WIKA standard documentation

Requirements

Extensive processes require detailed documentation. For complex operations, data sheets and operating instructions are not sufficient anymore as documents accompanying the products.
Additional documents such as certificates, analyses or quality management procedures provide exact proof that the instruments are ideally suited for the particular application.
In this way a detailed documentation conforming to the law contributes to plant safety.

WIKA standard documentation

WIKA standard documentation

The WIKA standard documentation complies with the legal conditions of acceptance (in paper format and/or as a navigable CD-ROM).
Our individual documents are constantly updated. They are subject to the "product lifecycle" (further development of the existing product). A unique attribution of the documents to the production order at the time of manufacture is ensured.
WIKA provides these documents in many languages and in the desired quantity.

Customer-specific designs
Of course we can also provide the documentation according to your requirements:
- Customer logo
- Cover sheet layout
- Ring binders
- Sequence
- Further documents

Table of Contents

WIKA standard documentation

This contains following documents:

Abbreviation	Description
TAG	Item list (Tag no. list)
CATL	Data sheets (catalogues)
IOM	Operating instructions (installation, operation and maintenance)
DOC	Declaration of conformity (EC, ATEX, EMC, PED)
ZGN	Certificates/Test reports
WFC	Wake frequency calculation (optional)
FLC	Flow calculation (optional)

These documents can be provided additionally:

Abbreviation	Description
DRWG	Drawings
QM	Quality management procedures
QT	Quality test procedures
CSP	Commissioning spare parts list
2SP	2 years spare parts list
NDE	Non-destructive examinations
SIP/RPP	Transport, packaging and storage instructions
MCOC	Manufacturer's certificates of compliance
PASS	Passport (import permit for instruments destined for Russia)

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Diaphragm seals and diaphragm seal systems
Application - Functionality - Design

Definition

Diaphragm 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

Functionality of a diaphragm seal

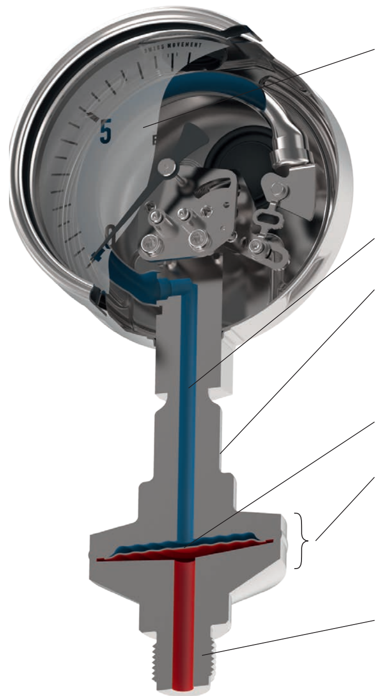
The functionality of a diaphragm seal is illustrated in the figure on the right.

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 process pressure is transmitted by the elastic diaphragm into the fluid and from there to the measuring element of the pressure measuring instrument.

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 fill fluid!

The diaphragm and the process connection 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.



Installation example of a diaphragm seal system

If the diaphragm is leaking, the system fill fluid can enter the medium. For applications in the food industry, 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. Customer-specific solutions can be realised for the different operating conditions of the applications.
Diaphragm seal systems are capable of withstanding extreme temperatures of -130 ... +450 °C [-202 ... + 842 °F] and pressures of 35 mbar ... 3,600 bar [0.5 ... 52,200 psi].

Fields of application

The use of diaphragm seals enables the user to employ a large number of pressure measuring instruments for the most difficult process conditions.

Examples

- The medium is corrosive and the pressure measuring instrument 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 ports, 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. This heating leads to a large temperature error in the measurement on the pressure measuring instrument. The increased temperature can also lead to the upper limits for the thermal loading of the measuring instrument components being exceeded.
- The measuring location is not favourably located. For reasons of space, the pressure measuring instrument can either not be mounted or cannot be read or can only be read with difficulty. 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 product, and in the production plant, hygienic requirements must be followed. For this reason, dead spaces and undercuts in the wetted parts 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.

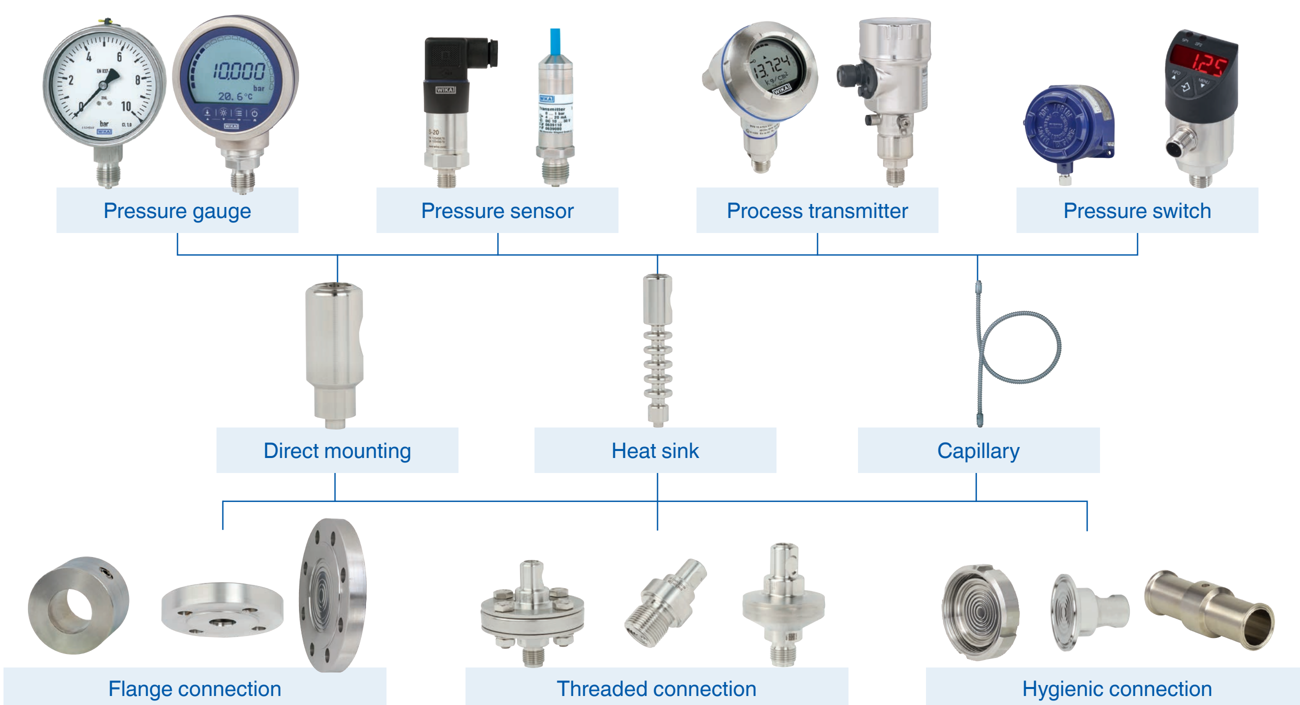
Thanks to its many years of experience, WIKA is able to turn challenging tasks into solutions with a technological edge.

Advantages from using diaphragm seals

- Long service life of the measuring assembly
- Reduced installation effort
- Elimination of maintenance

Combinations for diaphragm seal systems

A diaphragm seal system is defined with the pressure measuring instrument, the mounting type and the diaphragm seal with process connection.
The optimal diaphragm seal designs, materials, system fill fluids and accessories are available for each application.



Mounting types

The required mounting type for pressure measuring instruments with diaphragm seals depends, among other things, on the operating conditions of the diaphragm seal system. The choice is between direct mounting, flexible capillary or heat sink. This makes the diaphragm seal system adaptable to customer-specific conditions. When selecting the mounting type, influences on the measuring capability of the diaphragm seal system must be taken into account. Mounting via a capillary or a heat sink results in a longer response time than direct mounting, for example.

Direct mounting
Direct mounting is achieved by welding the measuring instrument directly to the diaphragm seal via a connection adapter.

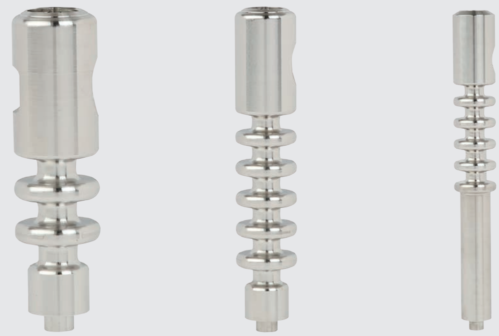
Direct mounting via axial connection adapter

Capillary
The capillary is a flexible connecting piece between the measuring instrument and the diaphragm seal, which typically consists of a tube, a capillary protection hose and, optionally, a further jacket. Capillaries are used where the process media are at high temperatures, as these are cooled down through the connecting line. Furthermore, this mounting type is suitable for decoupling strong vibrations, or if the measuring instrument cannot be mounted at the measuring location or is easier to read at another location.

Capillary (example)

Heat sink
With hot media, the heat sink ensures that the system fill fluid cools down sufficiently to guarantee precise measurement.

Heat sink (examples)



Process connection and design

Diaphragm seal systems are used in demanding applications in a wide range of industries. The optimal process connections and designs are available for each application.

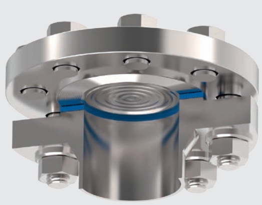
The decision for the right diaphragm seal depends on both the specifications as well as the installation options and requirements of each specific measuring task.

Classification of the process connections
- Flange connection
- Threaded connection
- Hygienic connection

Flange connection

Diaphragm seals with flange connection can be used for processes with aggressive, adhesive, corrosive, highly viscous, environmentally hazardous or toxic media.
Diaphragm seals with flange connections are available with dimensions for all common standard flanges. The sealing face is flush and the diaphragm is designed to be either flush or internal.

