Online-Chlorine Measurement in the Water Technology

Referee: Ulrike Storm (Dipl.-Biologist)

Introduction of JUMO

JUMO GmbH & Co.KG, Germany
Equipped for the Global Market

Founding year: 1948

Employees: 1,300 Germany, 900 internationally

Locations: In over 60 countries worldwide

Production sites: At 14 locations worldwide

Temperature sensor production   Headquarter, administration, and production sensors + automation

Our Sensor Solutions

Our Automation Solutions

Control

Recording

Automation

Monitoring

Your contact in Brazil:

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Online-Chlorine Measurement
in the Water Technology

Agenda

- Portrait of Chlorine - Features

- Chlorine Measurement - Operation Conditions
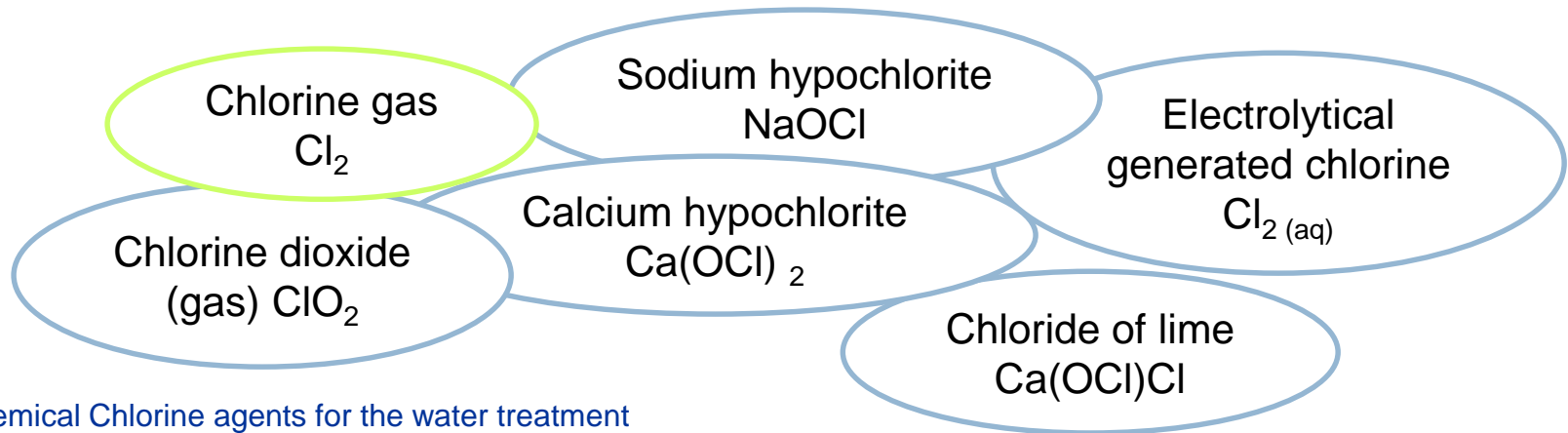
- Online-Chlorine Measurement

- JUMO digiLine

Portrait of Chlorine - Features

Portrait of Chlorine - Features

- At room temperature pure Chlorine (Cl_2) is a yellowish green gas with a pungent odour

- Chlorine and ít´s anorganic compounds are **oxidzing agents**

- Added to water they work as an **disinfectant** to reduce pathogens

Chlorine gas
Cl_2

Sodium hypochlorite
NaOCl

Electrolytical
generated chlorine
$Cl_{2\ (aq)}$

Chlorine dioxide
(gas) ClO_2

Calcium hypochlorite
Ca(OCl) $_2$

Chloride of lime
Ca(OCl)Cl

Chemical Chlorine agents for the water treatment

Portrait of Chlorine – Features

Advantage

- **Highly reactive/effective** against bacteria and other microbes

- **Easy to handle**, safety rules must be observed!

- The most **economical** (price/performance) way for disinfection

Disadvantage

- **Toxic and harmful** on human beings
- **Corrosive** on materials

=> Dosing rate and Chlorine concentration in water has to be controlled!

