

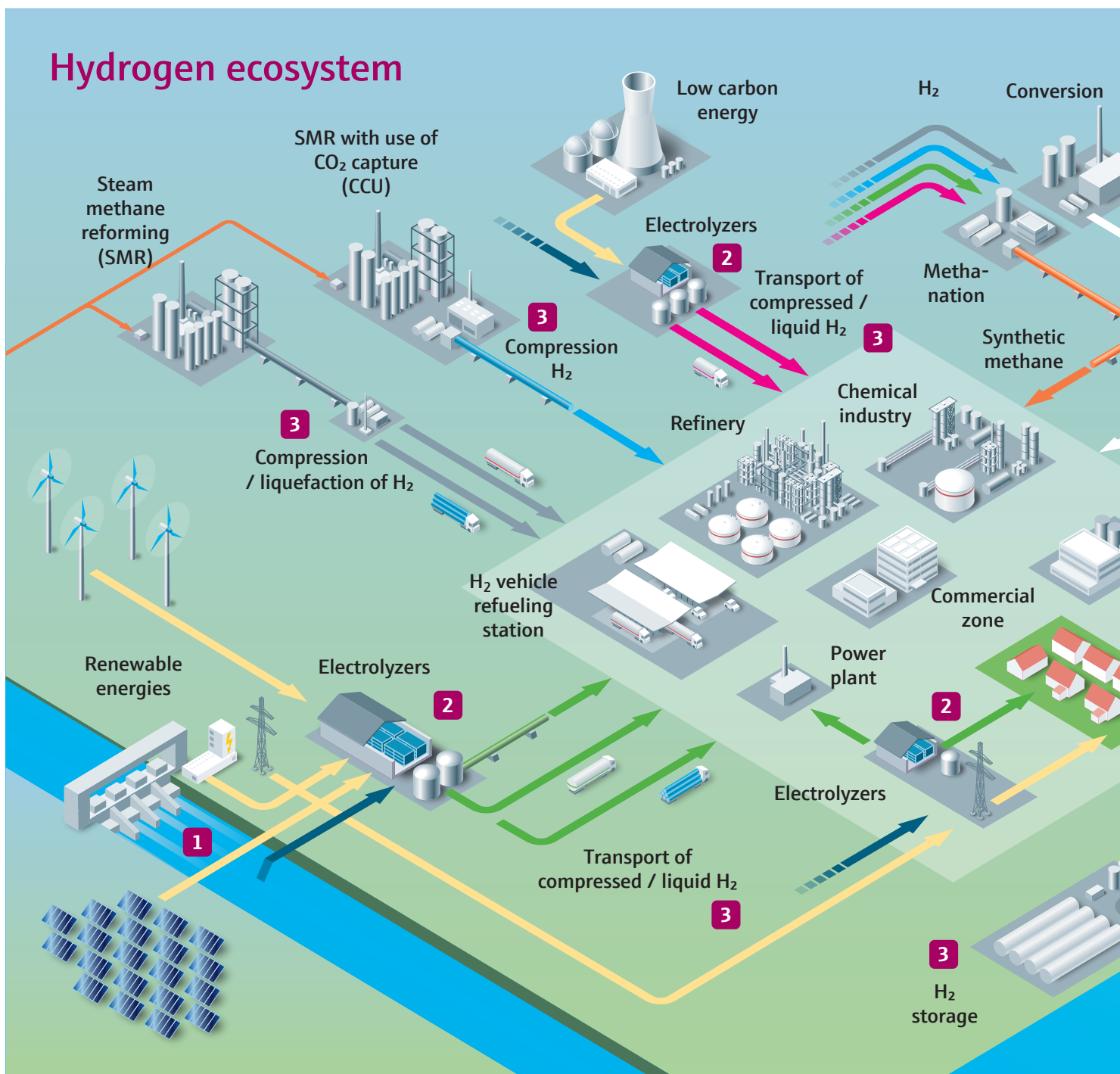
Supporting the Hydrogen Economy

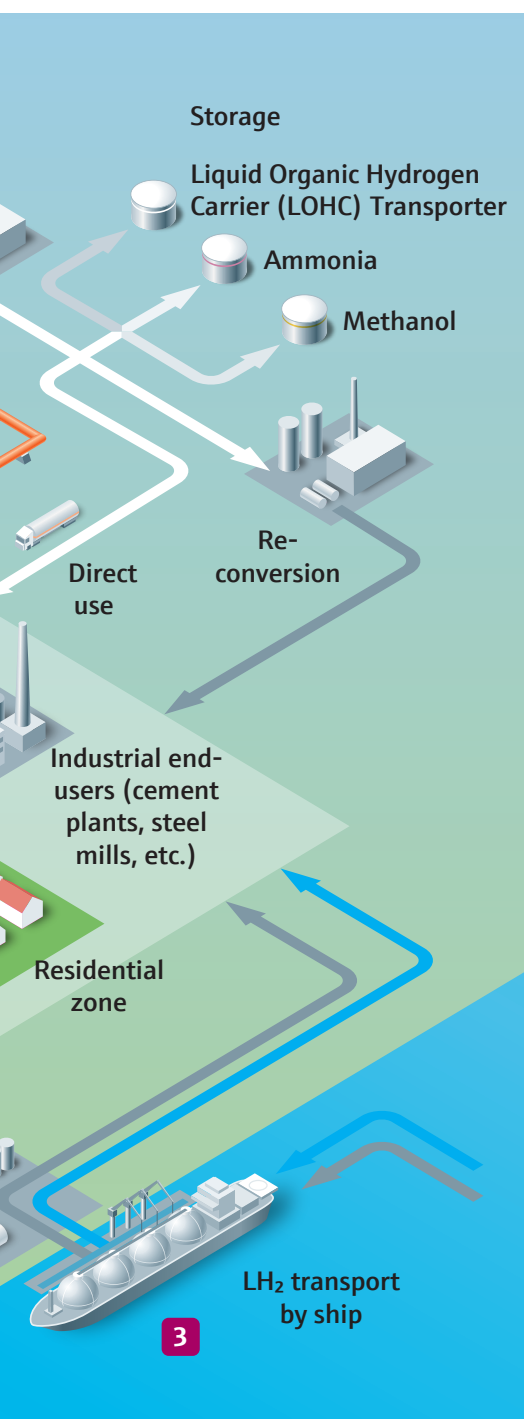
Products, services and solutions to enhance the reliability and security of the entire H₂ value chain



The skills of Endress+Hauser serving the energy transition

Drawing on years of experience in instrumentation, Endress+Hauser offers a comprehensive range of solutions across the entire value chain of hydrogen.