Flush diaphragm



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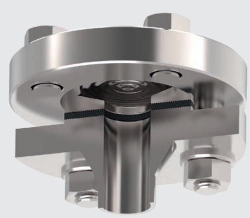
Internal diaphragm



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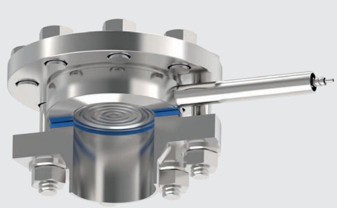
Cell-type

The cell-type is a specific variant of diaphragm seal with flange connection. It consists of a cylindrical plate, whose diameter is matched to the sealing face area of corresponding standard flanges. The diaphragm is flush and matched to the nominal width.
A blind flange is used to mount the cell-type, available for all common flange standards.

Cell-type



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Extended-diaphragm version

Diaphragm seals with extended diaphragm are used, among other things, on thick-walled and/or insulated product lines, vessel walls, etc. The version with extended diaphragm is available for flange- and cell-type designs.

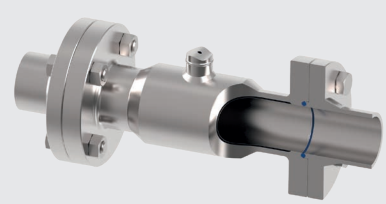
Extended-diaphragm version

14217473.01

In-line diaphragm seal with flange connection

These diaphragm seals are exceptionally suitable for the measurement of flowing media. The in-line diaphragm seal is clamped directly into the pipeline using flanges at both ends. This integration into the process line prevents disturbing turbulences, as this design has no corners, dead spaces or other obstructions in the flow direction. Different nominal widths allow the in-line diaphragm seals to be adapted to any pipeline cross-section. The in-line diaphragm seals are also available in a cell-type design.

In-line diaphragm seal with flange connection



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Threaded connection

Diaphragm seals with threaded connection can be used for processes with aggressive, adhesive, corrosive, highly viscous, environmentally hazardous or toxic media. The connection of the upper and lower bodies of the diaphragm seal is available in either a threaded or a welded design. These diaphragm seals are available with female or male thread in their basic design. The wide variety of available process connections enables many different adaptations without any problems. The material of the upper body of the diaphragm seal and the lower body of the diaphragm seal can be the same or be different.

Threaded design

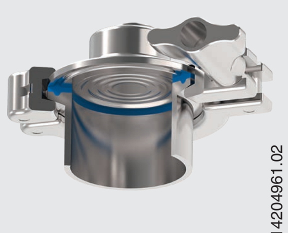
Welded design

Hygienic connection

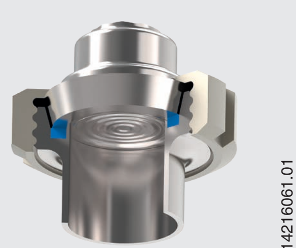
Diaphragm seals in hygienic design can be used for processes with gases, compressed air or vapour and also with liquid, pasty, powdery and crystallising media. The diaphragm seals resist the temperatures that occur and meet the requirements for sterile connections. The flush diaphragm can be integrated hygienically into all applications thanks to the various process connections.

SIP and CIP criteria, which are an essential requirement for sanitary applications, are met by using WIKA diaphragm seals.

Clamp connection



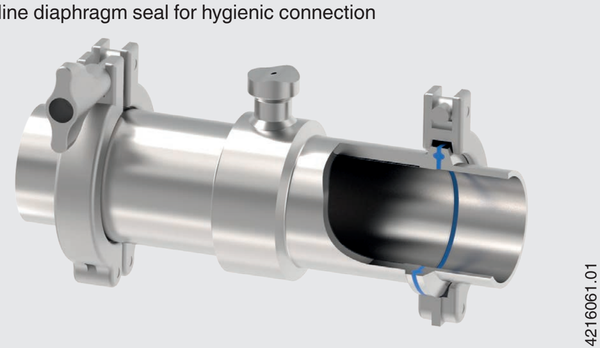
Grooved union nut



In-line diaphragm seal for hygienic connection

The in-line diaphragm seal is perfectly suited for use with flowing media. With the seal being completely integrated into the process line, measurements do not cause any disturbing turbulences, corners, dead spaces or other obstructions in the flow direction. The in-line diaphragm seal is clamped directly into the pipeline. With in-line diaphragm seals, the medium flows through unhindered and effects the self-cleaning of the measuring chamber. Different nominal widths allow the in-line diaphragm seals to be adapted to any pipeline cross-section.

In-line diaphragm seal for hygienic connection



Materials and coatings

The predominant material for diaphragm seals is stainless steel 316L. For the wetted parts, a wide range of special materials and coatings are available for specific areas of application. WIKA offers this variety of different materials in order to be able to find the best possible solution for the demands of the measuring location.

The material selection for diaphragm seals is strongly dependent upon the operating conditions. In addition to the pressure load, the requirements for the temperature and also the resistance against the medium must be known. Then the material selection for the diaphragm seal can be made. The selection can be designed with different materials for the base body, the sealing face and the diaphragm, as these are not equally wetted in every design.

Material combinations and coatings
Especially when using special materials, high costs and long delivery times can occur.
Such circumstance can be resolved by intelligent selection of material combinations or coatings. A cost-effective base material is used for the load-bearing parts, for example, and only the wetted parts are made of a special material or have a coating. The joining and connection technology play an important role here, as different materials cannot always be welded. Regardless of the type of connection technology, these diaphragm seals can withstand extreme operating conditions.

Material	Unified numbering system (UNS)
Stainless steel 316L (1.4404 or 1.4435)	S31603
Stainless steel 904L (1.4539)	N08904
Stainless steel 321 (1.4541)	S32100
Stainless steel 316Ti (1.4571)	S31635
Stainless steel 1.4466 (urea grade)	S31050
Duplex 2205 (1.4462)	S31803
Superduplex 1.4410	S32750
Tantalum (also lining)	R05200
Hastelloy C276 (2.4819)	N01276
Hastelloy C22 (2.4602)	N06022
Inconel 600 (2.4816)	N06600
Incoloy 825 (2.4858)	N08825
Inconel 625 (2.485)	N06625
Monel 400 (2.4360)	N04400
Nickel 200 (2.4066)	N02200
Nickel 201 (2.4068)	N02201
Titanium 3.7035 (class 2)	R50400
Titanium 3.7235 (class 7)	R52400
Zirconium GR702	R60702

The maximum permissible process temperature is limited by the joining method and the system fill fluid. The maximum process temperature can be found in the data sheet for the diaphragm seal.

Coatings
Stainless steel with ECTFE coating
Stainless steel with PFA (FDA; 21 CFR 177.1550 and 21 CFR 177.2440)
Stainless steel with PFA, anti-static (suitable for Ex applications)
Stainless steel with gold plating
Stainless steel with gold-rhodium
Stainless steel with Wikaramic®

System fill fluids

When selecting the system fill fluid for diaphragm seals, factors such as medium compatibility as well as temperature and pressure conditions at the measuring location are of critical importance in order to avoid endangering the process. Depending on the system fill fluid, the appropriate minimum and maximum operating temperature range must be observed. In addition, the change in volume of the system fill fluid at extreme application temperatures must be taken into account.

Highly flammable applications, such as oxygen and chlorine applications, and the high demands within both sanitary applications and the semiconductor industry are also crucial in choosing the right fluid.

The properties of the system fill fluids affect the permissible operating temperature of the diaphragm seal system. Since the parameters of the individual system fill fluids vary, WIKA offers a wide range to cover different applications.

FDA approval

The FDA (“Food and Drug Administration”) is a US authority under the Department of Health. It is responsible for the monitoring of foodstuffs and pharmaceuticals and serves to protect public health in the United States.
Liquids that could find their way into the end product in the event of a failure must be FDA-compliant.

Designation	Identi-fication number	Solidi-fication point	Boiling/ degradation point	Density at 25 °C	Kin. Viscosity at 25 °C	Remark
	KN	°C	°C	g/cm³	cSt	
Silicone oil	2	-45	+300	0.96	54.5	Universal application
Glycerine	7	-35	+240	1.26	759.6	FDA 21 CFR 182.1320
Silicone oil	17	-90	+200	0.92	4.4	Low temperatures
Halocarbon	21	-60	+175	1.89	10.6	Oxygen 1) and chlorine
Methylcyclopentane	30	-130	+60	0.74	0.7	For very low temperatures
High-temperature silicone oil	32	-25	+400	1.06	47.1	For high temperatures
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, SP

Other system fill fluids on request

Note:
- The stated lower temperature limit is a purely physical characteristic of the system fill fluid. The resulting response time has to be calculated and evaluated separately.
- The upper temperature limit for a diaphragm seal system is further restricted by the operating 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 per BAM test (Federal Institute for Materials Research and Testing) 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

Influencing factors on the measurement

Response time

A combination of the individual components generally causes a delay in the output of the measured value. This delay is referred to as the response time and varies depending on the assembly.
Factors such as the control volume of the measuring instrument as well as the capillary length and its associated cross-section are included in the calculation. It can therefore be concluded that the response time increases with a large control volume or a long capillary. This effect can be counteracted by selecting a measuring instrument with a smaller control volume, a shorter capillary or a capillary with a larger cross-section.

In addition to the geometric variables of the diaphragm seal system, the viscosity of the fill fluid, among other things, must also be taken into account. The higher the viscosity value, the more viscous the medium. An optimisation of the response time can thus be realised through the selection of a fill fluid with a lower viscosity.
Furthermore, the temperatures applied influence the physical properties of the system fill fluid. If the temperature increases, then the medium becomes less viscous and the response time shortens. Conversely, the response time of the measuring instrument increases as the temperature drops due to the increasing viscosity.

Temperature effect

Diaphragm seal systems are generally filled at room temperature. If there are now temperature changes in the environment or in the process, these have a negative effect on the output values of the measuring instrument. The reason is due to the change in the physical properties of the system fill fluid. If the measuring system experiences an increase in temperature, there is an increase in volume which leads to a deflection of the diaphragm in the direction of the process. The restoring force of the diaphragm simultaneously ensures a positive zero point offset on the measuring instrument.

To counteract this error, large diaphragm diameters should be chosen due to their low rigidity. Other factors that counteract the zero point offset are a lower dead volume of the entire system and a lower thermal expansion coefficient of the fill fluid.

The opposite effect is seen when the temperature drops. The decrease in volume now causes the diaphragm to deflect in the direction of the diaphragm bed. The temperature reduction causes a negative zero point offset due to the restoring force of the diaphragm.

