System Catalog **4**

Solenoid valves I Process and control valves I Pneumatics
Sensors I MicroFluidics I MFC and proportional valves

The smart choice of Fluid Control Systems

bürkert
Fluid Control Systems

Bürkert GmbH & Co. KG
Fluid Control Systems
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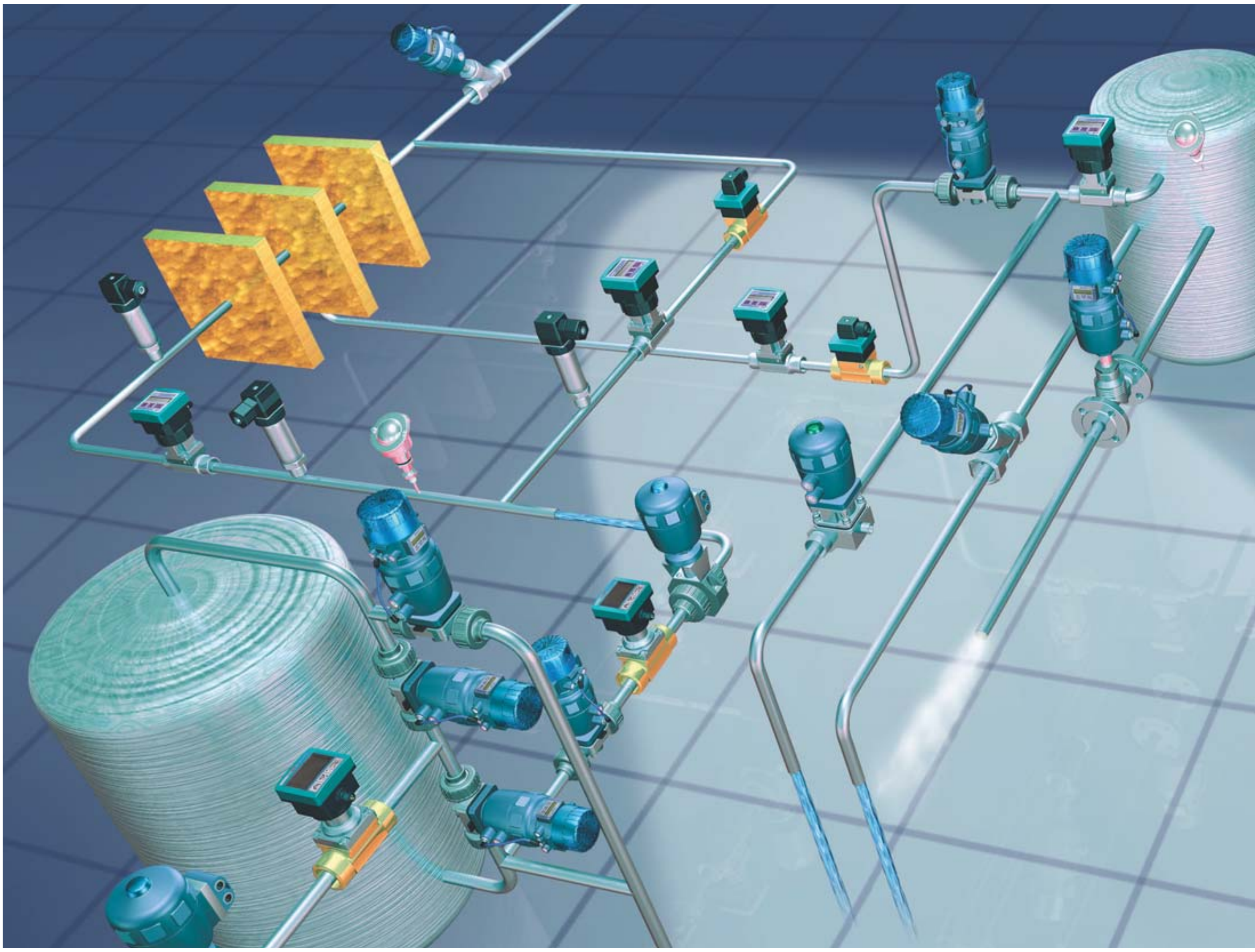
Contents

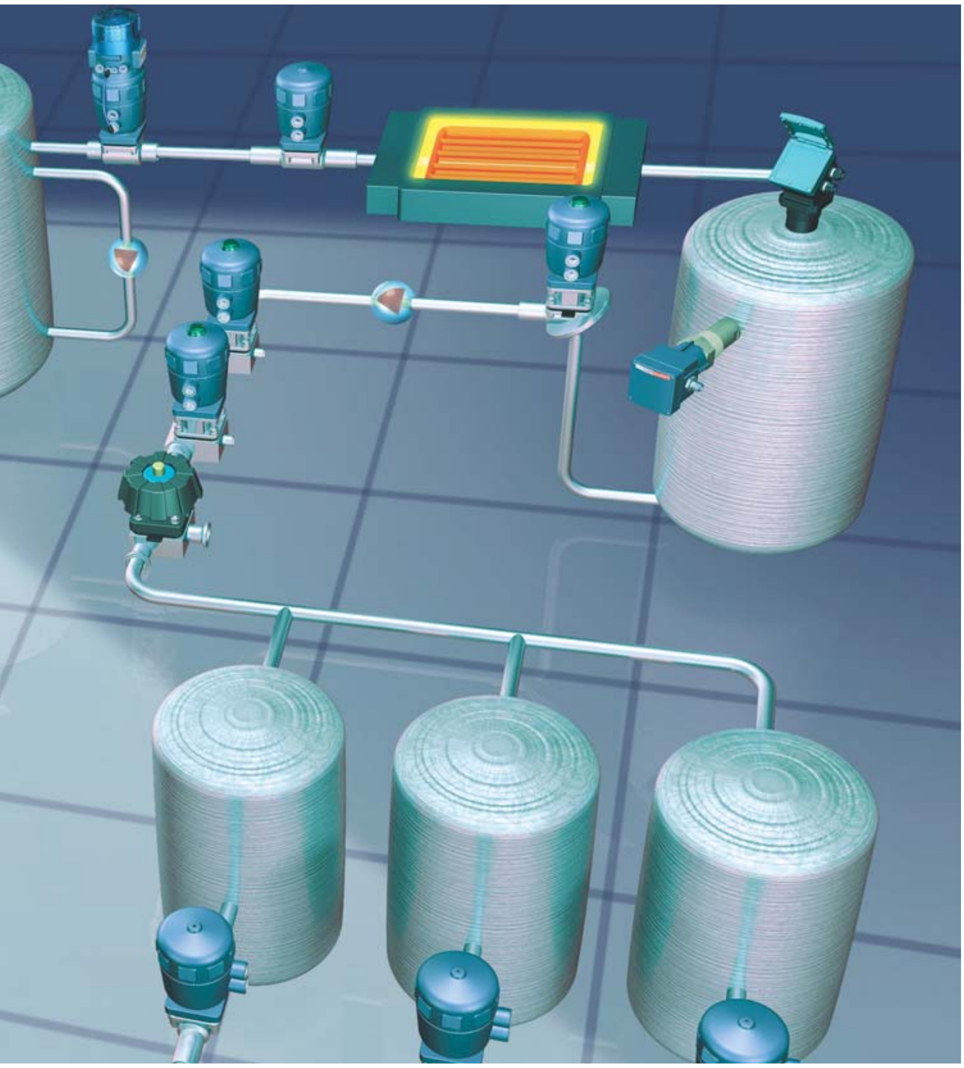
1. Customer proximity - from one source



For more than a decade now, Bürkert, with its own range of sensors, has been providing its customers the option of well-rounded system solutions from one source. In view of the wide variety of specific components linked to specific manufacturers, the availability of a standard concept that completes the control loop of actuators and controllers with suitable sensors appears to be the most consistent and logical step. From the onset on, the market proximate, practically-oriented alignment of the Bürkert sensor concept has offered clear advantages characterized by extremely easy operation and efficient standardization of layout, electrical interfaces and process connections. And the Bürkert brand stands for yet another benefit: optimum economy and efficiency and design geared to the future.

Open to all applications

Bürkert sensors prove their exceptional quality in all relevant applications. Wherever it is necessary to display process values, perform control functions and monitor alarms, the concept of simple menu prompting and easy integration and commissioning of actuators in an individual, tailor-made system is a convincing one. Regard-



less of whether they are required to control flow rates, monitor for leaks or control pH values in cooling water conditioning systems or monitoring temperature, conductivity and filling level: Bürkert sensors act precisely, systematically and economically. It goes without saying that the rugged design and long service life even in extreme continuous operation are “design features” which apply to all products manufactured by Bürkert.

Geared to the future, right down to the very last detail

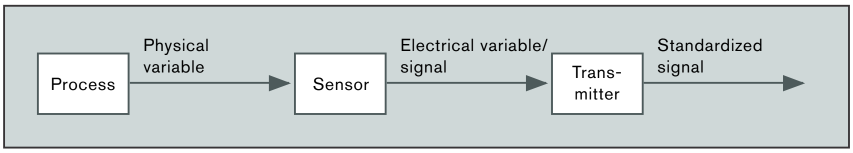
The trend in the sector of sensor systems pursues two directions. High-end technology with field bus interfaces and multi-channel designs defines one of these approaches. On the other hand, there is an increasing demand for “simple” monitoring with switching output and optional ASI bus interworking. Bürkert leads the way on both levels. Right from the very start, intelligent technology has been integrated using field buses, and those who only wish to control or measure a simple problem can be provided with individually adapted products and services. Bürkert’s strength is shown in the functional details of a comprehensive range of sensor systems – and its modularity. We offer individually configurable, systematic solutions – for any application problem.

Committed and competent

The dialogue between our researchers and developers and on-site practitioners has given birth to ground-breaking components. For example, in flow measuring technology, the paddle wheel measuring method plays an outstanding role owing to its broad range of application, and measurement with Finger MID opens up new, interesting potentials. Bürkert already provides suitable, fully-developed products for both areas. And new, innovative solutions will be added. Ultimately, our customers benefit from both the experience and synergies of a company which is internationally successful in all areas of fluidics. That is why Bürkert sensor systems will always lead the way in technology geared to the future.

2. The basics

2.1. Introduction



Schematic showing provision of signals in a technical process by means of sensors

Sensors and transmitters

Communication is crucial to the world of living beings. There can be no life without exchange of information. Evolution has provided all creatures with organs for generating, detecting and processing information. Information is also critical for the development of production. Originally, signals and information between those doing the producing sufficed for the manufacturing of products.

Initially control loops, and later, entire automatic installations and systems emerged with the development of modern production technologies. Information is detected, forwarded and evaluated in an automatic system in order to ultimately be able to intervene in the running process via control action using an actuator, without the need for action on the part of those involved. Sensors are used to procure signals from actual, running technical (physical) processes.

The term sensor (also referred to as measuring sensor or detector) refers to a component which serves the purpose of electrically measuring non-electrical variables. The variable to be measured (e.g. displacement, speed of rotation, temperature, flow rate, pressure, concentration of individual substances in gases and liquids or ion concentration) is converted by the sensor, utilizing a physical effect (e.g. induction, piezoelectric effect, photo effect or resistance changes resulting from heating) to what is initially generally an analog electrical signal. This signal can be supplied to other uniform analog or digital processing systems by analog-to-digital conversion and conversion in a downstream transmitter. Sensors are used in diverse applications, including applications in industrial production, chemical process engineering, mass production, such as the production of motor vehicles or domestic appliances, and in security systems for detecting fire and motion.

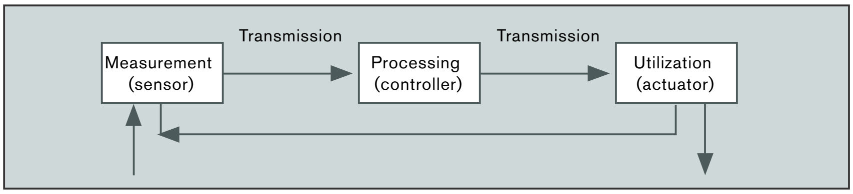
Signal processing

The signals provided via sensors are required in closed information systems (generally control loops) for controlling specific processes in their entire diversity. The standardized signals must then be “understood” by all subassemblies included in the process, i.e. they can be transmitted, processed and used without further conversion. A schematic of the closed information loop is shown below.

In the world of physics and technology, there is a wide variety of variables which can be mapped (detected) with a sensor. The range of Bürkert sensors focuses on the essential process variables which play the “major roles” in process engineering. These are as follows:

- Flow rate
- Filling level
- Analysis (pH value, ORP and conductivity)
- Pressure
- Temperature.

All other process variables (signals) are not addressed in this catalog.



Schematic of the closed information loop

2.2. Electrical interfaces

Electrical devices which are to operate jointly in a closed system must be connected to each other by means of electrical interfaces. Several requirements are necessitated by such an interface:

1. Mechanical ease of mating (geometry, number of contacts and threads) in order to guarantee reliable electrical connections under the given operating conditions. The mechanical ease of mating is implemented by the use of standardized plug-ins, screw-ins, crimp-ons or other connection elements. Country and region-specific standards, approvals, certificates and protection types (UR, UL, CSA, EN, ATEX and IP, etc.) should also be taken into consideration.

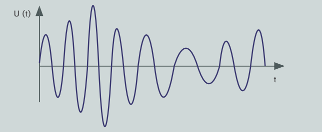
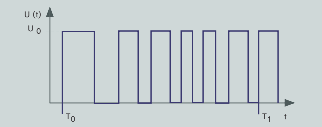
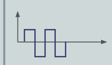
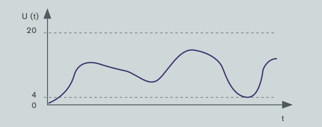
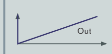
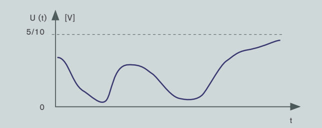
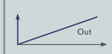
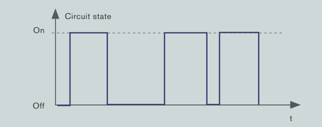
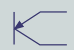
2. Electrical adaptation so that the signals passed on by the upstream device can be accepted and processed unfalsified in the receiving device. This includes e.g. input resistances, time constants and frequency responses. If using standard signals (standard signals for current and voltage), the connection conditions are standardized and compatible, regardless of the manufacturer. In the case of all other signals, either manufacturer-specific transmitters or other additional equipment for signal processing or signal conversion are required.

Electrical adaptation requires clear identification of the connections. When connecting the interfaces, it is extremely important to use permitted connection cables and the correct assignment of signal output to signal input (not vice versa!).

Input and output signals used by Bürkert

Signal parameter	Parameter	Signal level	Signal generation	Compatibility
Sinusoidal AC voltage; period of oscillation T	Frequency f(t) (f = 1/T)	0 to approx. 300 Hz	Induction coil	Various Bürkert devices
Square-wave AC voltage; period of oscillation T	Frequency f(t) (f = 1/T)	0 to approx. 300 Hz or 1,400 Hz	Hall element	Various Bürkert devices Various PLCs
Direct current standard signal (standard signal)	Amplitude I(t)	0 to 20 mA or 4 to 20 mA	Transmitter	Manufacturer-independent in the case of corresponding signal input
DC voltage standard signal (standard signal)	Amplitude U(t)	0 to 5 V or 0 to 10 V	Transmitter	Manufacturer-independent in the case of corresponding signal input
Switching signal for DC or AC voltage	On or Off	6/12/24 V DC 24/110/230 V AC (as permitted)	N/O contact, SPDT contact, N/C contact (relay or transistor)	Dependent on operating voltage of downstream device

Signal waveforms and symbols

Signal	Signal waveform	Symbol
Frequency of a sinusoidal AC voltage (number of positive or negative half-waves per unit of time)		
Frequency of a square-wave AC voltage (number of positive or negative edges per unit of time)		
Amplitude, standard current signal 0 mA to 20 mA or 4 mA to 20 mA		
Amplitude, standard voltage signal 0 V to 5 V or 0 V to 10 V		
Switching signal, relay On/Off		
Switching signal, transistor On/Off		
Switching signal, reed contact On/Off	An applied voltage U(t) is switched; contact rating dependent on manufacturer's specifications.	

2.3. Process connections

In order to be able to measure a variable, the measuring sensor must be positioned directly in the process stream. In process automation, this generally involves flowing gases or liquids in pipes or tanks. In order to simplify installation, Bürkert has developed various, modular-design installation fitting systems enabling fast and uncomplicated installation of sensors in a system. These are based on the various designs of sensors (measuring sensors). With certain measuring principles, however, the integration of fittings, measuring transducers and electronic systems is unavoidable due to the design. A distinction is thus made between the following installation fittings versions:

- Fittings for insertion measuring sensors (Insertion series); used primarily for flow sensors and – to a restricted extent – for analysis sensors as well.
- Fittings with integrated measuring sensor and electronic module which can be fitted by means of a bayonet catch (Inline series); used solely for flow sensors.
- Fittings with integrated measuring sensor and integrated electronics; used with Full bore MIF 8055 and flow sensors 8031 and 8071 for low flow rates.
- Fittings with threaded port (screwed fittings series G 1/2, NPT 1/2, Rc 1/2); used mainly for pressure and temperature sensors in pipes.
- Special forms of fittings (welded, flange, plug-in and screwed connections); used mainly for installation of temperature sensors in tanks.

Variable	Process connection	Also refer to section
Flow rate	Inline 	3.3.
	Insertion 	
	Integrated 	
Filling level	External thread 	
Analysis	Insertion 	6.3.
	Standard fittings 	
Pressure	External thread 	
Temperature	External thread 	

Overview of the various process variables and deployed process connections

2.4. Equipment, software and operating levels

The Bürkert range comprises sensors with various levels of compactness:

- Sensors without signal processing units
- Sensors with signal processing units (including transmitter) in compact design
- Separate components for sensors and signal processing units for field measurement and signal processing in a control panel or at a central point (wall mounting).

The signal processing units (electronic modules) feature a microprocessor. They are controlled internally by a software program and are very easily operated. The program and operating philosophy is simple and very similar on all devices. The display is an alphanumeric display (8 digits, 15 segments and 9 mm character height) implemented on a large liquid-crystal display (LCD) measuring 15 x 60 mm.

The user interface contains three selection keys for setting the numerical values, changing the digit and confirming entered values or selecting menu items.

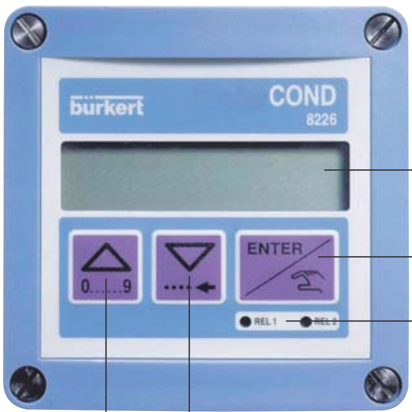
2.4.1. Display and keypad

Operation is performed at three levels

- Level 1: Display (e.g. flow transmitter: flow rate, output current, main counter and daily counter).
- Level 2: Program (language, units, K factor, standard signal, unit of measure, measuring range, pulse output, relay, filter, reset main and daily counters)
- Level 3: Adjust and Test (adjust offset, span, simulation of a flow rate for process value simulation for testing the switching thresholds without real flow, i.e. "dry run option" (for function tests); display of sensor frequency for diagnostic.

Transmitter user interface using Type 8226 as an example

The user interface and operating strategy are largely identical for all transmitters. The operating steps for the relevant transmitters are described in detail in the operating instructions supplied with each device.



Operating controls, indicators and displays for inductive conductivity transmitter, Type 8226

Alphanumeric display, liquid-crystal display, 9 mm high

Key for entering parameters and menu options

LEDs for relays 1 and 2 (LED of active relay illuminated)

Arrow key for digit selection or preceding menu item

Arrow key for numerical values 0...9 or next menu item

2.4.2. Possible program functions

The software programs of the transmitters contain various additional functions:

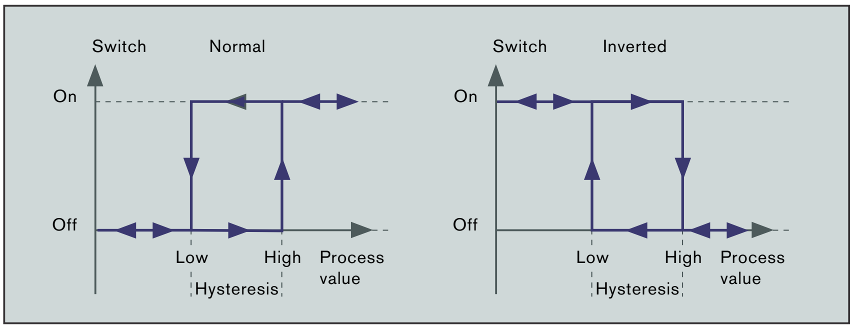
- Switch functions (Hysteresis mode, Window mode and Inversion)
- Delay time
- Filter function
- Teach-in calibration
- Test mode or process value simulation.

These program functions can be activated when programming the transmitter.

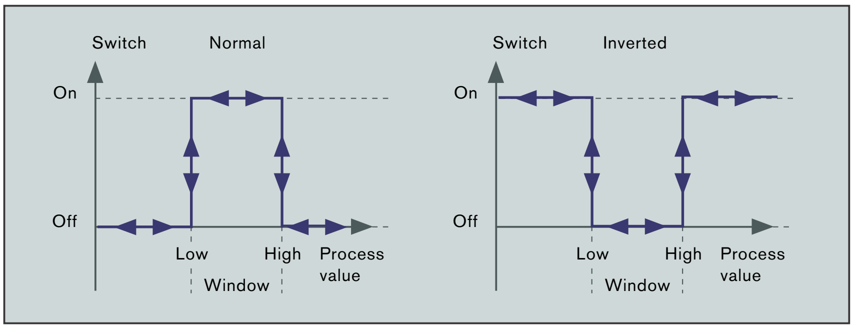
Switch functions

Various transmitters feature switching outputs (relays, transistors or reed contacts) with which connected devices can be actuated after reaching a threshold value (min./low or max./high) (triggering an alarm, actuating a valve or switching a heating system/cooling system, etc.).

The process value thresholds (min./low or max./high) which trigger the change of circuit state (from Off to On or from On to Off) are entered by the operator in the transmitter program. In addition, it is possible to preset whether the switch is to operate in Normal mode or in Inverse mode (mode of operation of a negator).



Hysteresis mode



Window mode

Hysteresis mode

With the Hysteresis function, the triggering threshold value is dependent on the crossing direction of the process value.

In Normal switching mode, the circuit state with an increasing process value only changes at the High threshold from Off to On. The Low threshold is ignored. With a dropping process value, the circuit state at the Low threshold changes from On to Off. In this direction, the High threshold is ignored.

In the Inverted switching mode, the switching directions are reversed (inverted), i.e. with increasing process value, the circuit state at the High threshold changes from On to Off; the Low threshold is ignored. With a dropping process value, the circuit state at the Low threshold changes from Off to On; the High threshold is skipped (Hysteresis mode illustration).

Window mode

With the Window function, the circuit state changes each time a threshold value is reached. In this case, the switching direction is dependent on the crossing direction of the process value.

In Normal switching mode, the circuit state with an increasing process value changes from Off to On at the Low threshold and changes from On to Off at the High threshold. With a dropping process value, the circuit state changes from Off to On at the High threshold and changes from On to Off at the Low threshold.

In the Inverted switching mode, the switching directions are reversed (inverted), i.e. with an increasing process value, the circuit state changes from On to Off at the Low threshold and changes from Off to On at the High threshold. With a dropping process value, the circuit state changes from On to Off at the High threshold and changes from Off to On at the Low threshold (Window mode illustration).

