



MEASUREMENT TECHNOLOGY



## Designing hygienic pressure and temperature measuring stations

A large, faint, stylized gauge with concentric circles and radial lines serves as a background for the lower half of the slide.

12.45

Instrumentation for monitoring pressure and temperature - Made in Germany

### Over 40 years of experience

LABOM has designed, manufactured and marketed industrial controls and instrumentation for over forty years. The company's primary focus is on technology for measuring and monitoring pressure, temperature and fill levels. LABOM is a global supplier of instrumentation to the food/pharmaceuticals/biotechnology sectors, as well as for chemicals, petrochemicals, energy, green technology and ocean shipping.

For the food, pharmaceuticals and biotechnology sectors, LABOM offers a wide range of custom devices that are specially designed for particular applications. These instruments meet hygienic design requirements. We deliver standard and custom solutions under our "Instruments made to measure" slogan.



Quality and customer satisfaction underpin all our thinking and actions. Our quality management system complies with DIN EN ISO 9001:2008, Pressure Equipment Directive 97/23/EC and ATEX 94/9/EC.

### Member of EHEDG



LABOM has built up valuable expertise over the years; our personnel are highly qualified and motivated; we use cutting edge manufacturing technology and work closely with research institutes and other manufacturers involved in hygienic manufacturing. Labom is a very competent partner. Since 2009, we have been a member of the EHEDG and are enhancing the reliability of production processes by deploying hygienic instrumentation.

Global distributors, technical consultants and sales representatives provide consultancy and service locally.

This brochure describes the special requirements of sensitive hygienic production processes. Technical issues and solutions are introduced.







## Introduction

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## Introduction to Hygiene

The industry is under increasing pressure to produce food, pharmaceutical and biotechnology products with reliable

and absolutely hygienic production processes. This is due to heightened public demand for flawless products.

Products, which have a direct or indirect impact on people's health, must be produced to global standards. Companies are forced to follow good manufacturing practice (GMP) in order to ensure reproducible quality. Hygienic production plants are a must in order to satisfy health and safety and environmental requirements and to address costs issues and risks for manufacturers.

Hygienic instrumentation and controls are needed to produce flawless products. All equipment must operate reliably throughout the entire life of the plant. In order to achieve this, the instrumentation needs to be designed and installed with the following in mind:

- all components can be cleaned properly
- the product cannot be contaminated
- bacteria cannot enter or spread throughout the plant
- there are no changes to product properties
- only nontoxic and suitable materials are used
- all materials are very durable and stable for process and cleaning cycles

This means that closed plants can be included in automated cleaning in-place (CIP) and sterilization in-place (SIP) cycles.





## EQUIPMENT REQUIREMENTS

LABOM hygienic pressure and temperature measuring devices are designed and manufactured to hygienic design standards. Our aim is to produce flawless, hygienic products for the food, pharmaceutical and biotechnology sectors. They are CIP and SIP compliant.

### Design of hygienic instrumentation

Good cleanability, absolutely no bacterial contamination of product, high reliability and no impact on product – these are the key principles underlying instrumentation design and selection.

These principles are then executed for the application at hand: the instruments are designed for hygienic use; they are manufactured in a competent manner; suitable materials and components are used and the instruments are properly installed. Among the key considerations are:

- dead zones, crevices and edges should be avoided
- flawless surfaces with minimum roughness
- components should be flush mounted
- use non-corrosive steels
- use suitable sealing compounds, materials and seal shapes
- self-draining design and installation
- Instruments should be easy to install and remove

Apart from engineering expertise, the company must be very competent when it comes to manufacturing the instruments. We have the necessary skills and expertise in our works in Hude, Germany – starting with the first machined part right through to the finished product. All materials and components used and all stages of production and tests are traceable. An in-house production line, HY, ensures the requirements listed above are met. Inspection certificates, issued by staff outside the production department, confirm the quality criteria, if necessary.

- Thus, hygienic instruments from LABOM are ideally suited to meet the high quality criteria of the GMP guidelines. Sealing compounds, plastic coatings and diaphragm seal oils are listed by the FDA. Diaphragm seal oils are NSF-H1 (old USDA-H1) approved. All materials used are thus completely food compatible.

LABOM hygienic instruments are EHEDG approved.

