Conductivity measurement in industrial processes

Selection and engineering guide for different industries and applications

Endress+Hauser
People for Process Automation

Step by step

It was over 50 years ago that we developed and deployed the first conductivity sensors. These sensors are used primarily to monitor water treatment and purification plants in the food industry, a sector in which we are leading the field. Since then, we have been able to expand the range of application with the development of new sensors, including sensors for the life science and chemical industries. Today, Endress+Hauser is regarded as a professional and reliable supplier across all industries.

Our portfolio includes sensors and transmitters for all conductivity measuring ranges. The choice of sensor is determined by your application conditions. For example, conductive sensors are often used to measure low conductivity values in pure and ultrapure water, while inductive sensors are suited to media with high conductivity (e.g. milk, acids and bases).

A complete measuring point always comprises a sensor, cable and transmitter, and in some applications an assembly may be required for installation. This guide is designed to help you select and assemble the right products for your applications.

Overview of conductivity measuring equipment

In this section you will find a brief description of the different components required:

- Conductivity sensors
- Transmitters
- Assemblies

Each section of this guide contains technical descriptions followed by tables listing technical data, benefits and applications.

Checklist/Data sheet

For a comprehensive specification, a checklist is available. Here, you also have the option to add a drawing showing the installation conditions. Please use this format for your queries.

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Selecting the right conductivity sensors

This section starts with a flow chart |3.1| and supports you in selecting the right sensor based on the conductivity of the medium and the regulatory requirements of the process.

This flow chart directs you to the individual sections |3.2 – 3.7|, where information is provided on the recommended conductivity sensors, key benefits, applications and possible alternatives.

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1. Conductivity sensors and types of installation

1.1 Sensor types (inductive, conductive, two and four electrodes)

Conductive sensors
These sensors have a straightforward design, offer a high degree of measuring sensitivity and can thus be used in applications ranging from ultrapure water to drinking water and beyond. The measuring principle basically involves two electrodes positioned opposite each other. An alternating voltage is applied, which generates a current flow in the medium. The more freely moving charge carriers present in the liquid, the greater the electrolytic conductivity and current flow. In order to calculate the electrolytic conductivity, it is necessary to determine the cell constant. The cell constant is based on the geometry of the electrode arrangement and describes the ratio of the distance between the electrodes to their surface area. The cell constant varies depending on the design of the sensor and is therefore suitable for a range of applications.

Endress+Hauser offers a variety of conductive conductivity sensors, which come in different materials and designs and therefore have different cell constants. The lower the conductivity, the lower the chosen cell constant. For ultrapure water, for example, it is preferable to have concentrically arranged cylindrical electrodes. Since the conductivity is also dependent on the temperature of the medium, this is typically measured in parallel and calculated automatically in the transmitter.

Conductive four-electrode Memosens sensor
A high concentration of freely moving charge carriers in the medium results in the generation of electrostatic forces. These cause the charge carriers to repel each other and the measured current flow to decrease, even though the conductivity value should actually increase. This effect is referred to as polarization. In the case of sensors with two electrodes, the polarization effect causes an erroneously low conductivity reading. Four-electrode conductivity sensors compensate for this effect by having two additional electrodes measure the voltage drop in the medium during polarization and pass this information on to the transmitter. The transmitter then displays the corrected value. The four-electrode method is therefore suitable for applications in which a broad measuring range is required.

What makes the four-electrode Memosens sensor unique is its innovative, ceramic sensor element with platinum electrodes. The advantage of these materials is that they all behave in very similar ways in the event of changes in temperature, with the result that the sensor remains permanently gap-free. The unique hygienic design guarantees not only cleanability, but also aseptic hygiene. It comes with EHEDG and 3-A certification and complies with the pharmaceutical requirements of the FDA and USP Class VI. In addition, a novel electrode connection surveillance function guarantees reliability.

Inductive sensors
An electromagnetic transmitter coil causes a voltage to be induced in the medium. This excites the ions in the medium, causing an alternating electric current to flow. This in turn generates a magnetic alternating field in the receiver coil, causing current to flow here too. This current is analyzed in the transmitter and used to determine the conductivity value. The current strength and conductivity increase with the number of free ions present in the medium.

Different types of inductive sensors are available. For example, there is the particularly robust CLS50D made of PEEK or PFA, or the CLS54D with its certified hygienic design. All inductive sensors have the advantage of being galvanically isolated from the medium, which means that the transmitter and receiver coils are sheathed in a protective plastic coating. Therefore, there are no polarization effects and the measuring principle is resistant to contamination.

Compact conductivity measuring systems
Compact devices, consisting of an inductive conductivity sensor and a transmitter, are ideally suited to the food and beverage industry. All combinations are interference-free, easy to operate and offer a hygienic design. This protects your products and processes from contamination.

Smartec
Compact systems for measuring conductivity are available for different applications in the food and beverage industry as well as the life sciences industry. These are smart, cost-effective solutions.

Revolutionary Memosens technology
Since Endress+Hauser developed Memosens, conductivity measurement has become easier and more reliable. The inductive transmission of signals and energy between the sensor head and cable connection, without metal contacts, ensures problem-free operation, even in damp environments. Due to the galvanically isolated system and the fact that the calibration data are stored in the sensor head, it is now possible to calibrate just the sensor instead of the entire measuring circuit. Decoupling of measurement and calibration is possible.

For more information, see Section 4.1 on Page 38 or go to
www.endress.com/memosens

1. Conductivity sensors and types of installation

1.2 Sensors in ultrapure, pure and process water applications

	Conductive sensor Condumax CLS12	Conductive sensor Condumax CLS13
		

	Power & Energy	
Measuring range	0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1})	0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1})
Repeatability	± 0.2 % of measured value ± 2 digits	± 0.2 % of measured value ± 2 digits
Maximum measured error	± 1.5 % of measured value ± 4 digits	± 1.5 % of measured value ± 4 digits
Process temperature	-30 to 160 °C	-20 to 250 °C
Max. process pressure	41 bar_{abs} (up to 100 °C) 7 bar_{abs} (at 160 °C)	41 bar_{abs}
Electrodes (in contact with medium)	Both made of stainless steel 1.4571/316L	Both made of stainless steel 1.4571/316L
Shaft (in contact with medium)	Stainless steel 1.4571/316L	Stainless steel 1.4571/316L
Seals (in contact with medium)	EPDM, PEEK	Kalrez, ceramic
Certificates and approvals	Quality certificate, explosion protection	Quality certificate, explosion protection
Applications	▪ For water/steam circuits (condensate) in the power and energy industry	▪ For water/steam circuits (condensate) in the power and energy industry

* k = cell constant

	Conductive sensor Condumax CLS15/CLS15D	Conductive sensor Condumax CLS19	Conductive sensor Condumax CLS16/CLS16D
			