Optimize your performance

- 1. Water preparation and treatmentp. 4
- 2. Alkaline electrolyzers p. 6
- 3. PEM electrolyzersp. 7
- 4. Hydrogen compression, distribution and storagep. 10

Secure your processes

- 5. Process Safety p. 12
- 6. Cybersecurity p. 13

Modernize your plant

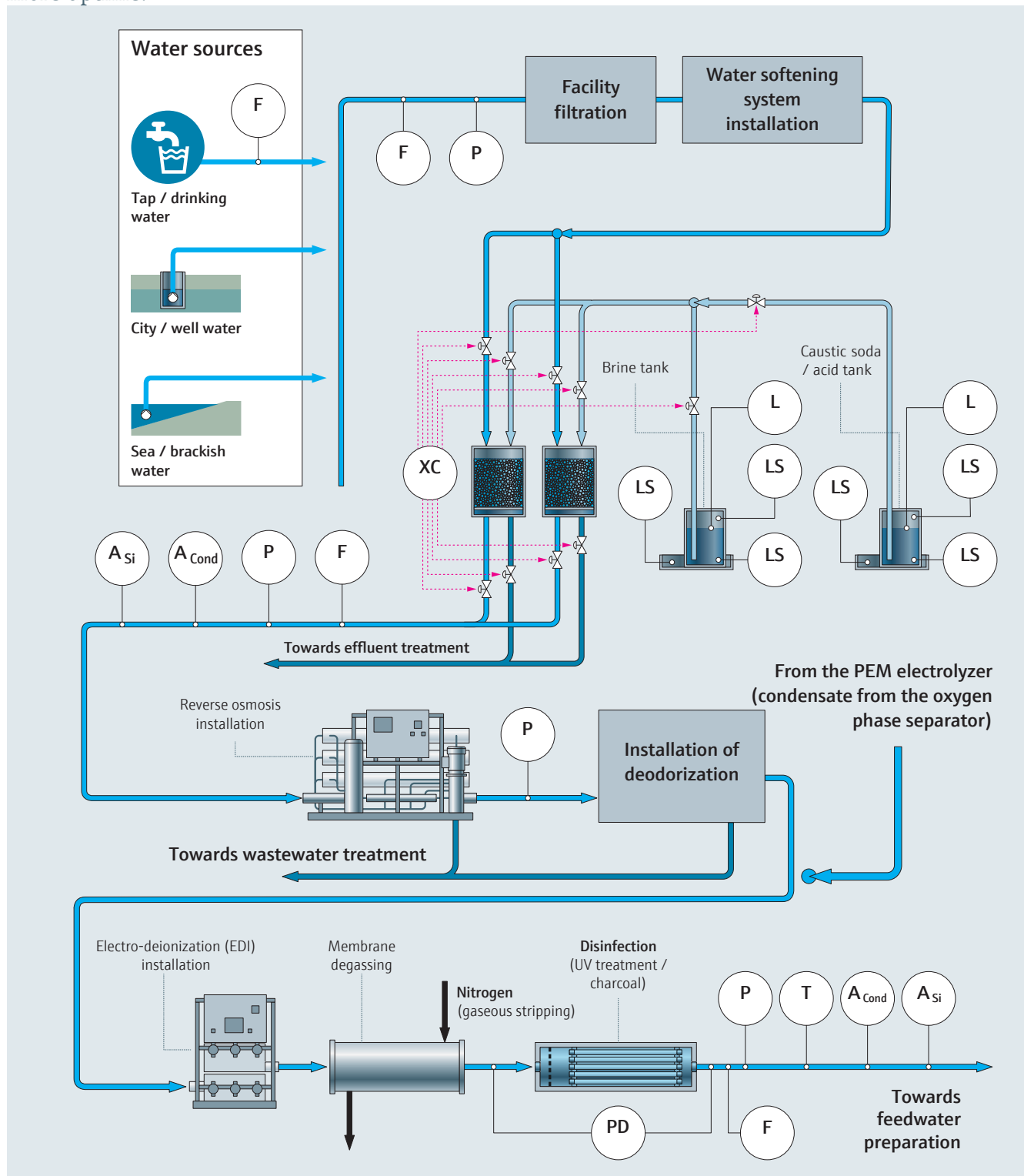
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Water preparation

One of the most critical steps for electrolysis is the water preparation to a particular quality specification, which varies for different types of electrolyzer technology. It is essential to measure the following parameters: level, flow, pressure, conductivity, and in some cases pH. As Green Hydrogen facilities scale up, TOC may be another parameter to quickly detect failures in upstream treatment that would not be caught by conductivity or pH. Endress+Hauser, with its expertise and platform for liquid analysis, addresses all your needs and increases ease of maintenance, ensuring more uptime.



Electromagnetic flow measurement – Promag W10

Flowmeter used for monitoring conductive liquids. The world's first electromagnetic flowmeter for unrestricted installation measurements.

- **Version 0 x DN with full bore:** without any upstream or downstream lengths and no pressure loss
- **Easy commissioning:** thanks to the touchscreen via smartphones using Bluetooth with the Smartblue application
- **High rangeability and measurement precision**
- **Embedded Heartbeat Technology** for simplified operational performance monitoring



Relative pressure measurement – Cerabar PMP51B

Reliable and easy-to-use sensor for monitoring and tracking pressure in pipelines.

- **Measuring accuracy up to +/- 0.055%**
- **Excellent reproducibility and long-term stability**
- **Easy and remote commissioning** via smartphone using the Smartblue application
- **Guided SIL commissioning** to streamline safety in the field

Conductivity measurement – CLS16E with transmitter Liquiline CM442

Conductivity measurement on ultra-pure water for PEM electrolyzers and on potassium for alkaline electrolysis, for optimal quality monitoring.