Height difference

Any height difference between the pressure measuring instrument and the diaphragm seal (this applies especially when using capillaries) affects the measurement. This is due to the hydrostatic pressure of the liquid column in the capillary. The display is reduced when the pressure measuring instrument is positioned higher than the diaphragm seal.
It is increased when the pressure measuring instrument is positioned lower. This height difference must be known when designing the entire system at the factory so that it can be taken into account accordingly.

Note: After mounting, a zero point test and, if necessary, a zero point correction is recommended.

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Conversion Table of commonly used pressure units

WIKA Data Sheet IN 00.08

SI Units - Engineering units (based on the metre)

	from \ to	bar	mbar	µbar	Pa	kPa	MPa	mmHg	mmWS	mWS	kp/mm^2	kp/cm^2	atm
		SI units						Engineering units					
SI units	**1 bar**	1	10^{3}	10^{6}	10^{5}	100	0.1	750.064	$10.1972 \cdot 10^{3}$	10.1972	$10.1972 \cdot 10^{-3}$	1.01972	0.986923
SI units	**1 mbar**	10^{-3}	1	10^{3}	100	0.1	$0.1 \cdot 10^{-3}$	$750.064 \cdot 10^{-3}$	10.1972	$10.1972 \cdot 10^{-3}$	$10.1972 \cdot 10^{-6}$	$1.01972 \cdot 10^{-3}$	$0.986923 \cdot 10^{-3}$
SI units	**1 µbar**	10^{-6}	10^{-3}	1	0.1	$0.1 \cdot 10^{-3}$	$0.1 \cdot 10^{-6}$	$750.064 \cdot 10^{-6}$	$10.1972 \cdot 10^{-3}$	$10.1972 \cdot \cdot 10^{-6}$	$10.1972 \cdot 10^{-9}$	$1.01972 \cdot 10^{-6}$	$0.986923 \cdot 10^{-6}$
SI units	**1 Pa**	10^{-5}	0.01	10	1	10^{-3}	10^{-6}	$7.50064 \cdot 10^{-3}$	$101.972 \cdot 10^{-3}$	$101.972 \cdot 10^{-6}$	$101.972 \cdot 10^{-9}$	$10.1972 \cdot 10^{-6}$	$9.86923 \cdot 10^{-6}$
SI units	**1 kPa**	0.01	10	$10 \cdot 10^{3}$	10^{3}	1	10^{-3}	7.50064	101.972	$101.972 \cdot 10^{-3}$	$101.972 \cdot 10^{-6}$	$10.1972 \cdot 10^{-3}$	$0.986923 \cdot 10^{-3}$
SI units	**1 MPa**	10	$10 \cdot 10^{3}$	$10 \cdot 10^{6}$	10^{6}	10^{3}	1	$7.50064 \cdot 10^{3}$	$101.972 \cdot 10^{3}$	101.972	$101.972 \cdot 10^{-3}$	10.1972	9.86923
Engineering units	**1 mmHg**	$1.33322 \cdot 10^{-3}$	1.33322	$1.33322 \cdot 10^{3}$	133.322	$133.322 \cdot 10^{-3}$	$133.322 \cdot 10^{-6}$	1	13.5951	$13.5951 \cdot 10^{-3}$	$13.5951 \cdot 10^{-6}$	$1.35951 \cdot 10^{-3}$	$1.31579 \cdot 10^{-3}$
Engineering units	**1 mmWS**	$98.0665 \cdot 10^{-6}$	$98.0665 \cdot 10^{-3}$	98.0665	9.80665	$9.80665 \cdot 10^{-3}$	$9.80665 \cdot 10^{-6}$	$73.5561 \cdot 10^{-3}$	1	10^{-3}	10^{-6}	$0.1 \cdot 10^{-3}$	$96.7841 \cdot 10^{-6}$
Engineering units	**1 mWS**	$98.0665 \cdot 10^{-3}$	98.0665	$98.0665 \cdot 10^{3}$	$9.80665 \cdot 10^{3}$	9.80665	$9.80665 \cdot 10^{-3}$	73.5561	10^{3}	1	10^{-3}	0.1	$96.7841 \cdot 10^{-3}$
Engineering units	**1 kp/mm^2**	98.0665	$98.0665 \cdot 10^{3}$	$98.0665 \cdot 10^{6}$	$9.80665 \cdot 10^{6}$	$9.80665 \cdot 10^{3}$	9.80665	$73.5561 \cdot 10^{3}$	10^{6}	10^{3}	1	100	96.7841
Engineering units	**1 kp/cm^2**	0.980665	$0.980665 \cdot 10^{3}$	$0.980665 \cdot 10^{6}$	$98.0665 \cdot 10^{3}$	98.0665	$98.0665 \cdot 10^{-3}$	735.561	$10 \cdot 10^{3}$	10	0,01	1	0.967841
Engineering units	**1 atm**	1.01325	$1.01325 \cdot 10^{3}$	$1.01325 \cdot 10^{6}$	$101.325 \cdot 10^{3}$	101.325	$101.325 \cdot 10^{-3}$	760	$10.3323 \cdot 10^{3}$	10.3323	$10.3323 \cdot 10^{-3}$	1.03323	1

Corresponding pressure units:
- 1 Pa = 1 N/m^2
- 1 hPa = 1 mbar
- 1 mmHg = 1 Torr
- 1 kp/cm^2 = 1 at (atü)

Notes

The table refers to DIN 1301 Part 1 (2002) and Part 3 (1979).
In accordance with the Execution Ordinance to the law on units in metrology (Ferderal German Units Ordinance) from 13th December 1985 only the following units are admissible for pressures:
- pascal (Pa)
- bar (bar)
- millimetre of mercury (mmHg), but only for blood pressure and the pressure of other physical liquids in medicine

Valid for these units in accordance with Federal German Unit Ordinance are the definitions and conversion factors per DIN 1301.

Listed in Part 1 of this standard
- pascal as derived SI unit with special name and with special unit symbol
- bar as generally applicable unit outside the SI
- millimetre of mercury as unit outside the SI with limited area of application

Part 3 of this standard defines amongst other things conversion factors for the following units
- conventional millimetre of mercury (mmHg)
- conventional metre of water (mWS)
- torr (Torr)
- technical atmosphere (at)
- standard atmosphere (atm)

WIKA
Smart in sensing

SI units - Engineering units (based on the foot)

	to / from	SI units: bar	mbar	µbar	Pa	kPa	MPa	Engineering units: psi	ft H_2O	in. H_2O	in. Hg
SI units	**1 bar**	1	10^3	10^6	10^5	100	0.1	14.50377	33.4553	401.463	29.52998
	1 mbar	10^{-3}	1	10^3	100	0.1	0.1 · 10^{-3}	14.50377 · 10^{-3}	33.4553 · 10^{-3}	401.463 · 10^{-3}	29.52998 · 10^{-3}
	1 µbar	10^{-6}	10^{-3}	1	0.1	0.1 · 10^{-3}	0.1 · 10^{-6}	14.50377 · 10^{-6}	33.4553 · 10^{-6}	401.463 · 10^{-6}	29.52998 · 10^{-6}
	1 Pa	10^{-5}	0.01	10	1	10^{-3}	10^{-6}	0.1450377 · 10^{-3}	0.334553 · 10^{-3}	4.01463 · 10^{-3}	0.2952998 · 10^{-3}
	1 kPa	0.01	10	10 · 10^3	10^3	1	10^{-3}	0.1450377	0.334553	4.01463	0.2952998
	1 MPa	10	10 · 10^3	10 · 10^6	10^6	10^3	1	0.1450377 · 10^3	0.334553 · 10^3	4.01463 · 10^3	0.2952998 · 10^3
Engineering units	**1 psi**	68.94757 · 10^{-3}	68.94757	68.94757 · 10^3	6.894757 · 10^3	6.894757	6.894757 · 10^{-3}	1	2.30666	27.6799	2.036020
	1 ft H_2O	29.8907 · 10^{-3}	29.8907	29.8907 · 10^3	2.98907 · 10^3	2.98907	2.98907 · 10^{-3}	433.5275 · 10^{-3}	1	12	0.8826709
	1 in. H_2O	2.49089 · 10^{-3}	2.49089	2.49089 · 10^3	0.249089 · 10^3	0.249089	0.249089 · 10^{-3}	36.12729 · 10^{-3}	83.3333 · 10^{-3}	1	73.55591 · 10^{-3}
	1 in. Hg	33.86389 · 10^{-3}	33.86389	33.86389 · 10^3	3.386389 · 10^3	3.386389	3.386389 · 10^{-3}	0.4911542	1.132925	13.59510	1

Corresponding pressure units:
- 1 Pa = 1 N/m^2
- 1 psi = 1 $lbf/in.^2$
- 1 mmHg = 1 Torr
- 1 kgf/cm^2 = 1 at

Notes

The table refers to ISO 31-1:1992 and ISO 31-3:1992
For lengths ISO 31-1 defines conversion factors for units no longer to be used:
- inch (in)
- foot (ft)

For pressures ISO 31-3 defines conversion factors for units no longer to be used:
- pound-force per square inch ($lbf/in.^2$)
- conventional millimetre of water (mmH2O)
- conventional millimetre of mercury (mmHg)
- Torr (Torr)
- technical atmosphere (at)
- standard atmosphere (atm)

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Notes on equipment protection per IEC/EN 60529 and NEMA For Bourdon tube or diaphragm pressure gauges

WIKA data sheet IN 00.18

General information

This technical information describes the measures to prevent both the formation of condensation within a hermetically sealed case, and also the intrusion of water into cases vented to the atmosphere. These measures apply both to Bourdon tube pressure gauges and to diaphragm pressure gauges.

1. Introduction and explanation of physical conditions

The formation of condensation in the cases of hermetically sealed, unfilled instruments cannot generally be avoided. This is based on the physical fact that the humidity found in air, under particular conditions, settles on cold surfaces as condensation. The warmer the air, the more humidity it can hold. If the air cools (e.g. at the window of a measuring instrument), then the air can only hold a small amount of humidity. The excess humidity settles as condensation on the window.

In addition, water in the form of splash, jet and rain water from outside can intrude into the case, so long as the instrument is vented to atmosphere.