			Life Sciences
	Water		
	0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1})	0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1})	0.04 to 500 µS/cm
	CLS15D: ± 0.2 % of measured value CLS15: ± 0.2 % of measured value ± 2 digits	± 0.2 % of ± 2 digits	CLS16D: ± 0.2 % of measured value CLS16: ± 0.2 % of measured value ± 2 digits
	CLS15D: ± 2 % of measured value CLS15: ± 1.5 % of measured value ± 4 digits	± 1.5 % of measured value ± 4 digits	CLS16D: ± 2% of measured value (< 200 µS/cm); ± 3% of measured value > 200 µS/cm); CLS16: ± 1.5 % of measured value ± 4 digits
	-20 to 120 °C (sterilization: 140 °C f. 1 h)	-10 to 60 °C	-5 to 120 °C (sterilization: 150 °C f. 45 min)
	13 bar_{abs} (up to 20 °C) 1 bar_{abs} (at 120 and 140 °C)	7 bar_{abs} (up to 20 °C) 1 bar_{abs} (at 60 °C)	0.1 up to 13 bar_{abs} (up to 20 °C) 9 bar_{abs} (at 120 °C) 6 bar_{abs} (at 150 °C)
	Both made of stainless steel 1.4435/316L	Both made of stainless steel 1.4435/316L	Both made of polished stainless steel 1.4435/316L
	Polyethersulfone (PES)	Polyethersulfone (PES)	Polished stainless steel 1.4435/316L
	EPDM	EPDM	FFKM (Isolast) FDA-compliant
	Quality certificate, explosion protection	–	Quality certificate, explosion protection, hygiene certificates
	▪ For monitoring and controlling ion exchangers, reverse osmosis, cooling water, distillation, boiler feedwater, condensate, chip cleaning. ▪ For pH measurement in power plants using differential conductivity	▪ For monitoring and controlling ion exchangers, reverse osmosis, distillation, chip cleaning	▪ For water treatment and water for injection (WFI)

1. Conductivity sensors and types of installation

1.3 Sensors in process water and drinking water applications

Conductive sensor
Condumax CLS21/CLS21D

	Water
Measuring range	10 µS/cm to 20 mS/cm
Repeatability	CLS21D: ± 0.2 % of measured value CLS21: ± 0.2 % of measured value ± 2 digits
Maximum measured error	CLS21D: ± 5 % of measured value CLS21: ± 1.5 % of measured value ± 4 digits
Process temperature	-20 to 135 °C
Max. process pressure	17 bar_{abs} (up to 20 °C) 3.5 bar_{abs} (at 135 °C)
Electrodes (in contact with medium)	Both made of graphite
Shaft (in contact with medium)	Polyethersulfone (PES)
Seals (in contact with medium)	EPDM
Certificates and approvals	Quality certificate, explosion protection
Applications	▪ For environmental applications ▪ Drinking water treatment ▪ Desalination systems ▪ Industrial water treatment ▪ Monitoring of bodies of water

	Conductive sensor Memosens CLS82D	
		
	Food & Beverage	
	Life Sciences	
	1 µS/cm to 500 mS/cm	
	± 0.2 % of measured value	
	± 4 % of measured value	
	-5 to 120 °C (sterilization: 140 °C for 45 min)	
	17 bar_{abs} (up to 20 °C) 9 bar_{abs} (at 120 °C) 6 bar_{abs} (at 140 °C)	
	Four electrodes made of platinum	
	Stainless steel 1.4435/316L, ceramic (zirconium oxide)	
	EPDM	
	Quality certificate, explosion protection, hygiene certificates	
	▪ Downstream processes ▪ Rinsing processes in life science applications ▪ Phase separations ▪ Chromatography ▪ Fermentation ▪ CIP monitoring in small pipes ▪ Ultrafiltration	

1. Conductivity sensors and types of installation

1.4 Sensors in process and auxiliary circuits with high conductivity

	Inductive sensor Indumax CLS50/CLS50D	Inductive sensor Indumax CLS54D
		
	Chemicals	
	Water	
		Food & Beverage
Measuring range	2 µS/cm to 2000 mS/cm	200 µS/cm to 2000 mS/cm
Repeatability	± 0.2 % of measured value	± (0.2 % of measured value + 3 µS/cm)
Maximum measured error	< 100 °C: ± (0.5 % of measured value + 5 µS/cm)	< 100 °C: ± (0.5 % of measured value + 10 µS/cm), after calibration
Process temperature	-20 to 180 °C depending on version	-20 to 125 °C (sterilization: 150 °C for 1 h)
Max. process pressure	Up to 21 bar_{abs} depending on version	0.1 to 13 bar_{abs} (up to 90 °C) 9 bar_{abs} (at 125 °C) 6 bar_{abs} (at 150 °C)
Shaft (in contact with medium)	PEEK or PFA	Pure PEEK
Seals (in contact with medium)	VITON or CHEMRAZ	FKM, EPDM
Certificates and approvals	Quality certificate, explosion protection	Quality certificate, explosion protection, hygiene certificates
Applications	▪ Concentration measurement in acids and bases ▪ Quality monitoring of chemical products ▪ Phase separation of product/ product mixtures ▪ Inlet monitoring in wastewater industry ▪ Monitoring of surface water	▪ For hygienic applications ▪ Phase separation of product/ water and product/product mixtures in pipe systems ▪ CIP process control/concentration control ▪ Product monitoring/quality assurance in pipe systems and filling plants

1.5 Compact systems for conductivity measurement

	Compact device (inductive) Smartec CLD18	Compact device (inductive) Smartec CLD134
		
		Life Sciences
	Food & Beverage	
Measuring range	200 µS/cm to 1000 mS/cm	200 µS/cm to 2000 mS/cm
Repeatability	±(0.5 % of measured value + 5 µS/cm + 2 digits)	± (0.2 % of measured value ± 2 digits)
Maximum measured error	±(2 % of measured value + 20 µS/cm)	± (1 % of measured value + 10 µS/cm + 4 digits)
Process temperature	Stainless steel: -10 to 110 °C (sterilization: 130 °C for 1 h); PVC: -10 to 60 °C	-10 to 125 °C*** (sterilization: 150 °C max. 1 h)
Max. process pressure	Stainless steel: 13 bar_{abs} (up to 50 °C) 6 bar_{abs} (at 130 °C) PVC: 9 bar_{abs} (up to 50 °C) 6 bar_{abs} (at 60 °C)	0.1 up to 13 bar_{abs} (up to 90 °C) 9 bar_{abs} (at 125 °C) 6 bar_{abs} (at 150 °C)*
Degree of protection	IP 69K/NEMA TYPE 6P	IP 67/Type 4
Shaft (in contact with medium)	PEEK	Pure PEEK
Seals (in contact with medium)	EPDM	FKM, EPDM
Number/output type	0/4 to 20 mA, conductivity and temperature	0/4 to 20 mA, conductivity (concentration) and temperature, fieldbus communication
Communication	Analog	HART, PROFIBUS PA/DP
Mounting/degree of protection	Pipe, IP 69K, NEMA TYPE 6P	IP 67
Certificates and approvals	Quality certificate, hygiene certificates	Quality certificate, hygiene certificates
Applications	▪ Phase separation of product/water and product/ product mixtures ▪ CIP process control/ concentration control ▪ Monitoring of industrial water ▪ Rinsing processes in pickling plants	▪ For hygienic applications ▪ Phase separation of product/ water and product/ product mixtures ▪ CIP process control/ concentration control ▪ Product monitoring/ quality assurance

*Depends on device version and ambient temperature

1. Conductivity sensors and types of installation

1.6 Types of transmitters for conductivity measurement

Liquiline CM44 and CM44R
The digital four-wire transmitter provides up to eight channels. It is easy and intuitive to operate with plain-text menus in 17 languages. Since the transmitter can be used to measure 12 different parameters, you can combine all Memosens sensors in any way you choose. Memosens technology already supplies an abundance of digital sensor data and process information and thus serves as the basis for predictive maintenance functions.