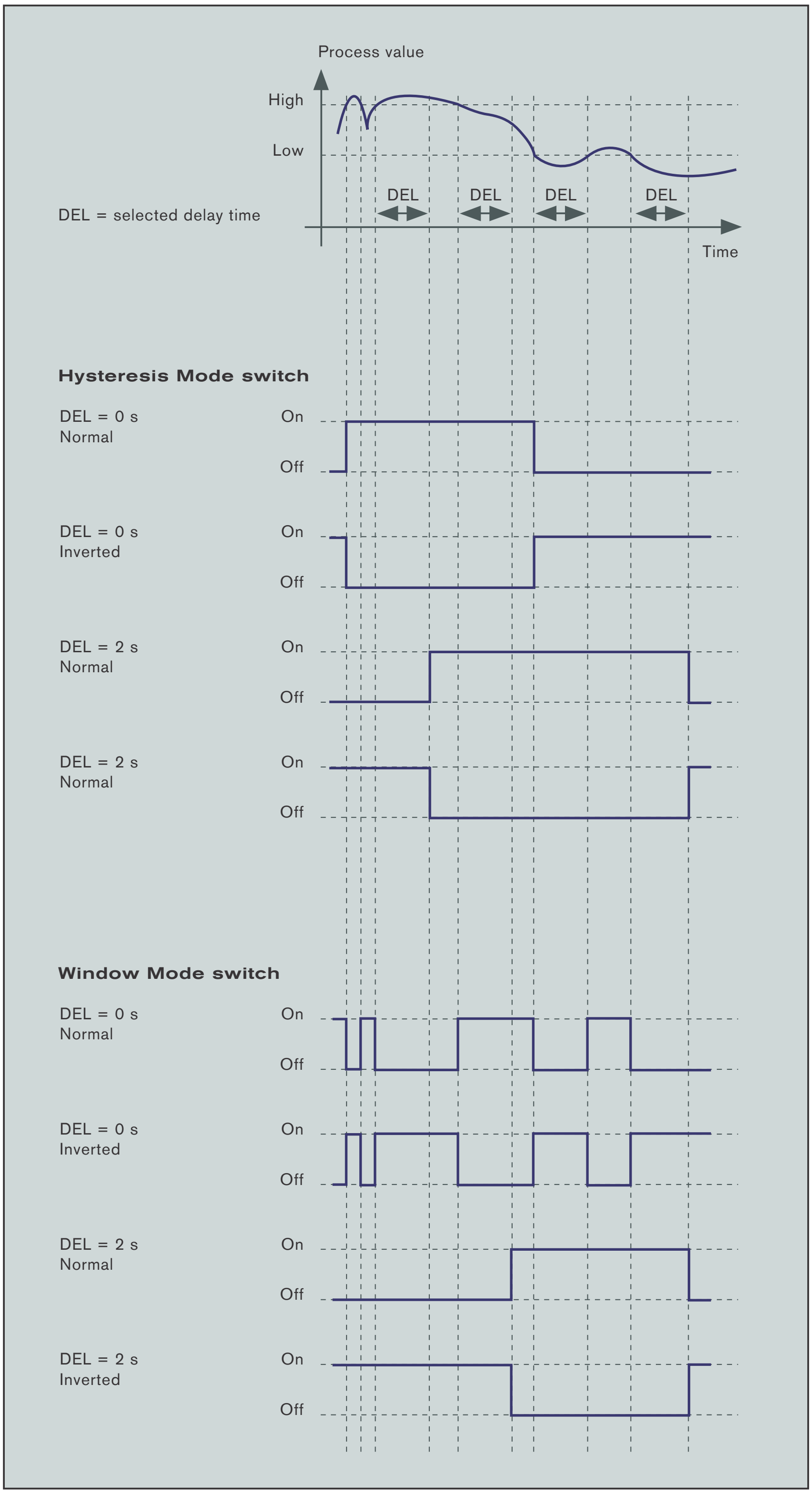
The term “process value” refers to all values measured with Bürkert sensors which are processed and converted in an electronic module (transmitter). This includes flow rate, filling level, pressure, temperature, pH value, ORP and conductivity.

For specific monitoring and control tasks, the process value ranges between low and high in Hysteresis or Window mode can be defined as permitted ranges for the process value.

Delay time

If the measured values are superimposed by fast disturbances, it is necessary to prevent an excessively fast reaction by the switch. This is done by waiting and observing the measured value characteristic. This “waiting position” can be implemented by setting a delay time. If the threshold value for the process variable is exceeded or falls short – depending on the presetting – the program waits for the delay time to elapse before the switch changes its circuit state. The circuit state is not changed (i.e. no alarm tripping for the time being) if the process variable has returned to the permitted range (to the normal value) before the delay time elapses. The change in circuit state is triggered (e.g. triggering an alarm) only if the process value is still exceeded or falls short after the delay time has elapsed.

The delay time can be linked to Hysteresis or Window mode. Both modes can, in turn, be linked to Normal or Inverted switch mode; overall, this means that there are eight different modes of operation for the switching outputs (see example of process value characteristic).



Example of a process value characteristic with possible circuit states. Switching output in Hysteresis and Window mode, with and without delay time, normal and inverted.

Filter function
Various influences may lead to stochastic, pulsatory disturbances of the measurement signal at the input of the transmitter. In order to avoid or minimize the influence of such disturbances on the output signal, it is possible to attenuate (filter out) these disturbances by using a filter.

The sensitivity of the transmitter input is selectable. It lies between Stage 0 (no attenuation) and Stage 9 (maximum attenuation). The appropriate stage should be determined experimentally. In many applications, Stage 4 or 5 provides good attenuation.

K factor
The K factor is a proportionality factor required for conversion with correct quantities between the signal of the measuring sensor and the real process value. The K factor of a transmitter comprises a specific share of the fitting Kfit and a share of the sensor Ksens on the basis of the following relationship:
K = Kfit x Ksens.

The Kfit values for the individual fittings are listed in the "Installation fittings" data sheet. Ksens is specified on the rating plates of the relevant sensor or transmitter.

Using this information, it is possible to calculate the K factor of the entire measuring device and enter it in the transmitter program. These values are relatively theoretical. They require normal conditions for the process (temperature, flow conditions and pressure) which cannot always be complied with in individual cases. In this case, it is advisable to determine the K factor experimentally (i.e. to correct the already calculated K factor) via teach-in calibration.

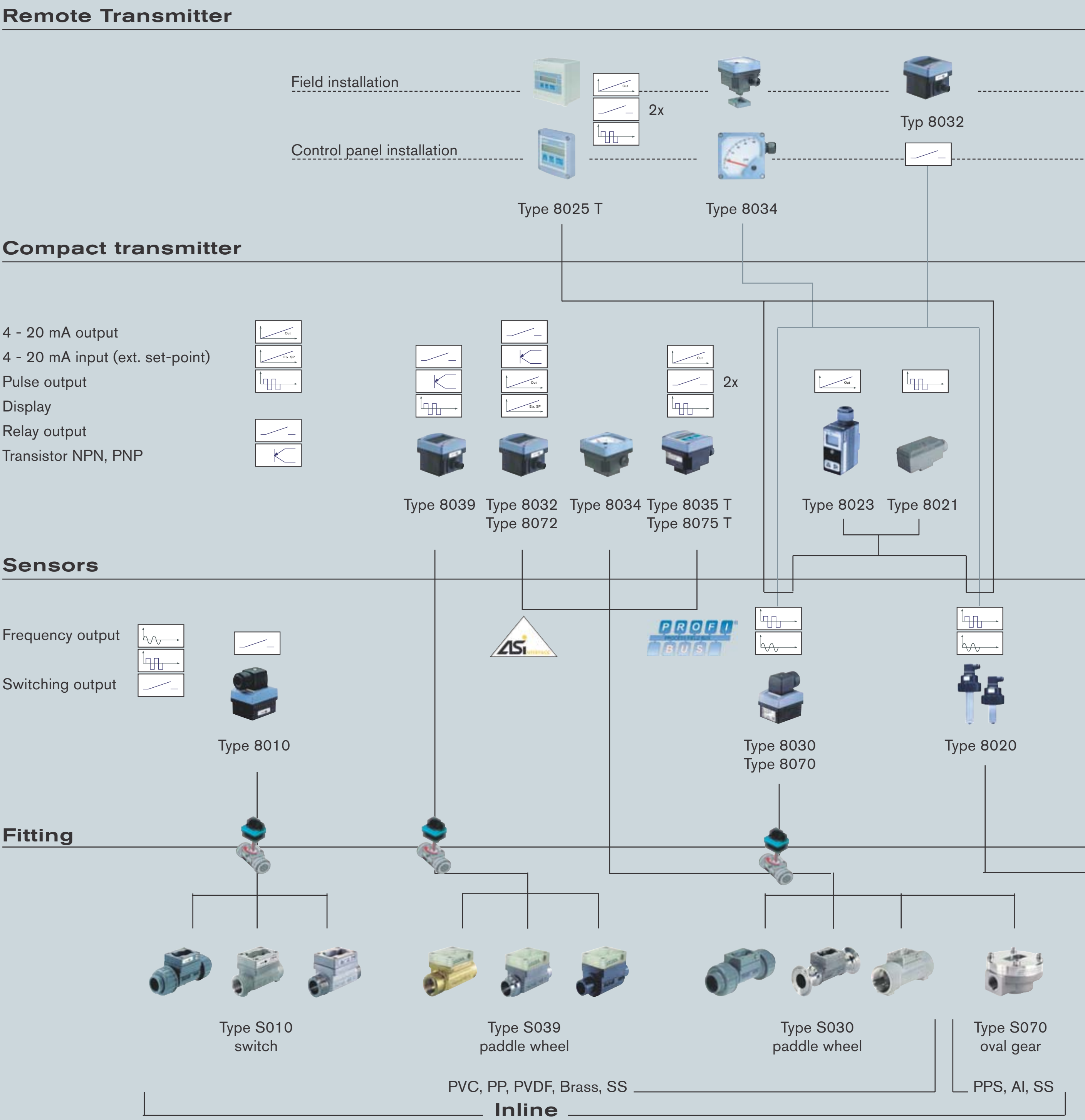
Teach-in calibration
Teach-in calibration for a specific application requires balancing the zero point and the measuring range limits of the transmitter and defined reference variables for the process value (e.g. known volume or defined reference flow-rate measurement). These reference variables are required in real terms and serve as the calibration quantity. After completion of the preparation measures, it is possible to start the teach-in function. If this program function is successful, the K factor that has now been determined experimentally is incorporated into the program and shown on the display. This allows very easy comparison with respect to the previously calculated (theoretical) value.

Test mode or process value simulation
The transmitters offer the option of process value simulation without measuring a real process value in order to be able to check correct setting of the threshold values for the switching outputs prior to commissioning of the technological process. In this program mode, it is possible to enter values for standard operation and values above or below the switching thresholds. The test run indicates whether all settings have been made correctly. In this case, required changes or subsequent corrections can be made before "real" commissioning without any harmful side effects.

Operation of the program functions
Menu-prompted operation of the individual program functions is described in great detail in the type-specific operating instructions for the transmitters. If required, we can send you these operating instructions even before you purchase a transmitter.

3. Bürkert's range of flow sensors

Paddle wheel and oval gear flow-rate measurement



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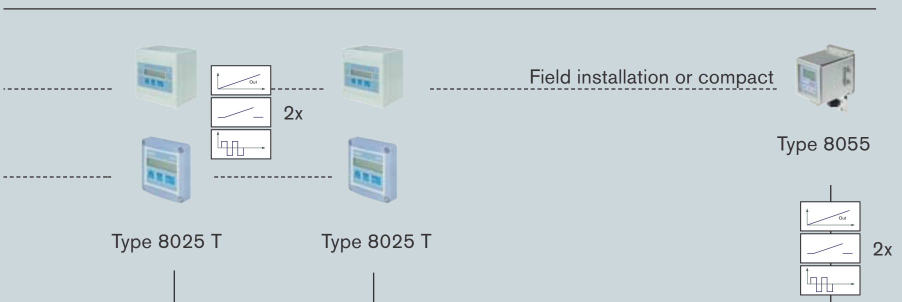
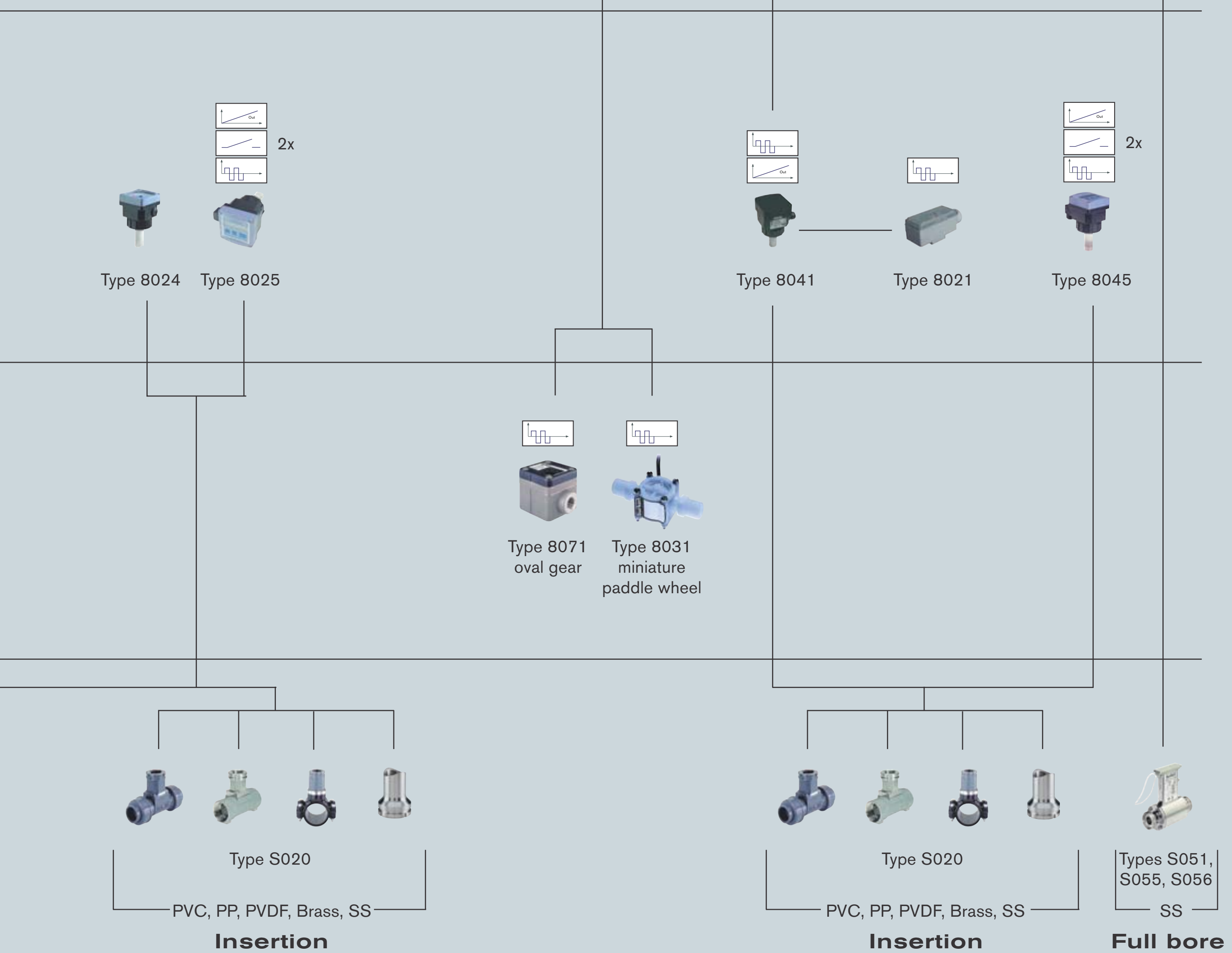
Bürkert flow sensors can be used in fluid media of an extremely wide variety of types. Flow-rate measurements can be conducted in media ranging from highly pure to highly contaminated, including aggressive or viscous media and applications in hygienic areas. The fact that individual sensors operating on the basis of various measuring principles can be combined with various electronic evaluation systems allows a tailor-made solution for almost any application in accordance with the requirements.

Magnetic inductive flow-rate measurement MIF





OW SENSORS

3.1.
Selection tables

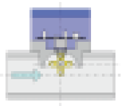
These selection tables enable you to find the right solution for the required field of application.

3.1.1. Selection of measuring principles

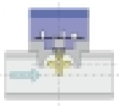
Paddle wheel measuring principle	Oval gear measuring principle	MIF finger measuring principle	Full MIF measuring principle
			
Types **8030/8031/8032** **8034/8035/8020** **8024/8025**	**Types** **8070/8071/8072** **8075**	**Types** **8040/8041/8045**	**Type 8055**
Less than 1% solids share No hairs or fibrous materials	No solids Filtration recommended	Min. conductivity of the medium 20 µS/cm	Min. conductivity of the medium 5 µS/cm
Max. viscosity 300 mm²/s (cSt)	Max. viscosity 1,000,000 mm²/s (cSt)	Max. viscosity 1,000 mm²/s (cSt)	Max. viscosity 1,000 mm²/s (cSt)
Clean, also aggressive media. **Particularly suitable for media similar to water.**	Pure, also aggressive media. **Particularly suitable for viscous media.**	Clean, also aggressive media, more viscous media. **Particularly suitable for contaminated media.**	Clean, also aggressive media, more viscous media, contaminated media. **Particularly suitable for hygienic applications and very precise measurements.**
Selection of device types Page 20 - 23	Selection of device types Page 24/25	Selection of device types Page 26/27	Selection of device types Page 26/27

3.1.2. Selection of device types

Paddle wheel, fluidic characteristics

			 Type 8010	 Type 8020	 Type 8030	 Type 8030 HT	 Type 8031	 Type 8024
Fluidic characteristics								
	Measuring range		3-1000 l/min	3-50000 l/min	1-1000 l/min	1-1000 l/min	0,17-4,2 l/min	3-50000 l/min
	Nominal diameter		DN 15-50	DN 15-400	DN 08-50	DN 08-50	G 1/4“	DN 15-400
Fitting material	Brass		PN 16 0-55 °C	PN 10 0-100 °C	PN 16 0-100 °C			PN 10 0-100 °C
	Stainless steel		PN 16 0-55 °C	PN 10 0-100 °C	PN 16 0-100 °C	PN 40 0-160 °C		PN 10 0-100 °C
	PVC		PN 10 0-55 °C	PN 10 0-50 °C	PN 10 0-50 °C			PN 10 0-50 °C
	PE			PN 10 0-50 °C				PN 10 0-50 °C
	POM						5 bar 10-55 °C	
	PP		PN 10 0-55 °C	PN 10 0-80 °C	PN 10 0-80 °C			PN 10 0-80 °C
	ECTFE						5 bar -10 – 80 °C	
	PVDF		PN 10 0-55 °C	PN 10 0-100 °C	PN 10 0-100 °C			PN 10 0-100 °C
Seal material	FPM		▪	▪	▪	▪	▪	▪
	EPDM		▪	▪	▪	▪	▪	▪
	FFKM						▪	
Fluid properties	Foreign bodies in medium	0 %	▪	▪	▪	▪	▪	▪
		<1 % *	▪	▪	▪	▪	▪	▪
		<1 % **	▪	▪	▪	▪	▪	▪
		<1 % ***				▪		
		<1 %	o					
		>1 %	o					
	Viscosity	<5 cst	▪	▪	▪	▪	▪	▪
		<300 cst	▪	▪	▪	▪		▪
		<1000 cst						
		>1000 cst						
	Conductivity	>20 µS/cm	▪	▪	▪	▪	▪	▪
		>5 µS/cm	▪	▪	▪	▪	▪	▪
		<5 µS/cm	▪	▪	▪	▪	▪	▪

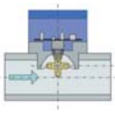
* Non-fibrous ** Non-ferromagnetic *** ferromagnetic o: conditionally suitable, precise clarification of the application required

			 Type 8034	 Type 8032	 Type 8039	 Type 8025	 Type 8035
Fluidic characteristics							
	Measuring range		1-1000 l/min	1-1000 l/min	1-1000 l/min	3-50000 l/min	1-1000 l/min
	Nominal diameter		DN 08-50	DN 08-50	DN 08-50	DN 15-400	DN 08-50
Fitting material	Brass		PN 16 0-100 °C	PN 16 0-100 °C	PN 10 0-100 °C	PN 10 0-100 °C	PN 16 0-100 °C
	Stainless steel		PN 16 0-100 °C	PN 16 0-100 °C	PN 10 0-100 °C	PN 10 0-100 °C	PN 16 0-100 °C
	PVC		PN 10 0-50 °C	PN 10 0-50 °C	PN 10 0-50 °C	PN 10 0-50 °C	PN 10 0-50 °C
	PE					PN10 0-50 °C	
	POM						
	PP		PN 10 0-80 °C	PN 10 0-80 °C	PN 10 0-80 °C	PN 10 0-80 °C	PN 10 0-80 °C
	ECTFE						
	PVDF		PN 10 0-100 °C	PN 10 0-100 °C	PN 10 0-100 °C	PN 10 0-100 °C	PN 10 0-100 °C
Seal material	FPM		▪	▪	▪	▪	▪
	EPDM		▪	▪	▪	▪	▪
	FFKM						
Fluid properties	Foreign bodies in medium	0 %	▪	▪	▪	▪	▪
		<1 % *	▪	▪	▪	▪	▪
		<1 % **	▪	▪	▪	▪	▪
		<1 % ***			▪		
		<1 %					
		>1 %					
	Viscosity	<5 cst	▪	▪	▪	▪	▪
		<300 cst	▪	▪	▪	▪	▪
		<1000 cst					
		>1000 cst					
	Conductivity	>20 µS/cm	▪	▪	▪	▪	▪
		>5 µS/cm	▪	▪	▪	▪	▪
		<5 µS/cm	▪	▪	▪	▪	▪

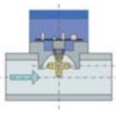
* Non-fibrous ** Non-ferromagnetic *** ferromagnetic

3.1.2. Selection of device types (continued)

Paddle wheel, electrical characteristics

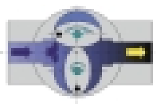
		 Type 8010	 Type 8020	 Type 8030	 Type 8030 HT	 Type 8031	 Type 8024
Electrical characteristics							
Basic function	Switch	▪					
	Sensor		▪	▪	▪	▪	
	Display						▪
	Transmitter						
	Batch controller						
Output	Reed cont. (max. 0.8 A/50 W)	▪					
	Transist. (max. 0.7 mA/30 V DC)						
	Relay (max. 3 A/250 V AC)						
	Pulse output (square-wave)		▪	▪	▪	▪	
	Pulse outp. (sinus. sign. fr. coil)		▪	▪	▪		
	4 – 20 mA						
	Profibus DP						
	ASI bus						
Supply voltage	None	▪	▪	▪	▪		▪
	Battery						▪
	10 – 36 V DC		▪	▪	▪	▪	▪
	115/230 V AC						
Equipment features	Display/analog indicator						▪
	Bargraph						
	Keypad						
	Totalizer						
	Teach-in calibration						
	Simulation						
	Hysteresis mode						
	Window mode						
Design	Compact device	▪	▪	▪	▪	▪	▪
	Control panel installation						▪
	Field device						▪
Expansibility	Stand alone		▪	▪	▪		▪
	With Bürkert remote electron.		8025 SE32, SE34	8025 SE32, SE34	8025 SE32, SE34	8025 SE32	
	To PLC or other ext. electronics	▪	▪	▪	▪	▪	
	W. other Bürkert electr. modules		8021, 8023	8021, 8023	8021, 8023		

Paddle wheel, electrical characteristics

		 Type 8034	 Type 8032	 Type 8039	 Type 8025	 Type 8035
Electrical characteristics						
Basic function	Switch		▪	▪	▪	▪
	Sensor			▪	▪	▪
	Display	▪	▪	▪	▪	▪
	Transmitter		▪	▪	▪	▪
	Batch controller				▪	▪
Output	Reed cont. (max. 0.8 A/50 W)					
	Transist. (max. 0.7 mA/30 V DC)		▪	▪		
	Relay (max. 3 A/250 V AC)		▪	▪	▪	▪
	Pulse output (square-wave)			▪	▪	▪
	Pulse outp. (sinus. sign. fr. coil)				▪	▪
	4 – 20 mA		▪		▪	▪
	Profibus DP				▪	▪
	ASI bus		▪			
Supply voltage	None	▪				
	Battery	▪			▪	▪
	10 – 36 V DC	▪	▪	▪	▪	▪
	115/230 V AC				▪	▪
Equip- ment features	Display/analog indicator	▪	▪	▪	▪	▪
	Bargraph		▪	▪		
	Keypad		▪	▪	▪	▪
	Totalizer				▪	▪
	Teach-in calibration		▪	▪	▪	▪
	Simulation		▪	▪	▪	▪
	Hysteresis mode		▪	▪	▪	▪
	Window mode		▪	▪		
Design	Compact device	▪	▪	▪	▪	▪
	Control panel installation	▪			▪	
	Field device	▪	▪		▪	
Expan- sibility	Stand alone	▪	▪	▪	▪	▪
	With Bürkert remote electron.			8025 SE32	▪	
	To PLC or other ext. electronics		▪	▪	▪	▪
	W. other Bürkert electr. modules					