- **Wide measuring range**
- **Compact design for simplified installation**
- **Memosens technology 2.0** with data storage and contactless transmission



Differential pressure measurement – Deltabar PMD55B

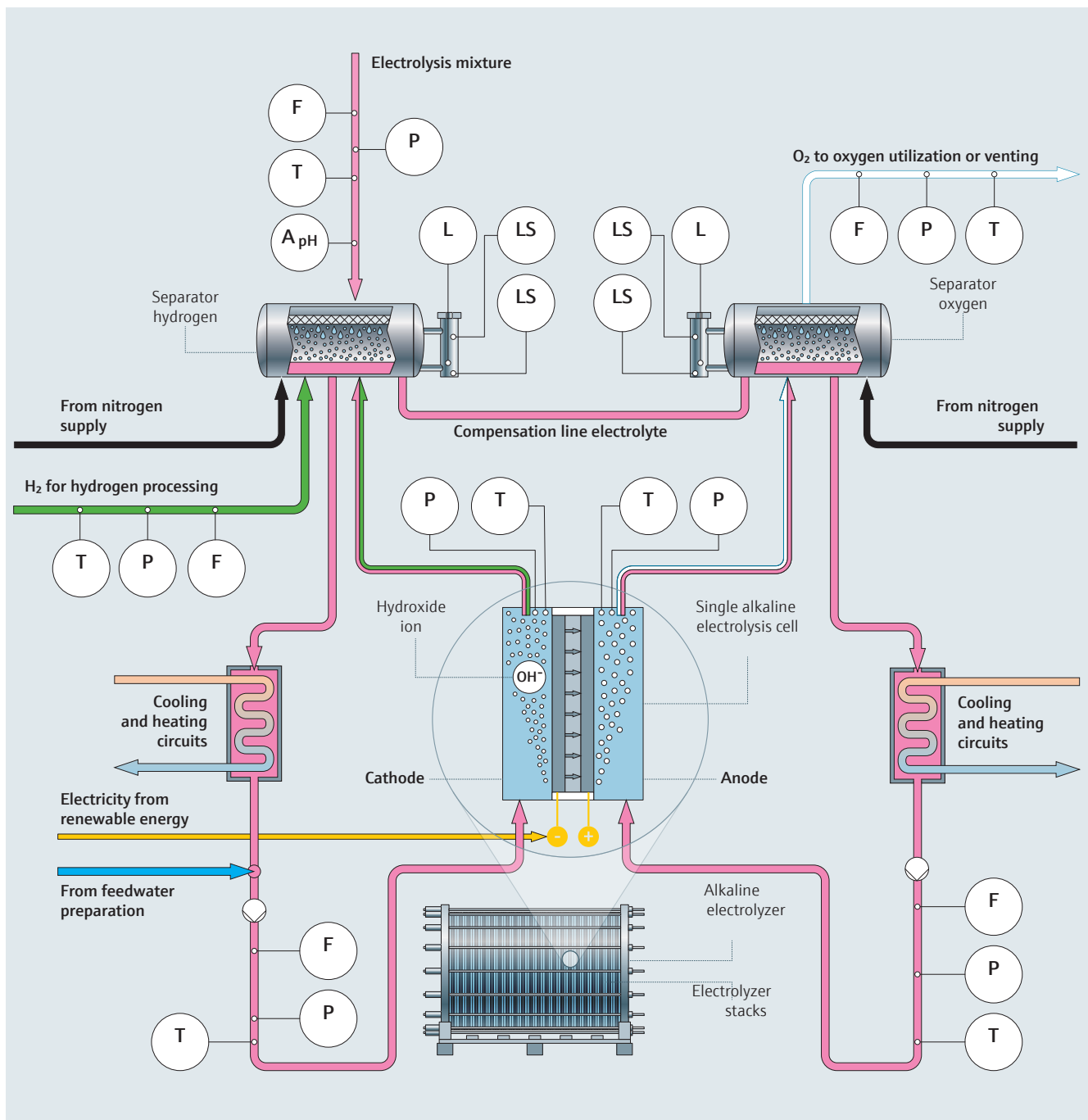
Differential pressure transmitter known for its robustness and reliability, enabling the monitoring of filtration quality throughout the water treatment process.

- **Measuring accuracy up to +/- 0.055%**
- **Compatible with smartphones** through secure Bluetooth connection using the Smartblue applications
- **Enables condition-based maintenance**