Heartbeat Technology, which is available for the Liquiline CM44, provides continuous process and device diagnostics, using functions such as PCS (Process Check System), the CIP/SIP counter, electrode connection monitoring or a calibration timer, for example. These functions help you to optimize your maintenance strategy. Heartbeat Technology also includes verification routines and enables the automatic generation of verification reports.

The Liquiline CM44 provides up to eight 0/4 to 20 mA current outputs, up to four relays, as well as fieldbuses such as HART, PROFIBUS DP, Modbus TCP/RTU, EtherNet/IP and Profinet. The four-wire transmitter also enables convenient remote access via Ethernet web servers. The Liquiline CM44 is available as a field device and also for mounting in control cabinets and on DIN rails.

Liquiline CM42
Its straightforward, easy operation with plain-text menus in 14 languages is one of the outstanding advantages of this two-wire transmitter. It is suitable for applications in both hazardous and non-hazardous areas. The predictive maintenance function can be used in conjunction with our Memosens sensors for the purpose of displaying calibration cycles, for example. It is extremely easy to reconfigure the device from conductivity measurement to the measurement of pH or dissolved oxygen; all you have to do is replace a sensor. Use the Liquiline M transmitter or the Memobase Plus to calibrate the Memosens sensors in a lab. The benefit to you is that precalibrated sensors can be replaced quickly in the process, which minimizes interruptions to conductivity measurement. Available outputs include FOUNDATION Fieldbus and PROFIBUS PA in addition to the 4 to 20 mA and HART output.

Liquiline CM14
The Liquiline CM14 is a basic transmitter that provides all that you need to run a standard measuring point. It fits in common cabinet cut-outs and is easy to commission thanks to digital Memosens technology. The Memosens hot plug and play concept allows you to quickly install and commission your digital sensors.

Liquiline Compact CM72/CM82
The Liquiline Compact CM72 and CM82 are the smallest transmitters for Memosens sensors and are attached directly to the sensor without their own power supply. As loop-powered two-wire devices, Liquiline compact transmitters can also be directly connected to a programmable logic controller (PLC), which also serves as the power supply. The compact transmitters measure only 11 cm long and 2 cm wide and, together with the sensor, can fit into most assemblies. Despite its slender housing, the Liquiline Compact CM82 offers the complete flexibility and configurability of a multi-parameter transmitter. In addition, it is easy and reliable to operate and configure via an encrypted Bluetooth connection using a tablet or smartphone. Using the SmartBlue app, you can see all measuring points that are within the Bluetooth range of the device, and configure them and generate diagnostics. The Liquiline Compact CM72 and CM82 can be used in hazardous and non-hazardous areas. This means that measuring points in dangerous or difficult to access locations can be checked and configured from a safe distance.

Liquisys CLM223/CLM253
The Liquisys transmitter is available in two versions: the CLM223 model is mounted in a cabinet, while the CLM253 model is installed in a field housing. Relay functions (e.g. neutralization processes and spray cleaning function) are optionally available. 0/4 to 20 mA-, HART or PROFIBUS PA/DP outputs make it possible to connect the device to your control system. The transmitter is available for measuring conductivity, pH, dissolved oxygen and chlorine content.

1. Conductivity sensors and types of installation

1.7 Conductivity transmitters

	Liquiline CM44/CM44R	Liquiline CM42	
			
Parameters measured	Conductivity, pH glass and ISFET, ORP, chlorine, oxygen, turbidity, nitrate, SAC, ammonium, sludge level, potassium, chloride	Conductivity, pH glass, pH ISFET, ORP, oxygen	
Input	Memosens, 4 to 20mA, digital	Memosens, analog	
Channels	Max. 8 channels	Single-channel	
Energy supply	24V DC/AC (+20/-15%) 100 to 230V AC, 50/60Hz (±15%)	12.5 to 30 V DC (HART, without HART) 9 to 32 V DC (fieldbus)	
Output	Max. 8 analog 0/4 to 20 mA, max. 4 digital, 8 relays, alarm relay, fieldbus communication	Max. 2 analog 0/4 to 20 mA, fieldbus communication	
Display	Graphic display in plain text	Graphic display in plain text	
Degree of protection	Field device: IP 66/67, NEMA TYPE 4X; cabinet/DIN rail device: IP 20; display: IP 66	IP 66/67, NEMA Type 4X	
Communication	HART, PROFIBUS DP, Modbus TCP/RTU, EtherNet/IP, Profinet, web server	HART, PROFIBUS PA, FOUNDATION Fieldbus	
Housing	Plastic	Plastic, stainless steel	
Installation	Mast, railing, DIN rail, wall	Wall, mast, panel	
Certificates and approvals	Quality certificate	Quality certificate, explosion protection	
Features	▪ Four-wire multi-parameter transmitter ▪ Heartbeat Technology ▪ Mathematical functions ▪ Cleaning function, controller ▪ Quick setup function ▪ Modular extensibility, SD card	▪ Two-wire transmitter ▪ Quick setup function ▪ Navigator ▪ Replaceable sensor module ▪ Predictive maintenance system ▪ Also suitable for analog sensors	

	Liquiline CM14	Liquiline Compact CM72/CM82	Liquisys CLM253/ CLM223
			
	Conductivity, pH glass, ORP, oxygen	Conductivity, pH glass, pH ISFET, ORP, oxygen	Conductivity, pH glass, pH ISFET, ORP, oxygen, chlorine
	Memosens	Memosens plug-in head	Memosens, analog
	Single-channel	Single-channel	Single-channel
	24 V to 230 V AC/DC universal power supply unit	12.6 to 30 V DC	100/115/230 V AC 24 V AC/DC
	Max. 2 analog 0/4 to 20 mA, 2 relays used as limit switches	1 analog 4 to 20 mA	2 analog (linear, optional user-defined curve), alarm relay, up to four additional relays
	Two-line, LCD with dot matrix, 7-segment	Red and green LED	Two-line, LCD
	Front: IP 65, NEMA Type 4X; housing: IP 20	IP 67/68 , NEMA type 6	Field device: IP 65, NEMA type 4X; panel-mounted instrument: IP 54 (front), IP 30 (housing)
	-	CM82: Bluetooth®, HART	HART, PROFIBUS PA, PROFIBUS DP
	Plastic	PEEK	Plastic
	Panel	Space-saving, directly on sensor	Wall, mast, panel
	Quality certificate	Quality certificate, explosion protection, radio approvals	Quality certificate
	▪ Four-wire transmitter ▪ Compact device for cabinets ▪ Low-priced alternative	▪ Two-wire transmitter ▪ Easy operation/commissioning ▪ Bluetooth connection ▪ Can be operated and configured via SmartBlue app ▪ Space-saving installation in assemblies	▪ Four-wire transmitter ▪ Cleaning by timer, Chemoclean, PID controller ▪ Also suitable for analog sensors

1. Conductivity sensors and types of installation

1.8 Types of assembly

Immersion assemblies
These types of assembly are used primarily for installation in open vessels and channels, usually in wastewater treatment plants or in the chemical industry. They are always a good choice in cases where installation is possible only from the top of the vessel.