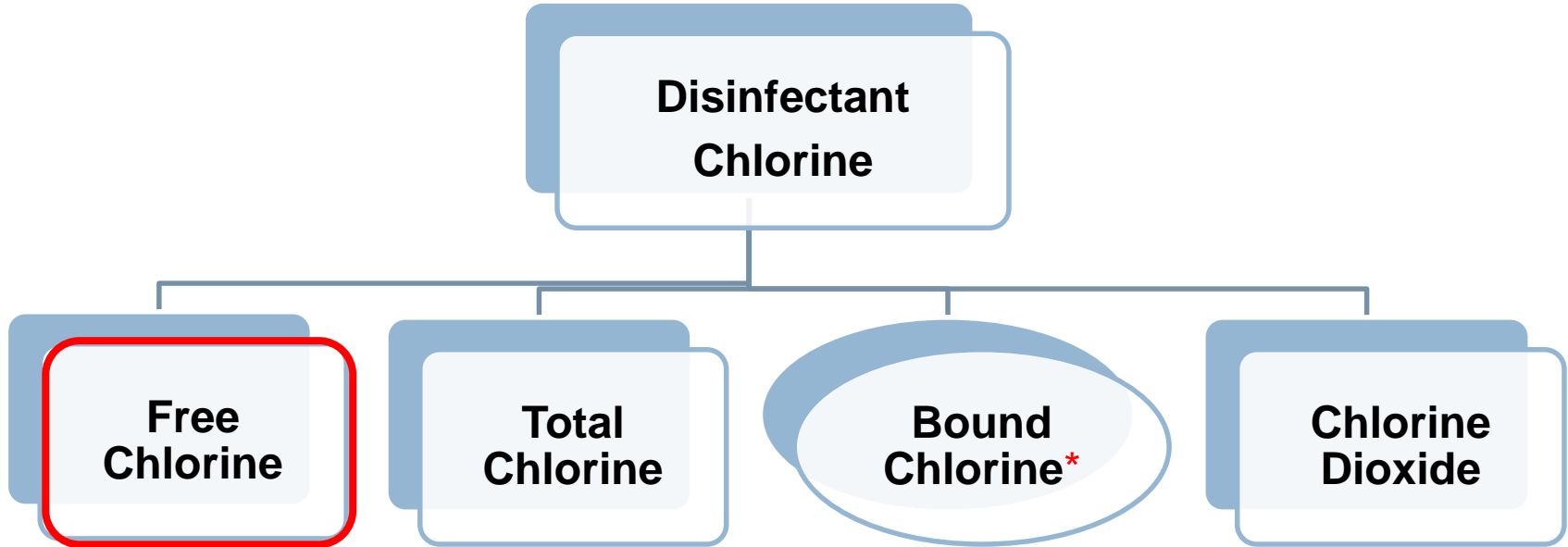# Water Chlorination - Applications

- Swimming Pool Water

- Drinking Water

- Sewage/Recycled Water Treamtent

- Inlet water of RO-Systems

- Cooling Towers

- Gas scrubber

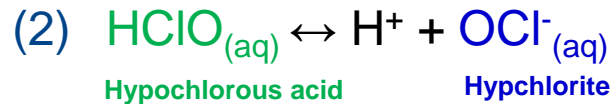# Chlorine Measurement and Operation Conditions
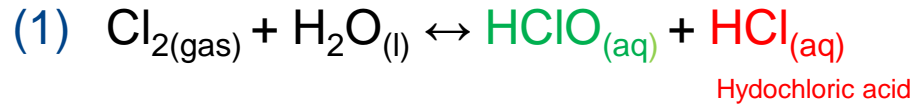
Chlorine Measurands

```
                    ┌─────────────────┐
                    │   Disinfectant  │
                    │    Chlorine     │
                    └────────┬────────┘
       ┌─────────────┬───────┴───────┬─────────────┐
  ┌─────────┐   ┌─────────┐   ┌─────────┐   ┌─────────┐
  │  Free   │   │  Total  │   │  Bound  │   │Chlorine │
  │Chlorine │   │Chlorine │   │Chlorine*│   │ Dioxide │
  └─────────┘   └─────────┘   └─────────┘   └─────────┘
```

Disinfectant Chlorine

Free Chlorine **Total Chlorine** **Bound Chlorine*** **Chlorine Dioxide**

* It is the difference of Total to Free Chlorine

Free Chlorine – Main Chlorine Measurand

- **Free Chlorine** $= Cl_2 + HClO + OCl^-$

- It´s concentration is the main parameter to be measured

Equilibrium of Chlorine (Cl_2) and Hypochlorite ($HClO$) in water:

(1) $Cl_{2(gas)} + H_2O_{(l)} \leftrightarrow HClO_{(aq)} + HCl_{(aq)}$

Hydochloric acid

(2) $HClO_{(aq)} \leftrightarrow H^+ + OCl^-_{(aq)}$

Hypochlorous acid   **Hypchlorite**

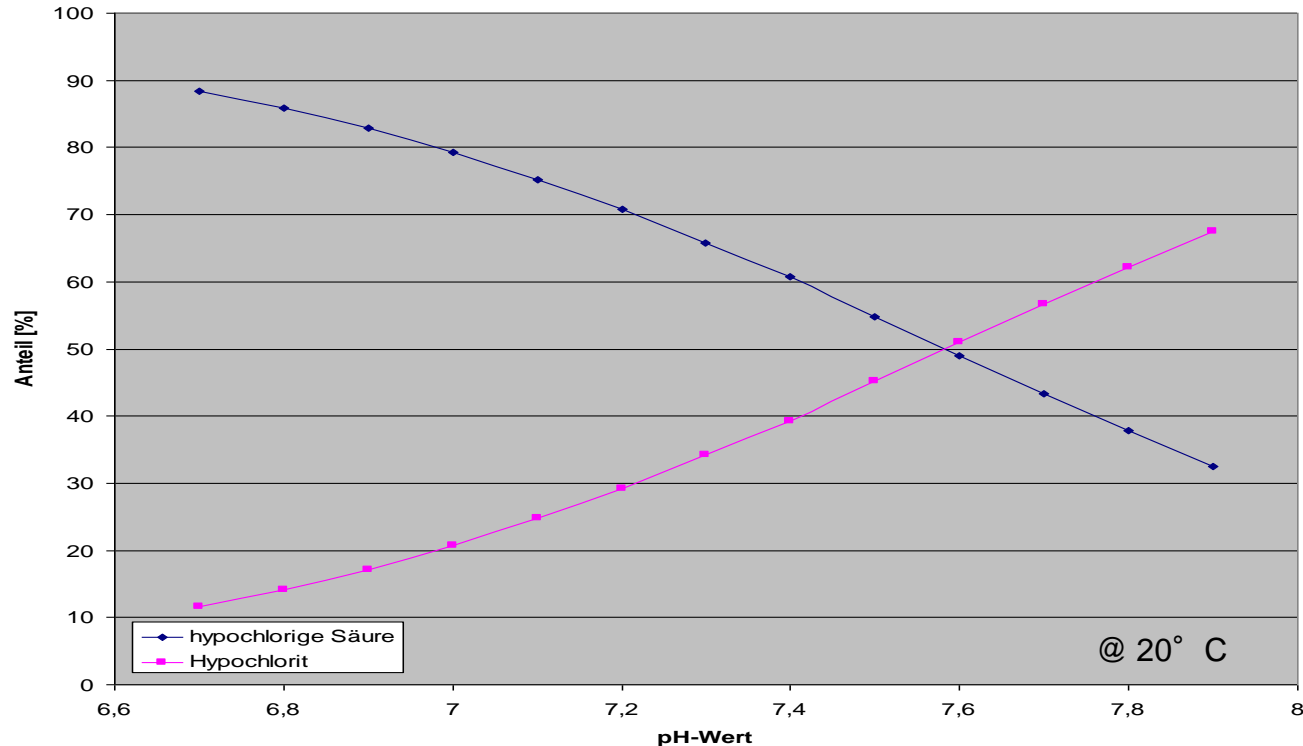- The proportion of the species in water is strongly **pH-dependant**

- **Cl2** is stable at pH < 3

- **HOCl** is the most effective disinfectant species at **pH 6,5 to 8,5**
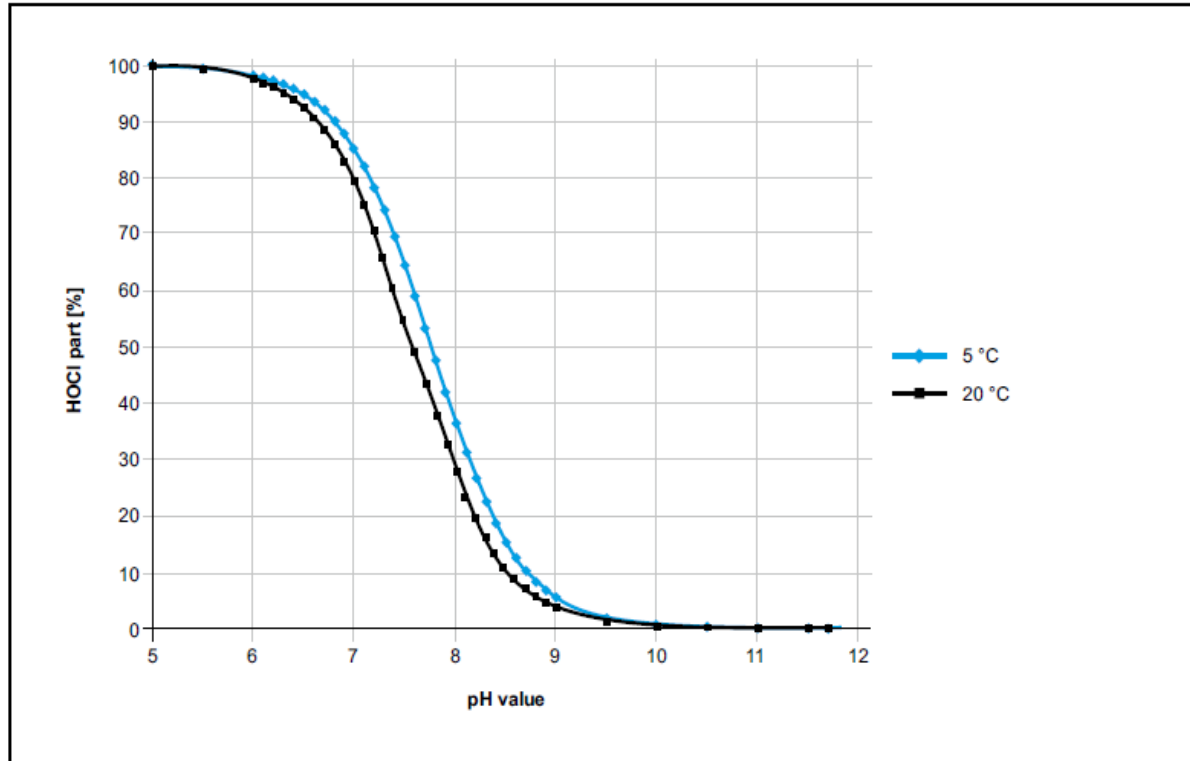
pH-scale