2. Explanation of the degrees of protection per IEC/EN 60529

Degrees of protection against solid foreign bodies, defined by the first index number

First index number	Degree of protection	
	Code designation	Definition
0	Not protected	–
1	Protected against solid foreign bodies of 50 mm diameter and larger	The object probe, a round body of 50 mm diameter, must not fully intrude 1)
2	Protected against solid foreign bodies of 12.5 mm diameter and larger	The object probe, a round body of 12.5 mm diameter, must not fully intrude 1)
3	Protected against solid foreign bodies of 2.5 mm diameter and larger	The object probe, 2.5 mm in diameter, must not intrude at all 1)
4	Protected against solid foreign bodies of 1.0 mm diameter and larger	The object probe, 1.0 mm in diameter, must not intrude at all 1)
5	Dust protected	Ingress of dust is not completely prevented, but dust may not intrude in a such a quantity that the satisfactory operation of the instrument or safety is impaired
6	Dust-proof	No ingress of dust

1) The full diameter of the object probe must not pass through any opening in the case.

Illustration 1
Source: IEC/EN 60529

WIKA

Smart in sensing

Degrees of protection against water, defined by the second index number

Second index number	Degree of protection	
	Code designation	Definition
0	Not protected	–
1	Protected against dripping water	Perpendicularly falling drops must have no damaging effects.
2	Protected against dripping water when the case is inclined to 15°.	Perpendicularly falling drops must have no damaging effects, when the case is inclined to an angle of up to 15°, either side of perpendicular.
3	Protected against sprayed water	Water that is sprayed at an angle of up to 60°, either side of perpendicular, must have no damaging effects.
4	Protected against splash water	Water that splashes against the case from any direction must have no damaging effects.
5	Protected against water jets	Water that splashes against the case, as a jet, from any direction, must have no damaging effects.
6	Protected against strong water jets	Water that splashes against the case, as a strong jet, from any direction, must have no damaging effects.
7	Protected against the effects of temporary immersion in water	Water must not enter in any quantity which could cause damage, when the case, under standardised pressure and temperature conditions, is temporarily immersed in water.
8	Protected against the effects of permanent immersion in water	Water must not enter in any quantity which could cause damage, when the case is permanently immersed in water, under conditions which must be agreed between the manufacturer and user. The conditions must, however, be more demanding than those for the index number 7.

Illustration 2

Source: IEC/EN 60529

Example: Ingress protection IP65

- First index number 6: Dust-proof, no ingress of dust
- Second index number 5: Protected against water jets: Water that splashes against the case as a jet from any direction must have no damaging effects.

3. Comparison of NEMA (National Electrical Manufacturers Association) and IEC/EN 60529

NEMA ingress protection Model number	IEC/EN 60529 ingress protection Classification
1	IP10
2	IP11
3	IP54
3 R	IP14
3 S	IP54
4 and 4 X	IP66
5	IP52
6 and 6 P	IP67
12 and 12 K	IP52
13	IP54

Illustration 3

4. Measures against the formation of condensation

Different fill fluids depending on the ambient temperature and the electrical conductivity

In order to avoid the formation of condensation in the case, WIKA recommends filling the instruments with glycerine. For contact gauges, the filling can be made with silicone oil, since silicone oil, unlike glycerine, is not hygroscopic and therefore prevents a short-circuit within the instrument.

If the ambient temperature drops below -20 °C, then we recommend that the instrument absolutely must be filled with silicone oil. Even at temperatures down to -50 °C, silicone oil can still be used due to its low viscosity.
For flammable and/or explosive media, e.g. oxygen, inert fill fluids must be used.

5. Hermetically sealed instruments and effects associated with them

In order to prevent the intrusion of water into the case, it is recommended that an ingress protection method is chosen that reliably inhibits this (see illustrations 1 and 2). The ingress protection demands that the instrument is hermetically sealed.

With vented instruments, the vent valve has to be closed in order to achieve the specified ingress protection. This, however, produces a temperature error, which can affect the measuring result (see illustrations 4, 5 and 6). Therefore the vent valve has to be opened for a short time before reading the measured value.

5.1 Temperature errors in unfilled and filled Bourdon tube pressure gauges

A standard 232.50/30 instrument with a pressure range greater than 25 bar can be made hermetically sealed without any problems, and manufactured with an ingress protection of IP66. The temperature error that occurs with these instruments is negligible, since it is so small in relation to the pressure range, that the instrument still will operate within its specified class accuracy.

Instruments with a scale range of less than 25 bar can likewise be made hermetically sealed, though a temperature error will then be present (see illustration 4). The temperature errors present are shown in the following graphs.