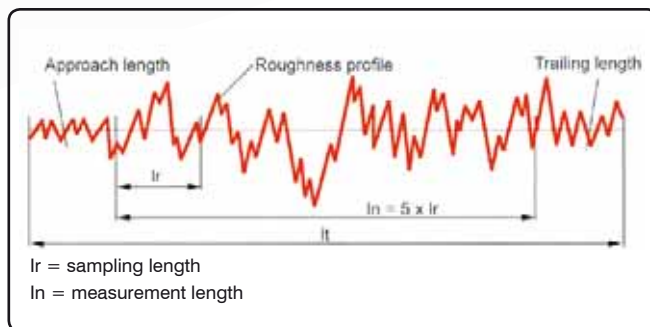


## Surface finish

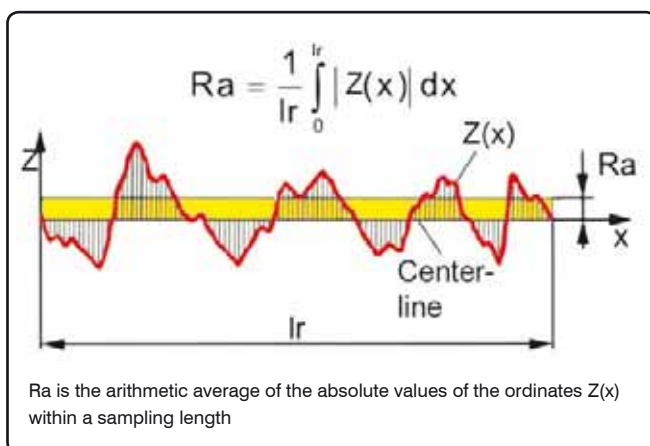
Surface finish is – besides instrumentation design – a critical success factor. Only flawless surfaces with no scratches, pores, fissures, cavities or clefts and with minimum roughness can be cleaned and sterilized with automated cleaning cycles.

Since a three-dimensional survey of surface topography followed by an assessment of results is impractical, the roughness  $R_a$  is generally accepted as a measure of surface texture. In the contact profile method, a diamond stylus connected to a displacement sensor travels a fixed distance across the surface. The roughness  $R_a$  – a standard metric for assessing surface cleanability – is calculated from the roughness profile produced by the profilometer.

### Measuring the roughness profile



### Roughness profile and roughness $R_a$ of a sampling length as per DIN EN ISO 4287



Typically, a roughness of  $R_a \leq 0.8 \mu\text{m}$  to EHEDG standard is acceptable. These surface roughness values are produced by precision machining, mechanical grinding, mechanical polishing and work hardening. No improvement in cleanability is to be expected with values below  $R_a = 0.4 \mu\text{m}$ .

LABOM guarantees a roughness  $R_a$  of  $\leq 0.8 \mu\text{m}$  as standard for all wetted surfaces in its hygienic instrumentation. Lower roughness values can be provided upon request. Membrane foils have a roughness  $R_a$  of  $\leq 0.4 \mu\text{m}$ .

The roughness  $R_a$  is the height of a rectangle, with the same length as the sampling length  $l_r$  and the same area as the area between the surveyed roughness profile  $Z(x)$  and the centerline. Typically, five sampling lengths are used to calculate the roughness.

Surface finish can be enhanced by electropolishing, which is an electrochemical process. The surface is cleaned and smoothed by very slight material abrasion; the average roughness remains practically unchanged. Any cavities and overlaps are removed. The result is a homogeneous passive layer with much better corrosion behaviour and a polished surface.

## CONNECTION TECHNOLOGY

### Pipe Fittings and Joints

Pipe breaks should be avoided if at all possible, but sometimes there is no other option but to break a pipe run. They bring with them the increased risk of contamination through crevices, dead zones and reduced flow conditions. In many cases, however, they cannot be avoided.

Pipe fittings are available that reduce the contamination risk to a minimum. Some of the key issues are:



- Self-centering with a cylindrical guide so that edges and protrusions can be avoided. The result is a perfect seal on the inside of the pipe.
- After assembly, a metallic stop ensures that the seal is subjected to a definite compressive loading.
- To ensure a perfect seal at different temperatures, there needs to be sufficient space between the ring gasket and the side facing away from the process to allow for thermal expansion.
- CIP- and SIP-compliant
- Easy to install and remove especially on plant that can be disassembled

LABOM instruments are available with a wide variety of fittings so they can be adapted to meet the requirements of different processes:

- pipe fittings for inline adaptation
- flat diaphragm seals
- protective tubes with different process connections for temperature measuring devices
- models with threaded, clamp and flanged connections
- metallic sealing process connections
- tubus solutions
- manufacturer-specific process connections
- custom solutions

### Gaskets

Instruments and pieces of equipment are adapted to the process by using the proven connection technology and gaskets. This is why the choice of gasket is key. It has to function properly under all process and cleaning conditions throughout its service life. O-rings and molded gaskets are used as seals. The key properties and requirements are:

- mechanically and chemically durable with the products and cleaning agents in the specified temperature range
- ensuring a definite compressive loading taking the thermal expansion of the seal into account
- minimum thermal expansion
- non-poisonous, colorless and tasteless
- chemically inactive
- smooth surface to prevent adhesion of particles
- adequate elasticity
- compliance with norms and guidelines

We recommend the elastomers listed below for standard seals in common applications:

- |           |  |
|-----------|--|
| • EPDM    | <i>ethylene propylene diene monomer</i>      |
| • NR      | <i>natural rubber</i>                        |
| • NBR     | <i>acrylonitrile butadiene rubber</i>        |
| • NHBR    | <i>hydrogenated nitrile butadiene rubber</i> |
| • VMQ     | <i>silicon rubber</i>                        |
| • FKM/FPM | <i>fluorocarbon rubber</i>                   |
| • FFKM    | <i>perfluoroelastomer</i>                    |

If you have any issues with your choice of seal for a given application you should discuss the matter with your seal supplier.