acid

basic
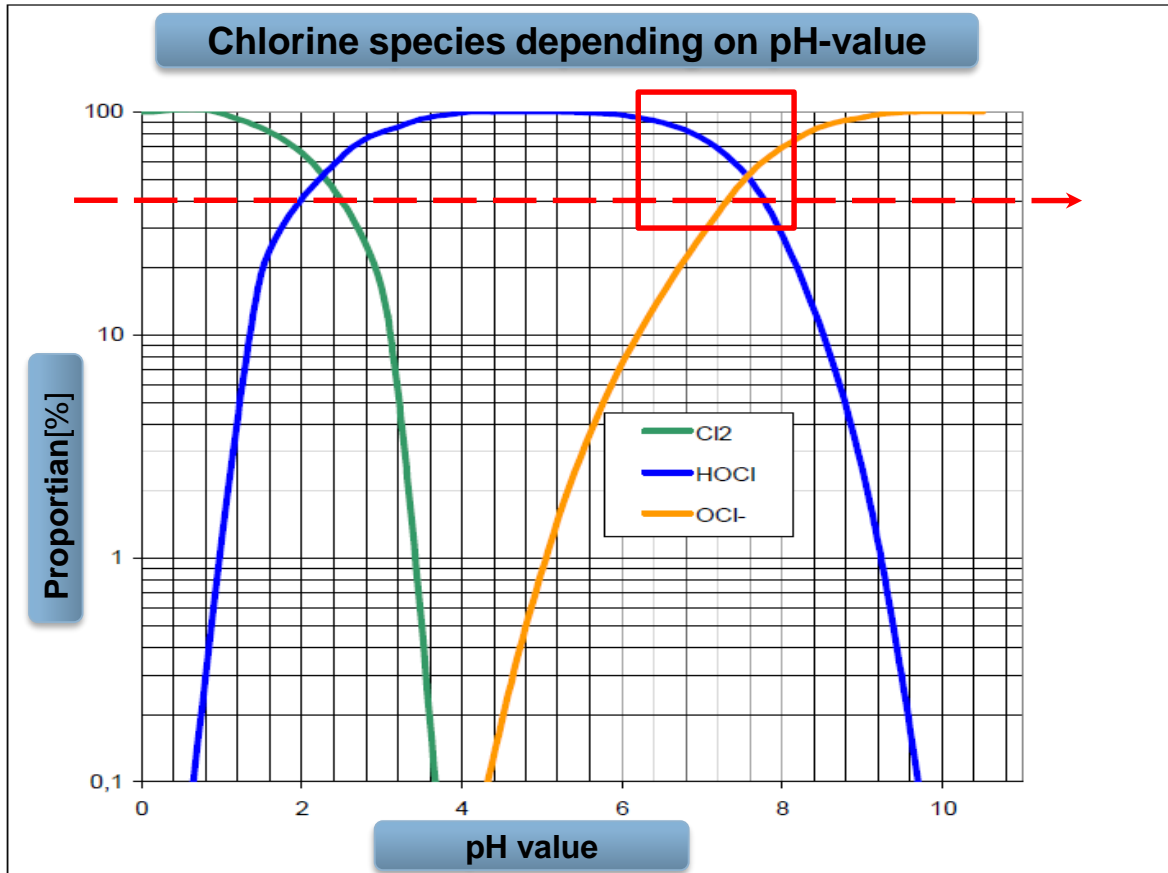
pH Dependency of the Proportion HOCl/OCl⁻

Source:

Dr. J. Schleicher, EW

Temperature Influence on the Chlorine Measurement

Chlorine and Operation conditions

Conclusion

- The water parameters **pH value** and **temperature** have also to be controlled beside the Chlorine concentration

Solution:

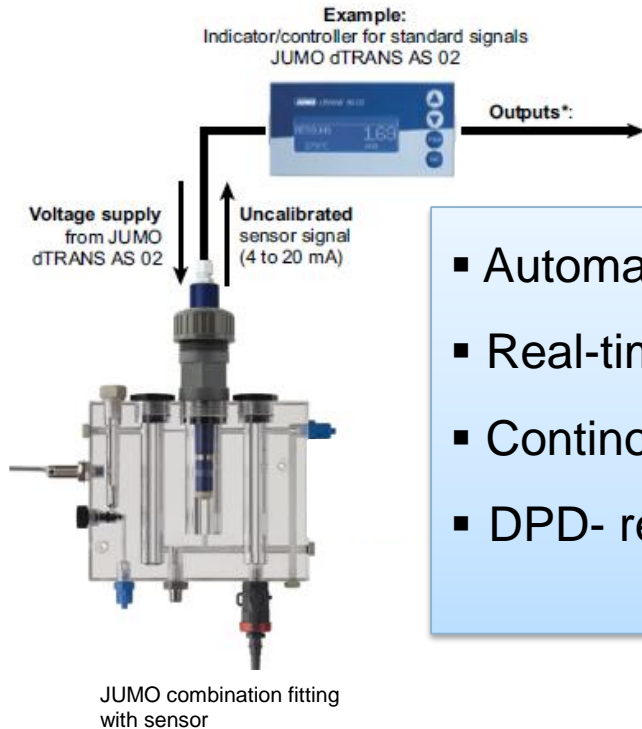- Complete online system for multiparameter measurings, visualisation, controlling and registration

Online-Chlorine Measurement System

Online Measurement – Core benefits

Example:
Indicator/controller for standard signals
JUMO dTRANS AS 02

Outputs*:

Voltage supply
from JUMO
dTRANS AS 02

Uncalibrated
sensor signal
(4 to 20 mA)

JUMO combination fitting
with sensor

- Automatic monitoring of permissible concentration limits

- Real-time measurement

- Continous and trouble-free operation of water disinfection

- DPD- reagents are only needed for calibration purposes

Online - Chlorine Measurement System
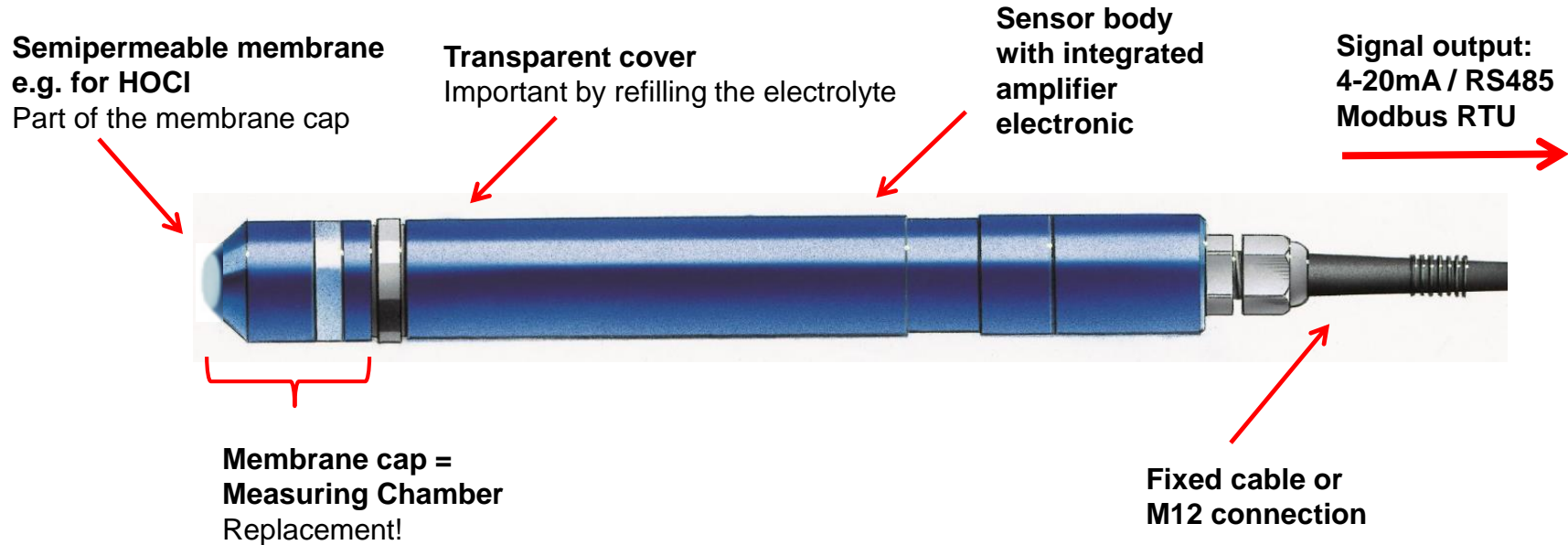

Amperometric Sensor

Fitting
with flow control

Transmitter with calibration menu

Amperometric Membrane covered Sensor

Semipermeable membrane e.g. for HOCl
Part of the membrane cap

Transparent cover
Important by refilling the electrolyte

Sensor body with integrated amplifier electronic

Signal output: 4-20mA / RS485 Modbus RTU

Membrane cap = Measuring Chamber
Replacement!

Fixed cable or M12 connection

▪ Sensor with integrated temperature compensation!