Temperature errors in hermetically sealed, unfilled Bourdon tube pressure gauges

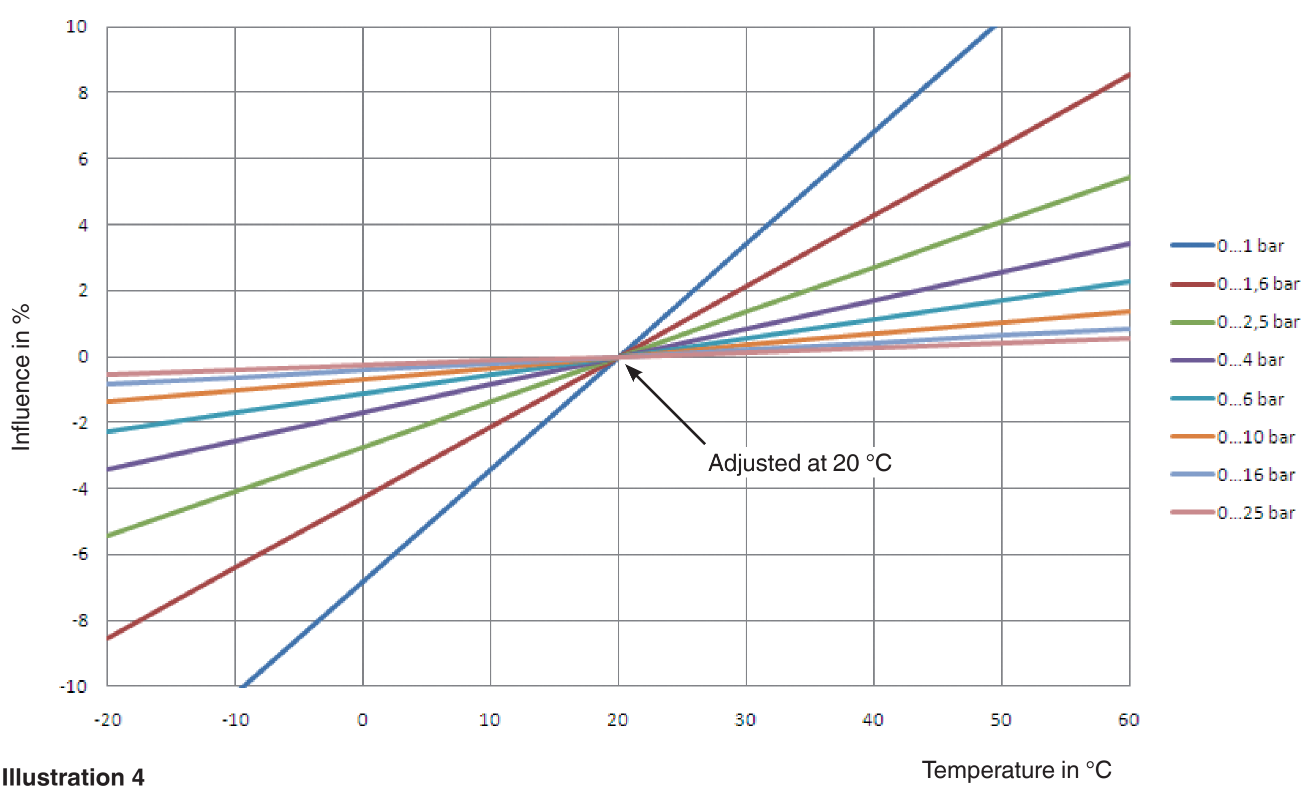

Illustration 4

Temperature errors in hermetically sealed, filled Bourdon tube pressure gauges

Filled to 90 % with glycerine

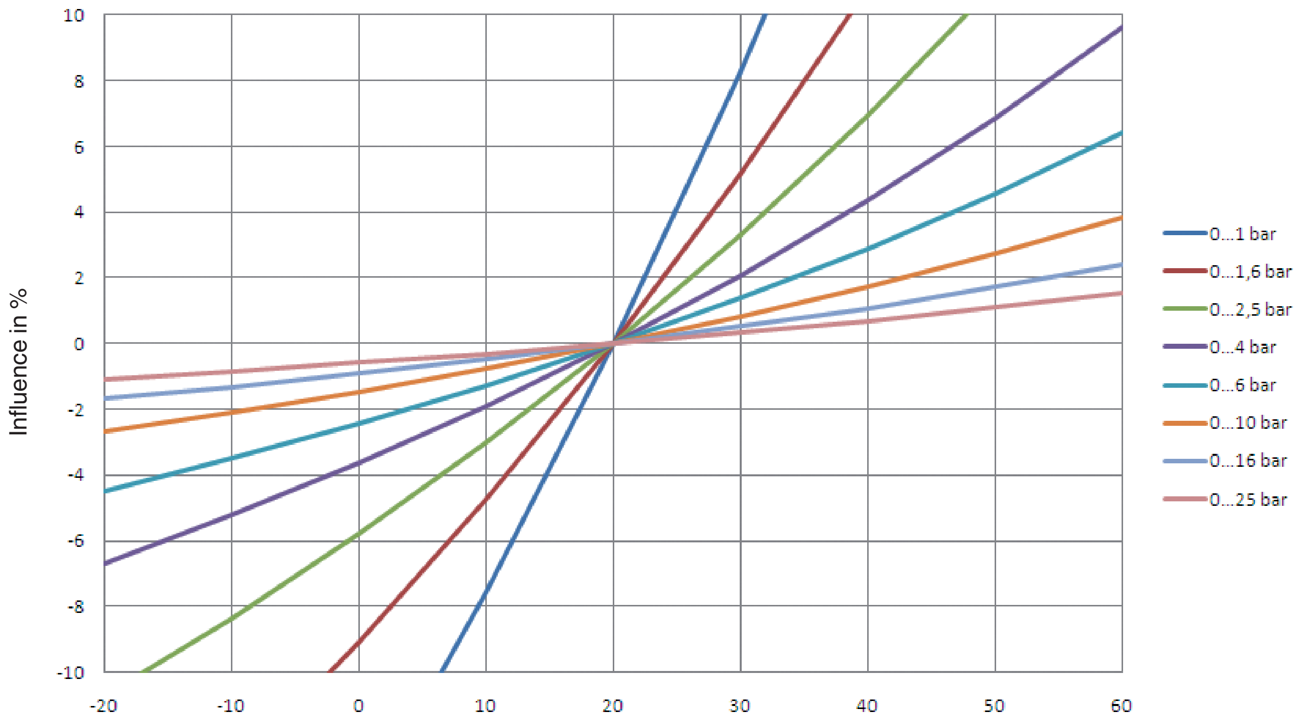

Illustration 5

Temperature in °C

Filled to 90 % with silicone oil

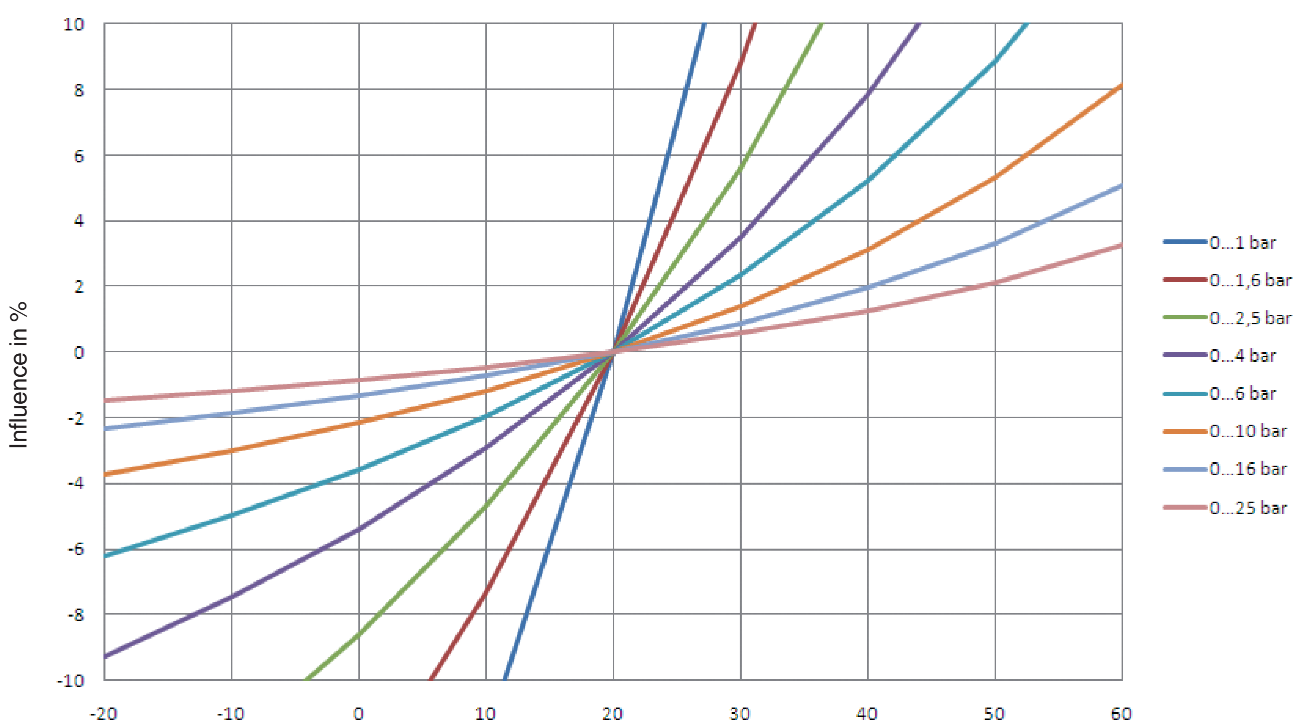

Illustration 6

Temperature in °C

5.1 Temperature errors in unfilled and filled diaphragm pressure gauges

With model 4, 5 and 7 hermetically sealed diaphragm pressure gauges, the temperature error for scale ranges ≥ 100 mbar is negligible. For scale ranges < 100 mbar we recommend only using instruments with a pressure compensating diaphragm.

For instrument models 7xx.14, DPG40, DPGS40, DPGS40TA, DPGT40, DPS40, 700.01/02 and 7x2.15, due to their mechanical design, there are no additional temperature errors.

5.3 Model overview

Pressure gauges for which the formation of condensation and the ingress of water from the outside can be prevented:

Influence	Bourdon tube pressure gauges					Diaphragm pressure gauges					
	Model 2 unfilled		Model 2 filled		Model 233.30 filled, with pressure compensating diaphragm	Model 4 and 7 unfilled		Model 4 and 7 filled		Model 4 and 7 unfilled, with pressure compensating diaphragm	Model 4 and 7 filled, with pressure compensating diaphragm
	≥ 25 bar	< 25 bar	≥ 25 bar	< 25 bar	all pressure ranges	> 100 mbar	< 100 mbar	> 100 mbar	< 100 mbar	all pressure ranges	all pressure ranges
Formation of condensation	unavoidable		✓	✓	✓	unavoidable		✓	✓	unavoidable	✓
Hermetically sealed 1)	Influence negligible	For influence see illustration 4	Influence negligible	For influence see illustration 5 or 6	✓	Influence negligible	Technically not solvable	Influence negligible	Technically not solvable	✓	✓

1) Hermetically sealed = air-tight case

Illustration 7

6. Pressure compensating diaphragm

As can be seen in illustration 7, formation of condensation in filled pressure gauges can be prevented by the use of pressure compensation diaphragms, without any temperature error. Pressure compensation diaphragms can be used for all safety pressure gauges per EN 837-1 S3.

Illustration 8: Rear wall of case with pressure compensating diaphragm, nominal size 63

Illustration 9: Rear wall of case with pressure compensating diaphragm, nominal size 100

Illustration 10: Rear wall of case with pressure compensating diaphragm for contact gauges, nominal size 160

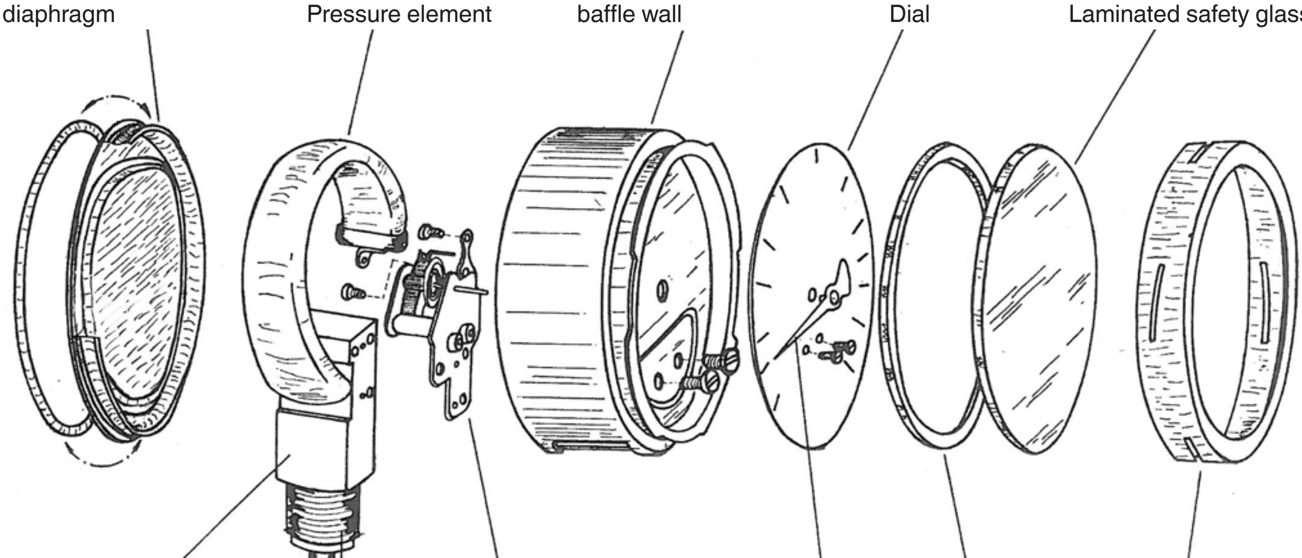

Illustration 11: Exploded view drawing

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General information about NACE standards
For sour gas applications with WIKA products

WIKA data sheet IN 00.21

General information

This technical information refers to two publications in the area of material requirements. Here MR stands for "**M**aterial **R**equirements".

- NACE [1] MR0175
  "Petroleum and natural gas industries. Material for use in H_2S-containing environments in oil and gas production."
- NACE [1] MR0103
  "Materials resistant to sulphide stress cracking in corrosive petroleum refining environments."
- Only for pressure gauges, pressure transmitters, diaphragm seals and thermowells

Fig. left: Bourdon tube pressure gauge model 232.30
Fig. right: Diaphragm seal, flange connection model 990.27

Application example:
Pressure transmitter models E-10 and E-11

Thermowells in various design

Description

Natural gas and crude oil, as raw materials, contain greater or lesser high levels of hydrogen sulphide (H_2S). If there is a minimum amount of H_2S and a minimum total pressure, such a mixture is recognised as "sour gas" or "sour oil".

Both standards describe the corrosion properties of metals in the presence of H_2S under different corrosion mechanisms. Firstly, hydrogen-induced stress cracking corrosion is considered. This is greatest at room temperature and is the focus of MR0103. A typical application for this standard is downstream processing in a refinery.
Secondly, chlorine-induced stress cracking corrosion under the influence of H_2S is considered. This is aided at higher temperatures and is described by NACE MR0175. A typical application is the production of oil and gas.

1) The term **"NACE"** refers to an organisation (**N**ational **A**ssociation of **C**orrosion **E**ngineers), which primarily deals with any form of corrosion. The results of their work are published in many publications as NACE standards and updated regularly. The headquarters of this organisation is in Houston, Texas/USA.

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The NACE MR0175 standard is represented in the ISO 15156 standard (part 1 - 3) internationally valid. This deals with technical issues regarding corrosion of materials during the extraction and processing of natural gas and crude oil. The ISO 15156 standard, Part 3, describes the use of corrosion-resistant metals and complies with to NACE MR0175.