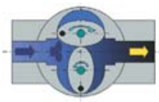
3.1.2. Selection of device types (continued)

Oval gear, fluidic characteristics

			 Type 8070	 Type 8071	 Type 8072	 Type 8075
Fluidic characteristics						
	Measuring range		1-350 l/min	0,03-8,3 l/min	1-350 l/min	1-350 l/min
	Nominal diameter		DN15-50	G 1/4“	DN15-50	DN15-50
Fitting material	Aluminium		55 bar 0-80 °C		55 bar 0-80 °C	55 bar 0-80 °C
	Brass					
	Stainless steel		55 bar 0-120 °C	10 bar 0-120 °C	55 bar 0-120 °C	55 bar 0-120 °C
	PVC					
	PE					
	POM					
	PP					
	PPS		10 bar 0-80 °C	5 bar 0-80 °C		
	ECTFE					
	PVDF					
Seal material	FPM		▪	▪	▪	▪
	EPDM		▪	▪	▪	▪
	FFKM		▪	▪	▪	▪
Fluid properties	Foreign bodies in medium	0 %	▪	▪	▪	▪
		<1 % *				
		<1 % **				
		<1 % ***				
		<1 %				
		>1 %				
	Viscosity	<5 cst	o	o	o	o
		<300 cst	▪	▪	▪	▪
		<1000 cst	▪	▪	▪	▪
		>1000 cst	▪	o	▪	▪
	Conductivity	>20 µS/cm	▪	▪	▪	▪
		>5 µS/cm	▪	▪	▪	▪
		<5 µS/cm	▪	▪	▪	▪

* Non-fibrous ** Non-ferromagnetic *** Ferromagnetic o: Restricted flow range

Oval gear, electrical characteristics

		 Type 8070	 Type 8071	 Type 8072	 Type 8075
Electrical characteristics					
Basic function	Switch			▪	▪
	Sensor	▪	▪		▪
	Display			▪	
	Transmitter			▪	▪
	Batch controller				▪
Output	Reed cont. (max. 0.8 A/50 W)				
	Transist. (max. 0.7 mA/30 V DC)			▪	
	Relay (max. 3 A/250 V AC)			▪	▪
	Pulse output (square-wave)	▪	▪		▪
	Pulse outp. (sinus. sign. fr. coil)				
	4 – 20 mA			▪	▪
	Profibus DP				▪
	ASI bus			▪	
Supply voltage	None				
	Battery				▪
	10 – 36 VDC	▪	▪	▪	▪
	115/230 VAC				▪
Equipment features	Display			▪	▪
	Bargraph			▪	
	Keypad			▪	▪
	Totalizer				▪
	Teach-in calibration			▪	▪
	Simulation			▪	▪
	Hysteresis mode			▪	▪
	Window mode			▪	
Design	Compact device	▪	▪	▪	▪
	Control panel instalation				
	Field device			▪	
Expansibility	Stand alone	▪	▪	▪	▪
	With Bürkert remote electron.	8025, SE32, SE34	8025, SE32		▪
	To PLC or other external electr.	▪	▪	▪	▪
	W. other Bürkert electr. modules	8021, 8032			

3.1.2. Selection of device types (continued)

Magnetic inductive measuring method, fluidic characteristics

			 Type 8040	 Type 8041	 Type 8045	 Type 8045 HT	 Type 8055
Fluidic characteristics							
	Measuring range		1-50,000 l/min	1-50,000 l/min	1-50,000 l/min	1-50,000 l/min	0-4,700 l/min
	Nominal diameter		DN 15-400	DN 15-400	DN 15-400	DN 15-400	DN 03-100
Fitting	Aluminium						
material	Brass		PN 6 0-60 °C	PN 16 0-150 °C	PN 6 0-80 °C	PN 16 0-110 °C	PN 16 -20 – 150 °C
	Stainless steel		PN 6 0-60 °C	PN 16 0-150 °C	PN 6 0-80 °C	PN 16 0-110 °C	PN 16 -20 – 150 °C
	PVC		PN 6 0-50 °C	PN 16 0-50 °C	PN 6 0-50 °C	PN 16 0-50 °C	PN 16 0-50 °C
	PE		PN 6 0-50 °C	PN 16 0-50 °C	PN 6 0-50 °C	PN 16 0-50 °C	PN 16 0-50 °C
	POM						
	PP		PN 6 0-60 °C	PN 16 0-80 °C	PN 6 0-80 °C	PN 16 0-80 °C	PN 16 0-60 °C
	PPS						
	ECTFE						
	PVDF		PN 6 0-60 °C	PN 16 0-150 °C	PN 6 0-60 °C	PN 16 0-110 °C	PN 16 0-100 °C
Seal/	FPM		▪	▪	▪	▪	
lining	EPDM		▪	▪	▪	▪	
	PTFE/PP		▪	▪	▪	▪	▪
Fluid	Foreign	0 %	▪	▪	▪	▪	▪
properties	bodies	<1 % *	▪	▪	▪	▪	▪
	in medium	<1 %	▪	▪	▪	▪	▪
		<1 %**	▪	▪	▪	▪	▪
		<1 %***					
		>1 %	▪	▪	▪	▪	▪
	Viscosity	<5 cst	▪	▪	▪	▪	▪
		<300 cst	▪	▪	▪	▪	▪
		<1000 cst	▪	▪	▪	▪	▪
		>1000 cst	o	o	o	o	o
	Conductivity	>20 µS/cm	▪	▪	▪	▪	▪
		>5 µS/cm					▪
		<5 µS/cm					

* Non-fibrous ** Non-ferromagnetic *** Ferromagnetic o: Conditionally suitable, precise clarification of the application required

Magnetic inductive measuring method, electrical characteristics

		 Type 8040	 Type 8041	 Type 8045	 Type 8045 HT	 Type 8055
Electrical characteristics						
Basic function	Switch			▪	▪	
	Sensor	▪	▪	▪	▪	▪
	Display			▪	▪	▪
	Transmitter	▪	▪	▪	▪	▪
	Batch controller					▪
Output	Reed cont. (max. 0.8 A/50 W)					
	Transist. (max. 0.7 mA/30 V DC)					▪
	Relay (max. 3 A/250 V AC)			▪	▪	▪
	Pulse output (square-wave)	▪	▪	▪	▪	▪
	Pulse outp. (sinus. sign. fr. coil)					
	4 - 20 mA	▪	▪	▪	▪	▪
	Profibus DP			▪	▪	
	ASI bus					
Supply voltage	None					
	Battery					
	10 - 36 V DC	▪	▪	▪	▪	
	115/230 V AC					▪
Equip-ment features	Display			▪	▪	▪
	Bargraph					▪
	Keypad			▪	▪	▪
	Totalizer			▪	▪	▪
	Teach-in calibration			▪	▪	
	Simulation			▪	▪	▪
	Hysteresis mode			▪	▪	▪
	Window mode					
Design	Compact device	▪	▪	▪	▪	▪
	Control panel installation			▪	▪	
	Field device			▪	▪	▪
Expan-sibility	Stand alone	▪	▪	▪	▪	▪
	With Bürkert remote electron.	8025, SE32	8025, SE32	8025, SE32	8025, SE32	
	To PLC or other external electr.	▪	▪	▪	▪	▪
	W. other Bürkert electr. modules	8021	8021			

3.2. Measuring principles: function and styles

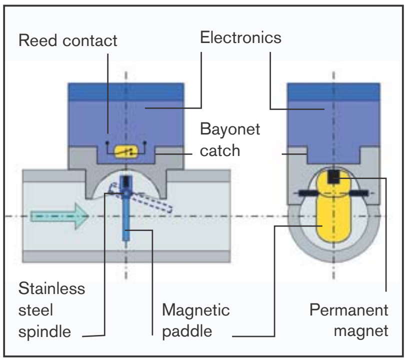
3.2.1. Magnetic paddle

A permanent magnet is integrated into a paddle. The paddle is mounted so that it is able to turn on a stainless steel spindle in the flow cross-section and is in vertical position when de-energized. A reed contact is positioned above the paddle. If a specific flow velocity is exceeded, the paddle is deflected in the flow direction and switches the reed contact. The switching point can be set for increasing and dropping flow velocities by means of an adjusting screw. The devices are available in the following versions:

- Normally open (NO). The flow closes the contact.
- Normally closed (NC). The flow opens the contact.

This measuring method is suitable for pure switching operations in clean fluids. It can also be used in aggressive media owing to encapsulation of magnet and electronics.

Magnetic paddle



3.2.2. Paddle wheel: magnetic, optical, stainless steel

A paddle wheel arranged perpendicular to the flow direction in a fluid-filled pipe is caused to rotate by the fluid flow. The rotational speed of the paddle wheel changes within the possible measuring range in proportion to the flow velocity. The rotary movement of the paddle wheel is detected using various measuring methods.

Flow measurement with a paddle wheel is chiefly used for fluids having only a low level of contamination (<1%). Due to the differing characteristics of the individual measuring principles, the devices may also be used in aggressive fluids – even with metallic foreign bodies – and medium temperatures up to +160 °C, depending on type and version.

Limits to application primarily apply as the result of fibrous or highly abrasive foreign bodies in the medium which may jam or destroy the moving parts in the sensor. In addition, maintaining a uniform flow profile is important (ensure that there are only a few edges and note the inlet and outlet section), since the velocity of the fluid is measured at a specific point in the pipe cross-section.

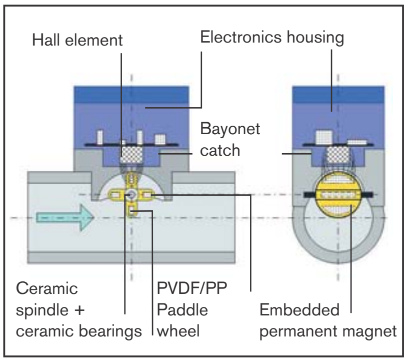
The paddle wheel sensors may be differentiated on the basis of the material used for the paddle wheel (plastic or stainless steel) or on the basis of signal detection/evaluation (coil sensor or Hall sensor). This results in 5 different paddle wheel versions whose principles are described in greater detail below:

Plastic paddle wheel (PVDF or PP) with permanent magnet and pulse output

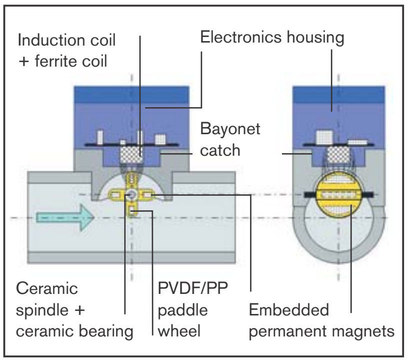
The paddle wheel is made of PVDF or PP. The four permanent magnets in the paddle wheel are fully coated with plastic. The spindle and two bearings consist of wear-resistant ceramic material (Al_2O_3). A Hall sensor which detects the magnetic field of the paddle wheel is arranged outside of the medium area in the electronics housing. The integrated electronics converts this signal to a square-wave frequency signal. The frequency changes proportionally with the speed of rotation of the paddle wheel. Two signals are output per revolution.

This version enables use even in aggressive media. The pulse output can be easily and directly detected by an external control system. Ferromagnetic

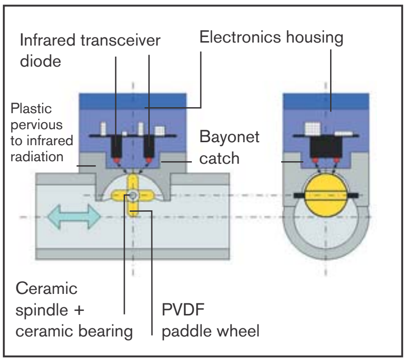
Plastic paddle wheel with permanent magnet and pulse output



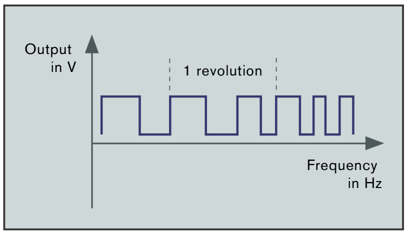
Plastic paddle wheel with permanent magnet and sinusoidal output



Plastic paddle wheel with IR sensor and pulse output



particles in the medium, which may adhere to the paddle wheel and thus disturb the proportionality response or even stop the paddle wheel moving, must be entirely avoided.

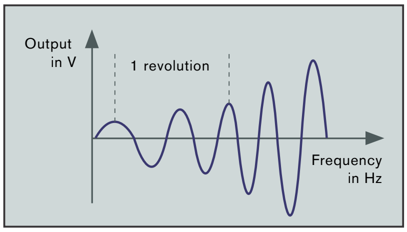


Output signal

Plastic paddle wheel (PVDF or PP) with permanent magnet and sinusoidal output

The paddle wheel is made of PVDF or PP. The four permanent magnets in the paddle wheel are fully coated with plastic. The spindle and two bearings consist of wear-resistant ceramic material (Al_2O_3). A ferrite core with coil which detects the magnetic field of the paddle wheel is arranged outside of the medium area in the electronics housing. Rotation of the paddle wheel generates a sinusoidal voltage signal, proportional to the flow rate, in the coil. The frequency and voltage change in proportion to the rotational speed of the paddle wheel. The magnets have alternate polarity so that two positive signals are output per revolution.

The range of application is basically the same as with signal detection via the Hall sensor. However, this sensor is a two-wire version which requires no additional auxiliary energy supply. A connected, battery-operated display unit thus allows operation independent of mains voltage.

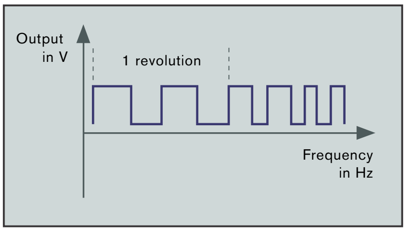


Output signal

Plastic paddle wheel (PVDF) with IR sensor and pulse output

The paddle wheel is made of PVDF material. The spindle and both bearings are made of wear-resistant ceramic material (Al_2O_3). Two infrared transmitters and receivers are arranged in the electronics housing outside of the medium area, separated by plastic which allows infrared radiation to pass through it. The rotation of the paddle wheel is detected with these IR diodes. The integrated electronics converts this paddle wheel signal to a square-wave frequency signal, proportional to the flow rate. The frequency changes proportionally with the rotational speed of the paddle wheel. Two positive signals are output per revolution.

This optical method allows the flow rate to be detected even in media with ferromagnetic particles. This function is guaranteed even with very turbid fluids (ink-like fluids). Moreover, it enables detection of the flow direction. Fluids which form coatings that build up in layers on the translucent plastic, thus impeding the passage of infrared radiation, or which can significantly change the reflection behavior of the paddle wheel due to deposits on the paddle wheel restrict the field of application. Very strong light sources in the direct vicinity of the sensor must be avoided since they could disturb or prevent detection of the reflected infrared signal.



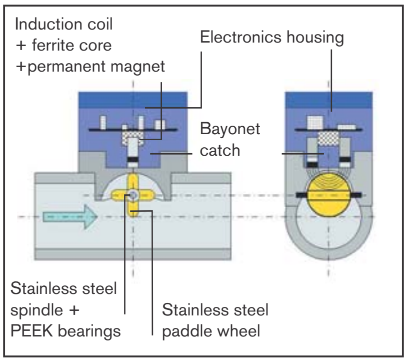
Output signal

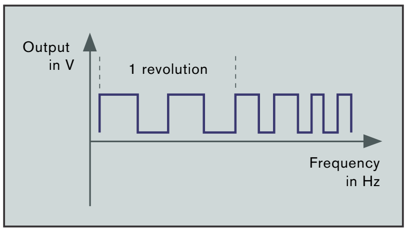
Stainless steel paddle wheel with coil sensor and pulse output

The paddle wheel consists of stainless steel with a very low iron share and is not magnetized. The spindle is made of coated stainless steel and the bearings are made of PEEK. There is a ferrite core with coil, permanent magnet and top-mounted electronics outside of the medium area in the electronics housing. Rotation of the paddle wheel causes the magnetic field of the coil to close or open alternately. This generates a sinusoidal frequency signal, proportional to the flow rate, in the coil. The integrated electronics converts this signal to a square-wave frequency signal. The frequency changes in proportion to the speed of rotation of the paddle wheel. Two positive signals are output per revolution.

This method is particularly used for media with temperatures up to 160 °C. Ferromagnetic foreign bodies do not restrict the range of application. The pulse output can be easily and directly detected by an external control system. In the case of very aggressive media, using a paddle wheel made of stainless steel results in restrictions in regards to material resistance under certain circumstances.

Stainless steel paddle wheel with coil sensor and pulse output



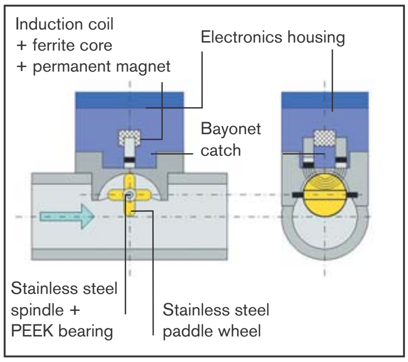


Output signal

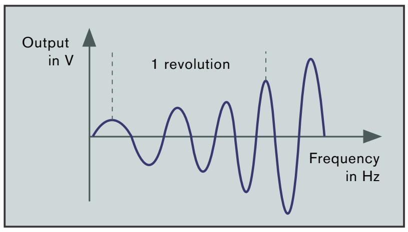
Stainless steel paddle wheel and coil sensor and sinusoidal output

The paddle wheel consists of a stainless steel with very low iron share and is not magnetized. The material of the spindle is coated stainless steel and bearing is made of PEEK. There is a ferrite core with coil and permanent magnet outside of the medium area in the electronics housing. Rotation of the paddle wheel causes the magnetic field of the coil to close or open alternately. This generates a sinusoidal frequency signal, proportional to the flow rate, in the coil. The frequency and voltage change in proportion to the speed of rotation of the paddle wheel. Four positive signals are output per revolution.

Stainless steel paddle wheel with coil sensor and sinusoidal output



The range of application is basically the same as with signal detection via the Hall sensor. However, this sensor is a two-wire version which requires no additional auxiliary energy supply. A connected, battery-operated display unit thus allows operation independent of mains voltage.

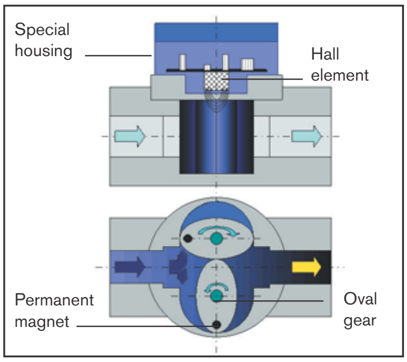


Output signal

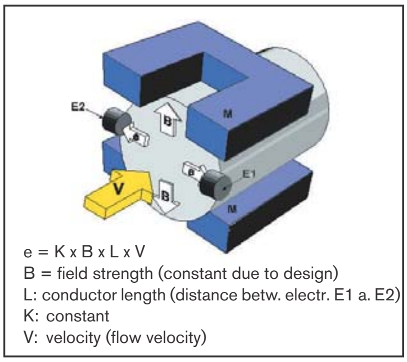
3.2.3. Volumetric measuring method: oval gear

Two intermeshed oval cogs – mounted perpendicular to the flow direction in a special housing – are caused to rotate by a flowing fluid. One of the two oval gears meshing 90° offset alternately encloses a defined fluid volume between the outer wall of the housing, outer side of the oval wheel and the two flat covers of the housing. Rotation of the oval gear pumps this chamber volume towards the chamber outlet. Two chamber volumes per oval

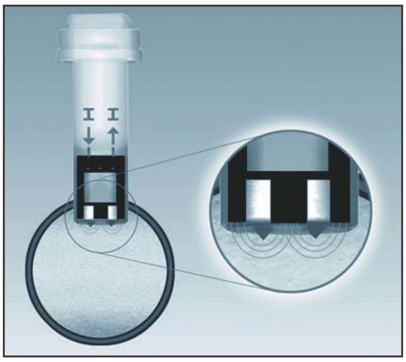
Principle of oval gear with pulse output



Principle of Full MID



Principle of Finger MID



gear – thus totaling four – are pumped per revolution. A permanent magnet positioned on one of the oval gears is used to detect the rotary movement. A Hall sensor which detects the magnetic field of the oval gear and generates a square-wave signal is arranged outside of the medium area in an electronics housing. A coil sensor cannot be used since the rotational speed of the oval gear is too low to allow signal detection. The number of pulses is directly proportional to the number of chamber volumes pumped.

This measuring method is particularly suitable for flow measurement of viscous media even at high pressure. Owing to gap losses, the measurement error increases in the case of thinner-bodied media and low flow rates. Due to the design, a minimum pressure loss (at minimum flow) of approx. 0.3 bar must be assumed.

3.2.4. Magnetic inductive measuring methods: Full bore MIF, Insertion MIF

The liquid, conductive measured medium flows through a pipe section at flow velocity v, in which a constant magnetic field B is created via 2 solenoid coils M. The 2 solenoid coils M are each arranged on the outside of the pipe, opposite to one another. A voltage in accordance with Faraday's law is induced between electrodes E1 and E2, on account of magnetic field M and the flow of a conductive medium. The voltage is proportional to the flow velocity and is thus proportional to the flow rate. A measured value transducer amplifies the signal and converts it to a standard signal (e.g. 4 - 20 mA).

Magnetic inductive flow sensors may be designed as Full bore MIF or Finger MIF. On the Full bore MIF, the induced voltage is detected by electrodes, which are arranged directly opposite through the pipe outer wall, over the full pipe inside diameter. The advantage is that the flow profile can be fully detected. This results in very precise measurement of the medium velocity.

On the Finger MIF, the two electrodes are arranged parallel and adjacently on the underside of a cylindrical measuring finger. This measuring finger is fitted through an opening in the pipe perpendicular to the flow direction at the marginal area of the pipe. This design means that Finger MIFs are very compact and can also be easily fitted into existing pipe systems.

MIFs are suitable for flow measurement of virtually all conductive fluid media - even with a high level of contamination. Only non-conductive fluids, fluids causing coatings or highly abrasive fluids restrict application options.

3.3. Process connections for flow measuring instruments

Bürkert distinguishes between two fitting variants in relation to the installation of flow sensors in the process:

- Series S020 for Insertion sensors
- Series S030 for Inline sensors.

Both fittings series feature a standard interface to the sensor modules, thus enabling very easy installation and fastening in the system.

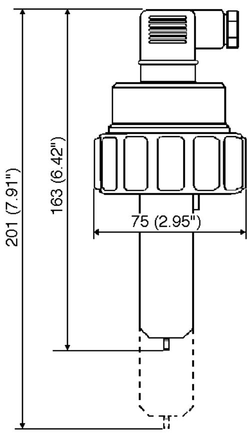
The special feature of Inline sensors S030 in comparison with Insertion sensors S020 lies in the fact that the electronic modules of the Inline system can be exchanged with no leakage during operation of the process. The measuring sensor is located in the fitting and the measurement signal is transmitted without physical contact (magnetically or optically) to the electronic module. This means that the measuring sensor does not need to be directly connected to the electronics. On the Insertion sensor, the measuring sensor is located in a finger which is immersed into the process (finger design). The sensor can be exchanged only after depressurizing the entire system, in order to avoid leakage.

3.3.1. Insertion fitting system S020
When using Bürkert finger sensors, it is advisable to use Type S020 installation fittings of the correct nominal diameter. It must be ensured that the right finger length, dependent on nominal diameter, is selected. We distinguish between a short sensor finger and a long sensor finger.