Amperometric Membrane covered Sensor

(1) Pg screw fitting
(2) Cover
(3) O-ring
(4) 2-pin terminal for measurement cable connection
(5) Electrode shaft with integrated electronics
(6) O-ring
(7) Electrode finger (reference electrode)
(8) Measurement electrode
(9) Transparent cover
(10) Membrane cap
(11) PTFE membrane
(12) Valve opening
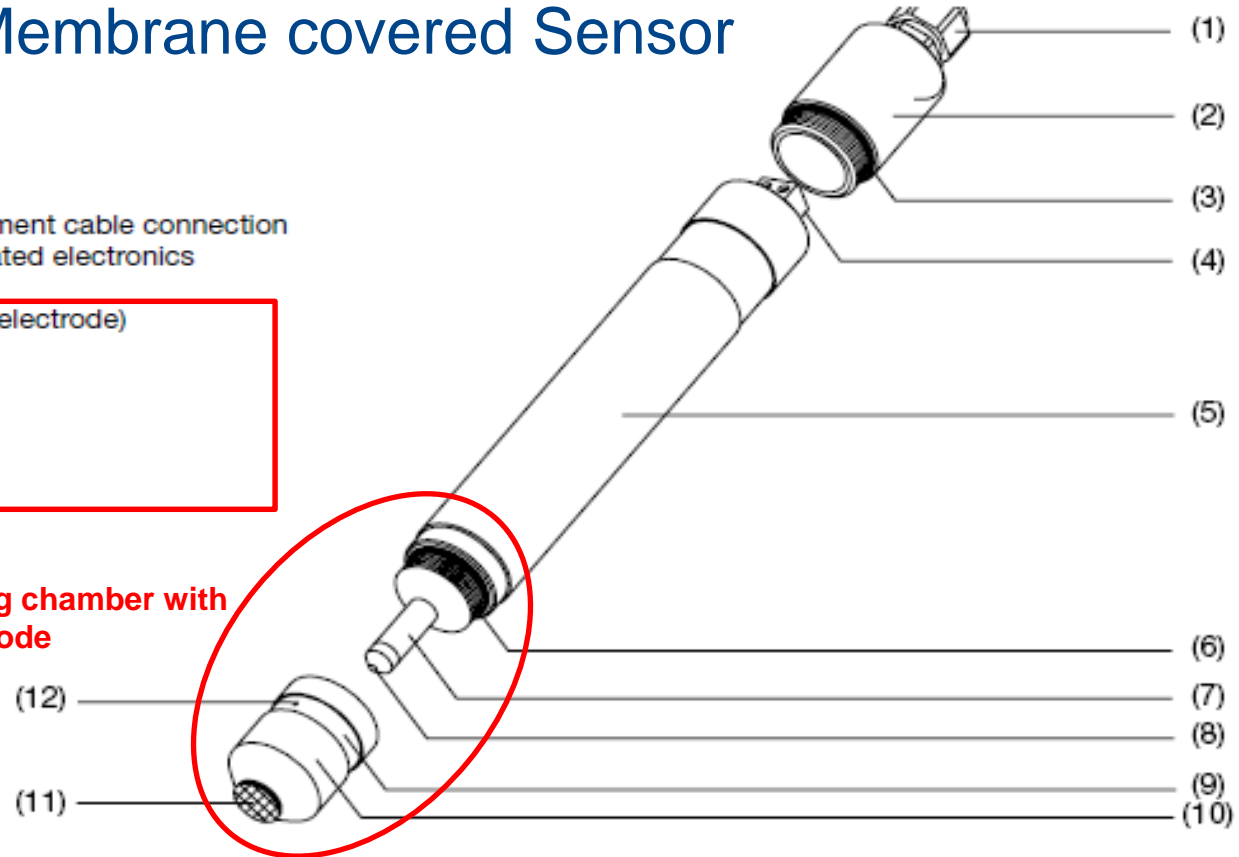
**Measuring chamber with the electrode**

Amperometric measuring principle

- Parts: 2 /3 –Electrodes, Electrolyte*, Membrane*

- The analyte (=disinfectant) penetrates through the membrane into the electrolyte and is converted, a current is measured.
  - ⇒ A certain constant voltage (**polarization voltage**) is applied between working electrode (WE) and counter electrode (CE).
  - ⇒ The analyte (e.g. HOCl) reacts at the given voltage.
  - ⇒ The electrical current is proportional to the chlorine concentration in the liquid.

* Replacement!

Amperometric sensor

Anode (CE)

Cathode (WE)