NACE MR0175
NACE MR0175 (ISO 15156-3) describes, according to the application, for the various material groups, the relevant requirements for each individual material and the maximum permissible temperature limits (see table).

NACE MR0103
This standard is similarly constructed and can also be implemented for WIKA products if a customer wishes. It defines the material requirements and temperature limits for applications in refineries.

Material selection

In sour gas applications, the corrosion properties of metals depend on the environmental conditions (pH value, chloride content, H_2S concentration and temperature limits) and the maximum strength of the materials. For different materials there are different strength requirements.

In accordance with the standard, ISO 15156-1/section 5 “General principles”, it is the responsibility of the user to specify which material is suitable for the application.

With knowledge of the above-mentioned environmental conditions, WIKA can make recommendations on the selection of materials.

If the details of the environmental conditions are not adequately known, WIKA specifies the operating conditions for ISO 15156-3 under the assumption of critical environmental conditions.
On this basis, therefore, only the lowest maximum process temperature can be confirmed.

Example:
For nickel-based alloys such as HC276, in a work-hardened condition, without knowledge of the environment conditions, a maximum temperature of 132 °C will apply, whereby, at a given partial pressure of H_2S of less than 200 kPa, a maximum temperature of 232 °C would be possible.

Generally, with its products, WIKA fulfills the strength requirements (maximum hardness) of materials. Exceptions are the elements of mechanical pressure gauges. Here, due to their elastic properties, higher strength is required. WIKA has demonstrated in detail the suitability of its Bourdon tube measuring system in accordance with ISO 15156-3 through independent laboratory testing up to 120 °C.

The following table gives an example-based overview of the lowest maximum operating temperatures by material and product group per “Any equipment and component” in accordance with ISO 15156-3/NACE MR0175.

Product group	Stainless steel 316L	Monel 400	Duplex 1.4462	Alloy C276	Elgiloy 2.4711
Mechanical pressure measuring instruments	max. 120 °C 1)	no limit	n/a	n/a	n/a
Electronic pressure measuring instruments	n/a	n/a	n/a	n/a	no limit 3)
Diaphragm seal	no limit 2)	no limit	max. 232 °C	max. 132 °C	n/a
Thermowells	no limit 2)	no limit	max. 232 °C	max. 132 °C	n/a

1) Measured using laboratory testing
2) Classified using “Instrumentation and control device”: as of 2009
3) Classified using “Diaphragms, pressure diaphragms, pressure measuring devices and pressure seals”

Even if the NACE standard has no temperature limit, the product-specific details, which can limit the maximum operating temperature, should be considered.

General information

Welding
The welding processes (WPS/PQR) are qualified in accordance with the appropriate standards (AD 2000 or ASME). One element of the welding procedure tests is hardness testing of the weld seam. A retrospective verification of the hardness on the welded product is not prescribed by the NACE standards for cracking-resistant alloys.

Heat treatment following welding
Heat treatment (PWHT) is not mandatory. For certain materials (e.g. carbon steel) heat treatment can be required due to technical considerations of the welding.

Hardness values on semifinished product
A proof of the hardness values of the semi-finished products is made via the supplier's 3.1 acceptance test certificate (except for stainless steel Bourdon tubes and NiCrCo alloy 2.4668 (Inconel 718) diaphragm elements).

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Diaphragm seal systems for vacuum processes

WIKA data sheet IN 00.25

Vacuum

The word vacuum (from the Latin: vacuus - empty) means "(largely) empty or free space".
Physics refers to a space that is completely free from molecules as a vacuum. In practice, this condition is never feasible.

Diaphragm seals

Diaphragm 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. Hydraulic transfer of the pressure to the measuring instrument

(see also Technical information IN 00.06 "Diaphragm seals - Diaphragm seal systems, application, operating principle, designs")

Differential pressure transmitter connected to two flange-type diaphragm seals via a capillary

Absolute pressure

Absolute pressure refers to the perfect vacuum. In this absolutely molecule-free space the zero point of the absolute pressure is defined. An example of a common "absolute" indicated value is the air pressure.
For the required differentiation from other types of pressure, it is denoted with the index "abs.", which is derived from the Latin "absolutus", meaning detached or independent.

Diaphragm seal systems in vacuum service

For application in vacuum, there are different diaphragm seal system fill fluids (KN 2, KN 17, KN 21, KN 32, KN 59 and KN 92) used. Each reacts differently in vacuum applications. In terms of physics, the boiling point temperature of a liquid decreases with falling pressure.

In a liquid, at a temperature of greater than 0 K, the particles attempt to leave the liquid bond (transition from liquid to gaseous).
The vapour pressure increases with increasing temperature and is dependent on the substance or mixture present.
Thus the operating limits for the individual measuring assemblies drop with a process pressure < 1 bar abs. WIKA has developed three manufacturing processes for this (Basic, Advanced and Premium), which are described below.
This technical information should assist in assessing the limits of the measuring instruments.

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Vacuum in the process industry

In the meantime, vacuum processes have established themselves in many industrial and biotechnology plants. Many processes are no longer conceivable without vacuum processes. An example for a vacuum process in an industrial operation is a distillation column or rectification column in crude oil production.
Crude oil is the base. It is introduced to the process, and the products are then distilled from it separately according to the individual boiling point ranges (also known as fractions). The products are then subjected to further processing.

This occurs in two steps:
Initially, the easily evaporated substances can be separated at "normal" pressure (≥ 1,013 mbar abs.). In a second step, the hard-to-evaporate substances are distilled in a vacuum (< 1,013 mbar abs.). In a vacuum, the boiling point of individual compounds can be lowered significantly without destroying them through too high temperatures.
The temperature increases during the course of the process, while the pressure decreases.

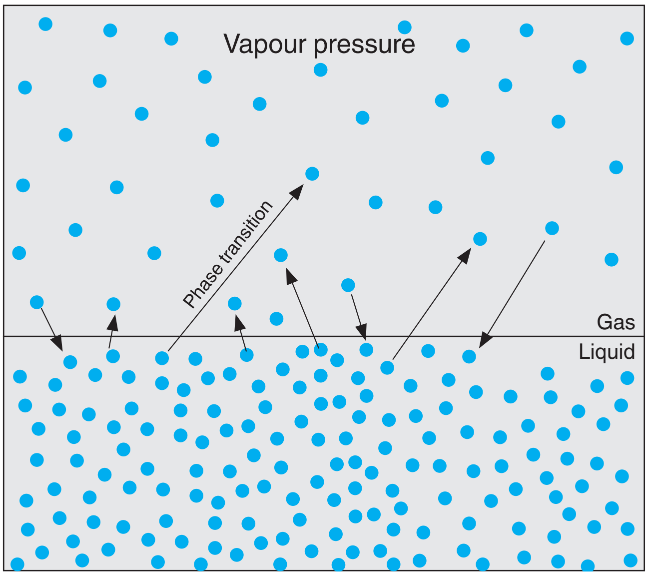


Illustration of the vapour pressure of liquid particles at their transition to the gaseous phase

Diaphragm seal systems in vacuum service

The following basically applies: The higher the temperature and the smaller the corresponding process pressure, the more difficult it is to design a functioning measuring assembly.
In terms of physics, there are different types of vacuum. From low vacuum, fine vacuum, high vacuum through to ultra-high vacuum. The process pressure in industrial plant is generally ≥ 5 mbar abs. (low vacuum range).

Applicable core factors for the required design of a functioning measuring assembly are given in the following points:

Influence quantities for the application process:
- Process temperature
- Process pressure

Influence quantities of the diaphragm seal system:

- Production process of the diaphragm seal system
- Vapour pressure curve of the selected system fill fluid
- The selected process connection with the corresponding diaphragm diameter

Below, the vacuum processes available from WIKA are described in more detail. The processes basically depend on the minimum process pressure at maximum temperature and the individual system fill fluids. This technical information applies for electronic process and industrial transmitters.

Section ① Basic service

Through ongoing and continuous advancements in WIKA's vacuum production processes, measuring ranges, for which specific conditioning of components is no longer necessary, are possible.

The basic service will be designated in the following illustration by section no. ① "Basic service".

Section ② Advanced service

For the more-demanding measuring points, WIKA has established the advanced service. The majority of all measuring assemblies which are intended for use in vacuum can be covered by the advanced service.
The illustration of this service will be designated below in section no. ② with "Advanced service".

Section ③ Premium service

For measuring points in lower vacuum ranges and/or with high process temperatures, the "Advanced service" is no longer sufficient.
For this, WIKA has developed the "Premium service" with specifically designed component conditioning and a refinement of the system fill fluid. The "Premium service" is designated in the illustration with the section no. ③.

Section ④ Customer support

If the application finds itself in section no. ④ "Customer support", our technical clarification will work out a solution for your application.
For this, precise information on the application process is required. For this reason, simply fill out this questionnaire and send it to your contact person at WIKA.