Dipfit
The standard version, CLA111, which is made of polypropylene (PP), is used mainly for measurements in the water, wastewater and utilities industries. In addition, we also offer the model CLA140, which is made of PVDF or stainless steel and was designed for applications under harsher conditions (e.g. in the chemical industry). There are different immersion lengths available; both assemblies can accommodate up to three sensors for redundant measurements. An optional spray cleaning system can be installed in both assemblies (CPR30/CPR31).

Modular immersion assemblies
These types of assembly offer real benefits in immersion applications such as those found in the wastewater industry. They are suitable for sensors with different connection threads. This means that they can be used not only for 12 mm sensors for measuring conductivity, pH or oxygen, but also for turbidity or nitrate sensors. The system can be installed using different pipes, brackets, etc. in almost any mounting location (pipes, rails, etc.).

Flexdip
The Flexdip CYA112 is used for installation in open vessels and channels. These assemblies are usually found in wastewater treatment plants. The modular system allows an optimum configuration for each measuring application.

- Use of 120 mm Memosens sensors
- Stainless steel or PVC versions
- Assembly lengths of 600 mm (23.6") to 3600 mm (142") in increments of 600 mm (23.6")
- Float assembly for varying water levels
- Quick-fastening elements for:
  - fast installation and exchange of Memosens sensors with inductive plug-in head
  - twist-free installation of fixed-cable sensors
  - alignment of sensors.

Insertion assemblies
Fixed installations with insertion assemblies are found particularly in batch processes, where the user needs to have access to the conductivity sensor between two batches. These assemblies are often used in Life Sciences and food production.

Unifit
The CPA842 is a stainless steel assembly for the food and life science industries. Various options, in particular hygienic clamp connections, are available for the process connection. For special hygiene requirements, a certified hygiene design with the appropriate surface roughness, as well as certificates in accordance with EHEDG, 3-A, ASME BPE and Pharma CoC, are available.

Flow assemblies
Flow assemblies can be used for installation in process pipes or bypasses. These configurations are often found in water works, in the beverages industry, the chemical industry or in analytical cabinets in power plants.

Flowfit
The CPA250, which is made of polypropylene (PP), is excellently suited for use in water works. The robust CPA240 is also available in chemically resistant PVDF or stainless steel and was designed for the measurement of ultrapure water (prevents electrostatic charging). For both assemblies we offer three sensor slots as well as the option to upgrade to chemical spray cleaning.

Retractable assemblies
The main advantage of retractable assemblies is that the sensor replacement or cleaning process can be performed quickly and easily and without interrupting the process. They can be installed or removed either manually or automatically (pneumatically).

Cleanfit
In addition to manual and automatic options, we also offer different materials, sealing strategies and safety functions so that the system can be fully customized to your application. For safety reasons, pneumatically operated retractable assemblies can be fitted with a ball valve.

1. Conductivity sensors and types of installation

1.9 Flow and insertion assemblies for conductivity sensors

	Flowfit CPA240	Flowfit CPA250	Flowfit CCA250	
				
For sensor	CLS82D	CLS82D	CLS82D	
Max. process pressure	Stainless steel: 11 bar_{abs} at 150 °C; PVDF: 9 bar_{abs} at 50 °C, 1 bar_{abs} up to 120 °C	7 bar_{abs} at 20 °C 1 bar_{abs} at 80 °C	4 bar_{abs} up to 40 °C	
Process temperature	Stainless steel: -15 to 150 °C PVDF: 0 to 120 °C	0 to 80 °C	0 to 45 °C	
Materials (in contact with medium)	PVDF, stainless steel 1.4404/316L	Polypropylene (PP)	Plexiglas (PMMA), PVC, stainless steel 1.4571/316L, EPDM	
Seals (in contact with medium)	EPDM/Viton/Chemraz/ Fluoraz	Viton/FKM	EPDM	
Sensor connections	3 x PG 13.5	3 x PG 13.5	2 x PG 13.5; 1 x M40 x 1.5 for disinfection sensor	
Process connections	Weld-in adapter for DN-25 pipe; flange DN 25 PN 16; flange ANSI 1" 150 lbs; flange JIS 10K 25A; thread FNPT ½"	Thread G 1"; thread NPT 1"	Thread G ½"; thread NPT ¼", ½"	
Cleaning	Spray cleaning connection G ½"	Spray cleaning CPR31, Chemoclean CPR3	-	
Comments	PAL (potential matching) for C4 alloy; tantalum	PWIS-free version available	-	
Applications	Water, boiler feedwater, ultrapure water and cooling water, gas scrubbers, petrochemical industry	Water, wastewater treatment or drinks industry	Drinking water, industrial water, process applications, swimming pool water	

	Unifit CPA842	Flowfit CLA751	Flowfit CLA752	Flowfit CYA21
				
	CLS82D	CLS12, CLS13, CLS21D	CLS12, CLS13, CLS21D	CLS15D, CLS19, CLS82D
	17 bar_{abs}	13 bar_{abs}	7 bar_{abs} up to 90 °C	17 bar_{abs}
	-15 to 140 °C	0 to 150 °C	0 to 90 °C	0 to 100 °C
	Stainless steel 1.4435/316L	Stainless steel 1.4571/316L	Polypropylene (PP)	Stainless steel 1.4404/316L
	EPDM-FDA, FKM-FDA, silicone FDA	-	-	sensor-specific
	1 x PG 13.5	Thread G 1	Thread G 1	1 x PG 13.5; thread NPT ½"
	DN 25 standard; DN 25 also for B.Braun connection; Tri-Clamp connection 1,5‴; Tri-Clamp connection 2"; sanitary connection DN 50 DIN11851; Varivent DN 40-125/0.4‴	DN 20 with coupling nut G1	DN 20 with internal thread G ½	Piping, 6mm outer diameter (OD) for commonly used pipe union systems
	-	-	-	-
	EHEDG approval with surface roughness R_a = < 0.76 µm or < 0.38 µm; 3-A; FDA-compliant, explosion protection	-	-	Compact version; perfect for applications where space is restricted; low volume: 69 ml
	In-line measurement, CIP/SIP, food, life sciences, chemicals, water	Condensate measurement	Bypass measurements	Water, boiler feedwater, ultrapure water, cooling water