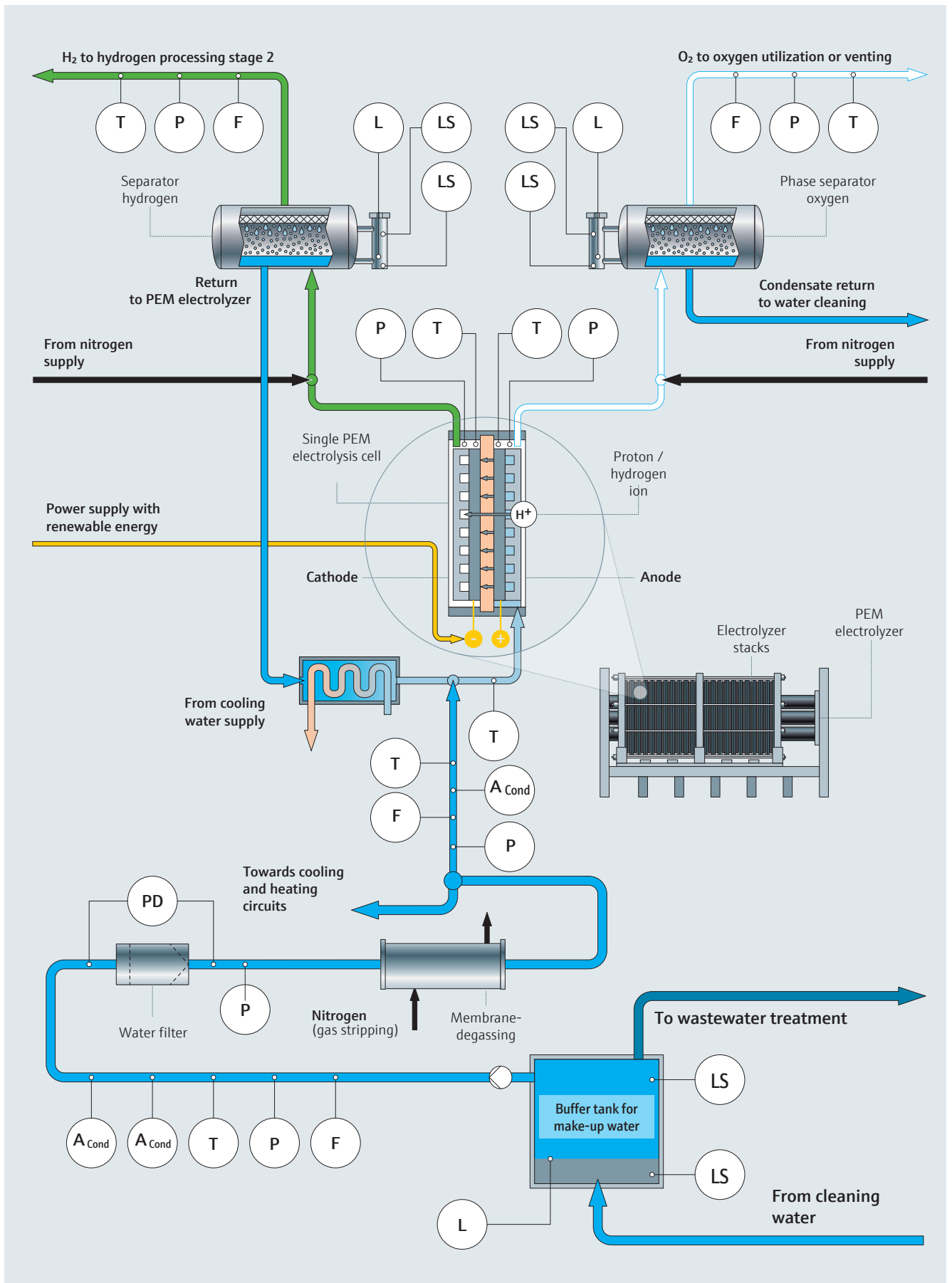
Electrolyzers

The alkaline electrolyzer

For the production of green hydrogen, the alkaline electrolyzer is currently the most widely used technology. To optimize and ensure better production efficiency, the following parameters need to be measured: flow, level, temperature and pressure. All these parameters are available from Endress+Hauser.



The PEM electrolyzer



Instrumentation for electrolyzers

Guided wave radar level measurement - Levelflex FMP51

Technology suitable for liquid level control in hydrogen and oxygen separators, highly resistant to corrosive substances.

- Reliable measurement even in narrow measuring ranges
- Optional supply of the measuring chamber (bypass)
- Certified according to IEC 61508 for maximum safety – SIL2/3 applications
- Degreasing possible for oxygen applications



Relative pressure transmitter – Cerabar PMP71B

Pressure measurement on all fluids present such as ultra-pure water, brine, hydrogen, oxygen and nitrogen.

- Measurement accuracy up to +/- 0.025 %
- Gold-casted membrane for hydrogen and degreased for oxygen
- Remote configuration via Bluetooth and Smartblue application
- Verification of proper functioning through embedded Heartbeat Technology

Coriolis mass flow measurement – Promass F300 / A300

Mass flowmeter renowned for its robustness, reliability and precision in measuring liquids and gases.

- High precision
- Multivariable execution integrating mass flow, temperature and even density for liquids
- No required straight inlet and outlet lengths
- Embedded Heartbeat Technology for operational performance monitoring



Conductivity measurement – CLS16E with CM44x for multi-channel transmitter

Robust conductivity measurement assembly consisting of a conductive sensor, cable and a field transmitter suitable for demanding environments.

- Measurement range from 0.04 $\mu\text{S}/\text{cm}$ to 500 $\mu\text{S}/\text{cm}$
- Reliable and accurate measurement for low conductivity fluids
- Easy cleaning due to its stainless-steel body and removable electrode



Liquid level detection with vibrating fork/blades – Liquiphant FTL51B

Secure your processes with Liquiphant installed in over 3,000,000 applications worldwide. Benefit from the expertise of a sensor developed and patented by Endress+Hauser.

- Certified to IEC 61508 for maximum safety – SIL2/3 applications
- Advanced diagnostics and self-testing functions with Heartbeat Technology
- Simplified loop control, even remotely via Bluetooth

Temperature Sensor – iTherm Moduline TM131

Pt100 sensor with an integrated thermowell, suitable for both hazardous and non-hazardous zones.

- Pt100 sensor range -328°F to +1112°F (-200°C to +600°C)
- Vibration-resistant version up to 60g (iTherm StrongSens) or fast response time of 1.5s (iTherm QuickSens)
- Dual Seal: containment enclosure for process safety with corrosion/leak detection of the protective sleeve - protects against hydrogen leakage
- Transmitter TMT82, HART with options SIL certification, dual channel inputs for delta-T or redundancy



Vortex flow measurement – Prowirl D/F 200

Robust and drift-free capacitive sensor for flow measurement of all types of fluids: liquids (ultra-pure water, oxygen...)

- **2-wire technology** for simple and cost-effective integration
- **Process safety and monitoring** with Heartbeat Technology
- Flanged or sandwich-mounted version available

Hydrogen quality at electrolyzer outlet

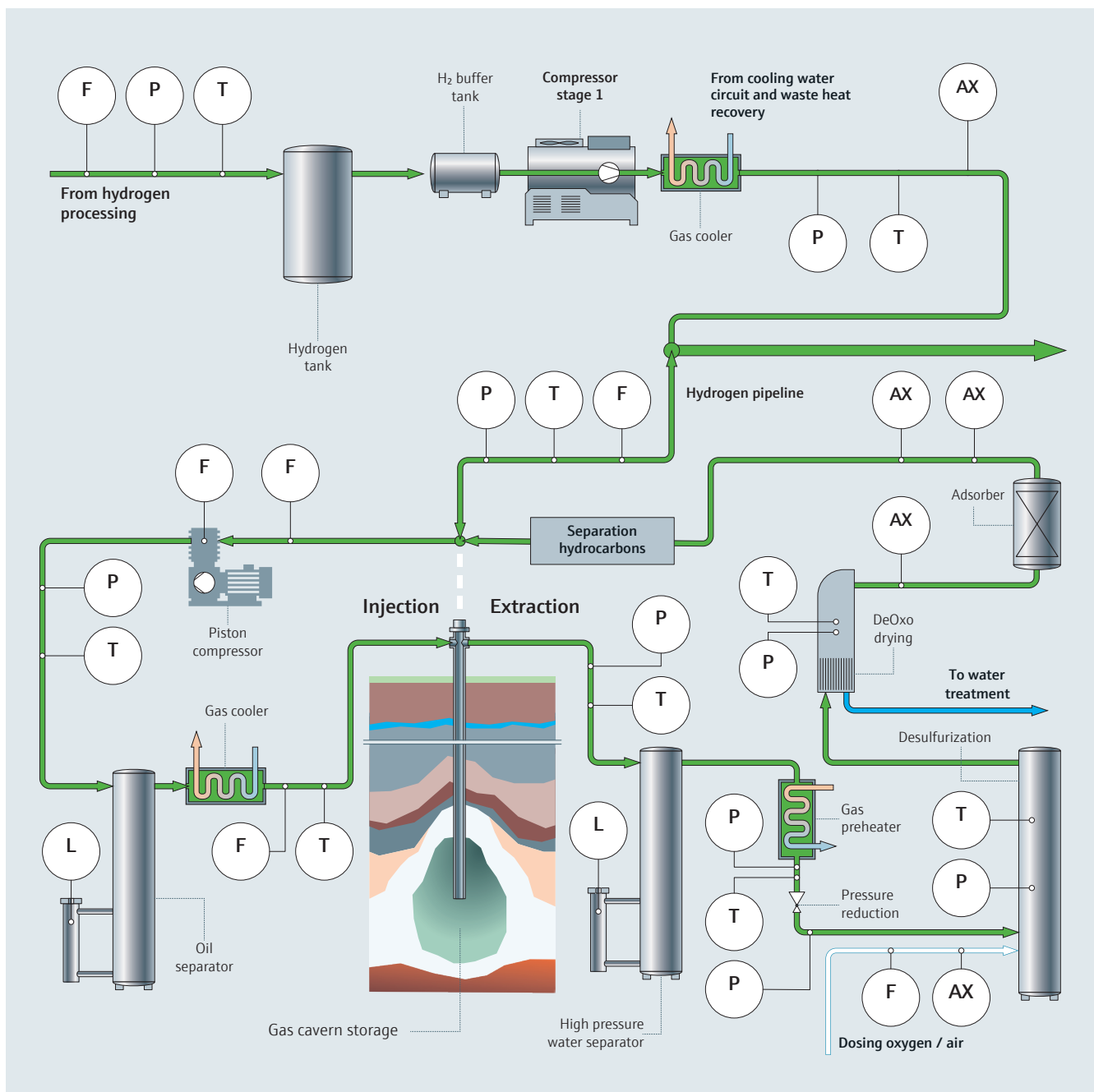
Combined Optical Analysis panel using TDLAS (J22) and Quenched Fluorescence (Oxy5500) for continuous monitoring of moisture (H₂O) and oxygen (O₂) in hydrogen, offering the following advantages:

- **Real-time measurement of process risk H₂ impurities** as outlined in ISO 19880-8 table B.5
- **Low maintenance:** No moving parts, no consumables
- **Robust and reliable construction**
- **Operational control** through embedded Heartbeat Technology on the J22 for reliable and lasting monitoring
- Easy installation with combined sample conditioning system mounted in single solution



Hydrogen compression and storage

Whether it's compression or storage in caverns, hydrogen remains the only energy vector capable of storing surplus energy. The highly precise sensors from Endress+Hauser will allow you to monitor the smooth progress of your process.



Relative pressure transmitter – Cerabar PMP71B / PMC71B

Pressure sensor with gold-coated metallic membrane for measurements on hydrogen.

- Measurement accuracy up to +/- 0.025 %
- Measuring range up to 700 Bar
- Remote configuration via Bluetooth and Smartblue application
- Verification of proper functioning through Heartbeat Technology



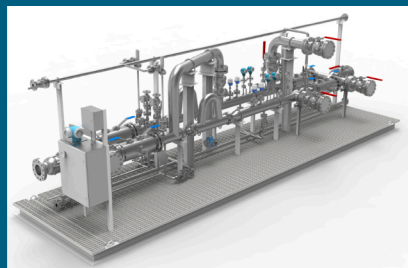
Temperature probe – iTherm Moduline TM131

Pt100 sensor with an integrated thermowell, suitable for both hazardous and non-hazardous areas.



- Pt100 sensor range from -328°F to +1112°F (-200°C to +600°C)
- Vibration-resistant version up to 60g (iTherm StrongSens) or with fast response time of 1.5s (iTherm QuickSens)
- Dual Seal: Containment enclosure for process safety with corrosion/leak detection of the protective sleeve
- Transmitter TMT82, HART with optional SIL certification

Transfer and zero loss solutions in hydrogen



Endress+Hauser, a 'ONE-STOP' supplier for your metering skids across the entire hydrogen value chain, including Hydrogen Blending into Natural Gas. To ensure reliable transactions and compliance with local and international standards, our expertise in the field accompanies you throughout the project.

Process safety

In hydrogen production applications, safety is a crucial element. Whether it involves personnel, facilities or the environment, it adheres to strict regulations and standards that evolve over time, requiring investments. However, we strive to ensure that safety does not compromise productivity for your plants.

i Functional safety

- **IEC 61505 – Functional safety of electrical/electronic/programmable electronic safety-related systems:** This generic standard provides specifications for the design of safety-related systems.
- **IEC 61511– Functional safety - Safety instrumented systems for the process industry sector:** This international standard for process industries establishes best practices in engineering systems to ensure the safety of an industrial process through instruments. These systems are referred to as Safety Instrumented Systems (SIS).



i Explosion protection

- **EX, FM and IECEx:** In electrical engineering, a hazardous area is defined as a location where concentrations of flammable gases, vapors or dust may occur. Electrical equipment intended for installation in these areas is specially designed and tested to ensure that it cannot trigger an explosion due to contact with an electrical arc or a high surface temperature of the equipment.
- Endress+Hauser instrumentation is offered across a wide variety of protection concepts including intrinsically safe, explosion proof, non-incendive and more.



Innovations in the service of safety

Dual Seal for TM131

Finger guard/glove for temperature sensor with containment chamber. The integrated pressure switch allows detection of a break in the finger guard/glove and communicates the information to the sensor. The containment chamber keeps the liquid secure and provides additional safety for operators.



Failsafe FTL80

Thanks to its self-diagnostic functions allowing it to achieve a SFF (Safe Failure Fraction) > 99% as well as its innovative system of internal redundancy, it is possible to implement it in a SIL 3 loop single track! Its 12-year test interval allows you to optimize your maintenance operations safely.