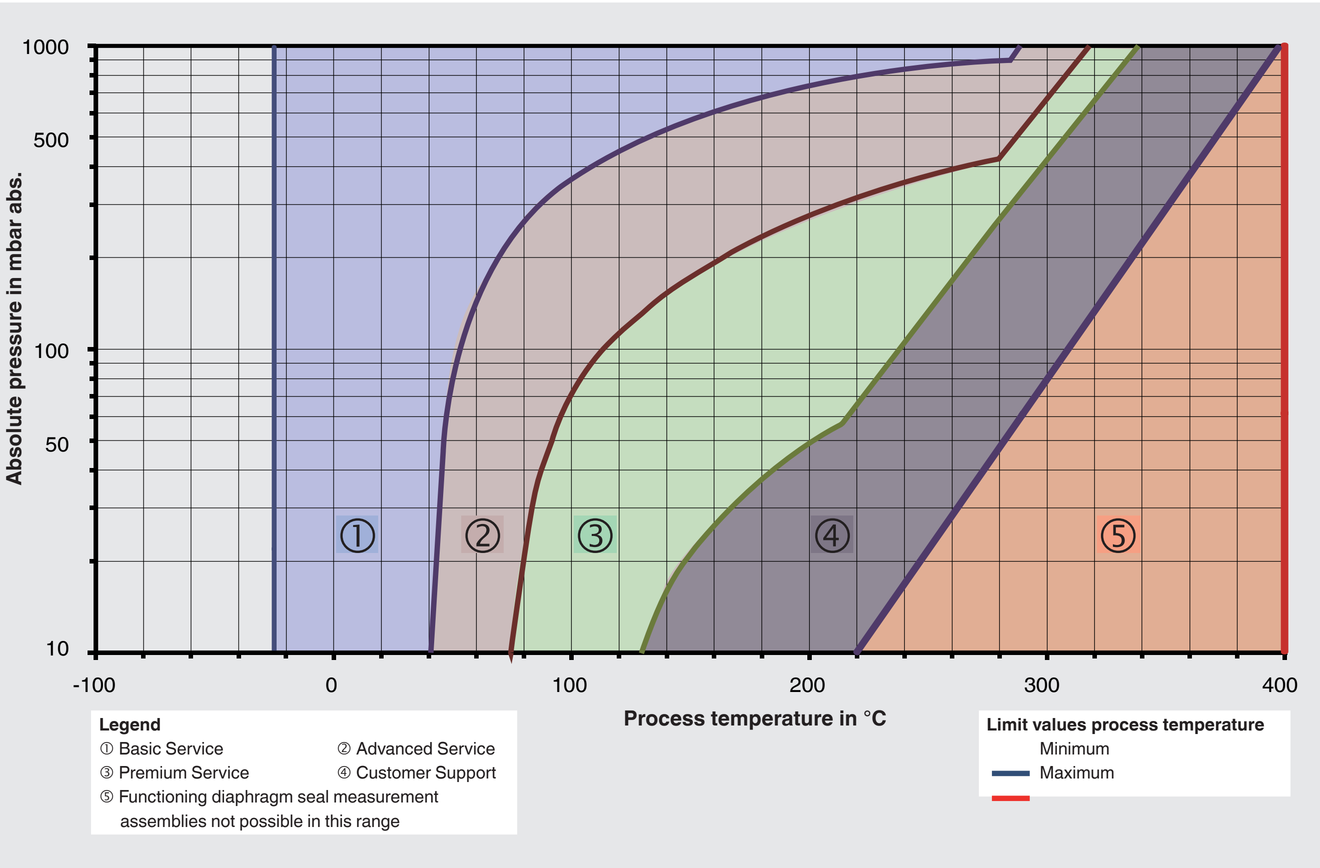
Questionnaire for diaphragm seals

http://de-de.wika.de/upload/DS_QuestionnaireDS_GB_5796.pdf

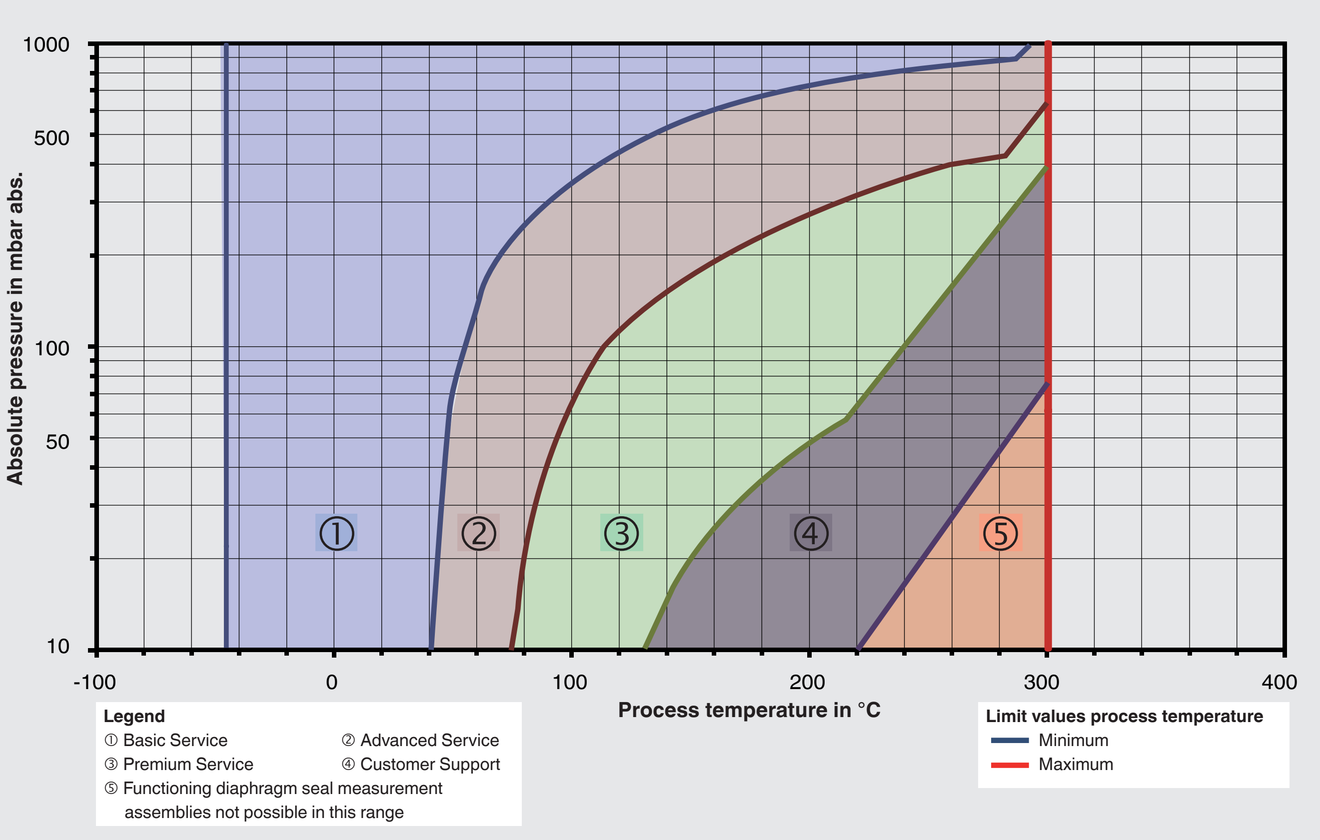
Explanation of the vacuum processes

Our vacuum processes are clearly illustrated in the following diagrams.

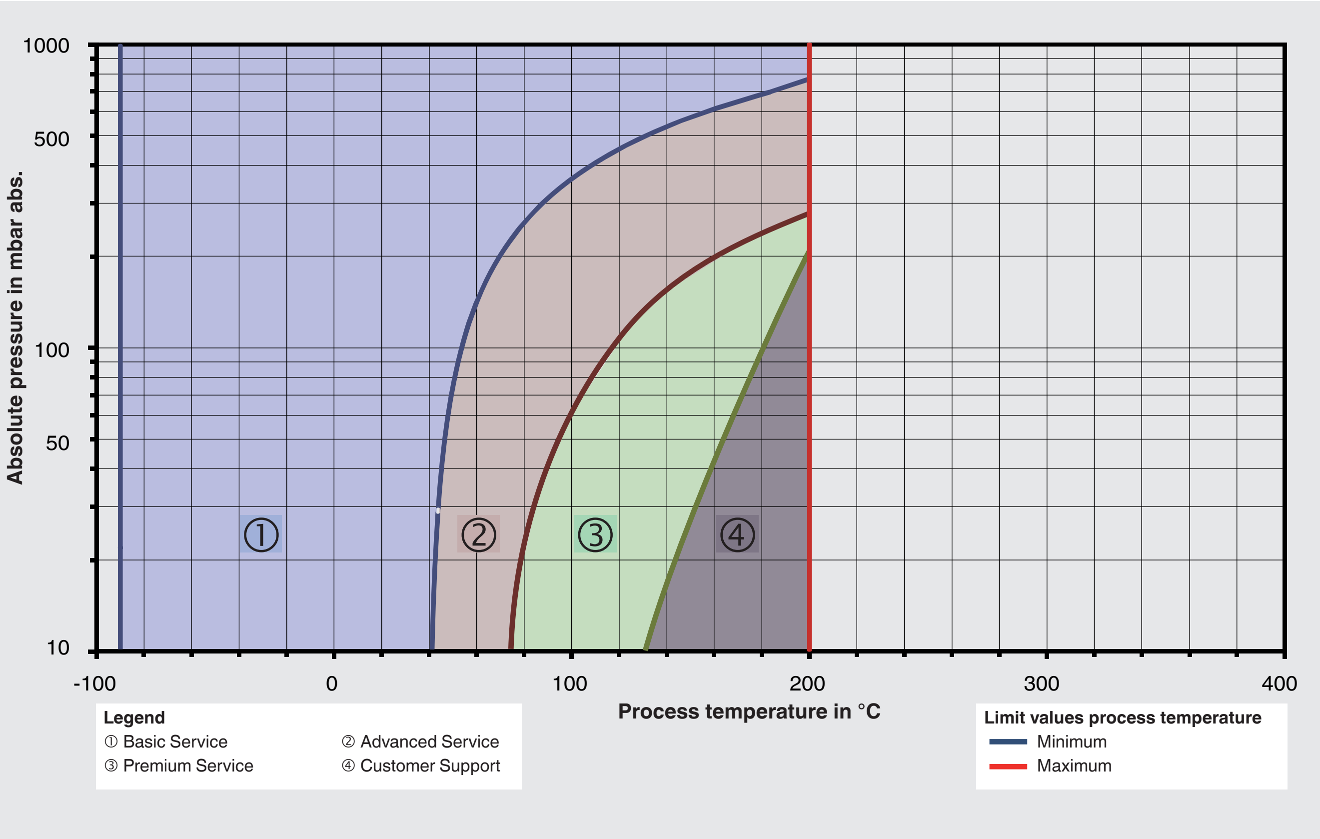
Vacuum application with system fill fluid KN 32