1. Conductivity sensors and types of installation

1.10 Immersion assemblies for conductivity sensors

	Flexdip CYA112	Dipfit CLA111	Dipfit CLA140
			
For sensor	CLS21D, CLS50D	CLS21D, CLS50D	CLS21D, CLS50D
Max. process pressure	1 bar_{abs}	5 bar_{abs} at 20 °C, 1 bar_{abs} at 80 °C	11 bar_{abs} at 100 °C, metal
Process temperature	0 to 60 °C	-10 to 80 °C	Stainless steel: -15 to 150 °C PVDF: 0 to 120 °C
Materials (in contact with medium)	PVC, stainless steel 1.4404/316L	Polypropylene (PP)	PVDF, stainless steel 1.4404/316L
Seals (in contact with medium)	EPDM	EPDM	EPDM/Viton/Chemraz/ Fluoraz
Sensor connections	Thread G ¾", 1"; thread NPT ¾"; 1 x PG 13.5	Thread G ¾", 1"; thread NPT ¾"	Thread G ¾", 1"; thread NPT ¾"
Process connections	Floater; chain; rail mounting	Flange DN 100; adjustable flange DN 100; suspension bracket	Without; flange DN 80/ PN 16; flange ANSI 3"/150 lbs; flange JIS 10K 80A
Cleaning	-	External spray cleaning CPR30 Internal spray cleaning CPR31	External spray cleaning CPR30 Internal spray cleaning CPR31
Comments	Modular system, extensive range of accessories	-	-
Applications	Water/wastewater treatment, plant design, open channel, basin, open tanks and process vats	Water/wastewater	Chemical industry, petrochemical industry, power plants, metal industry

1.11 Retractable assemblies for conductivity sensors

	Cleanfit CPA871	Cleanfit CPA450	CTSP-LA2xx
			
For sensor	CLS82D	CLS82D	CLS15D/CLS21D/CLS50D
Max. process pressure	17 bar_{abs} (depends on version)	5 bar_{abs} at 120 °C, 13 bar_{abs} (static)	4 bar_{abs} at 100 °C (static) 2 bar_{abs} in motion
Process temperature	-10 to 140 °C (depends on version)	-15 to 130 °C	0 to 100 °C
Materials (in contact with medium)	Stainless steel 1.4404/316L, Alloy C22 PEEK, PVDF, PVDF conductive	Stainless steel 1.4404/316L, Alloy C22 , titanium	Stainless steel 1.4404/316L, Hastelloy, titanium
Seals (in contact with medium)	EPDM/FKM/FFKM	EPDM/FKM/FFKM	EPDM/Viton/Kalrez, Chemraz
Operation	Manual/pneumatic	Manual	Manual
Sensor connections	PG13.5	PG13.5	On request
Process connections	Clamp 2", 2½"; flange DN 40, DN 50, DN 80; flange 2", 3" (ASME B16.5); flange JIS 10K50, 10K80; thread NPT 1½"; thread G 1¼"; dairy fitting DN 50, DN 65	G1½" internal; G1¼" external; NPT 1¼" external; flange DN32 Iso 1092-1; flange ANSI 1¼"; G1¼" internal; NPT 1¼" external; M-NPT 1½" external; flange ANSI 2"	On request
Process seal	O-rings (2x)	Ball valve	With/without ball valve
Comments	Immersion chamber version, 3.1 certificate	Safety kit for higher process pressures, 3.1 certificate	
Applications	Water, wastewater, process industry	Water, wastewater, process industry	Chemical, paper and process industries

2. Checklist

Customer contact data:			
Name:		Company:	
E-mail:		Tel.:	
		Please complete	Notes
Medium	Conductivity value		
	Concentration		
	Acids		
	Bases		
Process data	Process temperature		
	Max. process pressure		
Process connection	Connection type/size		
Installation	Ambient temperature		
	Installation in pipes		
	Installation in vessels		
Transmitters	2-/4-wire		
	Degree of protection		
	Digital communication (HART, PROFIBUS, FOUNDATION Fieldbus)		
	Dosage to be controlled by transmitter?		
	Automatic cleaning?		
	Could cleaning medium contaminate medium being measured?		
	Multi-channel device		
Device approvals/ certificates	Ex (Ex ia, Ex d)		
	EHEDG		
	3-A		
	FDA-listed material		
	3.1 certificate		

Specific requirements/short description of application/drawing:

3. Selecting the right conductivity sensor

3.1 Flow chart for selecting conductivity sensors

B

When selecting the appropriate conductivity sensor, the main determining factor is the degree of conductivity of the solute in the medium in the real-life application. Depending on the requirements, there are sensors specifically for measuring low conductivity and for measuring medium to high conductivity. The degree of conductivity is an indicator of the purity of water or the quantity of dissolved salts in the water. Conductivity measurement can therefore also be used to determine the concentration of substances in a medium.

To carry out a measurement requires the lowest possible intrinsic conductivity of the pure medium as well as a dissolved substance that has the ability to form ions. Only then can electrical current be conducted and measured. The medium used in most applications is water, which in its pure form has a very low intrinsic conductivity of 0.055 µS/cm at 25 °C.

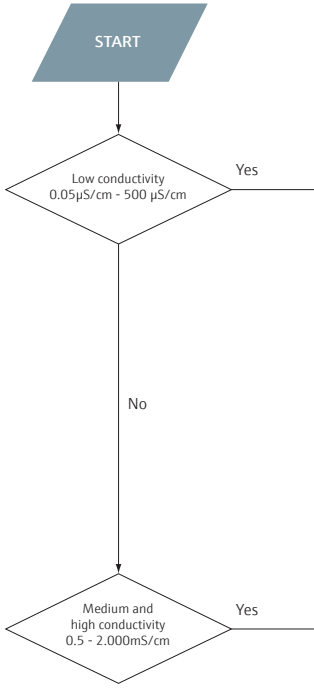
Conductivity measurements have a wide range of application, from ultrapure water treatment and surface water monitoring to concentration measurement in acids and bases. In the food and beverage industry, conductivity sensors are used in product monitoring and CIP control.

