to the environment. It cannot be allowed to escape into the atmosphere or environment through leakage. On the grounds of safety and environmental protection, the appropriate protective measures must therefore be taken.

In addition, this means that the user can benefit from the extensive experience of the manufacturer to gain a technological advantage from their own practical problems and their solutions.

Not least, this means the use of diaphragm seals to increase the efficiency of the plants and processes:

- through longer service life of the measuring assembly
- through lower mounting costs
- through elimination of maintenance

Combination possibilities

Assembly of the diaphragm seal and measuring instrument may be made via a rigid direct connection or a flexible capillary. The "rigid" assembly is made by a direct threaded connection or by welding the measuring instruments to the diaphragm seal or via an adapter.
For high temperatures a cooling element can be fitted between seal and instrument. The configuration of the combination of pressure measuring instrument and the diaphragm seal depends, among other things, on the application conditions in which the assembly must work.

Direct assembly

Capillary

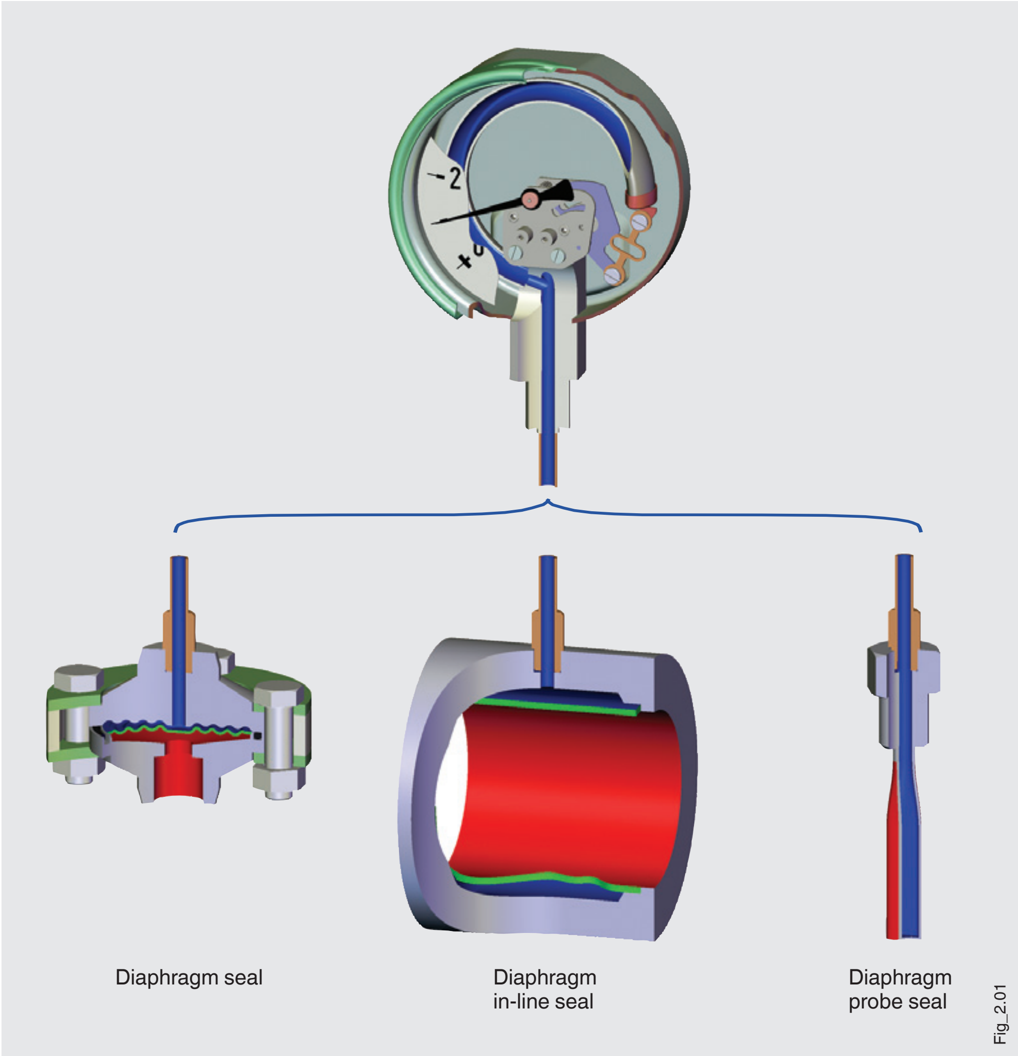
Cooling element

Designs

Since diaphragm seals are used under a great variety of conditions, one single model is not enough to cover the whole range of applications. Over time, various designs have proven to be particularly advantageous for specific applications.