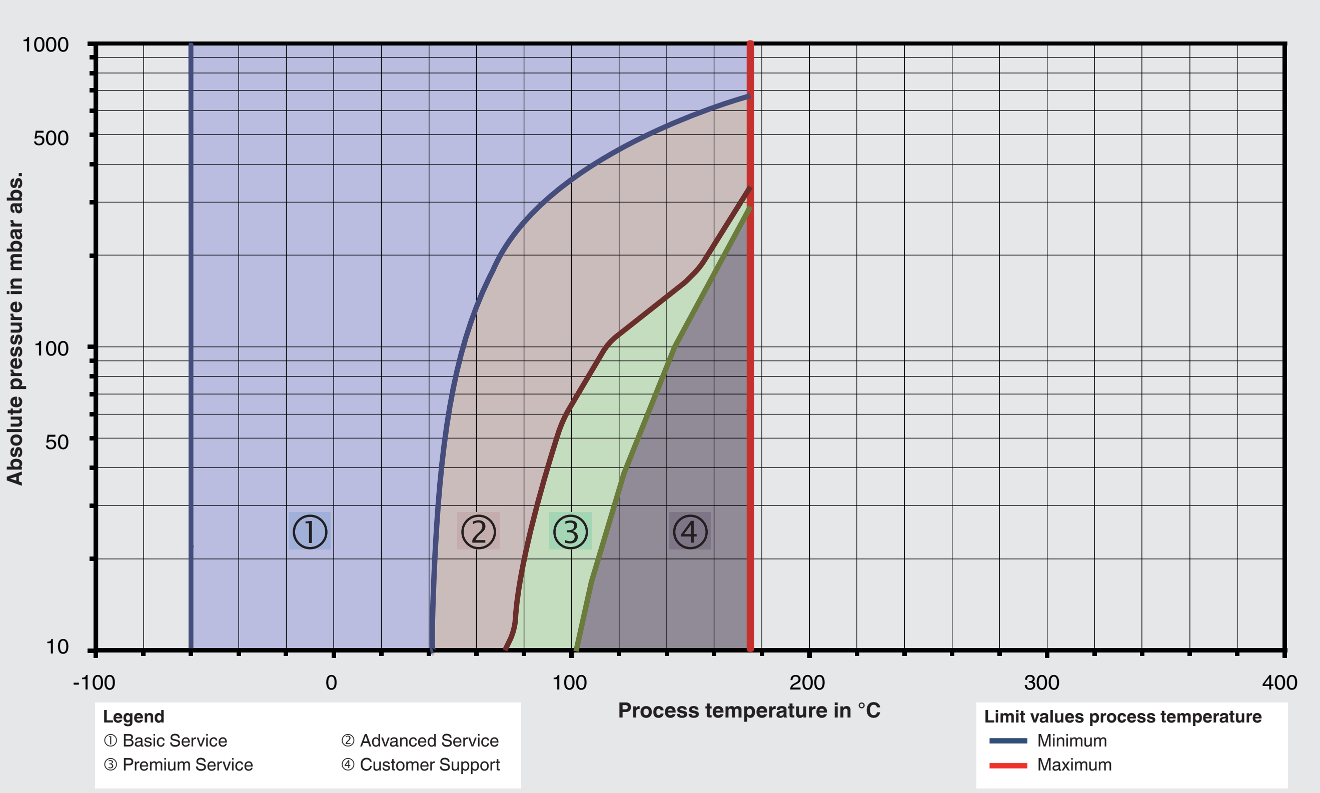
Vacuum application with system fill fluid KN 2



Vacuum application with system fill fluid KN 17



Vacuum application with system fill fluid KN 21

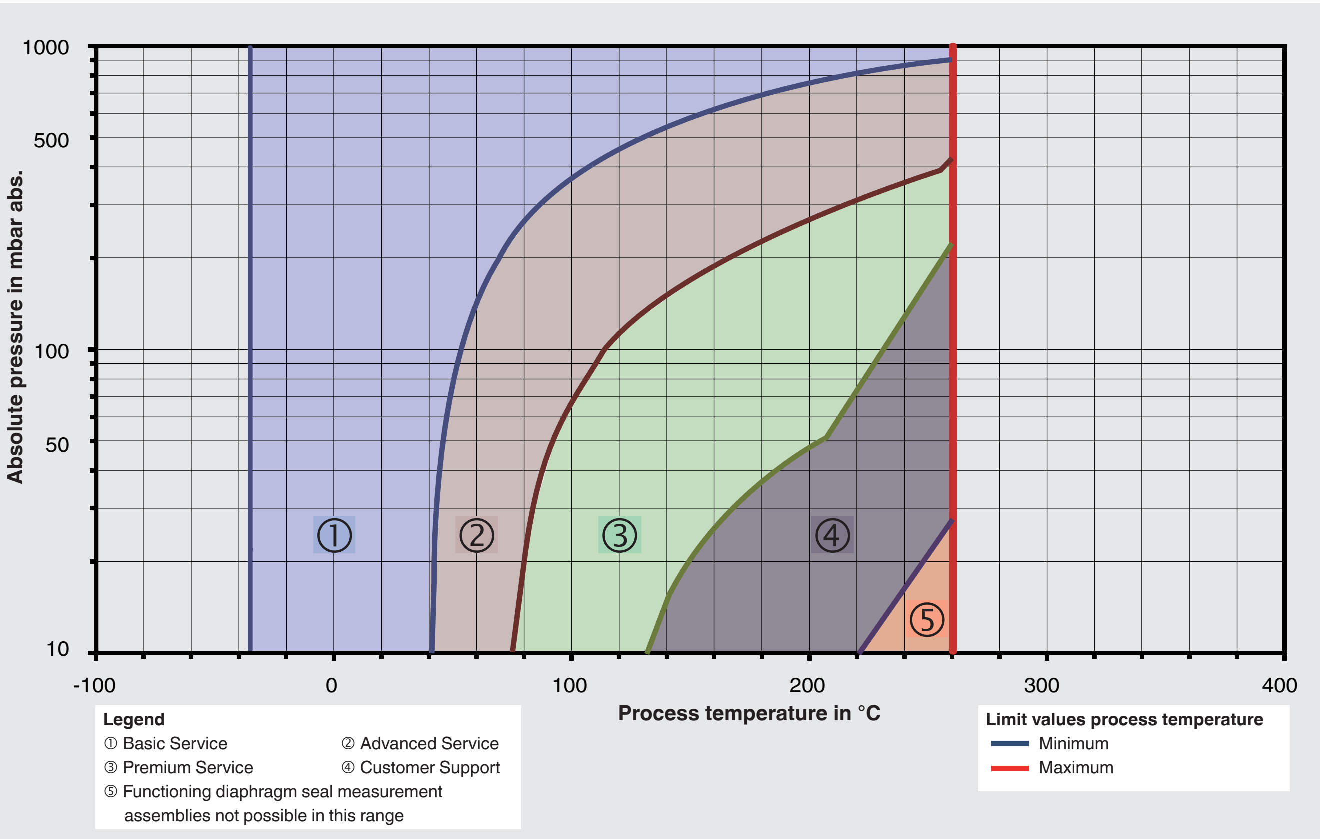


Oxygen applications

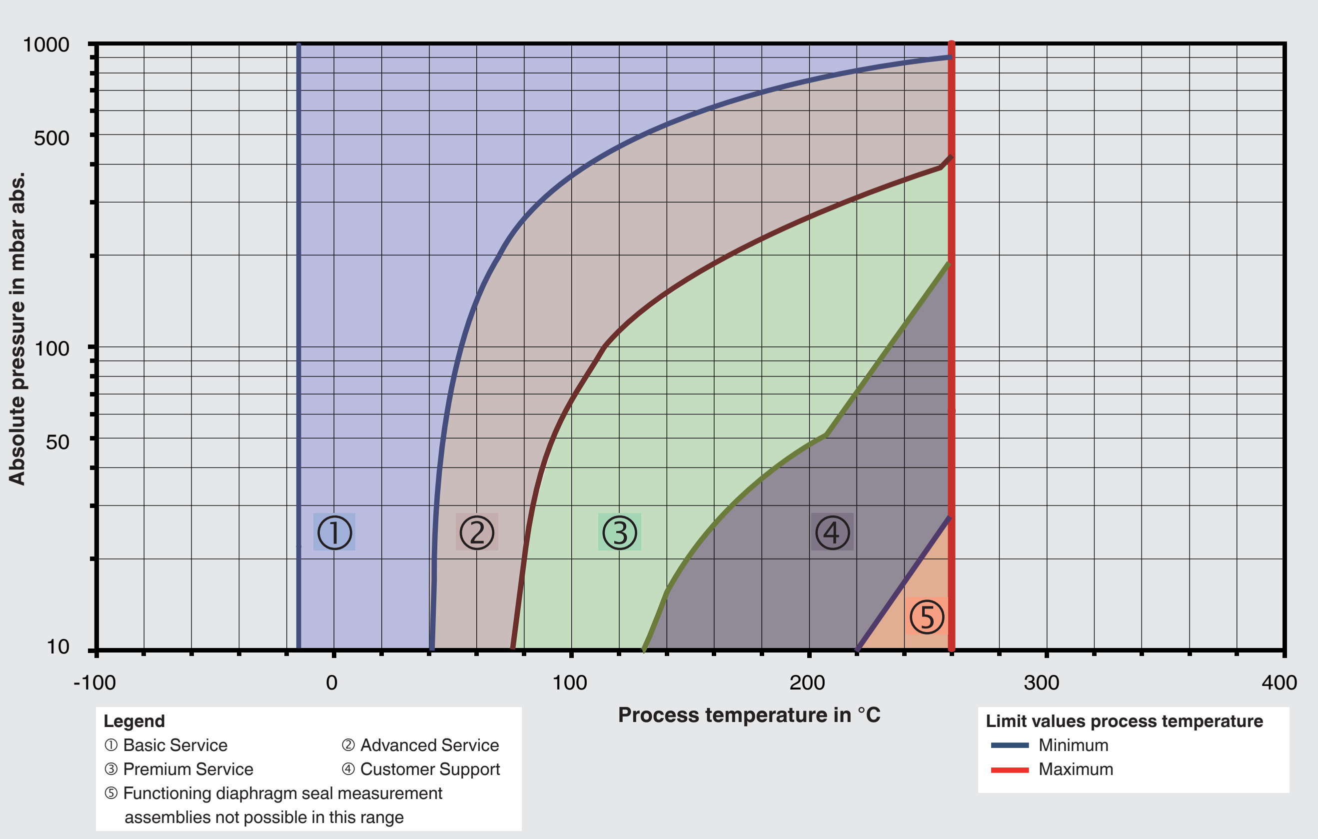
Per BAM test (Federal Institute for Materials Research and Testing) these table values apply.

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

Vacuum application with system fill fluid KN 59



Vacuum application with system fill fluid KN 92



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