Photo: COG



## INTRODUCTION PRESSURE MEASUREMENT

Ideally, pressure measuring instruments - together with diaphragm seals - meet the specifications for hygienic pressure measuring stations. Diaphragm seals are partitions for pressure measuring instruments and they perform three key functions:

1. Separating the sensitive sensor element from the process. This protects the pressure measuring instruments from:
  - aggressive, highly viscose or crystalizing process liquids
  - high process liquid temperatures and temperature variations
  - pressure peaks and pipe hammer
2. Transmitting the process pressure to the sensor element
3. Hygienic process adaptation of pressure measuring instruments.

**LABOM diaphragm seals are adapted to suit the pressure measuring instruments in a given application by means of their design, the choice of materials and the manufacturing method used. This ensures best performance in the face of stringent specifications for hygienic design.**



Pressure transmitter PASCAL Ci  
with inline diaphragm seal, connections as per  
DIN 11864-1, EHEDG approved

LABOM hygienic diaphragm seals are suitable for use in the food/pharmaceuticals/biotechnology sectors.

LABOM diaphragm seal technology has the following characteristics:

- flush-mounted, robust membrane with suitable surface finish of  $Ra \leq 0.4 \mu m$
- laser-welded membrane, roughness of weld  $Ra \leq 0.8 \mu m$
- CIP and SIP compatible
- numerous process connections for practically every process adaptation
- wetted parts made of 1.4435 (316L) as standard and with reduced delta ferrite as per Basle Standard BN 2
- special-order materials available
- food-grade coatings
- material inspection certificate to DIN EN 10204



Diaphragm seal/pressure switch PASCAL CS  
VARIVENT connection, EHEDG approved

### Membrane-type diaphragm seals

Diaphragm seals are fitted in the process to a weld-on nipple on the pipe or tank. The dead volume of the weld-on nipple can be minimized by using tube-type diaphragm seals.

### Inline diaphragm seals

Process adaptation with absolutely no dead zones or gaps is achieved with hygienic inline diaphragm seals. The device is installed between two connection sleeves in the pipe. Since the seal is almost circular in shape and the membrane is raised there is no turbulence. The system will drain in depressurized conditions when suitably installed.

### Diaphragm seal liquids

Various food-grade system fills are available for different requirements. They are listed by the FDA and have NSF-H1- (old: USDA-H1-) approval.

### Temperature decouplers and capillaries

Standard LABOM pressure measuring instruments are designed for sterilization temperatures up to 140°C. Temperatures of up to 400°C are possible by introducing a temperature decoupler between diaphragm seal and pressure measuring instrument. Capillaries protect the measuring instruments from vibrations.



Temperature decoupler



Capillary



## DIAPHRAGM SEALS FOR HYGIENIC APPLICATIONS

## Membrane-type diaphragm seals

		
<b>Aseptic connections</b> <ul style="list-style-type: none"> <li>- threaded connection DIN 11864-1</li> <li>- aseptic flange DIN 11864-2</li> <li>- NEUMO BioConnect</li> <li>- Südmo</li> <li>- Guth</li> </ul>	<b>Clamp connection</b> <ul style="list-style-type: none"> <li>- ISO 2852</li> <li>- DIN 32676</li> <li>- Tri-Clamp</li> <li>- DIN 11864-3</li> </ul>	<b>Standard threaded connections</b> <ul style="list-style-type: none"> <li>- threaded connection DIN 11851</li> <li>- SMS threaded connection</li> <li>- IDF threaded connection</li> </ul>
		
<b>Special-order connections</b> <ul style="list-style-type: none"> <li>- process connection per INGOLD</li> <li>- Fermenter</li> <li>- HYGIENIC, with no gasket</li> </ul>	<b>Manufacturer-specific</b> <ul style="list-style-type: none"> <li>- VARIVENT</li> <li>- NEUMO BioControl</li> <li>- DRD</li> </ul>	<b>Hygienic Tubus</b> <ul style="list-style-type: none"> <li>- Tubus Ø 76 mm</li> <li>- Tubus Ø 101 mm</li> <li>- Tubus Ø 43,3 mm</li> <li>- Tubus Ø 52,5 mm</li> </ul>

## Inline diaphragm seals

		
<b>Aseptic threaded connections</b> <ul style="list-style-type: none"> <li>- threaded connection DIN 11864-1</li> <li>- Südmo</li> <li>- Guth</li> </ul>	<b>Manufacturer-specific</b> <ul style="list-style-type: none"> <li>- NEUMO BioConnect</li> </ul>	<b>Standard connections</b> <ul style="list-style-type: none"> <li>- threaded connection DIN 11851</li> <li>- IDF threaded connection</li> <li>- clamp connection</li> <li>- specially designed for small nominal width</li> </ul>

Pressure measurement technology together with diaphragm seal technology - the ideal solution for a hygienic pressure measurement station.