Electrolyte

Membrane (semipermeable)
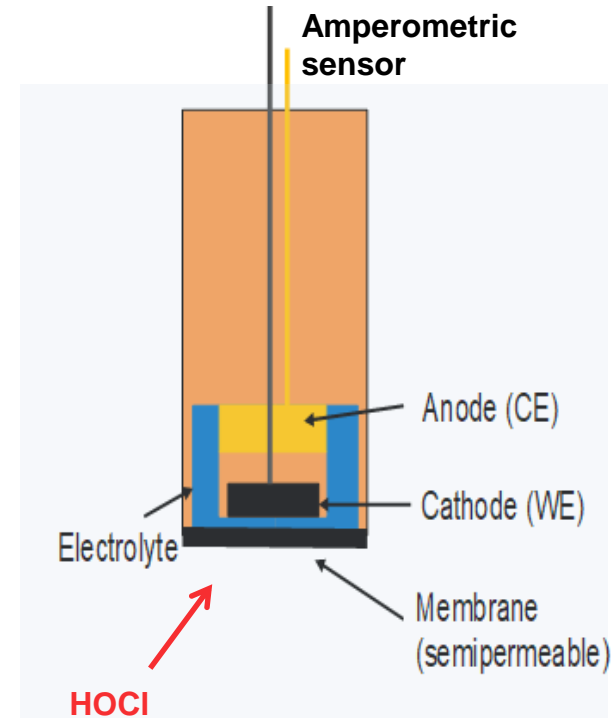
HOCl

Membrane – Features

- Avoids pouring out of the electrolyte

- Avoids contamination through impurities

- Is permeable for HOCl

- Limited to water pressure (max. 1 bar to 3 bar dependent on the type of membrane/sensor)

- Can block by biofilm

  $\Rightarrow$ Useable only in „optically clean" water

  $\Rightarrow$ Not useable for detecting the absence of disinfectant!

(1)
(2)
(3)
(4)

PTFE

(1)
(2)
(3)
(5)
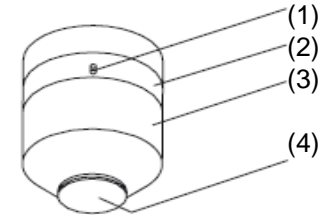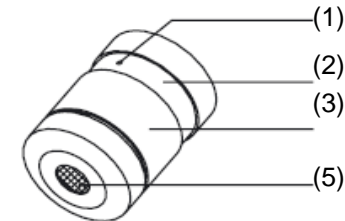
Rubber elastic

Components
1 – Valve opening
2 – Transparent cover
3 – Membrane cap
4 – PTFE membrane
5 – Rubbery elastic membrane

Amperometric Membrane covered Sensor

- Common technology with high measuring accuracy

- Easy installation, and maintenance

- Low dependency on the incident flow

- Integrated temperature compensation

- Long-term stability

Technical data specification

Sensor type	202630/40	202630/50
Measurand	Free chlorine	
Area of application	Swimming pool water, drinking water, service water and process water	
Suitable chlorination agents	Inorganic chlorine compounds: NaOCl (sodium hypochlorite), Ca(OCl)$_2$, chlorine gas, chlorine produced by membrane electrolysis (not suitable: chlorine electrolysis without a membrane)	
Measuring principle	Membrane-covered, amperometric, two-electrode system with integrated electronics	
Membrane type	Hydrophobic PTFE membrane	
Measuring cable connection	2-pin terminal connection (2 × 1 mm^2)	5-pin flange connector, M12
Voltage supply	U_B DC 12 to 30 V (galvanic isolation required)	U_B DC 22.5 to 26 V (galvanically isolated from the sensor)
Electromagnetic compatibility[a]	Interference emission: class B[b] Interference immunity: to industrial requirements	
Output signal	4 to 20 mA	Modbus RTU
Load/current consumption	≤ (U_B - 7.5 V) ÷ 0.02 A	approx. 20 mA
Settling time	1 h	
Inflow speed	Approx. 15 cm/s (corresponds to a flow of approx. 30 l/h when installed in the JUMO flow fitting (part no.: 00392611))	
Measuring ranges[c]	0.05 to 0.5 mg/l (ppm) 0.05 to 2 mg/l (ppm) 0.05 to 5 mg/l (ppm) 0.05 to 10 mg/l (ppm) 0.05 to 100 mg/l (ppm) 0.05 to 200 mg/l (ppm)	0.05 to 2 mg/l (ppm) 0.05 to 20 mg/l (ppm)