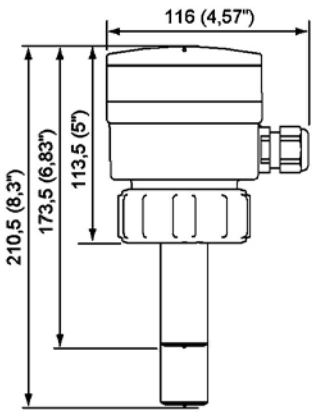
Insertion Series S020 fittings are available in plastic, brass or stainless steel. They consist of a connector with indentation, a plastic seal and a union nut for fixing the sensor in position. The connector is already permanently connected to a pipe fitting up to DN 50. A wide range of connection options for installation in a pipe are available (spigot, external thread, weld end, TriClamp or flange, etc.). In the case of nominal diameters from 65 to approx. 400 mm, it is advisable to use fusion spigots made of plastic or stainless steel, or a connection saddle made of plastic. Individual connectors which can be welded in (stainless steel) or screwed in (plastic) are recommended for installation in tanks.

T-fitting with divers pipe connections made of Stainless steel or plastic	Fusion spigot with or without radius made of Stainless steel	Threaded connectors and fusion spigots made of plastic (weld-o-let)	Connection saddle made of plastic
DN 15 – DN 50	DN 65 – DN 400	DN 65 – DN 400	DN 65 – DN 200
			

Illustration: Basic modules of S020 Insertion fittings

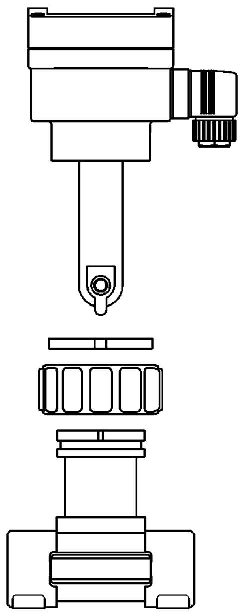


Paddle wheel sensor (Type 8020)



Fields of application
Short sensor: installation in fittings DN 15 to DN 100
Long sensor: installation in fittings from DN 125 upwards

Magnetic inductive flow meter MIF (Type 8045)



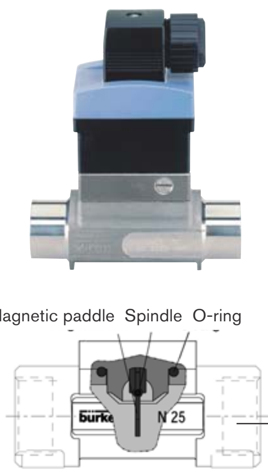
Installation example of a finger sensor in fitting S020

3.3.2. Inline fitting system S030 (S010)

When using Bürkert Inline sensors, it is necessary to use Type S030 installation fittings made of plastic or stainless steel. In this series, the measuring sensor (a paddle wheel) is inseparably integrated in the fitting and is closed to the outside so that the system is not opened even if the electronic module is detached (no leakage). Signals are transmitted from the paddle wheel to the electronic module magnetically via an induction coil or Hall element or optically by means of infrared.

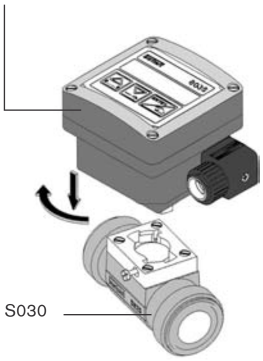
The Type S010 fitting is a special case since it features an integrated paddle – in place of the paddle wheel on the S030 – which triggers a reed contact in the electronic module after being appropriately deflected by the flow pressure. The overall dimensions of the S010 are the same as those of the S030. Version S010 was developed for flow switch Type 8010.

Inline Series S030 or S010 fittings are available in plastic, brass or stainless steel. They consist of a pipe fitting with integrated measuring sensor (paddle wheel or magnetic paddle) and a screwed-on bayonet catch. The corresponding electronic module is inserted in this catch, rotated through 90° and locked with a screw. Series S030 fittings are available in the nominal diameter range from 8 to 50 mm with a variety of connection options for installation in a pipe (threaded port, external thread, weld end, TriClamp or flange, etc.) as are those in Series S020. These sensors are not (yet) suitable for installation in tanks or pipes with nominal diameters upwards of 65 mm.



Flow switch, Type 8010

Flow transmitter (example, Type 8035)



- Plug electronic module onto fitting
- Turn bayonet catch through 90° clockwise
- Lock with grub screw

Installation of an Inline sensor using Type 8035 as an example

Plastic housing with true union connection with solvent or fusion spigot

Plastic housing with solvent joint or weld-endconnection

Brass housing with internal thread (threaded port)

Stainless steel housing with weld ends

Stainless steel housing with internal thread

Stainless steel housing with flange

Brass housing with external thread

Stainless steel housing with external thread

Stainl. steel housing w. TriClamp

Examples of S030 Inline fittings

3.4.
Selection helps

Various aspects for ensuring trouble-free operation must be noted when designing a flow measuring system.

3.4.1. Flow/flow velocity/nominal diameter diagrams

Flow rates stipulated as a function of the nominal diameter are possible depending on the measuring method and device type. The higher the flow velocity, the lower the measurement error, but the higher the pressure loss. Pipes for fluids similar to water are generally designed for an average flow velocity of approx. 2 to 3 m/s.

Example of nominal diameter selection

Given:

Flow rate 10 m^3/h at 2 to 3 m/s.

Solution:

The intersection of the flow rate and velocity of pipe flow results in the nominal diameter DN 40.

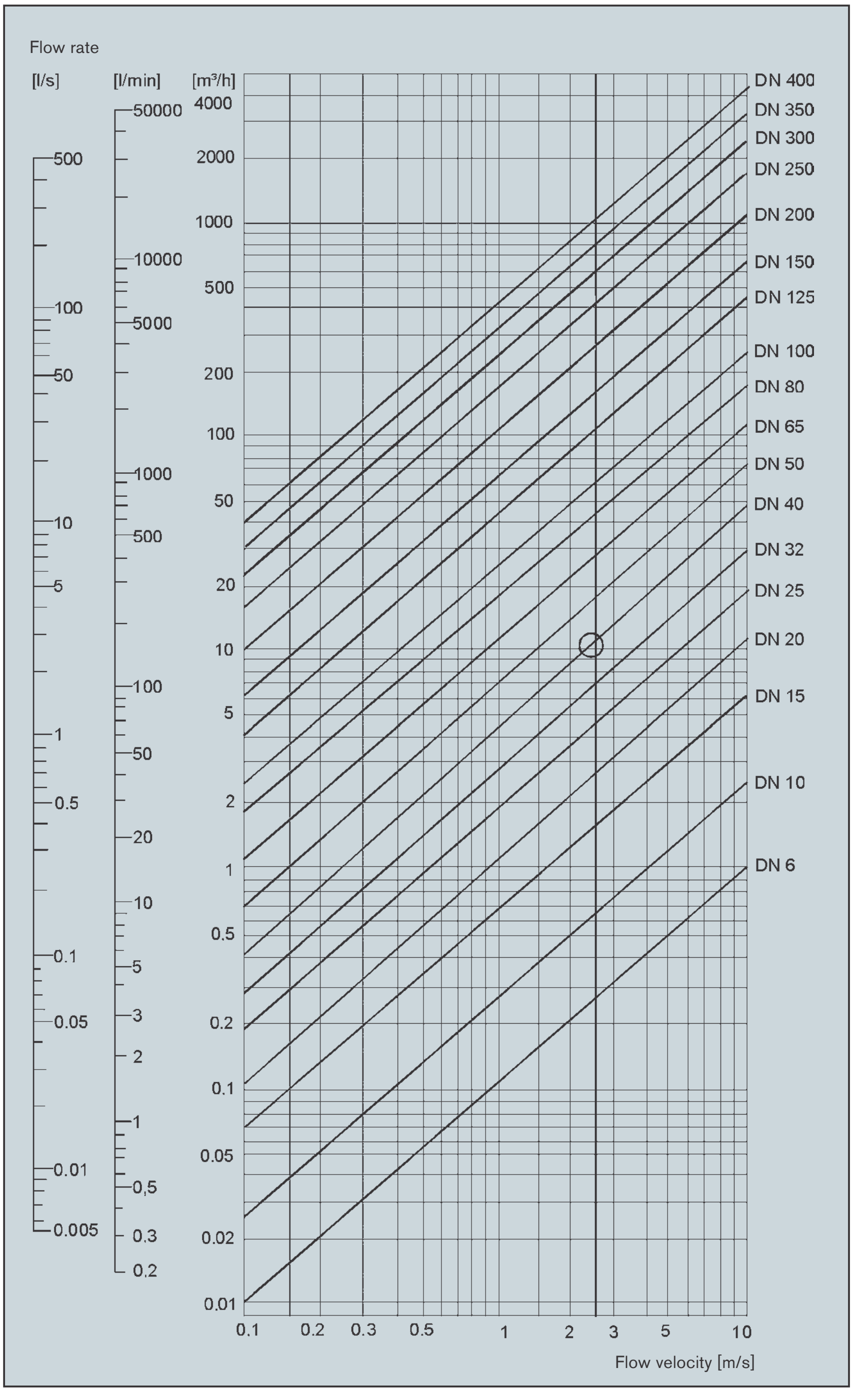


Diagram for nominal diameter selection

3.4.2. Viscosity influence

Viscosity describes the degree of internal friction (the interaction between the atoms and molecules) in the case of real fluids. We distinguish between the term “dynamic viscosity η“ and “kinematic viscosity ν“. The interrelationship between these two is based on multiplication of the relevant substance density.

$$\eta = \nu \cdot \rho$$

The adjacent table provides a general overview of conventional media.

Viscosity has a major influence on the pipe designs of installations since, at constant flow velocity and with a rise of viscosity (media becoming more viscous), the pressure loss in a pipe also rises and either the flow velocity drops or the upstream pressure needs to be increased in order to maintain a constant flow velocity.

The medium temperature also influences the viscosity. While with water, the change in viscosity can frequently be ignored, it is essential to allow for it e.g. in the case of oils.

Units, dynamic viscosity:

$[\eta]$ = 1 N/m² · s = 1 Pa · s = 10^3 mPa · s = 10 Poise = 10^3 cP (centipoise)

➔ 1 mPa s = 1 cP

Units, kinematic viscosity:

$[\nu]$ = 1 m²/s = 10^6 mm²/s = 10^6 cSt (centistoke)

➔ 1 mm²/s = 1 cSt

Medium/temp. [°C]	Dyn. viscos. η [cP]	Density ρ [kg/m³]	Kinem. viscosity ν [cSt]
Water/20 °C	1.01	1000	1.01
Ethanol/20 °C	1.19	1580	0.75
Turpentine/20 °C	1.46	860	1.70
Juice	2-5		
Milk	5-10		
Glycol/20 °C	19.90		
Cream (body lotion)	70-150		
Olive oil/20 °C	107.50	919	117.00
Detergent 20 °C	360.00	1028	350.00
Transformer oil/20 °C	986.00	860	1146.50
Thin honey	1000-2000		
Ketchup	5000		

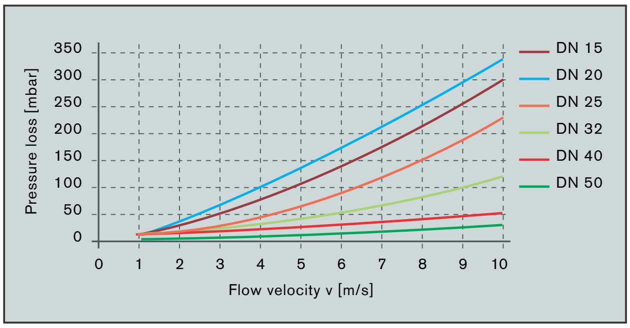
Viscosity values of conventional media

3.4.3. Pressure loss tables/diagrams

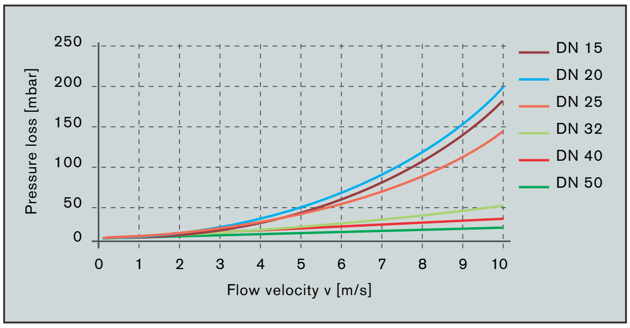
An additional pressure loss occurs, dependent on average flow velocity, in the case of fittings in pipes. In order to be able to estimate the total pressure loss in a pipe system, it is frequently necessary to be aware of the individual pressure losses.

The first three diagrams show the pressure loss of the paddle wheel types and Finger MIF types for water/ 20 °C as a function of the nominal diameter.

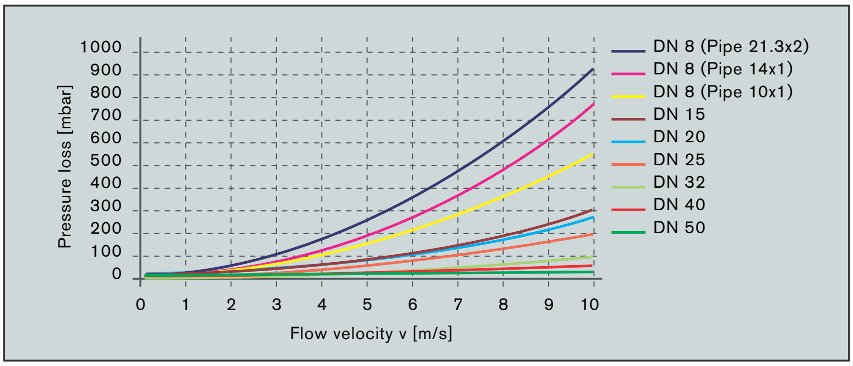
The pressure loss of the oval gear sensors depends very greatly on the viscosity of the medium. The pressure loss of fluids similar to water is virtually independent of the flow rate with this measuring principle. In more viscous media, the pressure loss increases with increasing viscosity. Likewise, it increases with rising flow velocity. The "Pressure loss, oval gear" diagram shows the pressure loss of an oval wheel flow meter 8072 with different media as a function of the flow velocity.



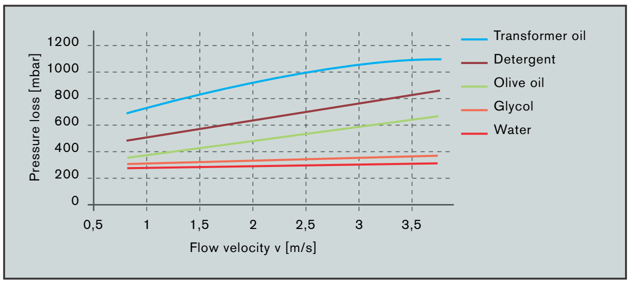
Pressure loss, Insertion fitting with paddle wheel



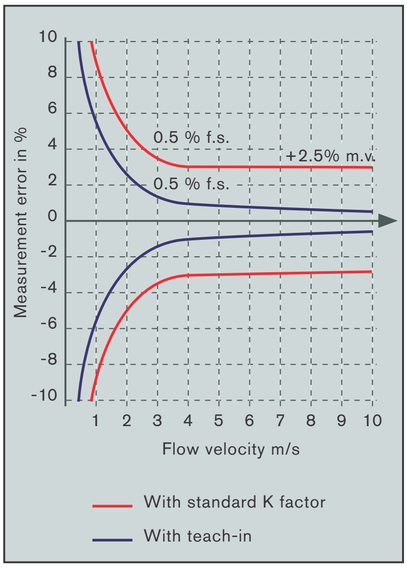
Pressure loss, Insertion fitting with Finger MIF



Pressure loss, Inline fitting with paddle wheel



Pressure loss, oval gear



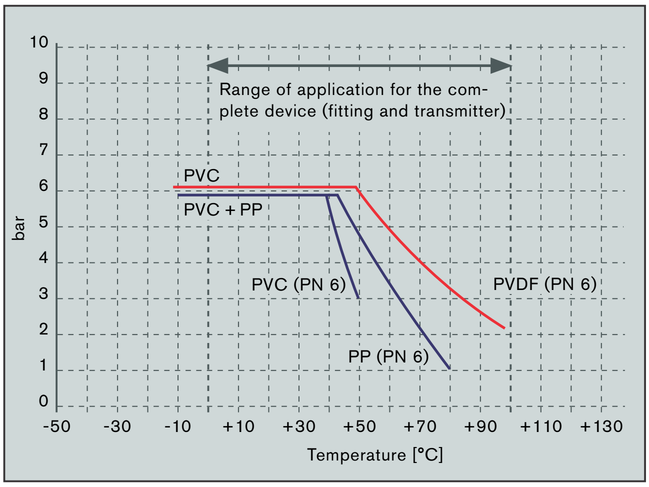
3.4.4. Measurement error consideration (linearity, measurement error and repeat accuracy)

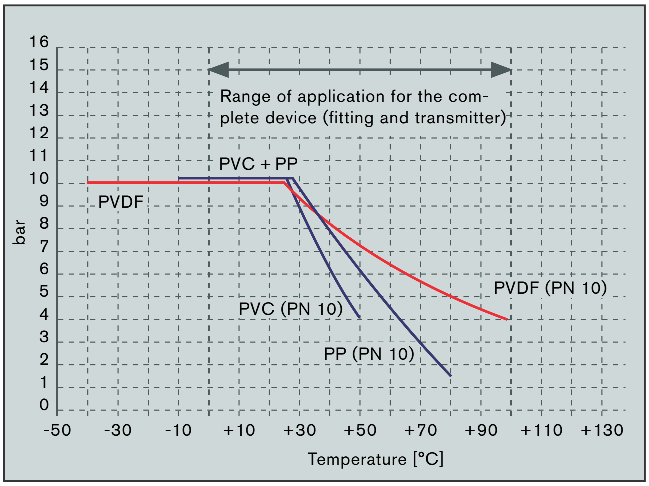
A decision to opt for a specific measuring method may also depend on the required accuracy. Basically, percentages refer either to the measured value or to the full scale value.

The maximum measurement error refers to the full scale value and describes the sum of all possibly occurring individual deviations and is frequently shown graphically as a bell-shaped curve. This includes:

- Linearity over the entire measuring range
- Repeat accuracy (referred to the measured value)
- Production-related tolerances
- Installation tolerances as the result of installation in the pipe system.

The production-related tolerances and installation tolerances can be eliminated by calibration (teach-in), greatly reducing measurement error.



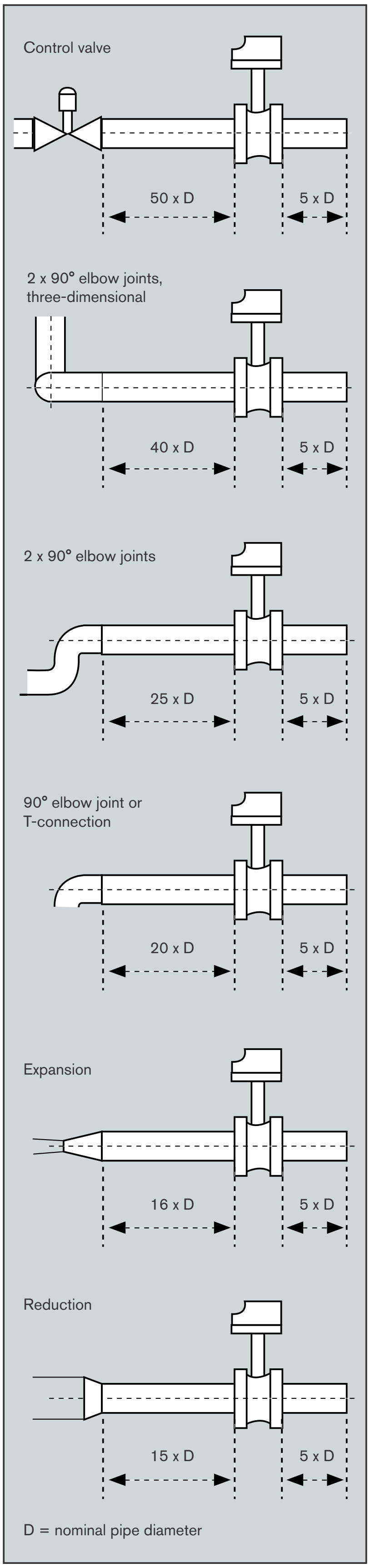


3.4.5. Pressure/temperature diagram for plastics

The pressure resistance of plastics drops with increasing medium temperature. This dependence is shown for pressure stages PN6 and PN10 in the two diagrams shown above.

3.4.6. Inlet/outlet sections

Inlet and outlet sections should be complied with in order to obtain as uniform a flow profile as possible at the flow measuring point. If installation conditions do not allow compliance, many Bürkert flow measuring instruments allow correction of the measured value via teach-in calibration (see 3.4.8., Explanatory information).



Inlet and outlet sections in accordance with EN ISO 5167-1

3.4.7. Installation information

Basically, when installing flow measuring instruments for fluids, it is always necessary to ensure that there are no gas bubbles and that no particles can be deposited at the measuring point, as this would falsify the measurement. Special, type-specific information is included in the corresponding operating instructions.