The challenge of cybersecurity

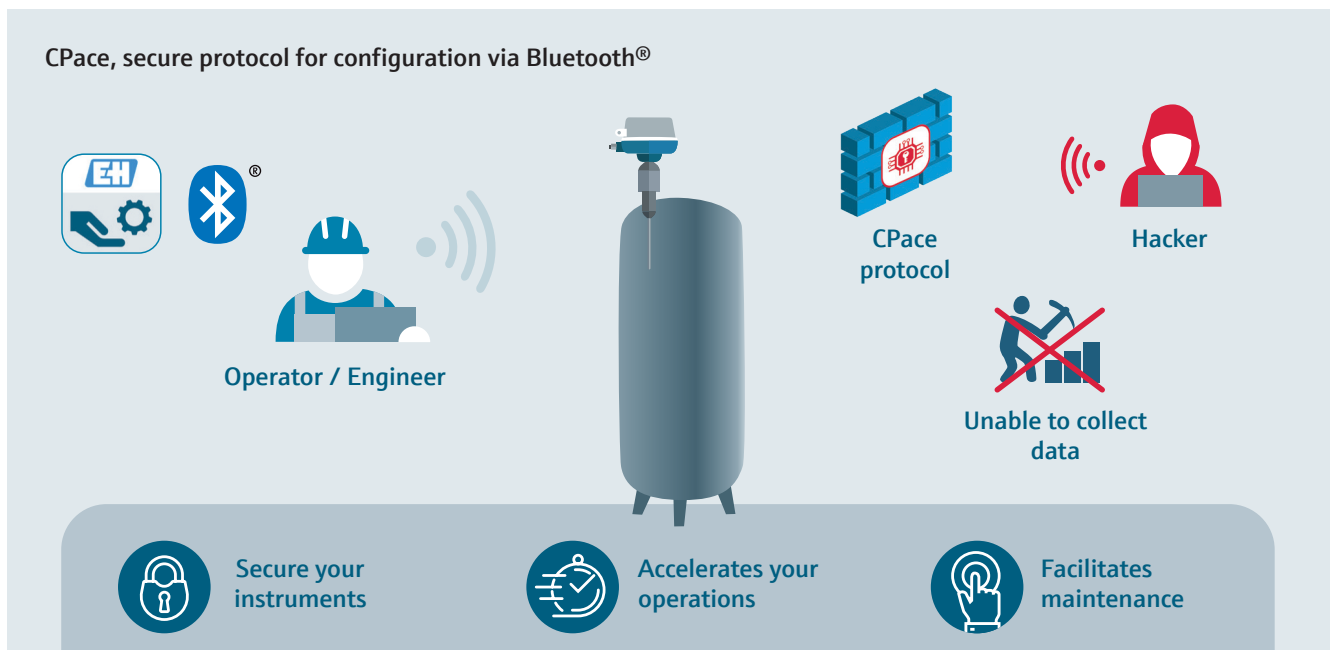
With the advent of digitization and the presence of so-called 'connected' instruments on industrial sites, the threat of a cyber-attack is a very real risk that should not be underestimated. At Endress+Hauser, we take this risk very seriously, which is why we are certified in both the design of our connected products (IEC62443), the security of our Netilion cloud solution (ISO 27017) and the data management of our production centers (ISO 27001).



Furthermore, we have aimed to position ourselves as a global player in cybersecurity with the development of a unique encryption protocol for password-free wireless communications. This protocol, already approved by the German Fraunhofer Institute, was selected following an

international competition by the IETF as the basis for future standards and is already used by all our Bluetooth devices* to ensure optimal security!

**Bluetooth option is enabled by chip and can be physically removed by the device or left off of the bill of materials for all associated transmitters.*



Our experts are here for you

Have a question or uncertainty about a standard? Trust our expertise:

- Qualified and certified personnel (SIL, DESP, FM, IECex, ATEX, CRN, INMETRO, NAMUR)
- Utilization of databases and useful software



Use ExiCalculator for your calculations of intrinsically safe loop Ex "i"
Download the application from the Apple Store or Play Store.



Applicator, for the selection of your devices, stress calculations, sizing and corrosion resistance.

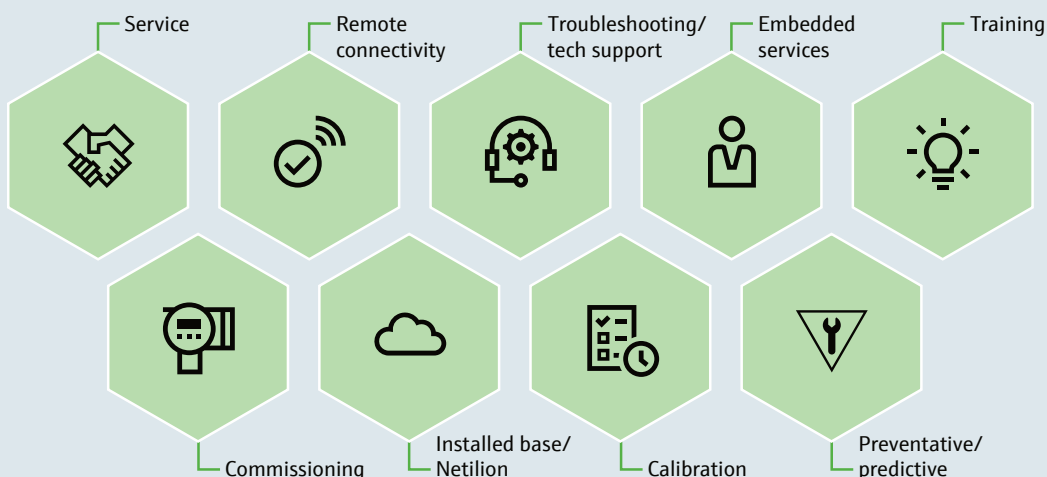


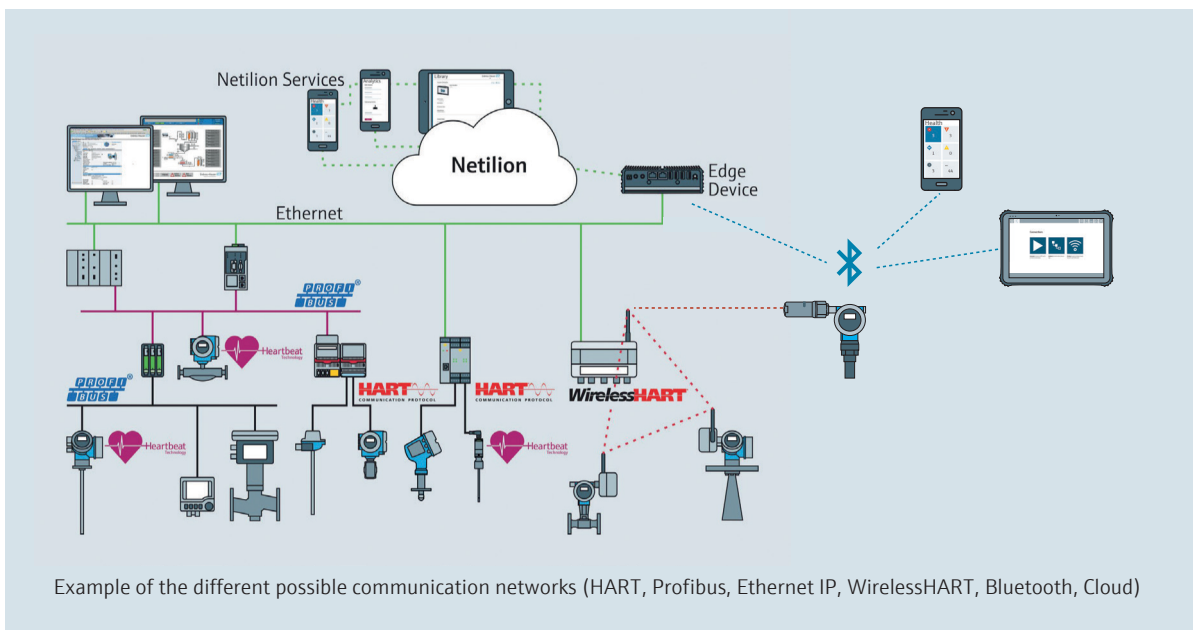
Digitalization is at the heart of the energy transition

Today, sensors have multiple pieces of information that are not fully utilized. Digitalization allows for optimizing the monitoring and maintenance of your process.