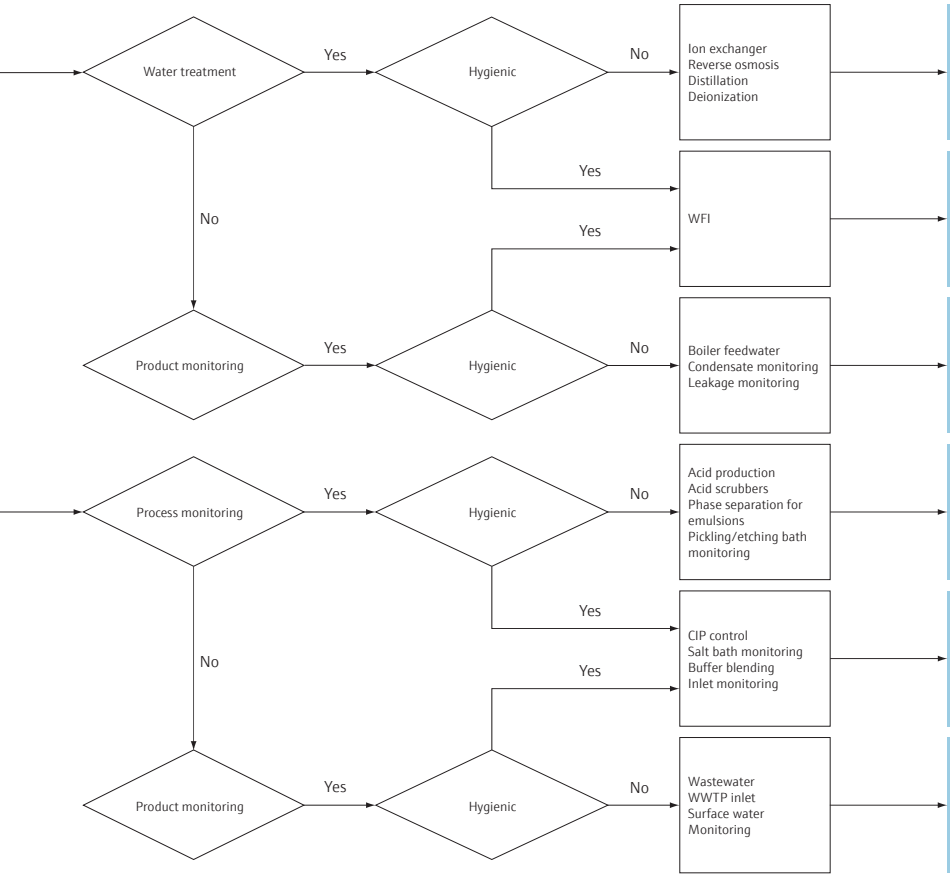
In addition to the degree of conductivity, the choice of sensor also depends on process- and industry-specific requirements, such as the temperature range, the need for explosion protection, or hygiene regulations. As the number of requirements increases, the number of suitable sensors decreases.

There are basically two approaches:
a) Verify the suitability of a known sensor for a new application
   ▸ Is my sensor also suitable for a different application?
b) Select a sensor that is recommended for the application in question
   ▸ Which sensor is suitable for my application?

For approach a), please look for the appropriate sensor in sections 1.1 to 1.4, and check if the sensor meets the requirements of your application.

For approach b), please follow the flow chart. From here, you will be directed to the individual sections (3.2 – 3.7) where you will find the recommended sensor along with key advantages, application limits and possible alternatives. The layout has been simplified in order to reduce the level of complexity. To obtain further information on a sensor, please refer to the relevant overview (sections 1.1 to 1.4).




Water treatment
Yes
Hygienic
No
Ion exchanger
Reverse osmosis
Distillation
Deionization
3.2
Ultrapure and pure water applications
See page 26
Yes
WFI
3.3
WFI
See page 28
No
Yes
Product monitoring
Yes
Hygienic
No
Boiler feedwater
Condensate monitoring
Leakage monitoring
3.4
High-temperature/ pure water applications
See page 30
Process monitoring
Yes
Hygienic
No
Acid production
Acid scrubbers
Phase separation for emulsions
Pickling/etching bath monitoring
3.5
Chemical applications
See page 32
Yes
CIP control
Salt bath monitoring
Buffer blending
Inlet monitoring
3.6
Hygiene applications
See page 34
No
Yes
Product monitoring
Yes
Hygienic
No
Wastewater
WWTP inlet
Surface water
Monitoring
3.7
Water/wastewater applications
See page 36

3. Selecting the right conductivity sensor

3.2 Ultrapure and pure water applications

	Suggestion **Conductive sensor Condumax CLS15/CLS15D**	**Conductive sensor Condumax CLS19**
		
Advantages	▪ Can also be installed in flow assembly ▪ Easy cleaning of stainless steel electrodes ▪ Two different cell constants available ▪ Can be sterilized for a short time at 140 °C ▪ Compact design ▪ Analog and digital versions available	▪ Low-priced alternative to CLS15 for moderate process conditions ▪ Can also be installed in flow assembly ▪ Easy cleaning of stainless steel electrodes ▪ Two different cell constants available
Applications	▪ Monitoring and control of ion exchangers, reverse osmosis, cooling water, distillation, boiler feedwater, condensate, chip cleaning ▪ For pH measurement in power plants using differential conductivity	▪ Monitoring and control of ion exchangers
Technical data ▪ Measuring range ▪ Process temperature ▪ Max. process pressure	 0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1}) -20 to 120 °C (sterilization: 140 °C for 1 h) 13 bar_{abs} (up to 20 °C) 1 bar_{abs} (at 120 and 140 °C)	 0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1}) -10 to 60 °C 7 bar_{abs} (up to 20 °C) 1 bar_{abs} (at 60 °C)

* k = cell constant

3. Selecting the right conductivity sensor

3.3 Water for injection (WFI)

B

WFI

	Suggestion
	Conductive sensor **Condumax** CLS16/CLS16D 
Advantages	▪ Hygienic ▪ Certified according to EHEDG, Document 8 ▪ Replaceable seal ▪ Minimum immersion depth is sufficient ▪ Easy cleaning of polished stainless steel electrodes ▪ Can be sterilized for a short time at 150 °C
Applications	▪ Designed for the life sciences industry ▪ For water treatment and water for injection (WFI)
Technical data ▪ Measuring range ▪ Process temperature ▪ Max. process pressure	0.04 to 500 µS/cm -5 to 120 °C (sterilization: 150 °C for 45 min) 0.1 to 13 bar_{abs} (up to 20 °C) 9 bar_{abs} (at 120 °C) 6 bar_{abs} (at 150 °C)

3. Selecting the right conductivity sensor

3.4 High-pressure/high-temperature and pure water applications

B

High-temperature/ pure water applications

Suggestion

	Conductive sensor Condumax CLS12	Conductive sensor Condumax CLS13
		
Advantages	▪ High degree of thermal, chemical and mechanical resistance ▪ Stainless steel electrodes ▪ Can be used in superheated steam ▪ Flow assembly CLA751 available ▪ Large connection compartment for cables ▪ Two different cell constants available	▪ High degree of thermal, chemical and mechanical resistance ▪ Stainless steel electrodes ▪ Can be used in superheated steam ▪ Can be used up to 250°C ▪ Large connection compartment for cables ▪ Two different cell constants available
Applications	▪ For water/steam circuits (condensate) in the power and energy industry	▪ For water/steam circuits (condensate) in the power and energy industry
Technical data ▪ Measuring range ▪ Process temperature ▪ Max. process pressure	 0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1}) -30 to 160 °C 41 bar_{abs} (up to 100 °C) 7 bar_{abs} (at 160 °C)	 0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1}) -20 to 250 °C 41 bar_{abs}

* k = cell constant

	Conductive sensor Condumax **CLS15/CLS15D**	**Conductive sensor** Condumax **Condumax CLS19**
		