All pressure transmitters can be combined with any diaphragm seal.



### Pressure transmitter PASCAL Ci

The pressure transmitter for the most challenging specifications.

- Hygienic stainless steel case, rotatable
- Degree of protection IP67 for extreme climatic conditions
- Text-based operation via graphical display
- Measuring ranges from 0...160 mbar to 0...400 bar
- Turndown ratio to 20:1
- High overload capability
- Output: 4...20 mA, 2-wire, HART protocol
- Up to 0.1% accuracy
- Separate electrical connection box
- SIL 2 grade
- ATEX approved



### Pressure transmitter PASCAL CV

The pressure transmitter with smarter module technology.

- Hygienic stainless steel enclosure
- Degree of protection IP66
- Replaceable function modules
  - multifunctional display
  - switching module
  - communication modules PROFIBUS PA and HART
- Measuring ranges from 0...80 mbar to 0...100 bar
- Turndown ratio 5:1
- Output, 4...20 mA, HART protocol, PROFIBUS PA
- Up to 0.15% accuracy
- Easy local programming
- SIL 2 grade
- ATEX approved



### Pressure transmitter / pressure switch PASCAL CS

The multifunctional pressure transmitter also serves as a pressure switch.

- Hygienic case design
- Degree of protection IP66
- 4-digit LED indication, rotating and can be mirror-imaged by 180°
- Measuring ranges from 0...160 mbar to 0...40 bar
- Output: 4...20 mA, 2-wire
- Up to 0.2% accuracy
- Easy local programming
- Optional with two PNP switching outputs
- Directly ventilated sensor element
- Fully encapsulated electronics

### Pressure transmitter UNIVERSAL CA

The universal pressure transmitter for almost all applications.

- Hygienic stainless steel case
- Degree of protection IP66
- Measurement range from 0...160 mbar to 0...40 bar
- Accuracy 0.2%
- Output: 4...20 mA, 2-wire technology
- Easy zero setting with magnet
- Directly ventilated sensor element
- Electronics fully encapsulated



### Pressure transmitter COMPACT ECO

The pressure transmitter for simple applications.

- Measuring ranges from 0...1 bar to 0...40 bar
- Accuracy  $\leq 0.3\%$
- Output signal 4...20 mA, 2-wire technology
- Hygienic stainless steel case
- Degree of protection IP 65, encapsulated electronics
- Easy zero setting with magnet



### Mechanical pressure gauges

For local mechanical indication.

- High-grade bayonet ring case in DN 63, DN 100 and DN 160
- Low temperature error due to reduced volume movement
- Optional with switched contacts and/or 2-wire 4...20 mA output
- Measuring ranges from 0...2.5 bar to 0...400 bar
- Class 1.0
- High overload protection
- Instrument connection welded with diaphragm seal
- Optional: autoclavable





## TEMPERATURE MEASUREMENT TECHNOLOGY

Temperature is the most commonly monitored process variable in the food/pharmaceutical/biotechnology sectors. Hygienic process adaptation along with high accuracy are the challenges that need to be met.

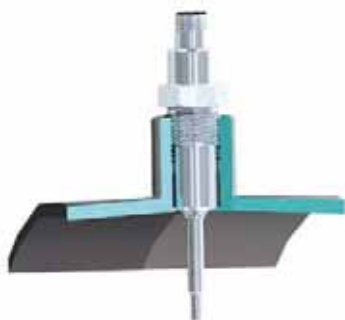
LABOM offers a wide range of temperature measuring devices using different measurement technologies. These devices can be equipped with different process connections that are suitable for the food/pharmaceutical/biotechnology sectors. Invasive solutions with protective

tubes, inline temperature transducers for inline measurements and clamp-on pipe collars are available. Pipe sizes from DN10 to DN100 in all common pipe standards are available.

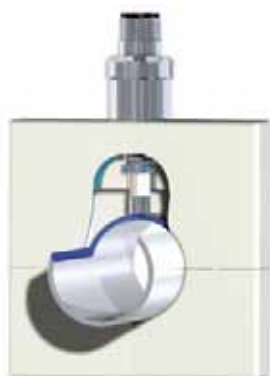
All wetted parts are supplied with a surface finish of  $Ra \leq 0.8 \mu m$  and better. Optionally, wetted parts can be electropolished. Material properties can be confirmed with 3.1 inspection certificate to DIN EN 10204.



Resistance thermometer GA 2540  
with clamp connection, EHEDG approved



MiniTherm GA 2700  
G1/2 conically sealed



Resistance thermometer clamp-on technology  
for pipe temperature monitoring

### Protective tubes

Protective tubes are recommended for invasive measurements. This allows the temperature probe to be calibrated without interrupting or altering the process. A variety of process connections for hygienic measuring stations are available. Tapered sensor tips cut device response times.