3.4.8. Explanatory information

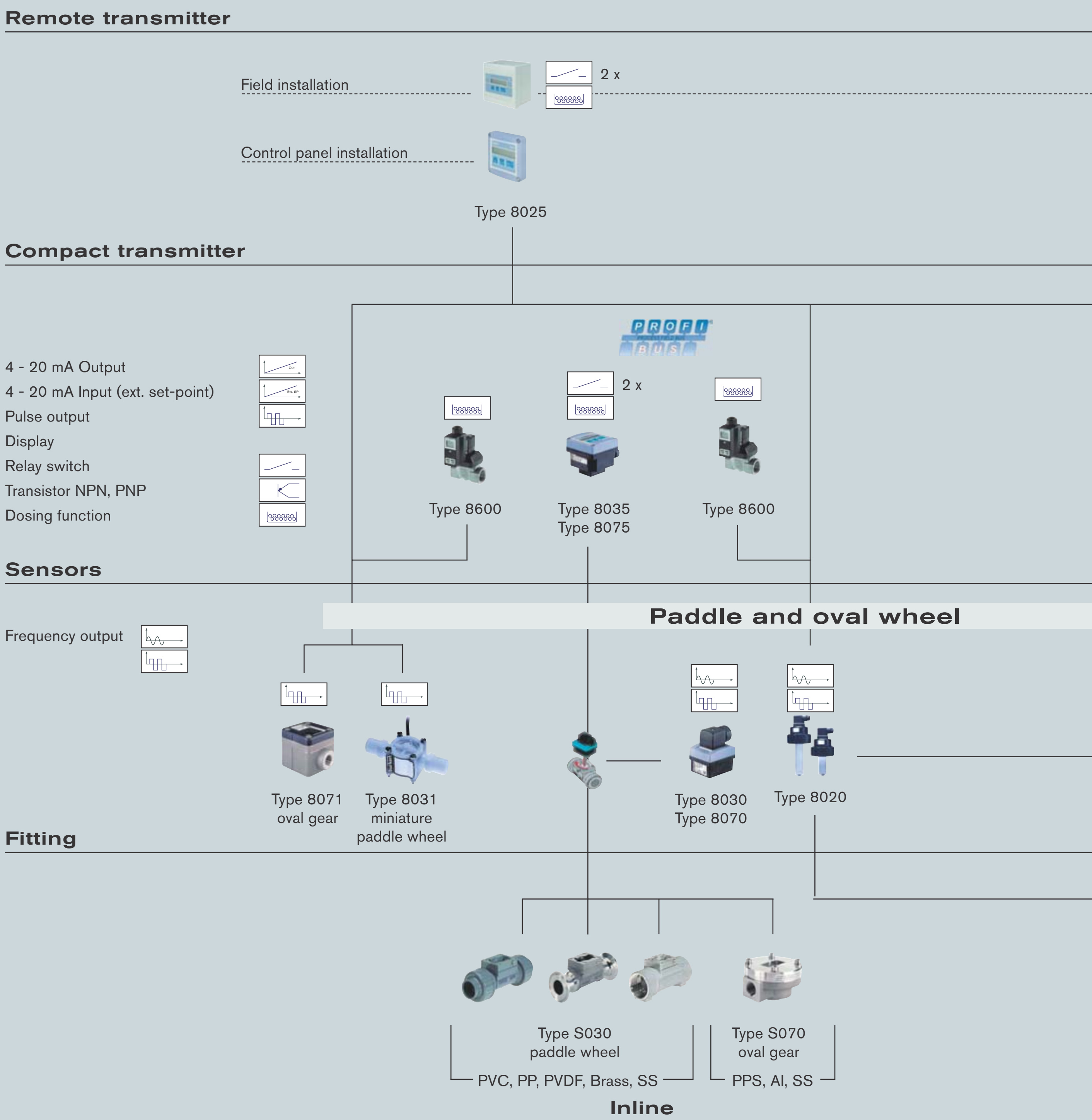
Teach-in calibration

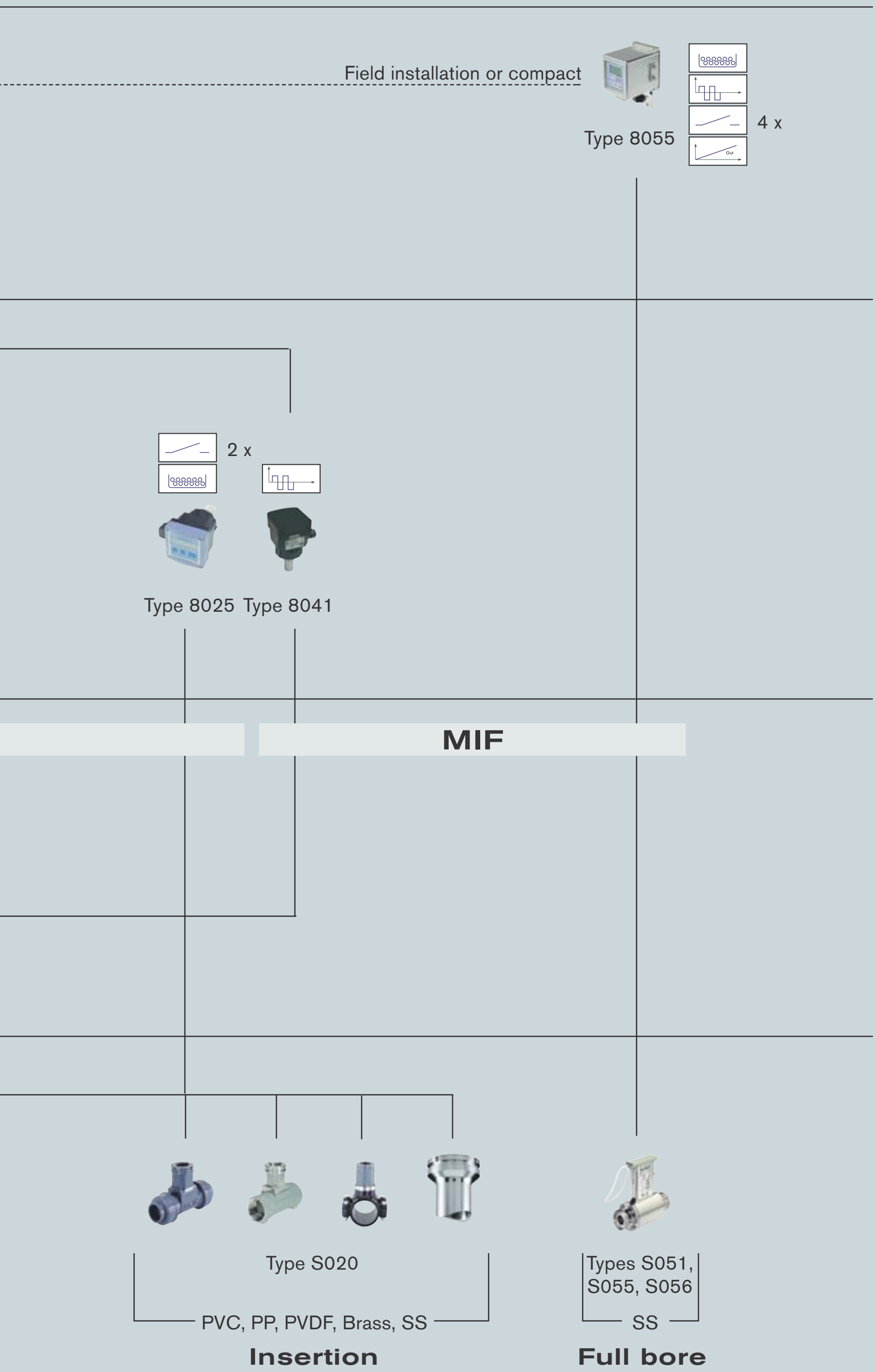
Many Bürkert flow devices can be calibrated in fitted condition for the precise determination of the K factor (proportionality factor between pulse frequency and flow rate).

“Volume” teach-in calibration involves filling a tank with a defined fluid volume. During this filling operation, the pulses generated by the flow sensor are counted by the electronics. After completion of the filling operation, the value of the filled volume is determined (e.g. with a balance or graduated container) and is entered on the keypad of the transmitter.
The device calculates the determined K factor after the entry has been confirmed.

“Flow rate” teach-in calibration involves entering the flow rate of a reference device in the same pipe on the keypad during the operation.
The K factor is calculated after this entry is confirmed.

4. Bürkert's range of batch controllers





Bürkert batch controllers can control very precise dosing and filling operations. Two switching relay outputs serve to actuate the valves for approximate and precise dosing or to trip an alarm. The dosing operations can be started manually or automatically.
The design and materials allow use in virtually all types of fluids. It is possible to select the most appropriate measuring principle (paddle wheel, oval gear, Full bore MIF or Finger MIF) depending on the properties of the medium.

ONTROLLERS

The batch controllers are based on the flow sensor range. Selection tables, measuring principles and further information on selecting the appropriate sensor/fitting can be found in Chapter 3: “Bürkert’s range of flow sensors”.

4.1. Batch controller modes of operation

Stand-alone mode

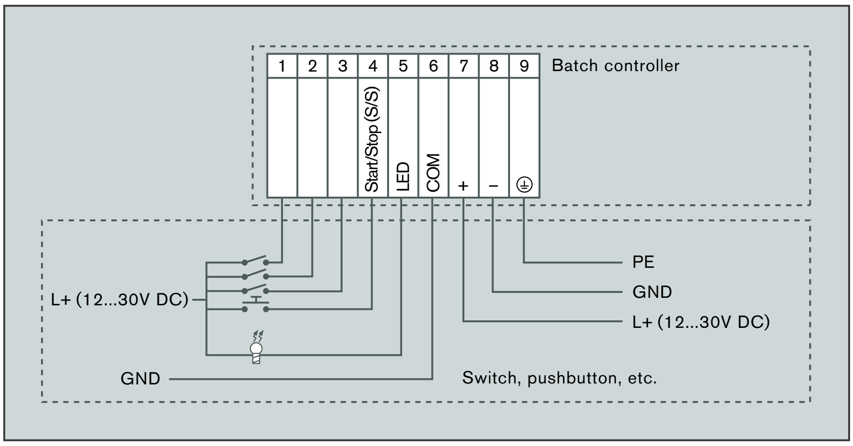
Dosing is performed on-site via the keypad. In this case, dosing is performed either manually prior to each dosing start or dosing can be selected using one of seven previously stored dosing quantities. The dosing operation is then started via the keypad.

Operation with selector switch

Dosing is performed via a BCD rotary switch and binary switch. The rotary switch is used to select one of seven preset dosing quantities and a binary switch (e.g. pushbutton) is used to start the dosing operation.

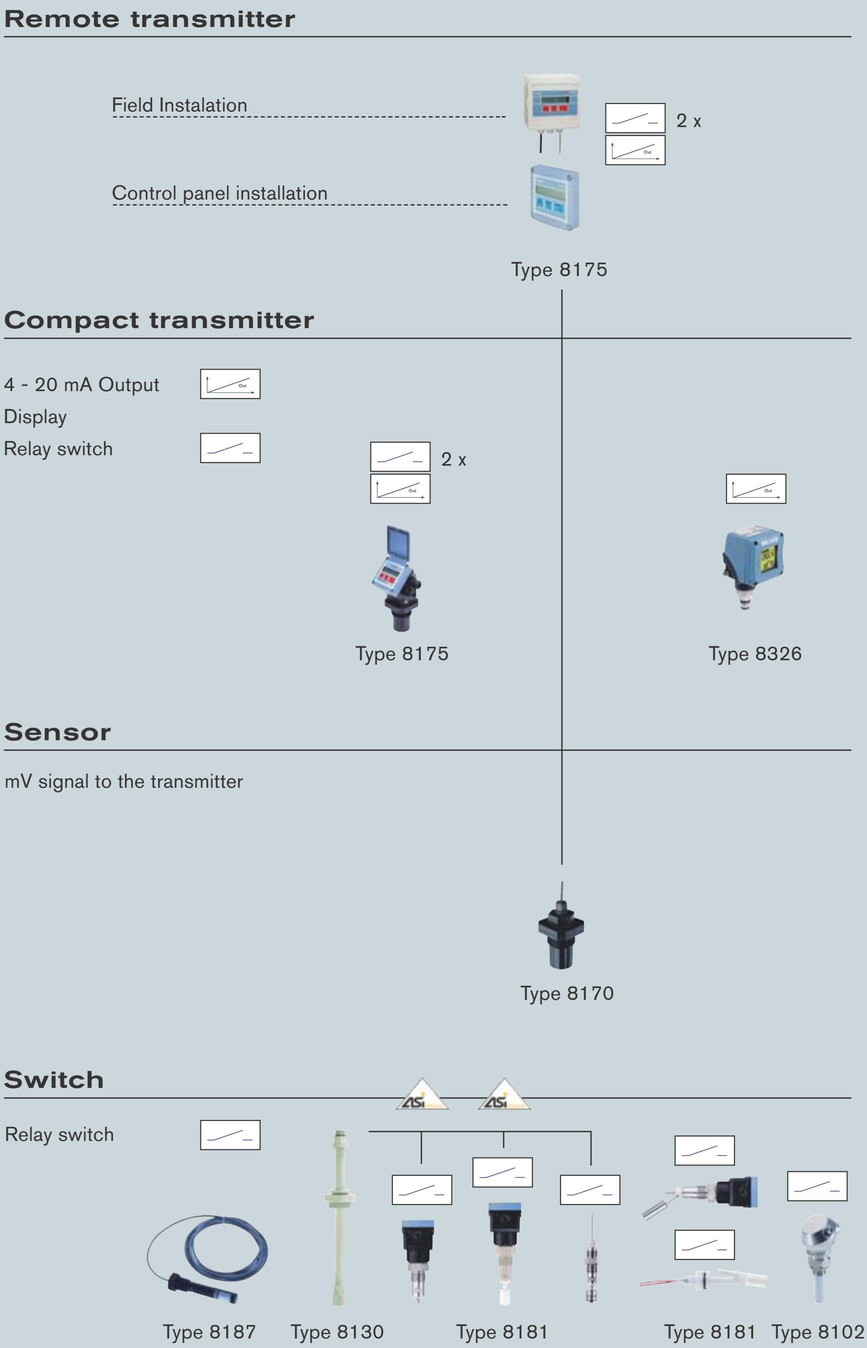
Operation with external control

Any dosing quantity which is proportional to the activation time of a binary input on the batch controller can be dispensed. The linear interrelationship between activation time and dosing quantity is programmed on the controller. Directly after activation of this binary input, the dosing operation starts automatically. During dosing, the binary input is deactivated, thus defining the dosing quantity.



Batch controller, Types 8025/8035: external connection facilities

5. Bürkert's range of level sensors



Bürkert level sensors can be used to perform a wide variety of measuring tasks. The applications extend from simple limit value monitoring to highly precise continuous measurement of filling levels of approx. 40 m in fluid-filled tanks. Various measuring methods are used in this case.

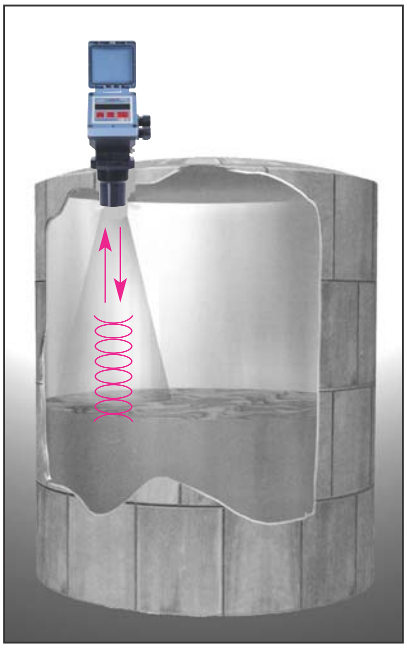
5.1.
Selection table

		 Types 8070/8071	 Type 8181	 Type 8326
Fluidic characteristics				
Sensor	Measuring range	0.3 to 10 m		0 to 40 m
material	Measuring principle	Ultrasonic	Float	Hydrostatic pressure
	Stainless steel		p ≤ 10 bar/t ≤ 120 °C	p ≤ 16 bar/t ≤ 105 °C
	PP		p ≤ 5 bar/t ≤ 80 °C	
	PVDF	p ≤ 2 bar/t ≤ 80 °C		
Fluid	Clean	▪	▪	▪
properties	Contaminated	▪	o	▪
Electrical characteristics				
Basic	Switch		▪	
function	Transmitter	▪		▪
Output	Reed cont. (max. 0.8 A/50 W)		▪	
	Relay (max. 3 A/250 V AC)	▪	▪	
	4 - 20 mA	▪		▪
	ASI bus		▪	
Supply	None		▪	
voltage	10 - 36 VDC	▪	▪	▪
	115/230 VAC	▪		
Equipment	Display	▪		▪
features	Keypad	▪		▪
	Teach-in calibration	▪		▪
	Simulation	▪		▪
	Hysteresis	▪		▪
	Spacing/filling level/volume	▪		
	Temperature compensation	▪		
	Echo filtration	▪		
Design	Compact device	▪	▪	▪
	Control panel installation	▪		
	Field device	▪		

5.2. Measuring principles: function and styles

5.2.1. Ultrasonic

The transmitter emits an ultrasonic wave and determines the propagation time of the signal reflected at a surface. On the basis of this time, the device calculates the distance between the lower edge of the sensor and the surface. The influence of the sound velocity dependent on the surrounding atmosphere is automatically compensated for by entering specific values and measurement of the ambient temperature by the transmitter. If the distance between the lower edge of the sensor and the bottom of a tank is known, the device is able to indicate the filling level or, if the tank geometry is known, the volume still inside the tank can be indicated. Various disturbance echo filters even enable use in containers with built-in fixtures generating a disturbance echo.



Installation example: ultrasonic

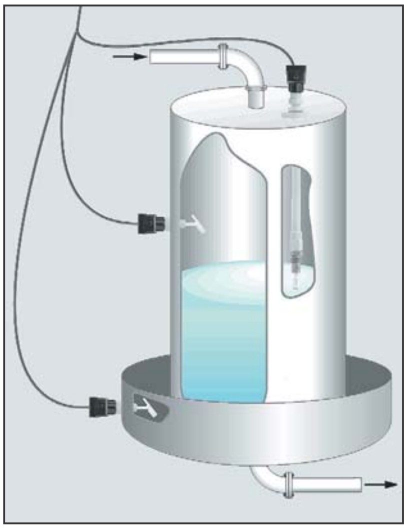
This measuring method allows very precise level measurements even with contaminated, aggressive fluids and in the case of bulk goods. The flow rate can be calculated by measuring the filling level in open channels and gutters.

In principle, all circumstances involving attenuation of the signal or the reflected signal not being reflected back to the sensor restrict the application. This includes frothing on the fluid surface (attenuation), very damp atmosphere (attenuation), condensate formation on the sensor (very great attenuation). Coarse-grained bulk goods reflect only a low share of the signal directly back, meaning that the maximum measurable distance or spacing is greatly reduced. In addition, formation of a bulk goods cone must be taken into account when measuring.

5.2.2. Float

A float floating on a fluid changes its vertical position in proportion to the level. A permanent magnet integrated in the float generates a constant magnetic field, thus causing a reed contact in this field to switch.

On a float switch, a float with magnet is mechanically connected to a reed contact. This allows a switching contact to be produced for a level. A mechanical stop on the float switch prevents the float rising if the fluid level continues to rise, so that the circuit state does not change. The float moves back out of the switch position only when the fluid level drops below this stop. Bürkert float switches are available for horizontal and vertical installation, made of plastic or stainless steel. Float switches can be used to very easily and cost-efficiently implement a



Installation example: float

limit value monitoring system on tanks with fluids which do not form coatings.

Restrictions apply to the use of fluids with a low density, since in that case, the float no longer floats on the fluid surface.

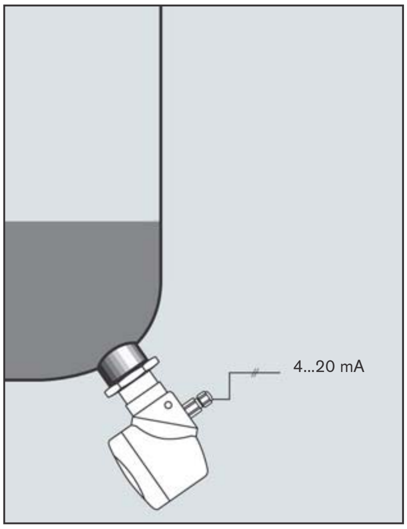
5.2.3. Hydrostatic pressure

A fluid column generates a specific hydrostatic pressure as a function of density and filling level. A pressure sensor attached to the bottom of a tank measures this pressure with respect to a reference pressure (generally ambient pressure). Conclusions are then drawn as to the filling level with the aid of the known fluid density.

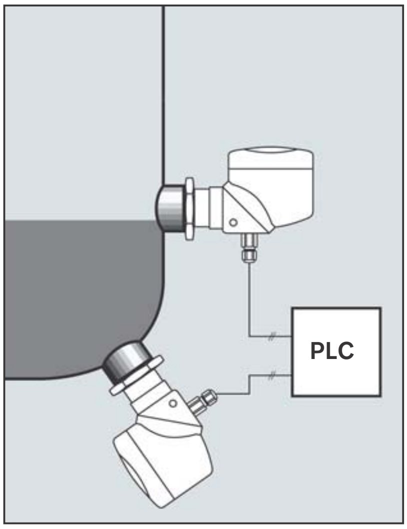
Hydrostatic level measurement is suitable for virtually all types of fluids and produces very precise measured values, dependent on the accuracy of the pressure transmitter.

Restrictions apply to applications in pressurized tanks. In such cases, it is then necessary to also measure this gauge pressure. This can be done by using a second pressure sensor which detects the pressure above the filling level. A corresponding evaluation unit corrects the measured value of the first pressure sensor on the tank bottom based on this value. The higher the internal pressure of the tank, the lower the share of hydrostatic pressure in the overall pressure, and the level measurement error increases. The measuring accuracy also drops further due to the use of two pressure sensors (addition of the measurement errors).

When a differential pressure transmitter is used, the absolute pressure at the bottom of the tank is applied to the front side of the pressure diaphragm and the absolute pressure above the filling level is applied to the rear side. This means that the measuring accuracy of the transmitter remains unchanged even in the case of increasing internal pressure. However, these measuring methods involve very complex designs and are thus extremely costly.



Installation example: hydrostatic pressure



Installation example: pressurized tank

5.2.4. Explanatory information

It is necessary to know the specific fluid and ambient characteristics and properties, depending on the selected measuring method.

Gas characteristic

The gas properties influence the measured value of an ultrasonic level measuring system. Depending on temperature and gas, the propagation speed of the sound wave will vary (see Table 5.4.2.). Since there may be a wide variety of gas mixtures present between the fluid and the sensor, these physical gas characteristics must be known or determined by two-point calibration. A temperature change in the tank is detected by a temperature sensor integrated into the ultrasonic level transmitter and the measured value is corrected automatically.

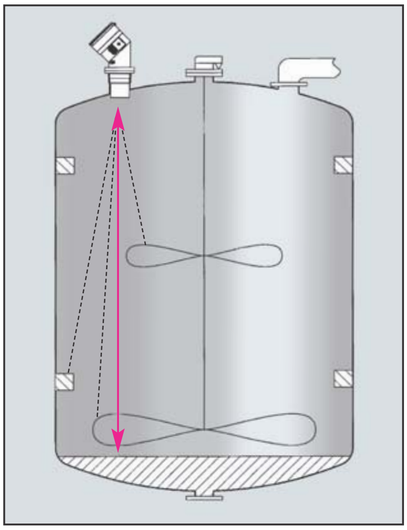
Echo filters

An ultrasonic signal is reflected by all objects extending into the sound cone. This means that a measured value may be disturbed or may be detected incorrectly. Such an influence can be caused in a tank by agitators, inlet pipes, installation elements or similar components. It is possible to perform echo filtration by means of calibration in order to allow the level transmitter to detect and mask these disturbance echoes.

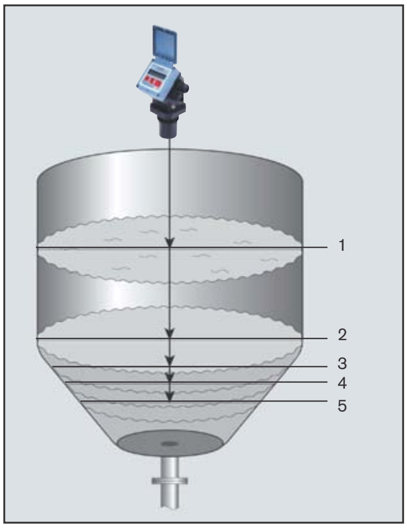
Calibration of units

Ultrasonic level measurement involves measuring the spacing or distance between the sensor and the fluid surface. If the spacing or distance with respect to the bottom of the tank is known, it is possible to calculate and indicate the filling level from it. The filling volume can be calculated and displayed if the tank geometry is known as well. With complex tank shapes, the interrelationship between spacing/distance and volume can be established by teach-in calibration involving step-by-step reference measurements (example: measuring points 1 to 5).

In the case of hydrostatic level measurement, it is necessary to know the density of the fluid in order to be able to assign a filling level to the measured pressure value. It is even possible to determine the volume if the tank geometry is known by step-by-step reference measurements. Depending on the equipment features of the pressure transmitter, this can also be indicated on the pressure transmitter or evaluated by a PLC.



Built-in fittings generating a disturbance echo



Volume calibration

5.3. Selection helps

Various information – in particular for ultrasonic measurements – must be noted in order to achieve trouble-free operation in relation to the design of the corresponding measuring system.

5.3.1. Installation information for ultrasonic level transmitters

Level transmitters 8170/8175 are designed for use in fluids. If they are used in powder or granulate, etc., the technical data changes (specifically, the maximum measurable spacing or distance is reduced).The sensor must be installed vertically above the medium.

Mounting on tank with cover

The transmitter should not be mounted at the center of the cover, but rather off-center (by approx. half the radius of the tank).

Mounting on connector or socket

It is essential to note the max. connector or socket length.

Radiation cone

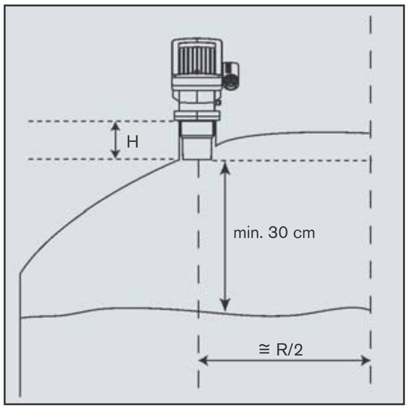
The radiation angle of the signal is 8°. Wherever possible, all attachments should lie outside of this radiation cone since, otherwise, this could lead to measurement errors (see also Echo filters).

Mounting with riser

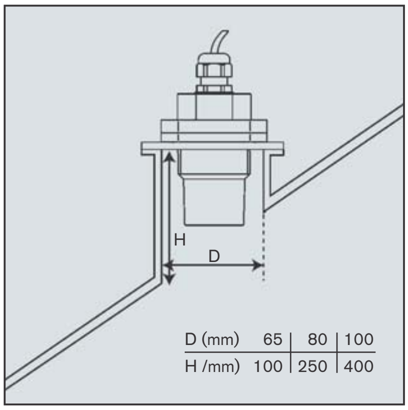
Using a riser offers several advantages:

- It smoothes unsteady surfaces, caused e.g. by inflowing medium.
- Disturbance echoes resulting from attachments are not present.
- Frothing is avoided.