	▪ Can also be installed in flow assembly ▪ Easy cleaning of polished stainless steel electrodes ▪ Can be sterilized for a short time at 140 °C ▪ Compact design ▪ Two different cell constants available	▪ Low-priced alternative for moderate process conditions
	▪ Monitoring and control of ion exchangers, reverse osmosis, cooling water, distillation, boiler feedwater, condensate, chip cleaning ▪ For pH measurement in power plants using differential conductivity	▪ Monitoring and control of ion exchangers
	0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1}) -20 to 120 °C (sterilization: 140 °C for 1 h) 13 bar_{abs} (up to 20 °C) 1 bar_{abs} (at 120 and 140 °C)	0.04 to 20 µS/cm (k*= 0.01 cm^{-1}) 0.1 to 200 µS/cm (k*= 0.1 cm^{-1}) -10 to 60 °C 7 bar_{abs} (up to 20 °C) 1 bar_{abs} (at 60 °C)

3. Selecting the right conductivity sensor

3.5 Chemical applications

	Suggestion
	Inductive sensor **Indumax CLS50/CLS50D** 
Advantages	▪ Broad measuring range ▪ High chemical resistance due to PFA coating ▪ PEEK version for temperatures up to 180 °C ▪ Robust design ▪ Resistant to contamination ▪ Large sensor opening
Applications	▪ Designed for the chemical industry ▪ Concentration measurement in acids and bases ▪ Quality monitoring of chemical products ▪ Phase separation of product/product mixtures ▪ Inlet monitoring in wastewater industry ▪ Monitoring of surface waters
Technical data ▪ Measuring range ▪ Process temperature ▪ Max. process pressure	 2 µS/cm to 2000 mS/cm -20 to 180 °C (depends on sensor version) 21 bar_{abs} (depends on sensor version)

3. Selecting the right conductivity sensor

3.6 Hygiene applications

Suggestion

	Conductive sensor Memosens CLS82D	Inductive sensors Indumax CLS54/CLS54D and Smartec CLD134
		
Advantages	▪ Applications with broad measuring range ▪ Certified in accordance with EHEDG and 3-A ▪ FDA-compliant ▪ Product monitoring and rinsing using a single sensor ▪ Easy cleaning due to electropolished surfaces ▪ Can be sterilized up to 140 °C ▪ Stainless steel shaft	▪ Hygienic design without gaps or joints ▪ With food-safe PEEK ▪ Fully encapsulated, sealless design ▪ Available in two sizes ▪ Very low surface roughness Ra ≤ 0.8 µm ▪ Also available as compact device with transmitter
Applications	▪ For life science and food industries ▪ Downstream processes ▪ Rinsing processes in pharmaceutical applications ▪ Phase separations ▪ Chromatography ▪ Fermentation ▪ CIP monitoring in small pipes ▪ Ultrafiltration	▪ For hygienic applications in the food industry, life sciences and biotechnology ▪ Phase separation of product/water and product/product mixtures ▪ CIP process control/concentration control ▪ Product monitoring/quality assurance
Technical data ▪ Measuring range ▪ Process temperature	1 µS/cm to 500 mS/cm -5 to 120 °C (sterilization: 140 °C for 45 min)	200 µS/cm to 2000 mS/cm -20 to 125 °C (sterilization: 150 °C for 1 h)
▪ Max. process pressure	17 bar_{abs} (up to 20 °C) 9 bar_{abs} (at 120 °C) 6 bar_{abs} (at 140 °C)	0.1 to 13 bar_{abs} (up to 90 °C) 9 bar_{abs} (at 125 °C) 6 bar_{abs} (at 150 °C)*

Compact device (inductive)
Smartec CLD18

	▪ Alternative to CLD134 ▪ Compact design ▪ With food-safe PEEK ▪ Compact device with transmitter ▪ Small sensor head for installation where space is tight	
	▪ Designed for hygienic applications ▪ For the food industry, life sciences and biotechnology ▪ Phase separation of product/water and product/product mixtures in pipe systems ▪ CIP process control/concentration control ▪ Monitoring of industrial water ▪ Rinsing processes in pickling plants	
	200 µS/cm to 1000 mS/cm Stainless steel: -10 to 110 °C (sterilization: 130 °C for 1 h) PVC: -10 to 60 °C Stainless steel: 13 bar_{abs} (up to 50 °C) 6 bar_{abs} (at 130 °C) PVC: 9 bar_{abs} (up to 50 °C) 6 bar_{abs} (at 60 °C)	

3. Selecting the right conductivity sensor

3.7 Water and wastewater applications

	Suggestion	
	Conductive sensor **Condumax CLS21/CLS21D**	**Inductive sensor** **Indumax CLS50/CLS50D**
		
Advantages	▪ Broad measuring range ▪ Robust, durable PES housing ▪ Different designs ▪ Can also be installed in flow assembly	▪ Broad measuring range ▪ Robust design ▪ Resistant to contamination ▪ Large sensor opening
Applications	▪ For environmental applications ▪ Drinking water treatment ▪ Desalination systems ▪ Industrial water treatment ▪ Monitoring of surface waters	▪ Suitable for wastewater ▪ For heavily contaminated applications ▪ Inlet monitoring in wastewater industry ▪ Monitoring of surface waters
Technical data ▪ Measuring range	10 µS/cm to 20 mS/cm	2 µS/cm to 2000 mS/cm
▪ Temperature range ▪ Max. pressure	-20 to 135 °C 17 bar_{abs} (up to 20 °C) 3.5 bar_{abs} (at 135 °C)	-20 to 180 °C (depends on sensor version) 21 bar_{abs} (depends on sensor version)

4. Life cycle management of measuring circuits

4.1 Optimum laboratory calibration concept thanks to Memosens and Memobase Plus

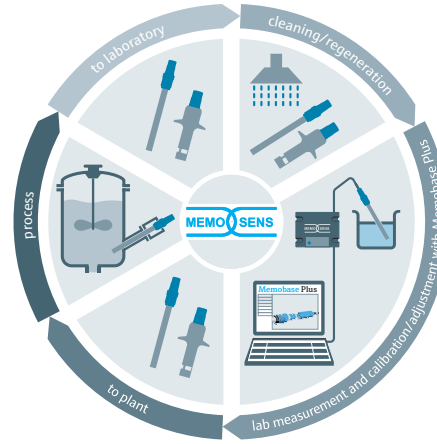
With Memosens technology, analog signals are converted to digital signals directly in the sensor. This is why the sensor is also the only component that must be checked and calibrated regularly. The cable and transmitter do not affect the measured value unlike in an analog system which can be sensitive to moisture and electromagnetic interferences.

Memosens sensors not only calculate and transfer the measured value but also save additional process data. This data can include operating hours at higher temperatures, for example, or maximum temperatures occurring in the process. This information enables predictive maintenance. Using Memosens technology, you can therefore replace the sensor quickly and easily in the process with a clean, pre-calibrated sensor. The measured value controlling your process is thus available immediately once again.