### Mechanical dial thermometers

Bimetallic thermometers or gas expansion thermometers with local read-out are available for mechanical temperature measurement with high reliability. When the devices are fitted with an electrical contact device or analog output, they are suited for temperature monitoring and control.

### Resistance thermometers

LABOM resistance thermometers for the food/pharmaceuticals/biotechnology sectors are available in many designs for invasive measurements with protective tube and for inline measurements with inline temperature transducers. As a minimum, class A Pt100 resistors are always fitted.

### Clamp-on resistance thermometers

Temperature measurements can be taken on the pipe from outside with the LABOM clamp-on resistance thermometer without opening or interfering with the process. The patented design allows very accurate measurements to be taken. The probe is mounted on the pipe with a resilient clamping system. The measurement station requires no further insulation. The probe with the fast-response Pt 100-element can be replaced without removing the pipe collar. The sensor can easily be replaced and calibrated without altering the measurement point in any way. Clamp-on resistance thermometers are ideally suited for sterilization monitoring.

**That's why LABOM can offer the best possible solution for every measurement task.**

## PROCESS CONNECTIONS

### Immersion probes for invasive temperature measuring



#### Standard threaded connections

- threaded connection DIN 11851
- SMS threaded connection
- IDF threaded connection



#### Clamp connection

- ISO 2852
- DIN 32676
- Tri-Clamp



#### Special threaded connections

- process connection per INGOLD
- Fementer
- HYGIENIC, no gasket



#### Aseptic threaded connections

- threaded connection DIN 11864 -1
- NEUMO BioConnect
- Südmo
- Guth



#### Manufacturer-specific

- VARIVENT
- NEUMO BioControl
- DRD



#### Hygienic connection

- conical metallic sealing

### Inline temperature transducers for installation in pipe



#### Standard connections

- threaded connection DIN 11851
- IDF connection
- Clamp connection
- Manufacturer-specific threaded connections

### Clamp-on for mounting on pipe



#### Pipe external diameters

- 4 mm to 57 mm



### Resistance thermometer Pt 100 with replaceable measuring insert

for invasive temperature measuring, type series GA254.

- Hygienic design, EHEDG approved
- Measuring resistor class A to DIN EN 60751
- Stainless steel measuring insert
- Replaceable measuring insert
- Process connections for food/pharmaceuticals/biotechnology
- Fast-response, optionally with tapered tip
- Optionally with transmitter
- ATEX approved



### Resistance thermometer with inline temperature transducer

for installation in a pipe, type series GA2200

- Temperature transducer for installation in the pipe
- Temperature measuring with integrated Pt 100
- Measuring resistor 1 (2) x Pt100, 3-wire, class A
- Hygienic design
- Optionally with transmitter
- Optional mit Messumformer
- ATEX approved



### Resistance thermometer MiniTherm

Compact temperature measuring, type series GA272.

- Hygienic design, EHEDG approved
- Small compact design
- Measuring resistor 1 x Pt 100, 3-wire, class A
- Fast-response
- Process connections for food/pharma/biotechnology
- M12 circular connector or field housing
- Optionally with transmitter
- ATEX approved



### Temperature transmitter/temperature switch MiniTherm GS

Compact temperature transmitter/temperature switch, type series GS270.

- Hygienic case design
- Degree of protection IP66
- 4 digit LED indication, rotatable and can be mirror-imaged by 180°
- Measuring ranges from -50°C to +150°C
- Output 4...20mA, 2-wire technology
- Easy local programming
- Optionally with two PNP switching outputs
- Electronics fully encapsulated



### Resistance thermometers clamp-on technology

For pipe temperature measuring, type series GA2610

- Hygienic temperature measurement with no contact with process liquid for 4 to 57 mm  $\varnothing$  pipes
- Patented measurement system
- High accuracy, fast response
- Clamp-on system allows quick and cost efficient installation
- No welding, no process interruption, consequently no dead zones
- No additional insulation required
- 1 x Pt 100 measuring resistor, 3-wire, class A
- Measuring range  $-30^{\circ}\text{C}$  to  $+200^{\circ}\text{C}$
- Measuring insert, can be recalibrated, replaceable; the installation arrangements are unchanged
- ATEX approved
- Optional transmitter



### Temperature transmitter/temperature switch clamp-on GS

Temperature transmitter/ temperature switch, for pipe temperature measuring, type series GS26..

- Hygienic case design
- Degree of protection IP66
- 4-digit LED, rotatable and can be mirror-imaged by  $180^{\circ}$
- Measuring ranges from  $-30^{\circ}\text{C}$  to  $+200^{\circ}\text{C}$
- Output 4...20mA, 2-wire technology
- Easy local programming
- Optional two PNP switching outputs
- Electronics fully encapsulated



### Gas expansion thermometer

For local mechanical indication, type series FN....