So there are three basic types:

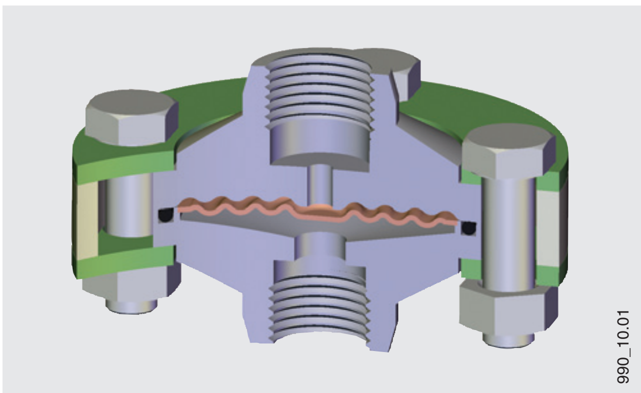
Diaphragm seals
Diaphragm in-line seals
Diaphragm probe seals



The decision for one diaphragm seal over another depends on both the specifications as well as the installation options and requirements of each specific measurement problem.

Diaphragm seal

Diaphragm seals are mounted to existing fittings. Usually the fittings consist of T-pieces which are integrated into a pipeline, or of welding sockets which are welded to a pipeline, the process reactor or a tank. This diaphragm seal type offers the advantage that the "contact surface" between pressure medium and diaphragm is relatively large, thus ensuring accurate pressure measurement. Furthermore, the fact that they can be easily dismounted, e.g. for cleaning or calibration purposes, is a further advantage.



Flange-type design

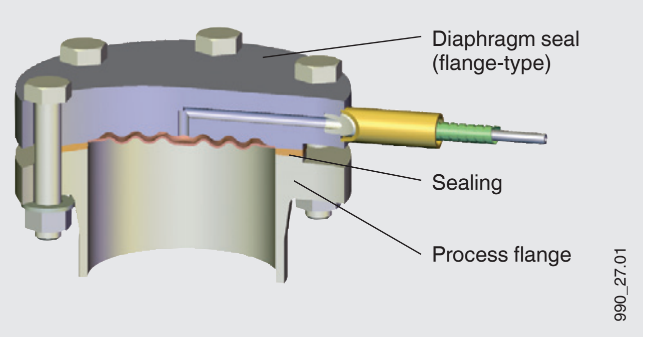
The flange-type diaphragm seal represents a modification. It essentially consists of a flange, whose connection dimensions are matched to the corresponding standard flanges. The diaphragm of the diaphragm seal, which is flush mounted to the sealing face, is located in the centre of the flange.

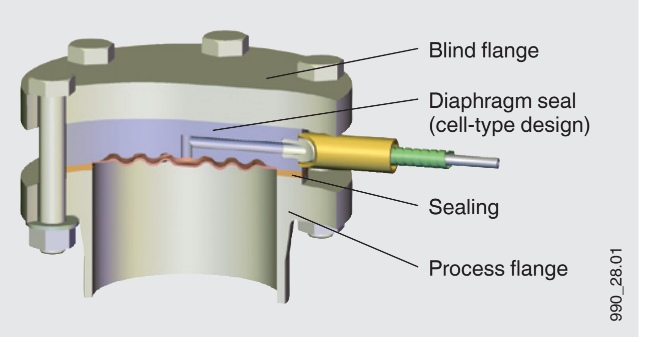
The flange-type diaphragm seal is mounted for pressure measurement in lieu of a blind flange.

Cell-type design

A further variant is the cell-type (sandwich) diaphragm seal. It consists of a cylindrical plate, whose diameter is matched to the sealing face area of corresponding standard flanges. The flush seal diaphragm , matched to the nominal diameter, is in the centre.