Regardless of the chosen communication networks, Endress+Hauser is here to support you at all levels: sensors, converters and gateways.

Predictive and preventative maintenance through verification, monitoring and diagnostics





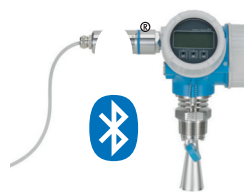
Store



Connect



Convert



Adapt



Collect



Optimize your maintenance, improve your process

Do you want to increase the availability of your facility and reduce your costs?



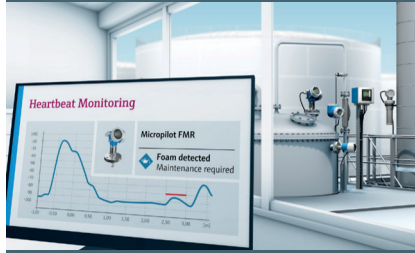
With **Heartbeat Technology**, Endress+Hauser offers the widest range of devices with an innovative diagnostic and verification concept.

Heartbeat Technology enables cost-effective and safe operation of the installation throughout its lifecycle by quickly combining diagnostic, verification and monitoring functions.

Digital reporting with Heartbeat Verification can reduce paper use in plant walkdowns or maintenance checks while offering pathway for partial proof testing to ensure safety loops are working properly.



More straightforward and efficient control of your measuring points.

Heartbeat Technology		
<p>Heartbeat Diagnostics</p>  <p>Continuous self-diagnosis of devices</p>	<p>Heartbeat Verification</p>  <p>Documented verification without process interruption</p>	<p>Heartbeat Monitoring</p>  <p>Information for predictive maintenance</p>
Increased availability of the installation and...		
...self processes	...optimization of the process and maintenance strategy	...optimization of the process and maintenance strategy

- Explicit and standardized **diagnostic messages** with clear operation instructions facilitate maintenance
- The **permanent self-diagnosis** of the device enables safe operation with extended verification cycles

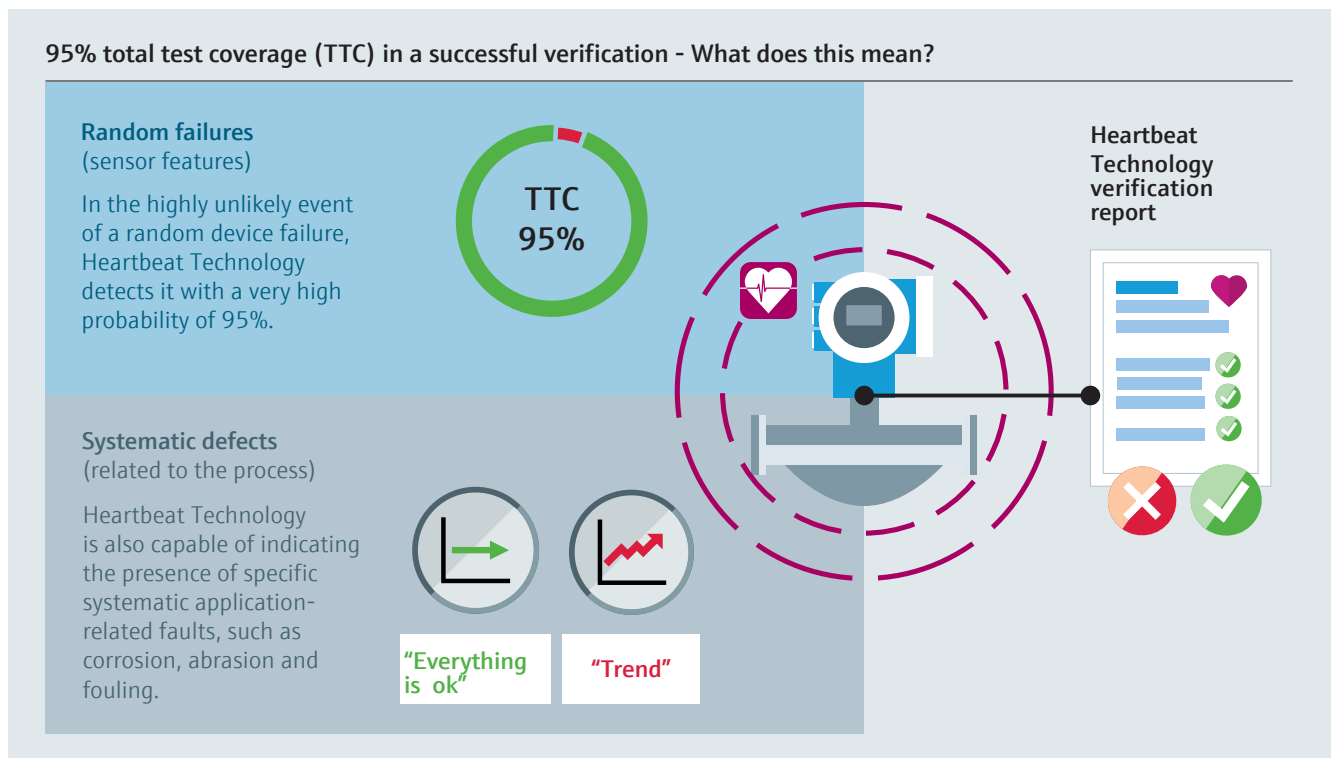
- The automatically generated **report of proper functioning** provides the evidence required by regulations, laws and standards
- The measuring point can be **verified and documented in-situ** at any time
- A simple and guided verification procedure consistently yields clearly documented verification results

- **Coriolis flowmeters:** Abrasion detection - corrosion or tube fouling detection - entrained gas detection - cavitation detection
- **Vibrating fork level detection:** Corrosion or abrasion detection of the forks
- **Pressure/differential pressure:** Detection of blocked impulse lines, water hammer, corrosion in the current loop

Heartbeat Verification: Improve production and maintenance efficiency in a comfortable, safe and compliant manner

With **Heartbeat verification**, the functionality of your measuring device can be assessed at any time, in situ, and in a very short time, without the need for external tools or interrupting the process. Verification not only involves checking whether the components of the device still conform

to their original reference values but also indicates the presence of systematic defects that could have a negative impact on the device or process performance, such as corrosion, abrasion or fouling.