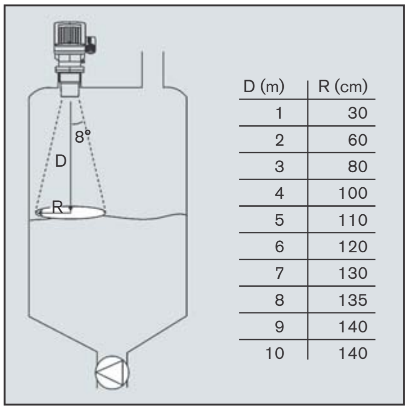
The inside diameter of a riser should be at least 80 mm.



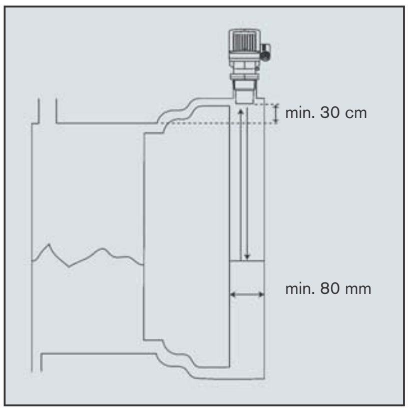
Mounting on tank with cover



Connector or socket mounting



Radiation cone



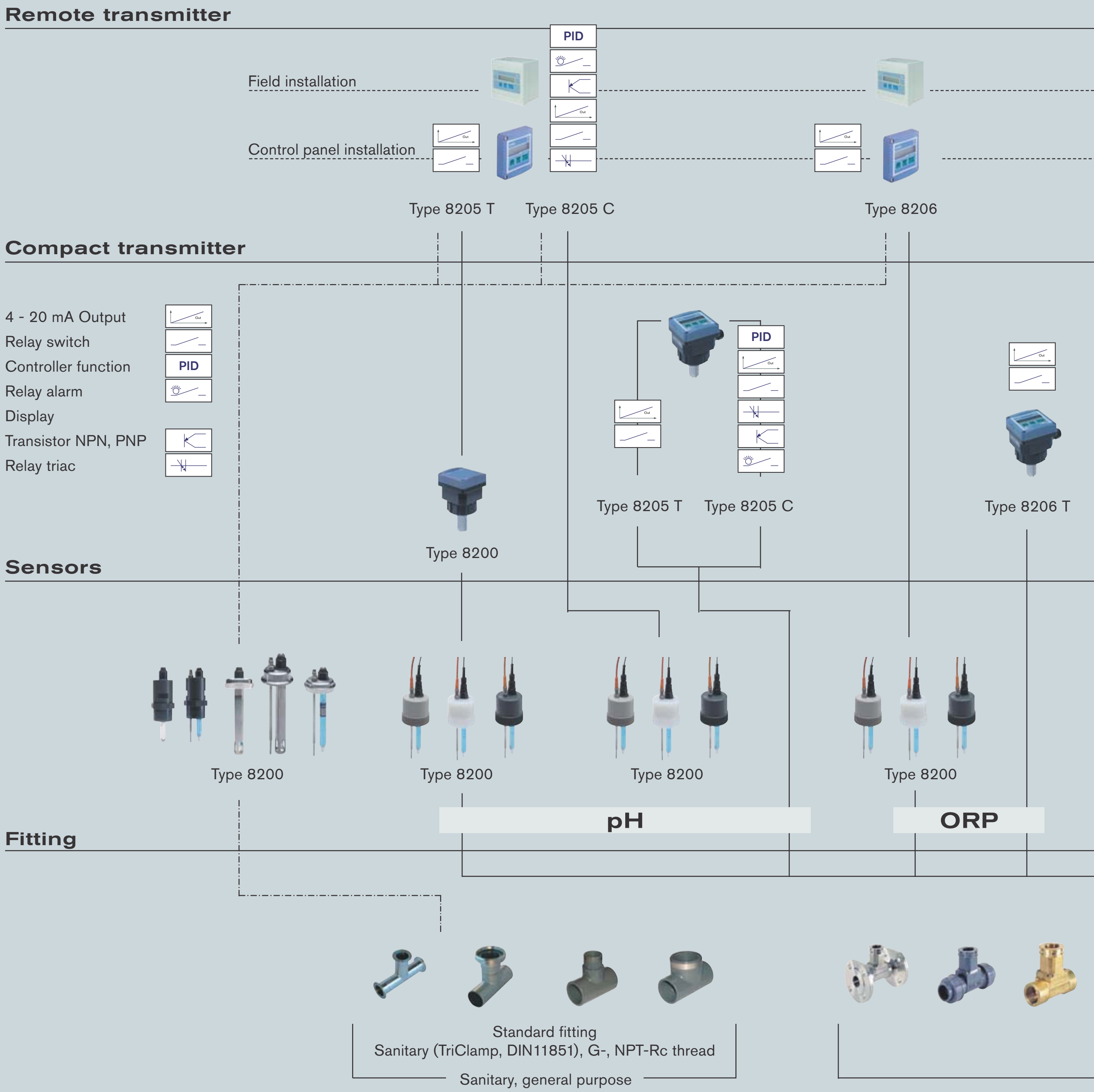
Mounting with riser

5.3.2. Table of various gases and their sound velocity

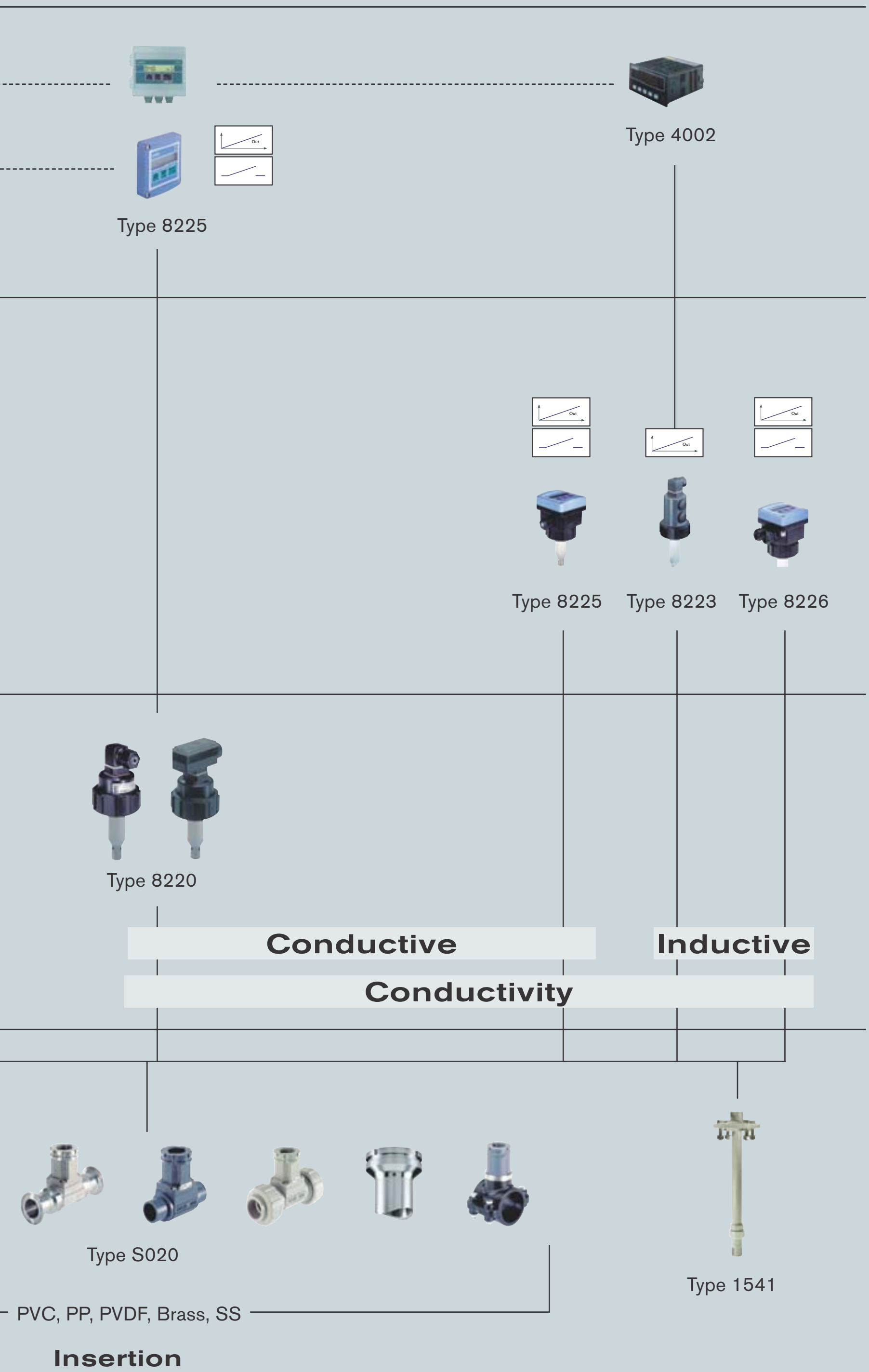
The table allows you to read off the substance and temperature-specific values of the sound velocity and the temperature gradient.

	Density at 0 °C [kg/m³]	Sound velocity at 0 °C [m/s]	dv/dt [m/s K]
Dry air	1.293	331.45	0.59
Ammonia	0.771	415.00	
Carbon monoxide	1.250	338.00	0.56
Carbon dioxide	1.977	259.00	0.60
Chlorine	3.214	206.00	
Ethylene	1.260	317.00	
Helium	0.178	965.00	0.80
Hydrogen	0.090	1284.00	2.20
Hydrogen bromide	3.500	200.00	
Hydrogen chloride	1.639	296.00	
Hydrogen sulfide	1.539	289.00	
Methane	0.717	430.00	
Neon	0.900	435.00	0.80
Nitrogen oxide	1.340	324.00	
Nitrogen	1.251	334.00	0.60
Oxygen	1.429	316.00	0.56
Sulfur dioxide	2.927	213.00	0.47

6. Bürkert's range of analysis sensors



ANALY



Bürkert offers a complete series of analysis sensors for detecting the following variables:

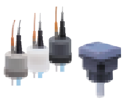
- pH value
- Oxydo-reduction potential (ORP)
- Conductivity.

The measuring instruments can be equipped with all necessary functions for measurement and control of these variables (4 - 20 mA current output, switching outputs and controller functions ...). Design, materials and electrode selection enable use in virtually all types of fluids (from ultra-pure water to effluent).

SIS SENSORS

6.1. Selection tables

Analysis sensors, fluidic characteristics

			 Type 8200	 Type 8205	 Type 8206	 Type 8220
Fluidic characteristics						
	Measuring range		pH 0 to 14	pH 0 to 14	−2000 to +2000 mV	0,05 µS/cm to 200 mS/cm
	Measuring principle		pH	pH	ORP	Conductivity
Fitting material	Brass		PN 16 0-130 °C	PN 6 0-130 °C	PN 6 0-130 °C	PN 6 0-100 °C
	Stainless steel		PN 16 0-130 °C	PN 6 0-130 °C	PN 16 0-100 °C	PN 6 0-100 °C
	PVC		PN 10 0-50 °C	PN 6 0-50 °C	PN 10 0-50 °C	PN 6 0-50 °C
	PE		PN 10 0-50 °C	PN 6 0-50 °C	PN 10 0-50 °C	PN 6 0-50 °C
	PP		PN 10 0-80 °C	PN 6 0-80 °C	PN 10 0-80 °C	PN 6 0-80 °C
	PVDF		PN 10 0-100 °C	PN 6 0-100 °C	PN 10 0-100 °C	PN 6 0-100 °C
Seal material	FPM		▪	▪	▪	▪
	EPDM		▪	▪	▪	▪
	FFKM					
Fluid properties	Foreign bod. in medium	Contaminated	▪	▪	▪	▪
		Not contaminat.	▪	▪	▪	▪
Conductivity	< 100 µS/cm		▪	▪	▪	▪
	> 100 µS/cm		▪	▪	▪	▪
	< 50 µS/cm		▪	▪		▪
	< 0,2 µS/cm					

		 **Type 8225**	 **Type 8223**	 **Type 8226**
Fluidic characterisrics				
	Measuring range	0,05 µS/cm to 200 ms/cm	100 µS/cm to 1 S/cm	100 µS/cm to 2 S/cm
	Measuring principle	Conductivity	Conductivity (inductive)	Conductivity (inductive)
Fitting material	Brass	PN 16 0-100 °C	PN 6 0-80 °C	PN 6 0-120 °C
	Stainless steel	PN 6 0-100 °C	PN 6 0-80 °C	PN 6 0-120 °C
	PVC	PN 6 0-50 °C	PN 6 0-50 °C	PN 6 0-50 °C
	PE	PN 6 0-50 °C	PN 6 0-50 °C	PN 6 0-50 °C
	PP	PN 6 0-80 °C	PN 6 0-80 °C	PN 6 0-80 °C
	PVDF	PN 6 0-100 °C	PN 6 0-80 °C	PN 6 0-100 °C
Seal material	FPM	▪	▪	▪
	EPDM	▪	▪	▪
	FFKM			▪
Fluid properties	Foreign bod. in medium: Contaminated	▪	▪	▪
	Foreign bod. in medium: Not contaminat	▪	▪	▪
Conductivity	> 100 µS/cm	▪	▪	▪
	< 100 µS/cm	▪		
	< 50 µS/cm	▪		
	< 0,2 µS/cm	▪		

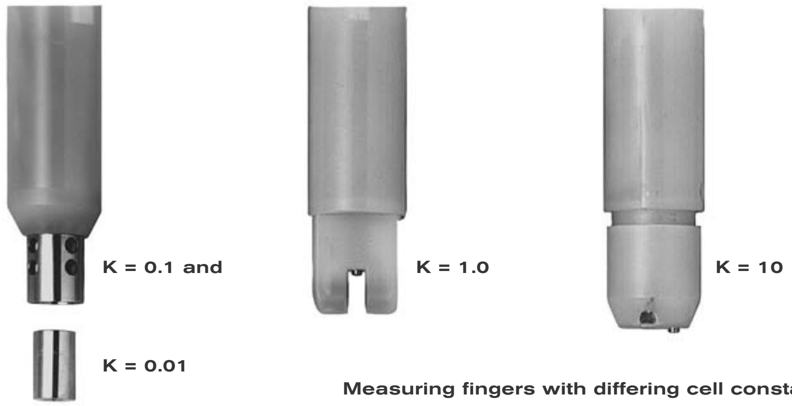
6.1. Selection tables (continued)

Analysis sensors, fluidic characteristics

		 Type 8200	 Type 8205	 Type 8206	 Type 8220
Electrical characteristics					
Basic function	Switch		▪	▪	
	Sensor	▪			▪
	Display		▪	▪	
	Transmitter		▪	▪	
	Controller		ON/OFF, continuous	ON/OFF	
Output	Relay (max. 3 A/250 V AC)		▪	▪	
	4 - 20 mA		▪	▪	
Supply voltage	10 - 36 V DC		▪	▪	
	115/230 V AC		▪	▪	
Equip-ment features	Display		▪	▪	
	Keypad		▪	▪	
	Teach-in calibration				
	Simulation		▪	▪	
	Hysteresis mode		▪	▪	
Design	Compact device	▪	▪	▪	▪
	Control panel install.		▪	▪	
	Field device		▪	▪	
Expan-sibility	Stand alone		▪	▪	
	W. Bürkert remote electr.	8205	▪	▪	8225
	To PLC or other ext. electr.		▪	▪	

		 Type 8225	 Type 8223	 Type 8226
Electrical characteristics				
Basic function	Switch	▪		▪
	Sensor	▪		
	Display	▪		▪
	Transmitter	▪	▪	▪
	Controller	ON/OFF		ON/OFF
Output	Relay (max. 3 A/250 V AC)	▪		▪
	4 - 20 mA	▪	▪	▪
Supply voltage	10 - 36 V DC	▪	▪	▪
	115/230 V AC	▪		▪
Equipment features	Display	▪		▪
	Keypad	▪		▪
	Teach-in calibration			
	Simulation	▪		▪
	Hysteresis mode	▪		▪
Design	Compact device	▪	▪	▪
	Control panel install.	▪		
	Field device	▪		
Expansibility	Stand alone	▪	▪	▪
	W. Bürkert remote electr.	▪		
	To PLC or other ext. electr.	▪	▪	▪

6.2. Measuring principles: function and styles



Measuring fingers with differing cell constants

6.2.1. Conductivity

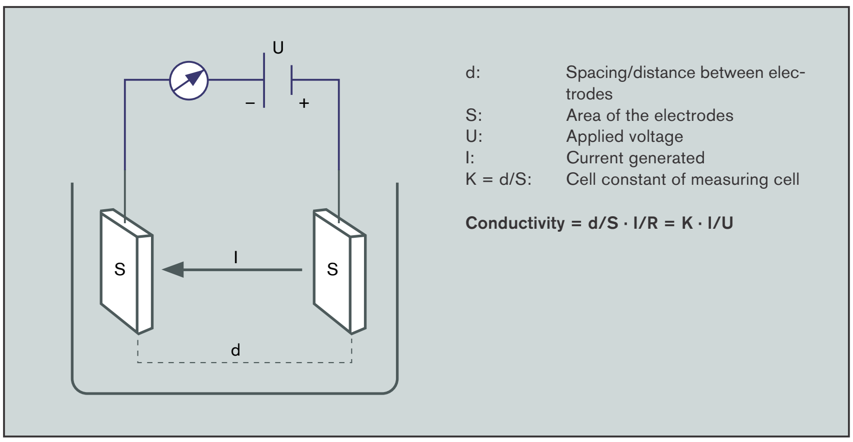
6.2.1.1. Conductive conductivity

The measuring cell consists of two open electrodes to which an AC voltage is applied. The medium is in direct contact with the electrodes. The applied voltage generates a current dependent on the resistance of the medium (Ohm's law). The geometry of the measuring cell (area S and distance d) is defined by its quotients K = d/S.

The conductivity of the solution is calculated on the basis of this known cell constant K and by measuring the current generated.

In order to be able to cover a broad conductivity range, measuring fingers with various cell constants are used. The lower the conductivity, the lower the cell constant must be (see also 6.4.2.).

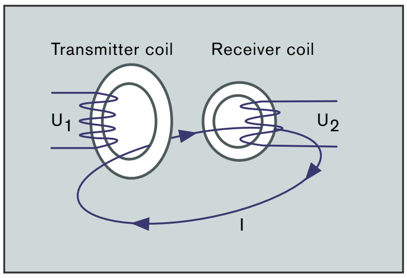
The conductivity of ultra-pure water up to concentrated solutions can be measured in dependence upon the selection of the cell constant. A PT1000 temperature sensor is integrated for temperature compensation. Use in coating-forming media is recommended only if the measuring electrodes are cleaned regularly, since, otherwise, the insulating effect of the coating would mean that the measured value no longer corresponds to the actual value.



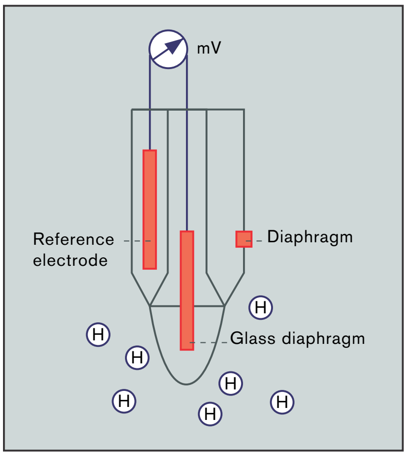
Measuring principle, conductive conductivity

6.2.1.2. Inductive conductivity

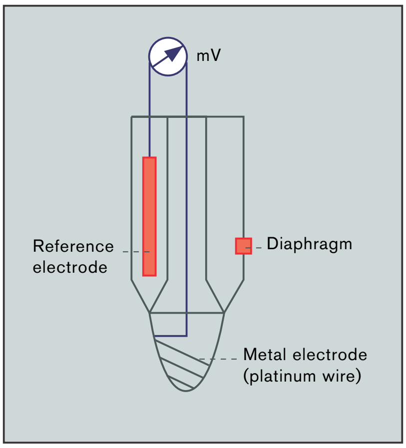
An inductive conductivity cell consists of two coils: a transmitter coil and a receiver coil. The coils are integrated in a finger-shaped housing. A bore is routed through the finger and the coil integrated into it. The fluid encloses the finger and is also in the bore. A sinusoidal AC voltage is applied to the transmitter coil. This produces a current in the fluid, proportional to the conductivity. This current in turn generates a voltage in the receiver coil. By measuring this voltage and knowing the cell constant, it is possible to determine the conductivity. A temperature sensor is integrated for temperature compensation.



Measuring principle, inductive conductivity



Measuring principle, pH value



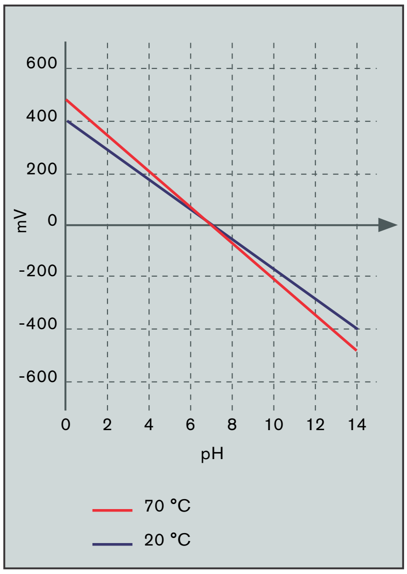
Measuring principle, ORP value

The measuring method also allows use in very problematic fluids. Owing to separation of the medium, all that needs to be ensured is that the housing has adequate resistance if used in such media. Since the measuring electrode has a very broad measuring range, different cell constants are not required. Use of the device is, however, not possible in very pure media since no measured value can be detected below a specific conductivity.

6.2.2. pH measurement

The hydrogen ion concentration (actually referred to as pH value) in an aqueous solution generates a potential difference at a measuring electrode (pH-sensitive glass diaphragm) with respect to a reference electrode (Ag/AgCl). This voltage is measured by a high-impedance pH measuring instrument and converted to a pH value. The relationship between pH value and voltage is linear, with a slope of 59.16 mV/pH value. The slope is temperature-dependent and is compensated for by an integrated temperature sensor.

Bürkert pH measuring instruments can be used in virtually all fluids on which pH measurement is required, depending on the selection of electrodes. The option of selecting between a compact device with on-site display, a remote version for short distances between measuring electrodes and electronics and a remote version for longer distances (up to 500 m) ensures that the optimum solution is available for virtually any application.



Dependence between pH value and voltage

6.2.3. Oxydo-reduction potential measurement

The oxydo-reduction potential electrode measures the potential of a solution on the basis of the presence of specific ions. This potential occurs between a metallic measuring electrode (platinum or gold) and a reference electrode (Ag/AgCl). It provides information on the oxidizing or reducing capability of the solution.

As with the pH measuring instruments, the appropriate device can be selected thanks to the choice between one compact version and two remote versions.

6.2.4. Explanatory information

pH/ORP electrode calibration

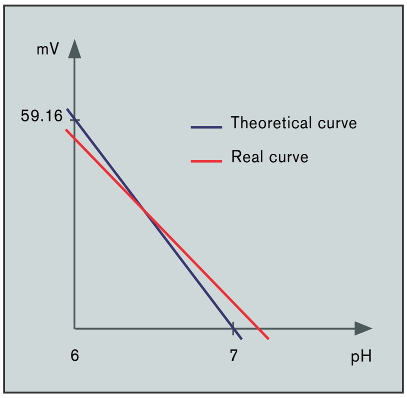
The pH and ORP electrodes have a restricted service life owing to escape of the reference electrolyte from the reference electrode. This aging process is a continuous process and its speed is dependent on the application conditions. The measurement errors produced by this are compensated for by regular recalibration.

The first step in calibration consists of zeroing. In general, a pH 7 buffer solution is used for this. The deviation is referred to as the offset.