- Case, measuring system and wetted parts made of stainless steel
- Case DN 100/160, degree of protection IP 66, optional case with liquid filling
- Process connections for food/pharmaceutical/biotechnology
- Nominal ranges  $0...60^{\circ}\text{C}$  to  $0...250^{\circ}\text{C}$
- Temperature detecting element 6, 8 and  $>10$  mm diameter
- Accuracy class 1 as per EN 13190
- Optionally with electrical contact device and/or analog output signal



### Gas expansion thermometer with inline temperature transducer

for direct mounting in a pipe, type series FS....

- Gas expansion thermometer for installation in pipes
- Entire inner surface of pipe acts as temperature sensor
- Nominal ranges  $0...60^{\circ}\text{C}$  to  $0...250^{\circ}\text{C}$
- Case, measuring system and wetted parts made of stainless steel
- Accuracy class 1 as per EN 13190
- Dead-zone free temperature measuring
- Process connections for food/pharmaceutical/biotechnology
- Optional with electrical contact device and/or analog output signal



## MATERIALS – STAINLESS STEELS

Stainless steel offers excellent corrosion resistance under the process conditions for applications in food, pharmaceuticals and biotechnology. This is why it is the most commonly used material. Materials 1.4301 (304) and 1.4404 / 1.4435 (316L) are the standard materials for pressure and temperature measurement applications.

Wetted parts in hygienic LABOM pressure and temperature instruments are typically manufactured with 1.4435 (316L) and also – when specified by the customer – according to the Basle Standard BN2 and with reduced delta ferrite.

Material No.	Abbreviated designation to DIN EN 10088-1	USA ASTM type	Typical applications and features	Examples
1.4301	X5CrNi18-10	304	Austenitic chromium nickel steel with good resistance to atmospheric corrosion	Enclosure and attachments
1.4404 / 1.4435	X2CrNiMo17-12-2 X2CrNiMo18-14-3	316L	Chromium nickel steel with additional molybdenum and reduced carbon content to significantly improve the resistance to crevice corrosion, intergranular crystalline corrosion and pitting	Wetted parts like diaphragm seals and protective tubes for temperature sensors. Instrumentation for more challenging specifications - especially in the pharmaceutical sector material no. 1.4435 is preferred.

We can also supply other stainless steel qualities to customer specifications.

### Special-order materials

High corrosion resistant nickel chromium molybdenum alloys such as Hastelloy are used for more stringent specifications. Special-order materials such as tantalum, titanium or monel are also available for wetted parts.

### Coatings

Applications, which require a plastic coating on the process side, can be implemented with FDA-listed PFA.

# CONVERSION TABLE FOR PRESSURE UNITS

Units		SI units					Engineering units					
		mbar	bar	Pa	kPa	MPa	mm WC	mWC	kp/cm <sup>2</sup>	atm	Torr	psi
SI units	1 mbar =	1	10 <sup>-3</sup>	100	0,1	0,1 · 10 <sup>-3</sup>	10,197	10,197 · 10 <sup>-3</sup>	1,0197 · 10 <sup>-3</sup>	0,98692 · 10 <sup>-3</sup>	0,75006	14,504 · 10 <sup>-3</sup>
	1 bar =	10 <sup>3</sup>	1	10 <sup>5</sup>	100	0,1	10,197 · 10 <sup>3</sup>	10,197	1,0197	0,9869	750,06	14,504
	1 Pa =	0,01	10 <sup>-5</sup>	1	10 <sup>-3</sup>	10 <sup>-6</sup>	0,10197	0,10197 · 10 <sup>-3</sup>	10,197 · 10 <sup>-6</sup>	9,8692 · 10 <sup>-6</sup>	7,5006 · 10 <sup>-3</sup>	0,14504 · 10 <sup>-3</sup>
	1 kPa =	10	0,01	10 <sup>3</sup>	1	10 <sup>-3</sup>	0,10197 · 10 <sup>3</sup>	0,10197	10,197 · 10 <sup>-3</sup>	9,8692 · 10 <sup>-3</sup>	7,5006	0,14504
	1 MPa =	10 · 10 <sup>3</sup>	10	10 <sup>6</sup>	10 <sup>3</sup>	1	0,10197 · 10 <sup>6</sup>	0,10197 · 10 <sup>3</sup>	10,197	9,8692	7,5006 · 10 <sup>3</sup>	0,14504 · 10 <sup>3</sup>
Engineering units	1 mm WC =	98,067 · 10 <sup>-3</sup>	98,067 · 10 <sup>-6</sup>	9,8067	9,8067 · 10 <sup>-3</sup>	9,8067 · 10 <sup>-6</sup>	1	10 <sup>-3</sup>	0,1 · 10 <sup>-3</sup>	96,784 · 10 <sup>-6</sup>	73,556 · 10 <sup>-3</sup>	1,4223 · 10 <sup>-3</sup>
	1 mWC =	98,067	98,067 · 10 <sup>-3</sup>	9,8067 · 10 <sup>3</sup>	9,8067	9,8067 · 10 <sup>-3</sup>	10 <sup>3</sup>	1	0,1	96,784 · 10 <sup>-3</sup>	73,556	1,4223
	1 kp/cm <sup>2</sup> =	0,98067 · 10 <sup>3</sup>	0,98067	98,067 · 10 <sup>3</sup>	98,067	98,067 · 10 <sup>-3</sup>	10 · 10 <sup>3</sup>	10	1	0,96784	735,56	14,224
	1 atm =	1,0133 · 10 <sup>3</sup>	1,0133	0,10133 · 10 <sup>6</sup>	0,10133 · 10 <sup>3</sup>	0,10133	10,332 · 10 <sup>3</sup>	10,332	1,0332	1	760	14,693
	1 Torr =	1,3332	1,3332 · 10 <sup>-3</sup>	0,13332 · 10 <sup>3</sup>	0,13332	0,13332 · 10 <sup>-3</sup>	13,595	13,595 · 10 <sup>-3</sup>	1,3595 · 10 <sup>-3</sup>	1,3158 · 10 <sup>-3</sup>	1	19,34 · 10 <sup>-3</sup>
	1 psi =	68,948	68,948 · 10 <sup>-3</sup>	6,8948 · 10 <sup>3</sup>	6,8948	6,8948 · 10 <sup>-3</sup>	0,70307 · 10 <sup>3</sup>	0,70307	70,307 · 10 <sup>-3</sup>	68,046 · 10 <sup>-3</sup>	51,715	1