Important maintenance measures such as sensor calibration can then take place in the comfortable surroundings of the laboratory – under constant and perfect conditions and with all of the necessary tools available there. This is much faster than at the site where the sensor is used in the process.

The perfect complement to this is Memobase Plus software, which supports the concept of laboratory calibration. This sensor and data management software allows you to calibrate and check your sensors very easily. Furthermore, Memobase Plus saves all of the sensor and calibration data in a database, enabling the automatic generation of visualizations and reports and the export of data. In addition to conductivity sensors, the software also supports pH electrodes and sensors for ORP, dissolved oxygen and chlorine. Memobase Plus is available in 12 languages and linked to Endress+Hauser's W@M Portal. This enables professional lifecycle management of all the sensors used in the process.

Complete, seamless documentation:
Life cycle of Memosens sensors



4.2 Calibrating conductivity sensors

The cell constant of a conductivity sensor must be accurate if the measuring point is to achieve a high level of accuracy. That is why Endress+Hauser individually calibrates, adjusts and certifies the cell constant for each conductivity sensor while it is still in the factory.

Furthermore, with our traceable calibration standards (CLY11), we will provide you with the support you need to perform consistently accurate conductivity measurements. The high degree of accuracy of these calibration solutions guarantees reliable validation of your conductivity sensors and therefore safeguards the quality and reliability of your product. All CLY11 standards have a quality certificate and are traceable to internationally recognized standards, such as NIST and PTB. They thus comply with all documentation guidelines.

Our wide range of calibration solutions with varying conductivity values ensures that you can calibrate all of your conductivity sensors as easily as possible.

CLY11 calibration standards for conductivity sensors

4. Life cycle management of measuring circuits

4.3 Conducal CLY421 calibration set for conductivity sensors

The Conducal CLY421 portable reference calibration is the ideal calibration tool for conductivity measuring devices in ultrapure water applications. It provides certified comparison measurements and full traceability of your instruments' verification and calibration. Furthermore, the tool is fully compliant with the requirements of the life sciences industry. The Conducal comes in a robust, portable hardshell case with a battery-powered Liquiline transmitter, enabling flexible calibration of your measuring devices, even in the field.

Application

The Conducal CLY421 is a portable calibration and verification tool for quality-relevant conductivity measurements. It is suitable for all ultrapure water applications up to 20 µS/cm:

- Life sciences industry
- Food industry
- Semiconductor industry

Its traceability to national standards (NIST, PTB and DAkkS) fulfills the most stringent legal requirements.

Advantages

- Factory calibration traceable to standard reference material NIST, PTB and DAkkS
- Factory calibration of Conducal system according to ASTM D-5391
- Flow assembly with adjusting and monitoring functions according to ASTM D-5391
- Accurate calibration by direct use of process sample and comparison with reference system
- Rapid setup of comparison measurement with practical flow assembly
- Flexible calibration in the field with carry case and battery-operated Liquiline transmitter

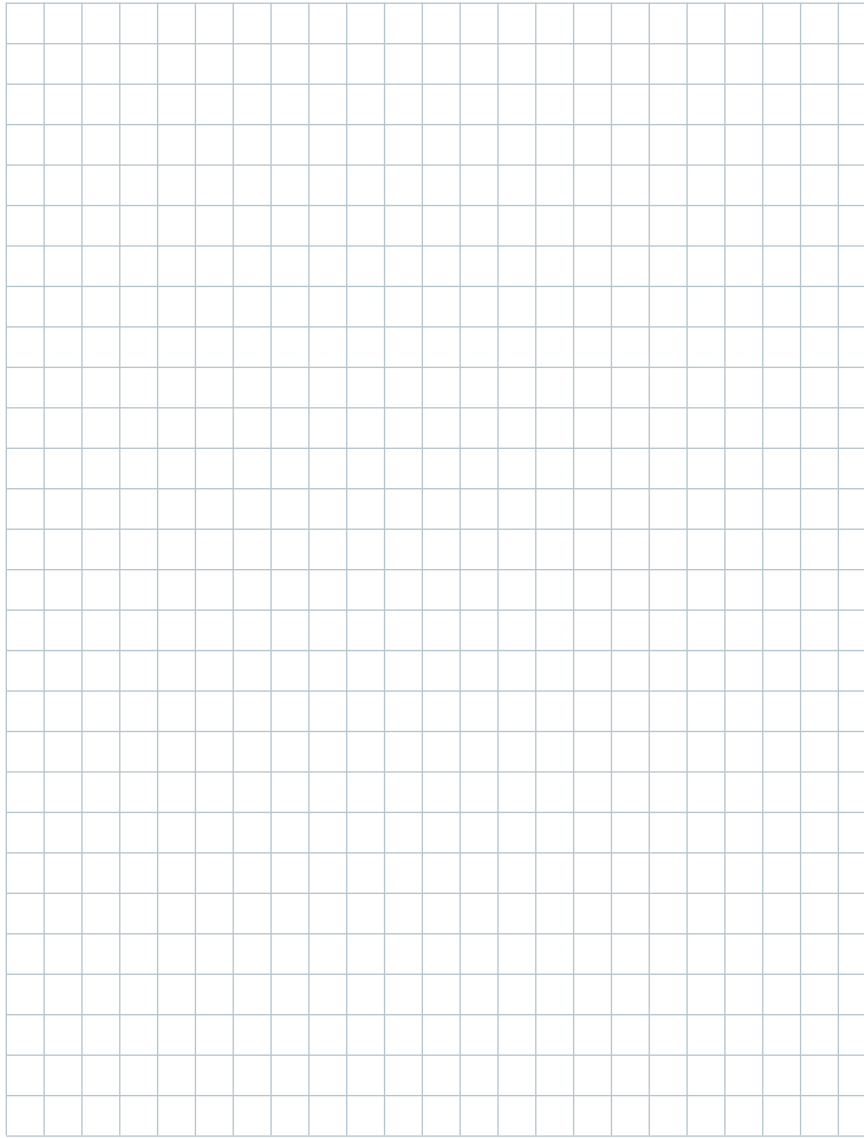
4. Life cycle management of measuring circuits

4.4 Steam/water analysis systems

In industrial processes, vast quantities of energy are required for steam production in particular. The use of high-quality water in boiler applications at power plants and public utility companies prevents corrosion and buildup. This guarantees a high degree of boiler efficiency, which in turn contributes to energy savings.

Endress+Hauser offers the full range of devices needed to analyze the pure water used in these types of boiler applications. Since the pressure and temperature in most cases are too high for the measurement to be performed directly in the process, it is necessary to install a sample conditioner upstream from the analytical cabinets. Sample conditioners are also included in Endress+Hauser's product range.

Notes



Notes

Supplementary documentation

- Parameter Overview
  FA00007C/07/en

Links

- "Application Selection" product selection software
  www.de.endress.com/applicator
- Overview of all components
  www.endress.com/conductivity
- Memosens technology
  www.endress.com/memosens

www.addresses.endress.com

CP01313C/07/en/01.19

Endress+Hauser

People for Process Automation