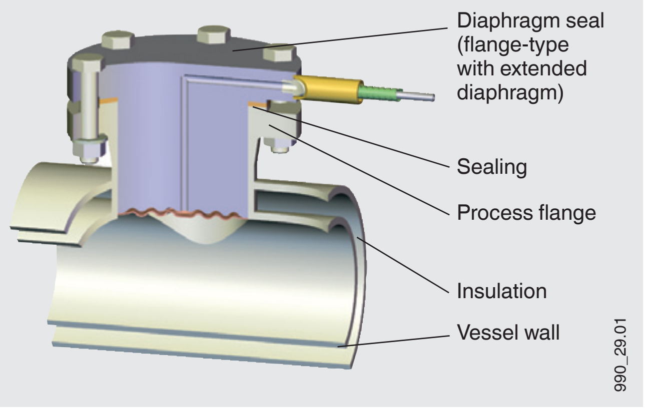
The cell-type diaphragm seal is mounted to the tapping flange using a blind flange.

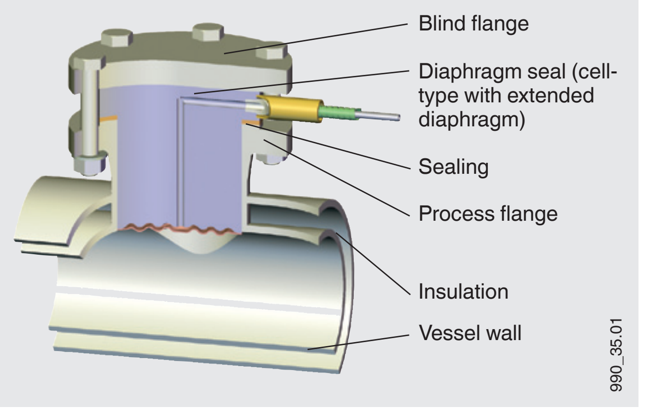




Extended diaphragm design

Seals with extended diaphragms are used at thick-walled and/or insulated product lines, tank walls etc. In addition to the flange-type, cell-type diaphragm seals are also available.



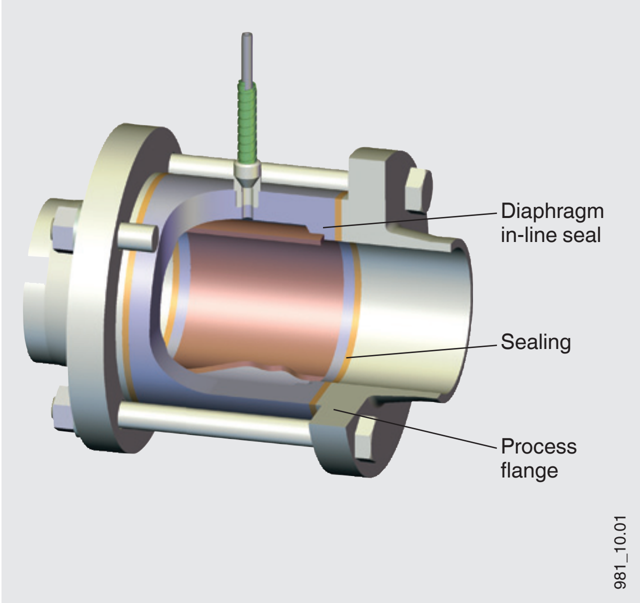


With diaphragm seals, pressures of up to 600 bar can be covered, with normal temperature limits at +400 °C.

Diaphragm in-line seal

The diaphragm in-line seal is perfectly suited for use with flowing media. With the seal being completely integrated into the process line, measurements do not cause any turbulence, corners, dead spaces or other obstructions in the flow direction. The medium flows unhindered and effects the self-cleaning of the measuring chamber.
The diaphragm seal consists of a cylindrical cover component which contains a welded-in thin-wall round-pipe diaphragm. The diaphragm in-line seal is installed directly in the pipeline between two flanges. This makes the designing of special measuring point connections unnecessary.
Different nominal diameters allow the in-line diaphragm seals to be adapted to the corresponding pipe cross-section.

The pressure range goes up to a maximum of 400 bar for PN 6 ... PN 400 flange connections, with the normal temperature limit being at +400 °C.