other relationships:

$$1 \text{ Pa} = 1 \text{ N/m}^2$$

$$1 \text{ hPa} = 1 \text{ mbar}$$

$$1 \text{ mm HG} = 1 \text{ hectopascal}$$

$$1 \text{ kp/cm}^2 = 1 \text{ at (gauge)}$$

## Temperature scales

Celsius scale	Kelvin scale	Fahrenheit scale
	SI-Input	
Use: Commonly used in Europe and in industry	Use: Scientific use, quoting temperature differences	Use: in the US and some English-speaking countries
$T_{\text{°C}} = \left( \frac{T_{\text{K}}}{\text{K}} - 273,15 \right) \cdot \text{°C}$ $T_{\text{°C}} = \left( \frac{T_{\text{°F}}}{\text{°F}} - 32 \right) \cdot \frac{5}{9} \cdot \text{°C}$	$T_{\text{K}} = \left( \frac{T_{\text{°C}}}{\text{°C}} + 273,15 \right) \cdot \text{K}$ $T_{\text{K}} = \left( \frac{T_{\text{°F}}}{\text{°F}} + 459,67 \right) \cdot \frac{5}{9} \cdot \text{K}$	$T_{\text{°F}} = \left( \frac{T_{\text{K}}}{\text{K}} \cdot 1,8 - 459,67 \right) \cdot \text{°F}$ $T_{\text{°F}} = \left( \frac{T_{\text{°C}}}{\text{°C}} \cdot 1,8 + 32 \right) \cdot \text{°F}$

T <sub>°C</sub>	T <sub>K</sub>	T <sub>°F</sub>
-273,15 °C	0 K (absolute zero)	-459,67 °F
-20 °C	253,15 K	-4 °F
0 °C (melting temperature of water)	273,15 K	32 °F (melting temperature of water)
20 °C	293,15 K	68 °F
35,56 °C	308,71 K	96 °F (human body temperature)
100 °C (boiling temperature of water)	373,15 K	212 °F



<b>Hygienic Design</b>	Design of equipment, components, accessories and fittings to meet cleanability specifications	
<b>CIP</b>	<b>Cleaning In Place</b>	Automated cleaning of a closed device or a closed process plant – no disassembly
<b>SIP</b>	<b>Sterilization In Place</b>	Automated sterilization of a closed process plant, which removes or kills microorganisms, often using superheated steam at 120°C and more.
<b>Aseptic piece of equipment</b>	A piece of equipment designed to comply with sanitary regulations, which can be sterilized and which prevents the intrusion of microorganisms.	
<b>Corrosion</b>	A material's interaction with its environment, which leads to a change in the properties of the material and possible failure of the component. This interaction is often electrochemical. There are different types of corrosion depending on the corrosion mechanism and the appearance of the corrosion. For example, there is pitting, stress-corrosion cracking (SCC), crevice corrosion....	
<b>Flawless surface</b>	A <b>flawless surface</b> is free of defects like scratches, fissures, pores and holes, where product residues, cleaning agents and microorganisms can accumulate. Only a surface that is as flawless as this is easy to clean.	
<b>GMP</b>	<b>Good Manufacturing Practice</b> , a quality assurance process for the manufacturer of pharmaceutical products and food in the US and Europe. It covers personnel, premises, documentation, shopfloor, quality controls and equipment.	
<b>EHEDG</b>	<b>European Hygienic Engineering &amp; Design Group</b> founded in 1989 to promote hygienic processes in food production. The EHEDG consists of experts from the food sector, suppliers and system installers, research institutes and government organizations. The group publishes guidelines and recommendations on the topic of hygienic design and develops test procedures and assessment criteria.	
<b>EHEDG approval classes</b>	<b>EL CLASS I</b>	Equipment for open and closed processes with CIP
	<b>EL ASEPTIC</b>	Equipment for open and closed processes with CIP, impervious to micro-organisms, SIP-compatible
	<b>EL CLASS II</b>	Equipment for open and closed processes with cleaning after disassembly