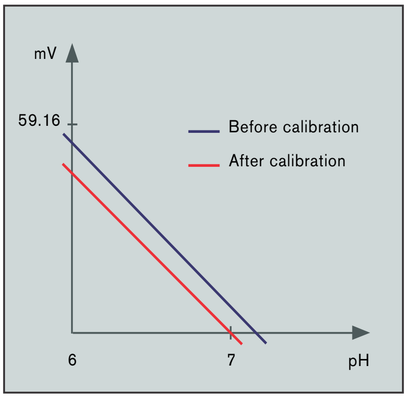
The second step is slope compensation. A further buffer value, depending on the application range, is used for this (pH = 4 or pH = 10). This second step is not conventionally used for ORP measurements.

The values of the offset and slope allow a statement to be made on the condition and anticipated remaining service life of the pH/ORP electrode.

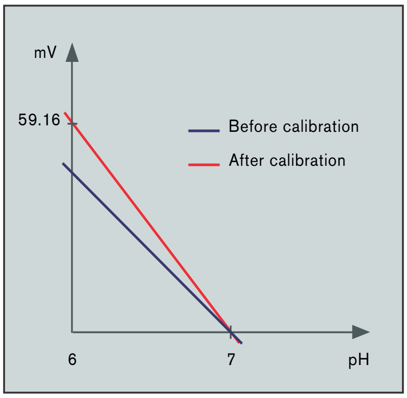
An electrode with an offset greater than 60 mV or with a slope lower than 48 mV/pH should be exchanged.



Measured value curve, pH electrode (real)



Zero point calibration



Slope calibration

Conductivity calibration

In the case of conductivity, the calibration procedure consists merely of a check of the cell constant, which may possibly have changed as the result of deposition or chemical attack. A reference which may be either a buffer solution or a reference measurement is required for this. The new cell constant is then calculated on the basis of the following equation:

$$K_{new} = K_{old} \times \frac{Cond_{ref.}}{Cond_{meas.}}$$

Where:

K_{new}	**New value of sensor coefficient**
K_{old}	**Old value of sensor coefficient**
$Cond_{ref.}$	**Conductivity measured with reference instrument**
$Cond_{meas.}$	**Conductivity measured with transmitter; old value of sensor coefficient.**

Temperature compensation with pH measurements

In the case of pH measurement, it is actually the dependence of the measurement signal on the temperature which is compensated for. This is represented by a temperature-dependent slope.

For example:

- Slope at 25 °C : 59.16 mV/pH
- Slope at 100 °C : 74.04 mV/pH

This dependence is permanently compensated for with the integrated temperature probe, thus the values are always comparable.

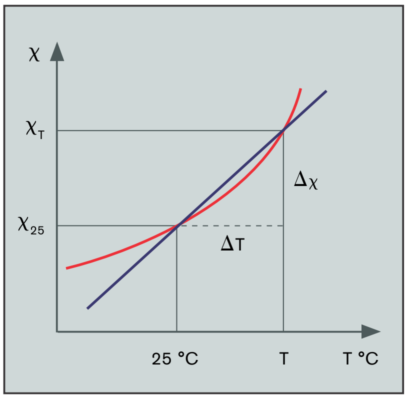
The temperature dependence of the solution is generally not compensated for (it is negligible with acids and higher with lyes).

Temperature compensation with conductivity measurements
In the case of conductivity measurement, the measuring cell has no dependence on temperature but the temperature dependence of the solution must be compensated for in order to allow a comparison between various measurements. The instrument offers three compensation methods:

Linear temperature compensation
In certain cases, linear compensation is accurate enough to monitor and control processes. Linear temperature compensation merely requires an input value, i.e. the average compensation both for the temperature range and the conductivity range. The following formula can be used for calculating the average compensation value α:

$$\alpha = \frac{\Delta\chi}{\Delta T} \times \frac{1}{\chi_{25}}$$

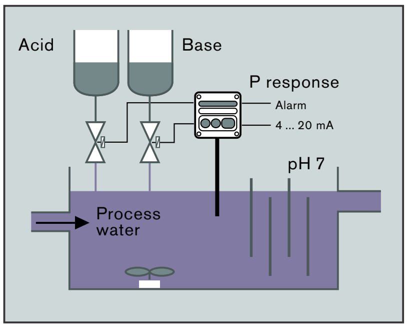
The illustration explains the importance of the coefficients for linear temperature compensation.



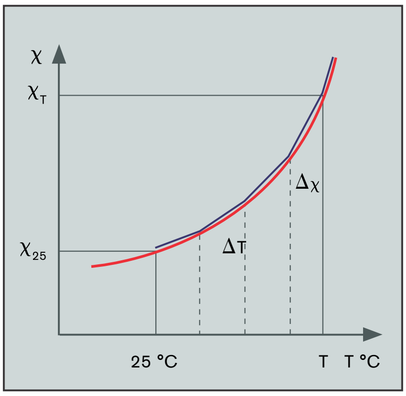
Linear temperature compensation

Temperature compensation with stored curves
The compensation curves for NaOH (caustic soda), HNO3 (nitric acid), H2SO4 (sulfuric acid) and NaCl (sodium chloride) have been determined over the temperature range 10...80 °C and stored in the instrument. In fact, the curve is a sequence of linear sections.

Temperature compensation with teach-in function
This function allows practical definition of the compensation curve over a specified temperature range. The solution is heated above the required temperature range, the instrument automatically determines the temperature and the corresponding conductivity and, on the basis of this, it calculates the sequence of linear sections. This curve is then stored.



System schematic for static control

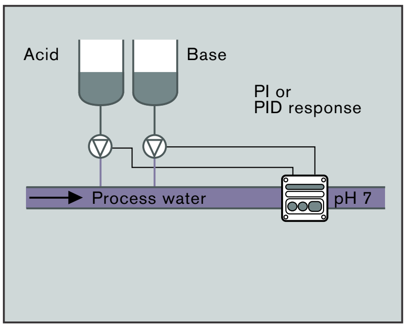


Teach-in temperature compensation

pH controller function
The pH controller was developed for application in static or dynamic processes for pH value checking. The output signals control a valve (e.g. Bürkert 2031) or a pump by means of pulses whose duration or frequency are calculated as a function of the parameters preset by the user (set-point value) and the pH value. A distinction is made between two types of control:

Static method
A fluid is checked in a tank with no appreciable flow. The control mode is proportional (P response).

Dynamic method
A fluid is checked in a pipe or a tank with substantial flow. The controller has PI or PID response.



System schematic for dynamic control

6.3. Process connections for analysis measuring instruments

The measuring sensors for pH, ORP and conductivity must have direct contact with the medium whose analysis parameters are to be determined. In addition, these measuring sensors are subject to a process-related aging process which necessitates cyclic exchange or regular regeneration. The measuring sensor must be removed at specific intervals for this purpose.

Due to the direct immersion of the sensing element in the medium, sensors are required which are inserted in the medium, meaning that it is not possible to exchange analysis sensors without leakage.

6.3.1. Insertion fitting system S020

Analysis sensors are suitable for installation with Bürkert Series S020 Insertion fittings.

Please refer to the data sheets for further information on selection of the fittings.

6.3.2. Other fixations and fittings

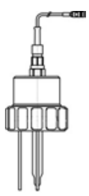
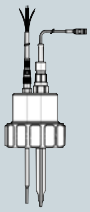
In addition to the use of Bürkert Type S020 standard fittings, various plastic or stainless steel fixations are also available for installation of ORP and pH sensors in industrial pipe connections.

This applies to fixations for:

- Threaded ports G 1, NPT 1 and Rc 1
- DIN 11851 fittings DN 40, DN 50 and DN 65
- TriClamp connections DN 32 and DN 40.

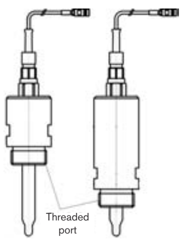
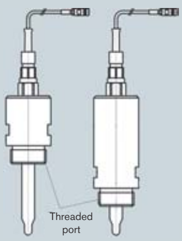
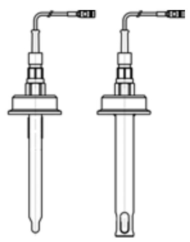
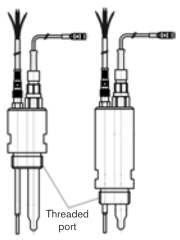
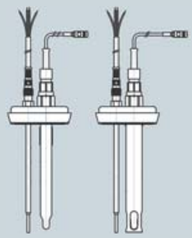
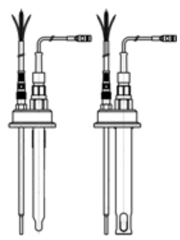
The analysis electrode can be accommodated in a protective tube to protect it against disturbing media influences.

In addition, all fixations are also available with fixture for a PT1000 for temperature compensation.

Insertion fitting system SO20			
pH transmitter Type 8205	**ORP transmitter Type 8206**	**Conductivity transmitter (conductive) Type 8225**	**Conductivity transmiter (inductive) Type 8226**
			
Examples of sensor fixations without transmitter for mounting with Type S020 fittings			
Fixation, Type 8200 SD for ORP or pH electrode; without PT1000 fixture	**Fixation, Type 8200 SD for pH or conductivity electrode with PT1000 fixture**	**Type 8200 SD: fixation with A-to-D converter f. accommodating pH or oxygen reduction potential electr.**	**Conductivity sensor Type 8220 SD with exchangeable electrode**
			

SD: short distance, i.e. cable length between sensor and electronic module max. 5 m.

LD: long distance. i.e. cable length between sensor and electronic module up to 500 m; the electrode fixations identified with LD feature an A-to-D converter; these digital signals are transferred with very low loss.

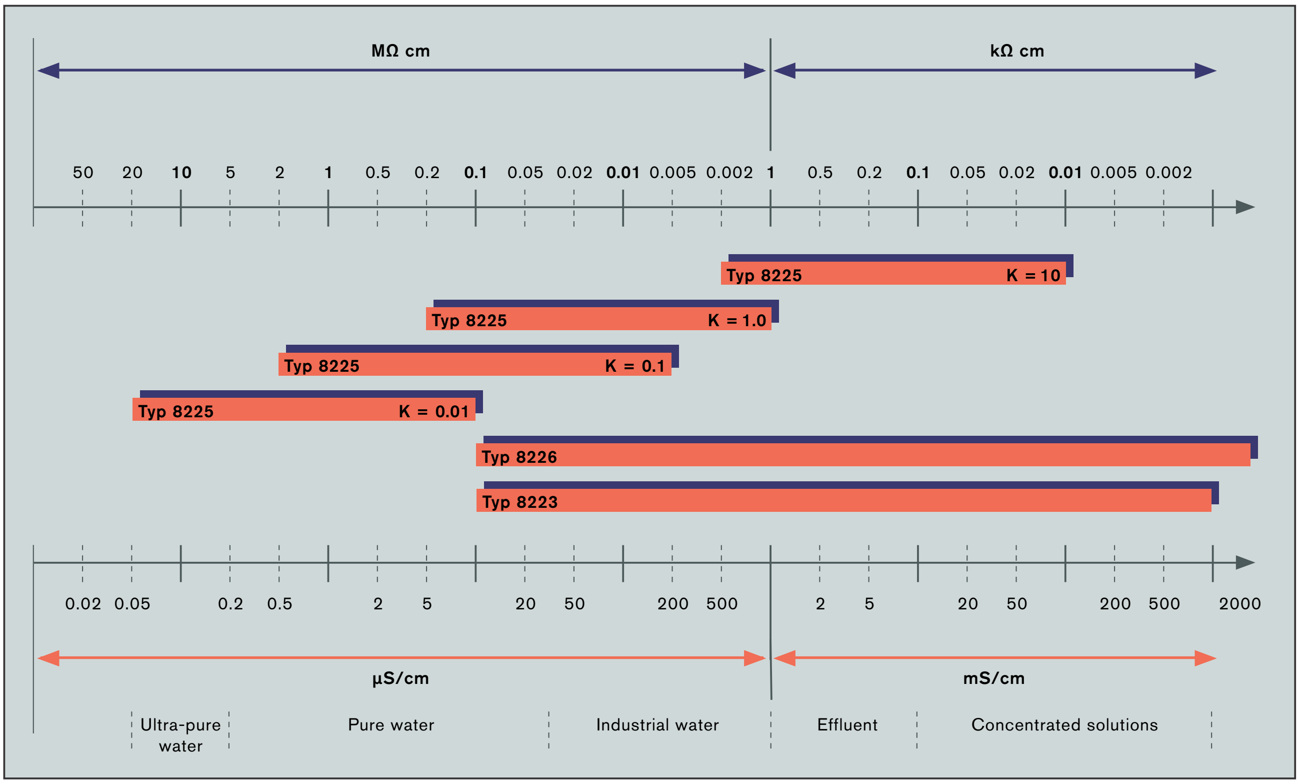
Fixation without PT1000 fixture (for ORP or pH sensors)		
Fixation for threads G 1, NPT 1 and Rc 1 without PT1000, short and long design	**Fixations for DIN 11851 fitting without PT1000, with and without protective tube**	**Fixations for TriClamp connection without PT1000, with and without protective tube**
		
Fixations with PT1000 fixture (for pH or ORP)		
Fixation for threads G 1, NPT 1 and Rc 1 with PT1000, short and long design	**Fixation for DIN 11851 fitting with PT1000, with and without protective tube**	**Fixations for TriClamp connection with PT1000, with and without protective tube**
		

6.4.
Selection helps

6.4.1. pH electrode selection
Selection of the right pH electrode ensures reliable operation of the measuring instrument. A general overview is provided below.

pH electrodes for seperate short distance versions				
	Clean fluids	**Contaminated fluids**	**Fluids with low conductivity**	**Fluids containing sulfides/proteins**
Selection	Logotrode pH 120 (T<50 °C) P<2bar	Unitrode pH 120 (T<130 °C) P<6bar	Ionotrode (T<40 °C) P<0,5bar	Unitrode pH 120 (T<130 °C) P<6bar
Application examples	Drinking water, rainwater, aquarium swimming-pool,	Effluent rinse water, cooling water, electroplating, paints cosmetics	Pure and ultra-pure water	Tannery, animal breeding, effluent, foodstuffs, cosmetics, biotechnology

pH electrodes for compact and seperate long distance versions				
	Clean fluids	**Contaminated fluids**	**Fluids with low conductivity**	**Fluids containing sulfides/proteins**
Selection	Unitrode pH (T<130 °C) P<6bar	Unitrode pH (T<130 °C) P<6bar	Unitrode pH (T<130 °C) P<6bar	Unitrode pH (T<130 °C) P<6bar
Application examples	Drinking water, rainwater, aquarium swimming-pool	Effluent rinse water, cooling water, electroplating, paints, cosmetics	Pure and ultra-pure water	Tannery, animal breeding, effluent, foodstuffs, cosmetics, biotechnology



Selection of conductivity electrode

6.4.2. Conductivity electrode selection

The selection of conductivity electrodes depends on the conductivity to be measured and relates only to the conductive measuring method.

6.4.3. Installation information

The pH and ORP instrument must be installed with the head pointing upwards at an angle of maximum 75° (see drawing).

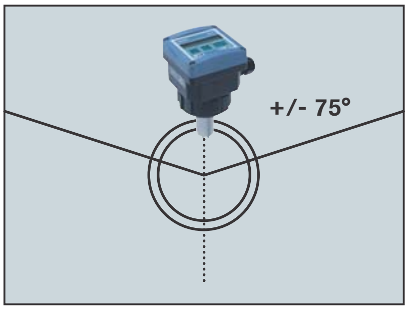
The conductivity instrument may be mounted as required in any position. However, a bypass installation – as explained on the following drawing – is recommended for all instruments.

The bypass installation offers several advantages:

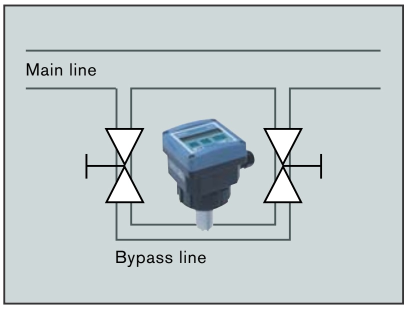
- Easy removal of the instrument for calibration (by means of isolation via valves).
- The electrode can be kept wet even if the main line runs dry.

Special installation information in relation to inductive conductivity

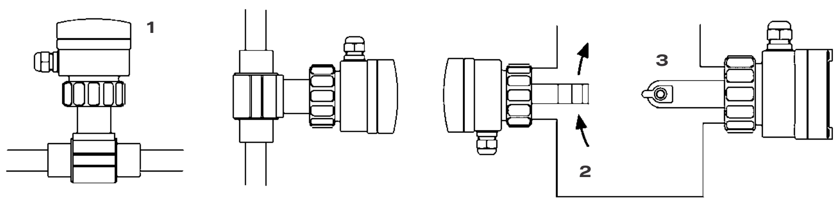
Choose a suitable mounting position in order to avoid formation of bubbles or cavities in the sensor duct.



Installation position, pH or ORP instrument



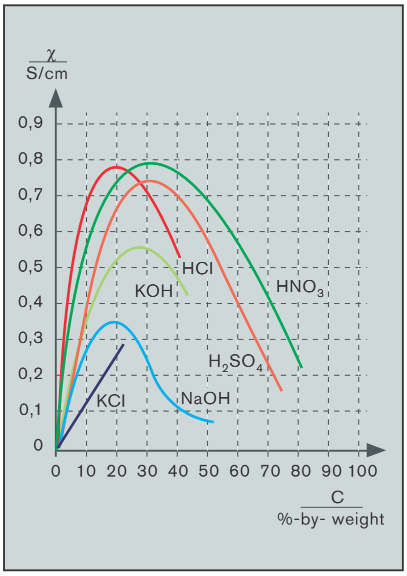
Bypass installation

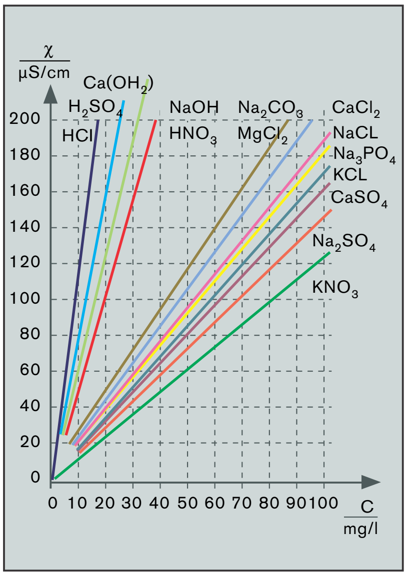


Position 1: horizontal or vertical mounting in a pipe
Position 2: mounting in a tank without agitator
Position 3: mounting in a tank with agitator

6.4.4. Conductivity of various concentrated and aqueous solutions

The two diagrams provide an overview of the conductivity values of solutions frequently used.

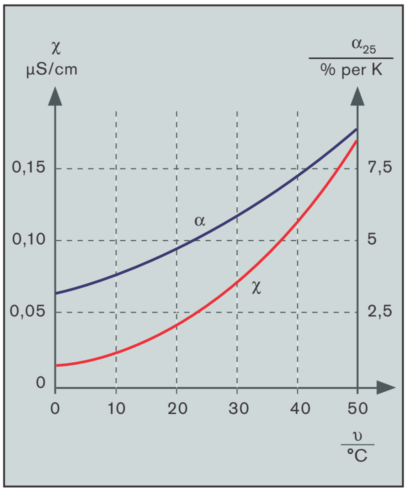




Conductivity of various solutions

6.4.5. Conductivity of ultra-pure water as a function of temperature

The diagram shows the intrinsic conductivity of water and the temperature compensation coefficients, referred to 25 °C, as a function of temperature.



Conductivity of ultra-pure water

6.4.6. Maintenance and error diagnostics of pH/ORP electrodes

If the electrode is not in operation, it should be stored in a 3-molar potassium chloride solution (223.6 g/l), which has a regenerative effect. If such a solution is unavailable, it is also possible to use normal tap water in the case of brief interruptions in measurement, for a maximum duration of 2 - 3 days. The electrode may not be stored in distilled or de-ionized water. This may be used only for rinsing. Experience has shown that most defects on pH electrodes as well as long response times are both caused by soiled electrodes or diaphragms. Since contamination depends on the relevant application, no universal cleaning agent has been available to date.

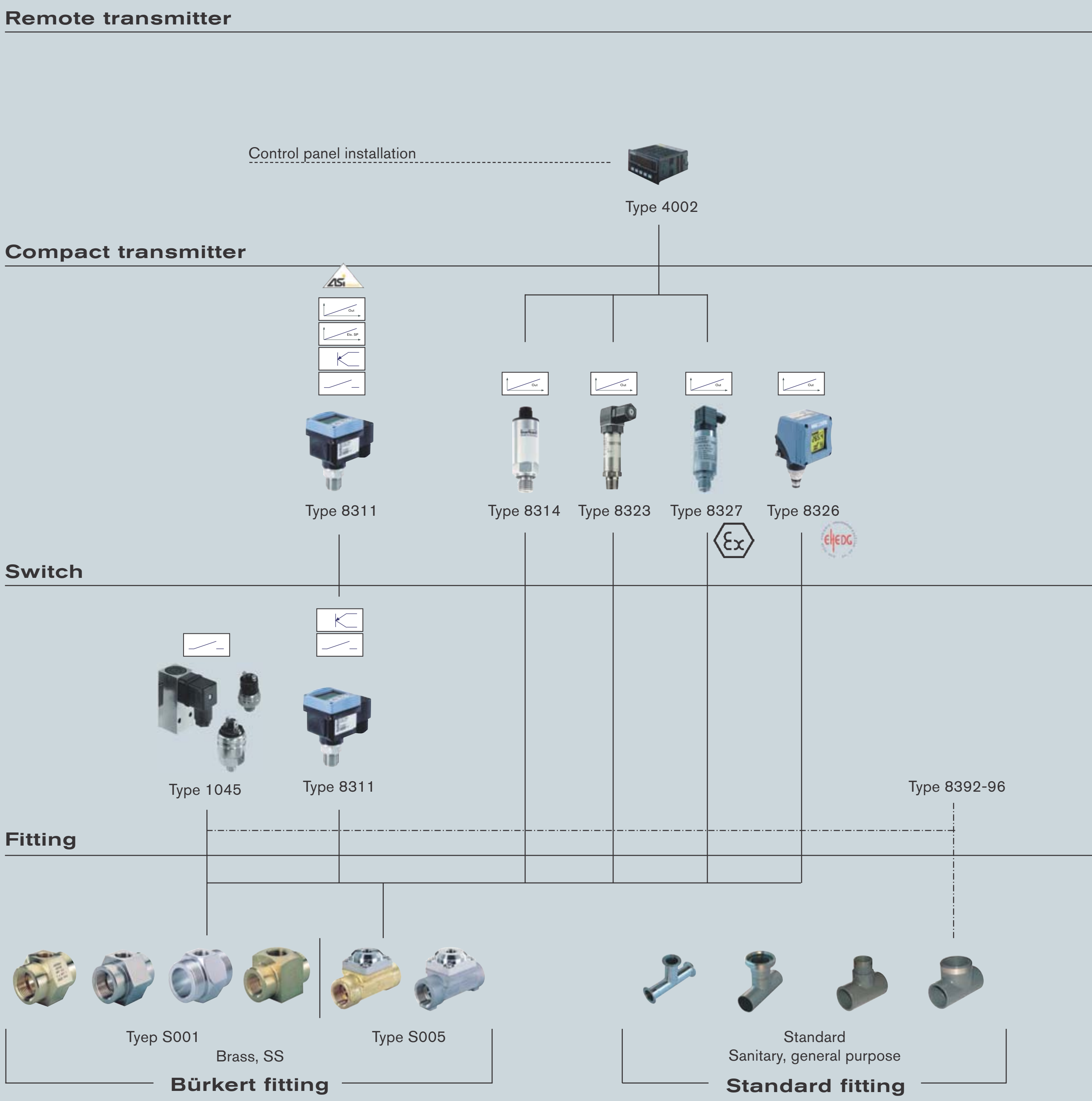
Information on cleaning, depending on type of contamination			
Type of contamination	**Cleaning agent**	**Cleaning water**	**Remarks**
Silver sulfide	Thiourea	5 - 60 minutes	Immersion until discoloration
All types of contamination, first cleaning solution	HCl 0.1 mol/l	12 hours	
All types of contamination, second cleaning solution	Mixture of chromic acid and sulfuric acid	30 minutes	Also cleans the diaphragm; then regenerate electrode
Proteins	HCl/pepsin solut.	>1 hour	
Lipophilic agents	Ethanol, acetone	30 minutes	Specifically with foodstuffs, greases
Calcium	Acetic acid	30 minutes	Then regenerate electrode
Soaps, tensides	Hot water (80 °C)	12 hours	Rinse off with hot water and allow to cool for 12 hours in fresh water

Problem recovery

The table below provides a list of possible causes of the most frequent pH electrode problems. The number of dots indicates the probability of the cause.