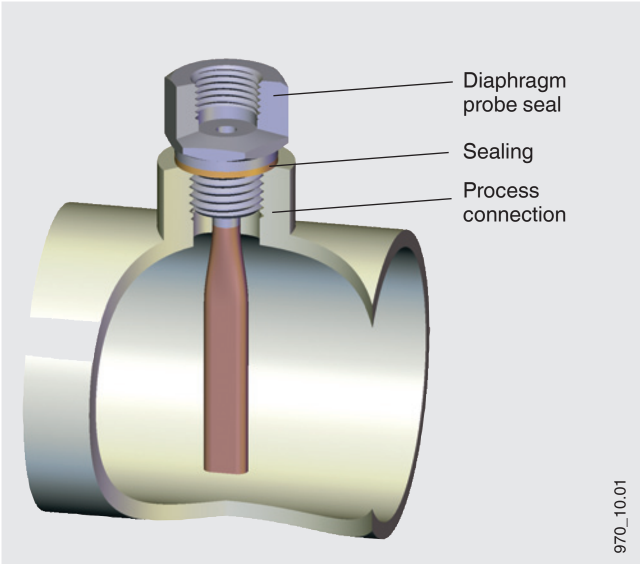


Diaphragm probe seal

This type is especially suitable for flowing heterogeneous measuring media, since it is inserted directly into the medium. It has a particularly small space requirement in comparison to other diaphragm seals. The pressure is captured 'at a point'.

The diaphragm seal consists of an oval tube, closed at one end, as a pressure sensor and a connector part welded to it. To stabilise it, the sensor is mounted to a fitting. The adaptation to the measuring point is made using female or male threads.

The maximum pressure range is 600 bar, the normal temperature limit is +400 °C.



The standard material for diaphragm seals is stainless steel 316L. For the wetted parts, a wide range of special materials are available for almost all diaphragm seal designs.

Standard materials (wetted parts)

Material	Brief description
Stainless steel	Mat. no. 316L, 1.4571, 1.4404, 1.4435, 1.4541, 1.4542, 1.4539
Duplex 2205	Mat. no. 1.4462
Superduplex	Mat. no. 1.4410
Gold	Au
Hastelloy C22	Mat. no. 2.4602
Hastelloy C276	Mat. no. 2.4819
Inconel alloy 600	Mat. no. 2.4816
Inconel alloy 625	Mat. no. 2.4856
Incoloy alloy 825	Mat. no. 2.4858
Monel alloy 400	Mat. no. 2.4360

Material	Brief description
Nickel	Mat. no. 2.4066 / 2.4068
Platinum	Pt
Tantalum	Ta
Titanium	Mat. no. 3.7035 / 3.7235
Zirconium	Zr
Ceramic	wikaramic®
Polytetrafluorethylene	PTFE
Perfluoralkoxy	PFA
Copolymer of ethene and chlor-trifluorethylene	ECTFE (Halar®)

Standard system fill fluids (others on request):

Name	Identification number KN	Solidification point °C	Boiling/degradation point °C	S.G. at temperature 25 °C g/cm³	Kin. viscosity at temperature 25 °C cSt	Notes
Silicone oil	2	-45	+300	0.96	54.5	Standard
Glycerine	7	-35	+240	1.26	759.6	FDA 21 CFR 182.1320
Silicone oil	17	-90	+200	0.92	4.4	for low temperatures
Halocarbon	21	-60	+175	1.89	10.6	for oxygen [1)] and chlorine
Methylcyclopentan	30	-130	+60	0.74	0.7	for low temperatures
High-temperatur silicone oil	32	-25	+400	1.06	47.1	for high temperatures
Caustic soda	57	-50	+95	1.24	4.1	
Neobee® M-20	59	-35	+260	0.92	10.0	FDA 21 CFR 172.856, 21 CFR 174.5
DI water	64	+4	+85	1.00	0.9	for ultrapure media
Silicone oil	68	-75	+250	0.93	10.3	
DI water / propanol mixture	75	-30	+60	0.92	3.6	for ultrapure media
Medicinal white mineral oil	92	-15	+260	0.85	45.3	FDA 21 CFR 172.878, 21 CFR 178.3620(a); USP, EP

Note:
- The stated lower temperature limit (solidification point) is a pure physical characteristic of the system fill fluid. Calculate and evaluate the resulting response time separately.
- The upper temperature limit (boiling/degradation point) for a diaphragm seal system is further restricted by the working pressure and the diaphragm. To determine the upper temperature limit for the individual diaphragm seal system, a calculation is required.

1) For oxygen applications, the following values in accordance with the BAM (Bundesamt für Materialforschung und Prüfung) apply:

Maximum temperature	Maximum oxygen pressure
to 60 °C	50 bar
> 60 °C to 100 °C	30 bar
> 100 °C to 175 °C	25 bar

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