**Food and Drug Administration**

US Federal Agency responsible for Public Health and Safety. It ensures the safety and effectiveness of pharmaceutical and biological products, medical devices, food, cosmetics and radiation emitted by devices. All materials used in pieces of equipment destined for the US market must comply with FDA standards. FDA approvals are recognized and promoted globally.

FDA

**National Sanitation Foundation**

NSF International is an independent, non-profit, non-governmental organization (NGO). In 1999 the NSF started the voluntary global registration program for nonfood and company-owned substances to re-introduce the approval program previously administered by the US Department of Agriculture (USDA). NSF registration is based on checking recipes to CFR 21, 9 and 40 from the FDA (CFR: Code of Federal Regulations). Products, which meet the requirements, are listed in the online list NSF White Book TM Listing. Oils with NSF-H1 approval are food-grade lubricants. They are used when there may be occasional contact with food.

NSF

**Machinery Directive**

Annex I, Section 2.1: Food processing systems and systems for cosmetics or pharmaceutical products must be designed so that there is no risk of sickness or infection. Suitable materials, including consumables and lubricants, must be used. It must be easy to clean and disinfect the plant. Surfaces must be smooth and there should not be any ridges, cavities, protrusions, edges or grooves. It must be possible to completely drain the system. External contamination should be prevented.

2006/42/EG

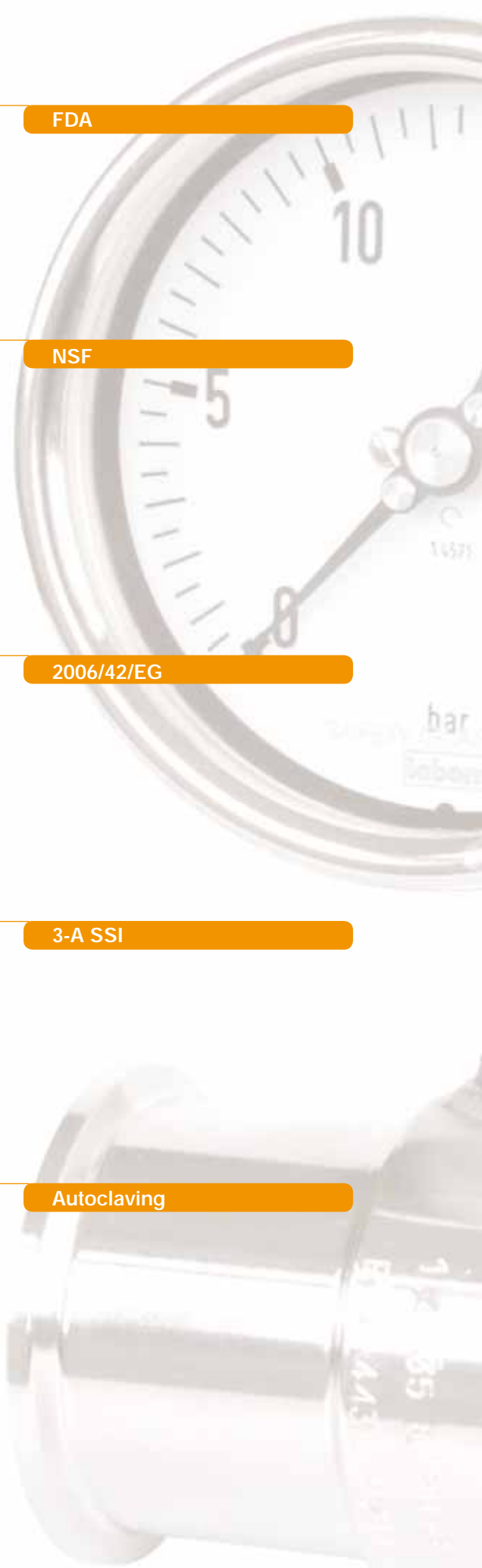
**3-A Sanitary Standards Incorporation**

3-A is a non-profit organization based in the US, whose members are from the American milk sector, the FDA and the USDA. Its mission is to promote product safety for consumers of food, beverages and pharmaceutical products. 3-A publishes standards for equipment and processes, which deal with issues relating to the design, manufacture, installation and operation of equipment. 3-A ensures and confirms that all requirements are met by means of a Third Party Verification Program, TPV.

3-A SSI

Sterilization of components in autoclaves using superheated steam.

Autoclaving





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