Possible cause of the most frequent problems on a pH electrode								
Cause / **Symptom**	**Glass aging**	**Crack in diaphragm**	**Shank or diaphragm**	**Leaching layer damaged**	**Electrode dried out**	**Calcium deposits (white coating)**	**Oil or grease layer**	**Unknown deposits**
Slope weak (Warning)	▪▪▪	▪				▪▪	▪▪	▪▪
Slope very weak (Error)	▪		▪▪▪	▪▪▪	▪▪▪			
Sluggish response time	▪▪▪	▪▪▪		▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪
Display unstable	▪▪	▪▪▪	▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪	▪▪▪
Offset drift	▪	▪		▪▪	▪▪	▪	▪	▪
Indication fluctuating	▪		▪			▪	▪	▪
Reason	High temperature, old electrode	Abrasion against solid, incorrect cleaning	Mechanical or thermal shock	Low conductivity, non-aqueous solution	Incorrect storage	Medium	Medium	Medium, no maintenance
Remedy	Regeneration	Electrode exchange	Electrode exchange	Washing with water or electrolyte solution	Washing with water or electrolyte solution	Immersion in acetic acid and regeneration	Cleaning with solvent, water and regeneration	Cleaning with appropriate agent, regeneration

7. Bürkert's range of pressure sensors



PRESSU

4 - 20 mA output
4 - 20 mA Input (ext. set-point)
Transistor NPN, PNP
Relay output
Display

Bürkert offers a complete range of pressure sensors for a very wide variety of applications: general mechanical engineering, food and beverage and water treatment ...

The measuring instruments can be equipped with all required functions for measurement and control of variables (4 - 20 mA current output, switching outputs and calibration functions ...). Design and materials enable use in virtually all types of fluid (from ultra-pure water to effluent) and gaseous media.

RE SENSORS

7.1.

Selection table

		 Type 8311	 Type 8314	 Type 8323	 Type 8327	 Type 8326
Fluidic characteristics						
	Measuring range	0 to 50 bar	0 to 100 bar	0 to 25 bar	0 to 16 bar	0 to 40 bar
	Measuring principle	Ceramic measuring cell	Ceramic measuring cell	Thin film str. gauge piezoresistive	Thin film str. gauge piezoresistive	Thin film str. gauge piezoresistive
	Materials coming into contact with the media	Stainless steel, FPM	Stainless steel, FPM	Stainless steel, FPM	Stainless steel, FPM	Stainless steel, FPM
Fluid properties	Max. medium temperature	100 °C	-15 to 125 °C	-30 to 100 °C	-30 to 100 °C	-30 to 105 °C
	Clean	▪	▪	▪	▪	▪
	Contaminated	With flush diaphragm		With flush diaphragm	With flush diaphragm	With flush diaphragm
	Hot or aggressive	W. press. transm.	W. press. transm.	W. press. transm.	W. press. transm.	
	Hygiene	With flush diaphragm EHEDG		With flush diaphragm EHEDG	With flush diaphragm EHEDG	With flush diaphragm EHEDG
Electrical characteristics						
Basic function	Switch	▪				
	Transmitter	▪	▪	▪	▪	▪
	Transmitter in accordance w. ATEX				▪	
Output	Transistor (max. 0.7 mA/30 V DC)	▪				
	Relay (max. 3 A/250 V AC)	▪				
	4 - 20 mA	▪	▪	▪	▪	▪
	ASI bus	▪				
Supply volt.	10 - 36 V DC	▪	▪	▪	▪	▪
Equipment features	Display	▪				▪
	Bargraph	▪				
	Keypad	▪				▪
	Teach-in calibration	▪				▪
	Simulation	▪				▪
	Hysteresis mode	▪				
	Window mode	▪				
Design	Compact device	▪	▪	▪	▪	▪
Expansibility	Stand alone	▪	▪	▪	▪	▪
	W. Bürkert remote electronics		▪	▪	▪	▪
	To PLC or other external electron.	▪	▪	▪	▪	▪

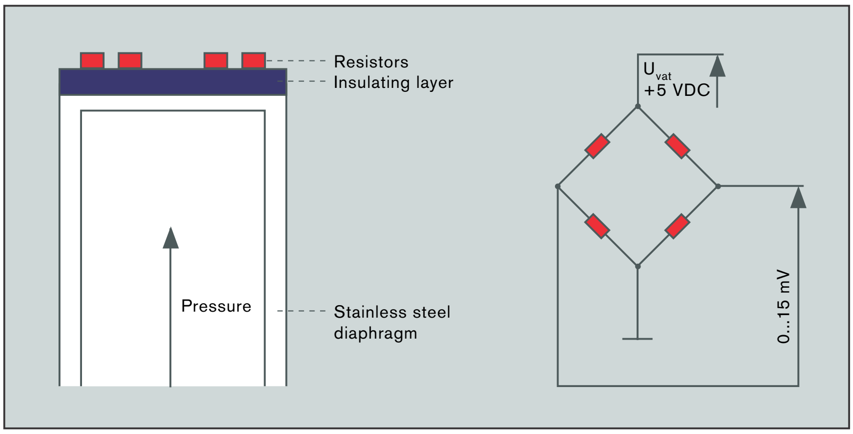
7.2. Measuring principles: function and styles

Three different pressure measuring principles are used: thin-film strain gauge, piezoresistive sensor and thick-film ceramic measuring cell. These principles are then used in a very wide variety of complete device models.

7.2.1. Thin-film strain gauge

A thin-film Wheatstone bridge, as a resistive sensor element, is bonded directly to a stainless steel diaphragm. Flexure of the diaphragm as the result of the external pressure causes a change in the resistances of this Wheatstone bridge, which is converted to a pressure-proportional signal.

Very high burst pressures and highly precise pressure measurements can be implemented by using this measuring method. Even applications in environments subject to shock and vibration can be easily implemented.

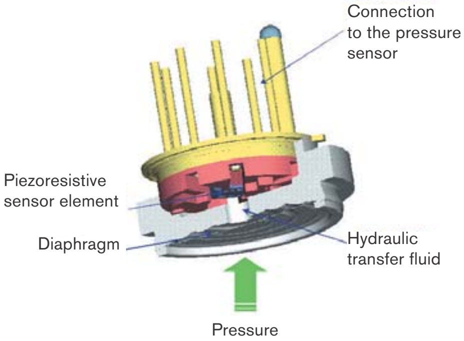


Principle of thin-film strain gauge

7.2.2. Piezoresistive sensor

For protective purposes, the piezoresistive sensor is flushed with a hydraulic fluid. The medium is separated by means of a stainless steel diaphragm. Flexure of the diaphragm as the result of the external pressure causes a change in the hydraulic pressure of the fluid around the piezoresistive sensor. The sensor emits a pressure-proportional signal which is converted to a 4 - 20 mA output signal.

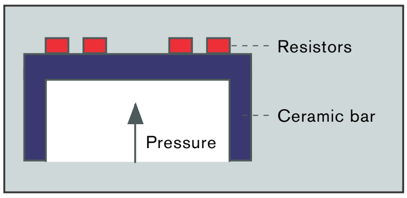
The measuring method is very well-suited for the detection of low pressures and high overload factors can be achieved with it.



Principle of piezoresistive sensor

7.2.3. Thick-film ceramic measuring cell

Unlike the thin-film strain gauge method, the Wheatstone bridge is bonded directly to a ceramic diaphragm in this case. Flexure of the diaphragm as the result of the external pressure causes a change in the resistances of this Wheatstone bridge, which is converted to a pressure-proportional signal.



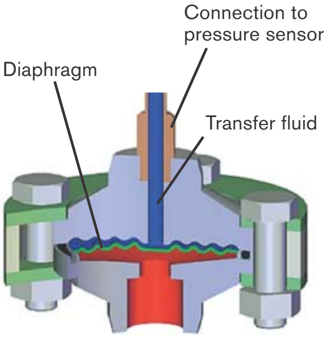
Principle of thick-film ceramic measuring cell

Using ceramics achieves a higher chemical resistance to aggressive media. The measuring range is higher than with the thin-film strain gauge method; measuring accuracy is not as high, however.

7.2.4. Chemical seal

A chemical seal consists of a chamber filled with a transfer fluid (oil-based mixture), closed on one side by a pressure sensor and closed off from the process on the other by means of a diaphragm (stainless steel or plastic). The pressure bends the diaphragm and is transferred from the fluid to the pressure sensor.

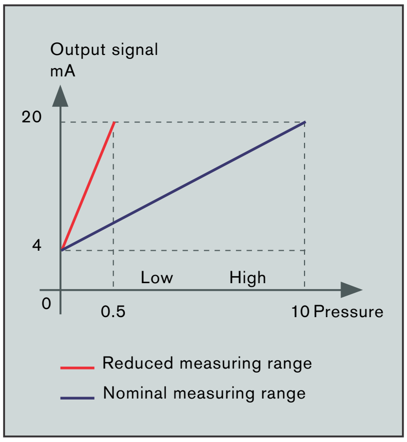
Pressure transmitters are used if the process conditions no longer allow direct attachment of a pressure sensor (extreme temperatures, chemical resistance, hygiene requirements or media which form coatings or are very viscous ...). A wide range of process connections also allows use in special applications.



Principle of pressure transmitter

7.2.5. Explanatory information on measuring range turn-down

Certain pressure measuring instruments allow the nominal pressure measuring range to be turned down to 1/20 (e.g. a nominal range of 0 - 10 bar can be reduced to 0 - 0.5 bar).



Measuring range turn-down

The accuracy decreases as the turn-down factor increases. The following applies as a general rule:

- Turn down <= 1/5:
  No change in accuracy
- Turn down > 1/5:
  New accuracy = nominal accuracy x (turn-down factor/5)

(e.g. turn-down 1/20, nominal accuracy 0.15 %, new accuracy = 0.15 x 20/5 = 0.6 %).

7.3. Selection helps

7.3.1. Configuration sheet for pressure transmitters

Certain information is required for the selection of a pressure transmitter for attachment to a pressure sensor. This information is summarized on the adjacent sheet.

Configuration sheet for pressure transmitters

Customer		Date
Address		
Name		
Telephone	Fax	
Project		
Quantity	Required delivery date	

Process details

Max. pressure (bar)/(psi)	or range from ____ to _____ ☐ bar ☐ psi
Vacuum	☐ yes ☐ no if yes, min. absolute press.____ at ____°C (e.g. during cleaning process)
Medium	
Mater. coming into cont. w med.	☐ copper alloy ☐ stainl. steel ☐ monel others ___________________________
Medium temperature	min. ____ max. ____
Ambient temperature at capillary (if present)	
Mounting of sensor	☐ vertical ☐ horizontal Inclination angle (horizontal = 0°)_____ °
Vibration in pipe	☐ yes, intensity __________________________ ☐ no
Application	
Special requirements	

Sensor pressure/measuring range details

Model (see data sheet) ____________________	Measuring range details in bar __________________
Process connection	☐ G 1/2 ☐ external ☐ internal ☐ NPT 1/2 ☐ external ☐ internal
	☐ flange
Mater. coming into cont. w med.	☐ copper alloy ☐ stainl. steel
Switching contacts	☐ yes ☐ no
Signal output	☐ yes ☐ no
Other options	

Pressure transmitter

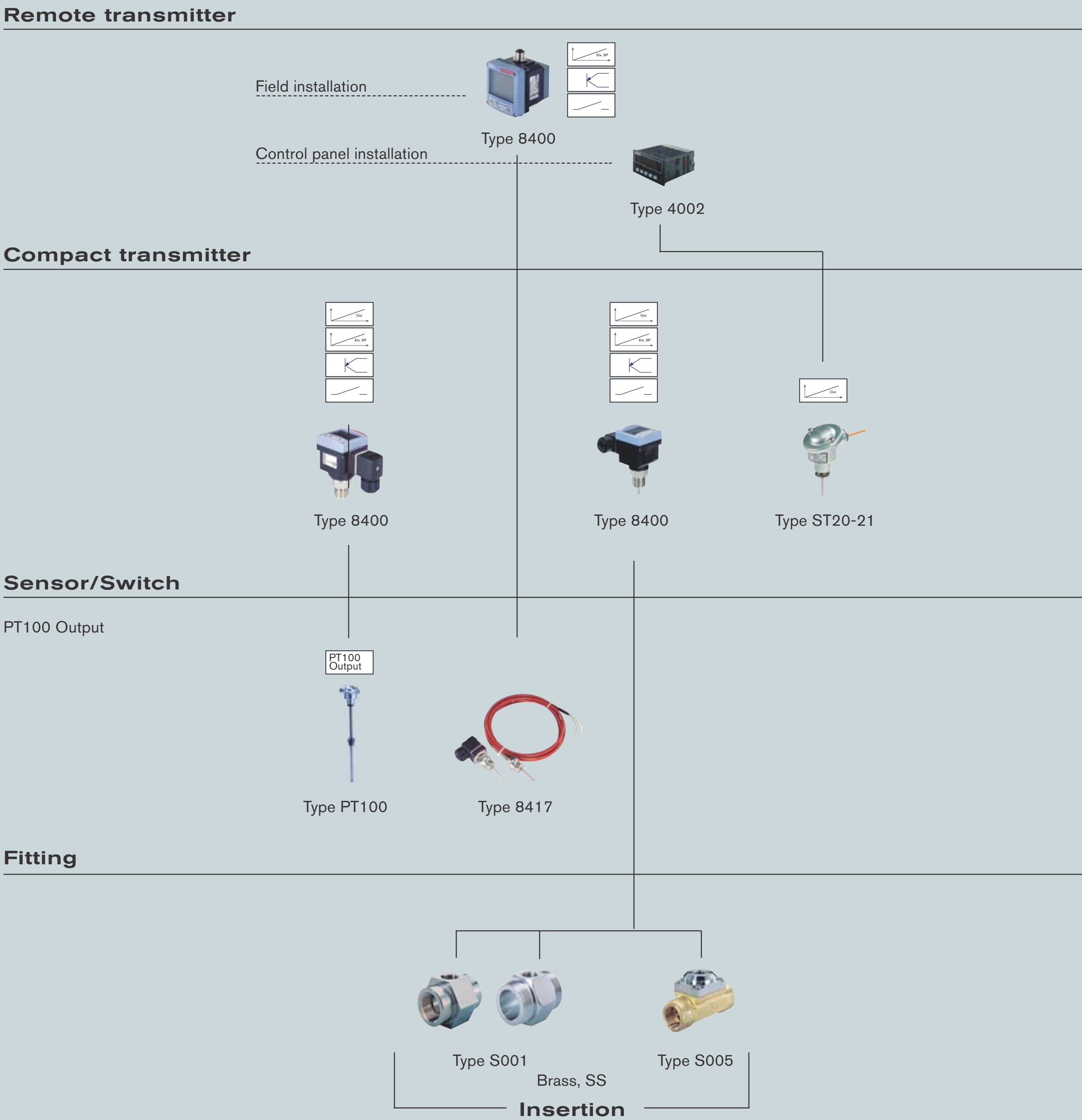
Model (see data sheet)	☐ in acc. w. DIN ☐ DN ☐ PN
Process connection	☐ threads ☐ flange ☐ TriClamp
	☐ flange ☐ DIN ☐ ANSI
	☐ DN ____ ☐ PN ____
Thread	☐ internal ☐ external size ___________
Mater. coming into cont. w med.	☐ stainl. steel ☐ monel ☐ titanium ☐ hastealloy ☐ others _____________
Transfer fluid	☐ silicon oil KN 17 ☐ glycerol KN 7 ☐ glycerol/water KN 12
	☐ vegetable oil KN 13 ☐ halocarbon KN 21
Other options	

Design of pressure sensor and pressure transmitter

Direct mounting (press. sensor mount. directly on the press.transm.)	☐ yes ☐ no
Cooling element	☐ yes ☐ no
Design with capillary	☐ yes long ______ m ☐ no
Other options	

Note: a pressure transmitter is available as one unit only in conjunction with a pressure sensor.

8. Bürkert’s range of temperature sensors



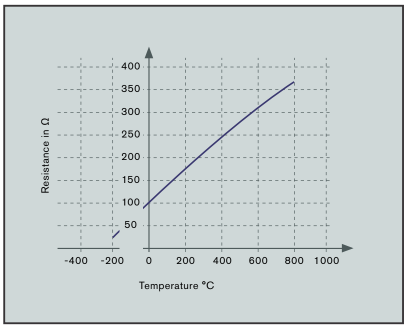
- 4 - 20 mA output
- 4 - 20 mA input (ext. set-point)
- Relay NPN, PNP
- Relay output
- Display

Bürkert temperature sensors meet diverse requirements in a wide variety of applications. The equipment features and process connection generally vary. Modularity in relation to device selection generally enables selection of equipment in line with customer requirements, regardless of whether a pure resistance measurement, on-site display, monitoring or a complete control system is required.

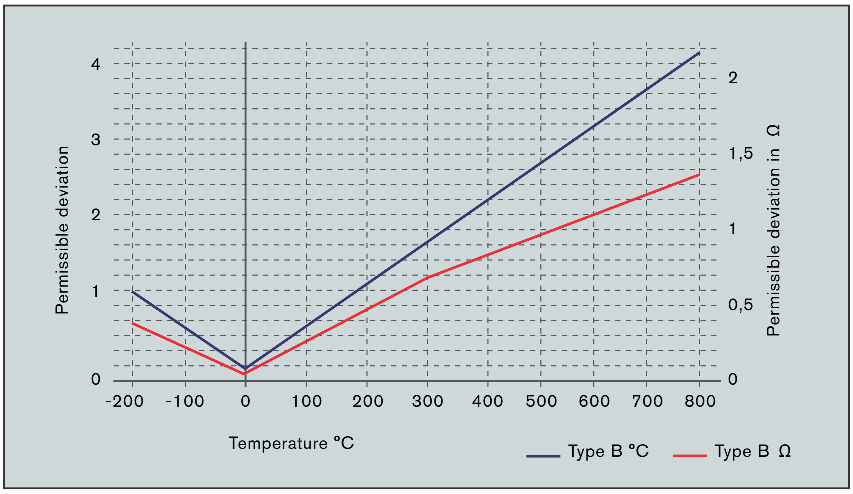
RE SENSORS

8.1.
Selection table

		 Type 8400	 Type ST20	 Type ST21
Fluidic characteristics				
	Measuring range	-40 to +125 °C	-40 to +500 °C	-50 to +150 °C
	Measuring principle	PT 100	PT 100	PT 100
Sensor material	Stainless steel	PN 16	PN 64	PN 25
	Brass	PN 16		
Fluid properties	Clean	▪	▪	▪
	Contaminated	▪	▪	▪
Electrical characteristics				
Basic function	Switch	▪		
	Sensor		▪	▪
	Transmitter	▪	▪	▪
Output	Transistor	▪		
	Relay (max. 3 A/250 V AC)	▪		
	4 - 20 mA	▪	▪	▪
	ASI bus	▪		
	Resistance		▪	▪
Supply voltage	None		▪	▪
	10 - 36 V DC	▪	▪	▪
Equipment features	Display	▪		
	Keypad	▪		
	Teach-in calibration	▪		
	Simulation	▪		
	Hysteresis mode	▪		
	Window mode	▪		
Design	Compact device	▪	▪	▪
	Control panel installation	▪		
	Field device	▪	▪	▪



PT100 resistance characteristic



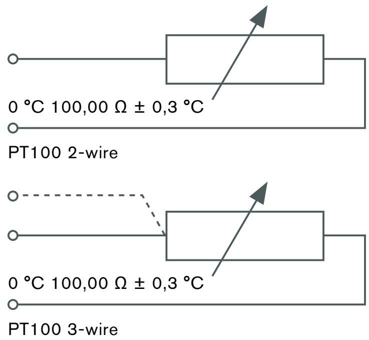
Permissible deviations in accordance with DIN EN 60751

8.2. Measuring principle of PT100 resistor element: function and styles

The temperature dependence of the electrical resistance of metals is very frequently used for electrical temperature measurements. The electrical resistance of metals increases with increasing temperature. In this case, we refer to a PTC (Positive Temperature Coefficient). Platinum has proven successful as a metallic resistive material in industrial measuring technology, since the high chemical resistance, good reproducibility of the electrical properties and easy processing offer optimum preconditions for such applications. The DIN EN 60751 standard defines the electrical resistances and permitted deviations as a function of temperature. The nominal value of a PT100 sensor is 100 Ω at 0 °C.

In order to measure the resistance of the sensor, the voltage drop across the sensor is measured on the basis of a constant current of 1 mA. With a two-wire circuit, the sensor is connected to the evaluation electronics by means of a two-core lead.

The increase in electrical resistance in the case of long transmission lines is minimized with a three-wire circuit. For this, an additional lead is routed to a contact of the resistance thermometer, with this further circuit being used as a reference.



If necessary, this signal can be converted to a standard signal by means of a transmitter. Versions with two sensors ensure high reliability in preventing measuring errors, since there is an automatic option for checking the measuring junction if the two values differ. Other equipment features can comprise additional switching contacts, field bus interface or on-site display.

Temperature	Basic value	Tolerance	Class B
-200 °C	18.49 Ω	±1.3 °C	±0.56 Ω
-100 °C	60.25 Ω	±0.8 °C	±0.32 Ω
0 °C	100.00 Ω	±0.3 °C	±0.12 Ω
100 °C	138.50 Ω	±0.8 °C	±0.30 Ω
200 °C	175.84 Ω	±1.3 °C	±0.48 Ω
300 °C	212.02 Ω	±1.8 °C	±0.64 Ω
400 °C	247.04 Ω	±2.3 °C	±0.79 Ω
500 °C	280.90 Ω	±2.8 °C	±0.93 Ω
600 °C	313.59 Ω	±3.3 °C	±1.06 Ω
650 °C	329.51 Ω	±3.6 °C	±1.13 Ω
700 °C	345.13 Ω	±3.8 °C	±1.17 Ω
800 °C	375.51 Ω	±4.3 °C	±1.28 Ω
850 °C	390.26 Ω	±4.6 °C	±1.34 Ω

Resistance as a function of the temperature on PT100 sensors

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Service brochure

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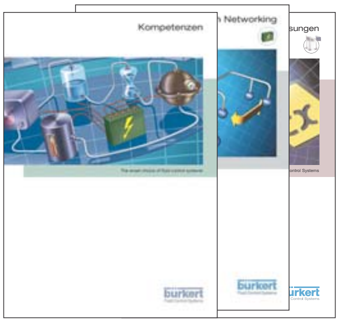
Competence brochures

Essential information for the person planning control loops and field bus systems and who wants to ensure basic knowledge of the structure and selection of system components.

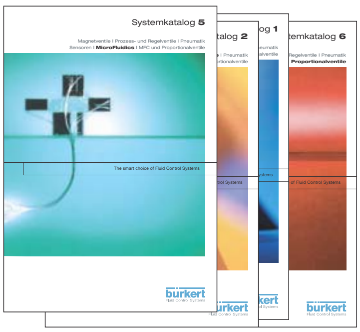


Application brochures

Example applications for deriving the appropriate system solution, supplemented by information on product advantages, user advantages and the range of products specifically available.

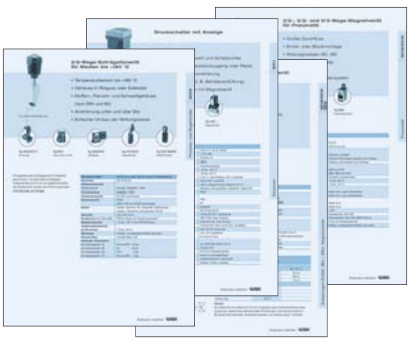
System catalogs

Background knowledge on product technology, including an up-to-date overview of the current offers. Rounded out with information to help you make your decision on the best application option.



Technical data sheets

Detailed technical information for checking specific suitability. In addition, all the data needed for direct ordering.



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