Heartbeat Monitoring: Be efficient and proactive in your operations

In particularly challenging process conditions, certain events can occur and influence the performance and reliability of a device. Examples of such events include corrosion or abrasion of parts of the sensor in contact with the fluid or the appearance of foam in a tank. These

events will influence the physical responses of the device. Heartbeat Technology detects these events and converts them into easily understandable information by providing insights into the process and the device.

Monitoring operating conditions enables predictive maintenance by identifying process conditions that may have a negative impact on the integrity of the instrument or on process performance.

Corrosion	Abrasion	Clogging	Mechanical stress	Thermal stress	Aging sensor
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Support for **process optimization** enables the identification of anomalies (non-critical to the integrity of the instrument but potentially affecting its performance) and monitoring the **state of the instrumental installation** enhances the reliability of the measuring point.

Inhomogeneous fluid	Foam detection	Availability	Connection and power
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Compliance of measuring points

The performance and compliance of your installations and measuring points require a rigorous and systematic approach to monitoring the critical instrumentation fleet. Call on us during your shutdowns or other maintenance activities.

Commissioning: your guarantee for operational instruments

Benefit from Endress+Hauser's expertise to commission instruments optimally. Take advantage of the extended warranty to cover any unforeseen costs and reduce the total cost of ownership.

Support and maintenance contract

With the service contract, you optimize your instrument fleet without the risk of additional costs. The implementation of a contract provides you with additional peace of mind.

- Be sure that maintenance services are **carried out on time**
- **Receive regular visits** from a technician who provides maintenance advice
- If you wish, **wear parts can be included in the contract**
- Contracts can also **include equipment from other brands**

Accredited laboratory calibration

Temperature, pressure, flow, physico-chemical analyses (conductivity, pH).

- **A single provider** for all types and brands of equipment
- **Services performed according to metrology standards and references** (NF EN ISO/IEC 17025, NF EN ISO 10012, NIST, ASME-MFC-9M)
- **Accredited laboratories** AL2A, COFRAC, SCS, SIT or Dakks (DKD)



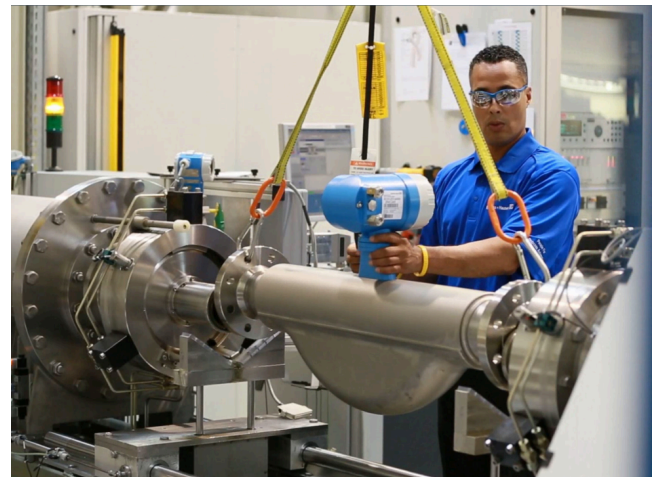
On-site calibration of your flowmeters with our Mobile Labs

For reasons of finished product quality and regulatory compliance, it is necessary to periodically check the measuring performance of critical instruments. Flow is one of the most important parameters in the process but also the most difficult to control.

To address this issue, we offer a new service: on-site calibration of flowmeters in a minimum of time and constraints.

This service is performed with our new fully autonomous mobile bench equipped with a water reservoir. With minimal footprint, this bench is designed to be brought as close as possible to the process. The device is placed on the bench, calibrated and immediately reinstalled on the process.

- The most accurate service on the market
- All brands
- Time savings and simplified planning
- Excellent value for money



Our offer We are able to field calibrate flowmeters of all brands

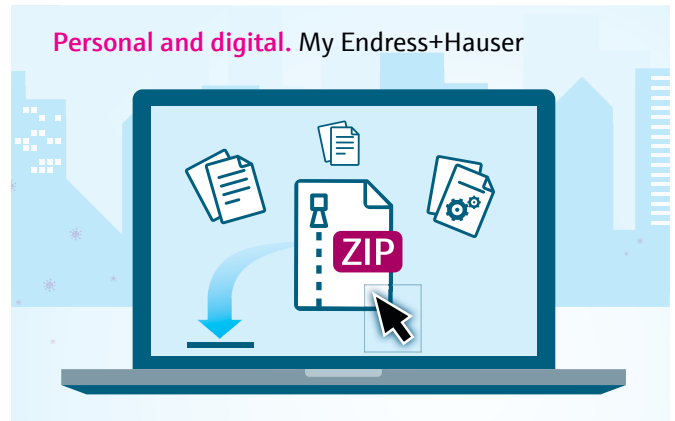
Type of instruments	From DN10 (3/8") to DN80 (3") - other diameters on request <ul style="list-style-type: none"> ■ Electromagnetic flowmeters ■ Coriolis mass flowmeters ■ Vortex flowmeters ■ Inline ultrasonic ■ Third-party rotameters
Fittings	ASME or DIN flanges, ISO 2853 Clamp, Tri-Clamp, SMS 1145 and DIN11851 fittings
Calibration range	0 to 100 gal/min
Uncertainty calibration (k=2)	± 0,25 % or the value read*
Calibration fluid	Water
Number of points	2 points as standard in the calibration range, 3rd point optional
Documents provided	<ul style="list-style-type: none"> ■ Calibration certification or Verification Report delivered on site ■ Proof of traceability of standards available on our website
Maintenance	<ul style="list-style-type: none"> ■ Guaranteed maintenance service provided for Endress+Hauser electromagnetic flowmeters: ■ Adjustment of flowmeters as feasible

* The uncertainties are not guaranteed and may be degraded by the device being calibrated (stability, repeat-ability...)

My Endress+Hauser always at your fingertips

Keep an overview of your prices, transactions and more with My Endress+Hauser.

The new features transform endress.com into a powerful and intelligent cooperation platform that connects you directly to us and our extensive network of sales representatives. Your personalized space allows you to perform your operations in just a few minutes. Manage your transactions, purchase products, order spare parts, download documentation and access your contacts – at the office, in the field or on the go, all with “My Endress+Hauser.”



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