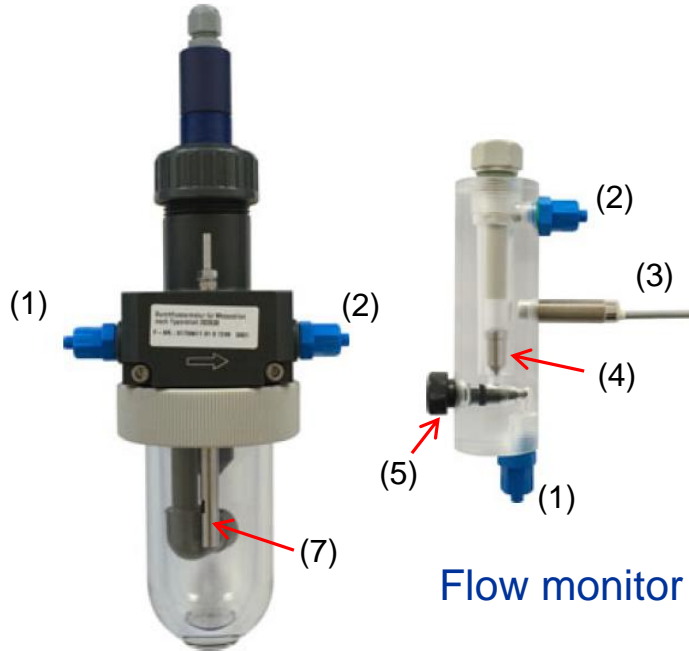| Resolution	0.01 mg/l with measuring range 0.5/2/5/10 mg/l 0.1 mg/l with measuring range 100/200 mg/l	0.001 mg/l with measuring range 2 mg/l 0.01 mg/l with measuring range 20 mg/l
Slope drift[d]	Approx. < -1 % per month	
Response time $_{t90}$	approx. 30 s	
Operating temperature		
Sample water temperature	0 to 45 °C[e]	
Ambient temperature	0 to 55 °C	
Temperature compensation	Automatic, using integrated temperature probe	
Zero point adjustment	Not required	
Slope adjustment	On evaluation unit/controller using analytical chlorine determination (DPD-1-method)	
pH value operating range	pH 6 to pH 8 Note the effect of the pH value on the disinfecting properties, corrosion and the dissociation curve.	
pH dependence (loss of slope)	with pH 8, approx. 65 % with pH 9, approx. 95 % (starting at pH 7)	
Disturbances	ClO_2: recorded with a concentration factor of 9 O_3: recorded Chlorine electrolysis without a membrane can cause disturbances	
Pressure resistance[f]	P_{abs} max. 2 bar P_{rel} max. 1 bar	
Materials	Semi-permeable membrane, PVC-U	
Dimensions	Dia. 25 mm, length 220 mm (housing with membrane cap)	Dia. 25 mm, length 205 mm (housing with membrane cap)
Weight	Approx. 125 g	

Further Disinfectants

Disinfectants
- Bromine
- Ozone
- Peracetic Acid
- Hydrogen Peroxide
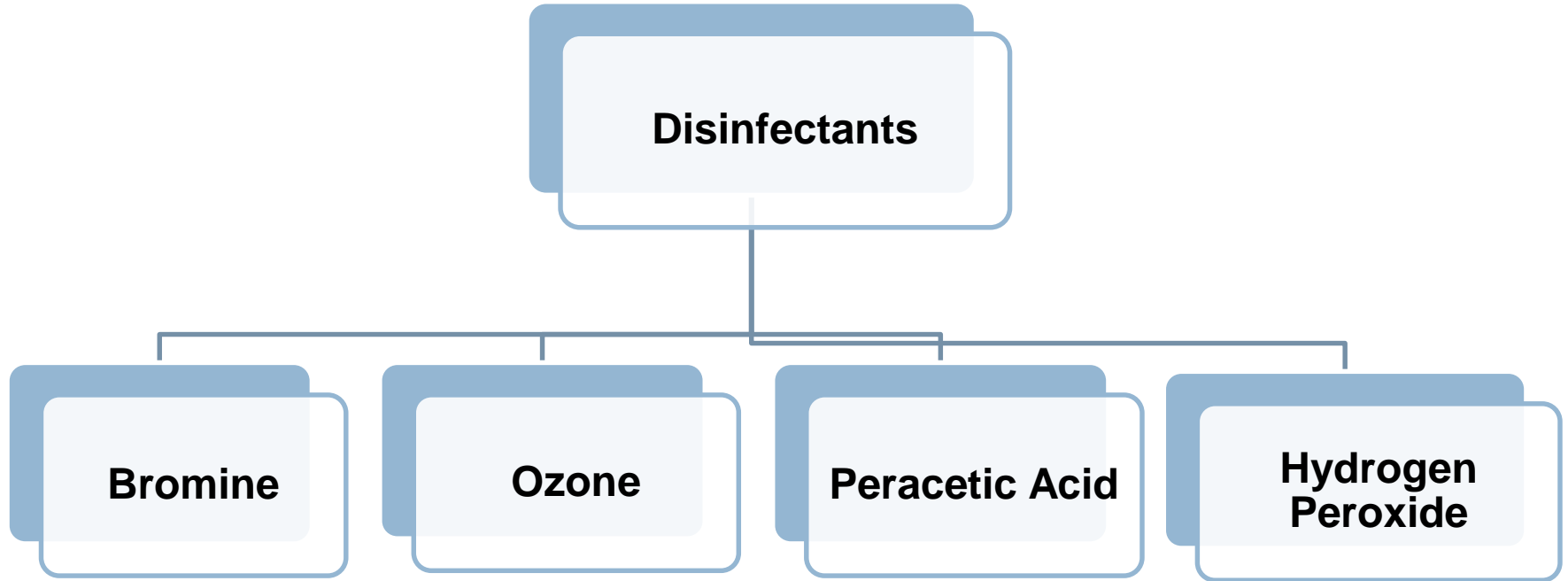
Fittings for Membrane covered Sensors

Fittings for Membrane covered Sensors

(1) — (2)

(7)

Single fitting

(2)

(3)

(4)

(5)

(1)

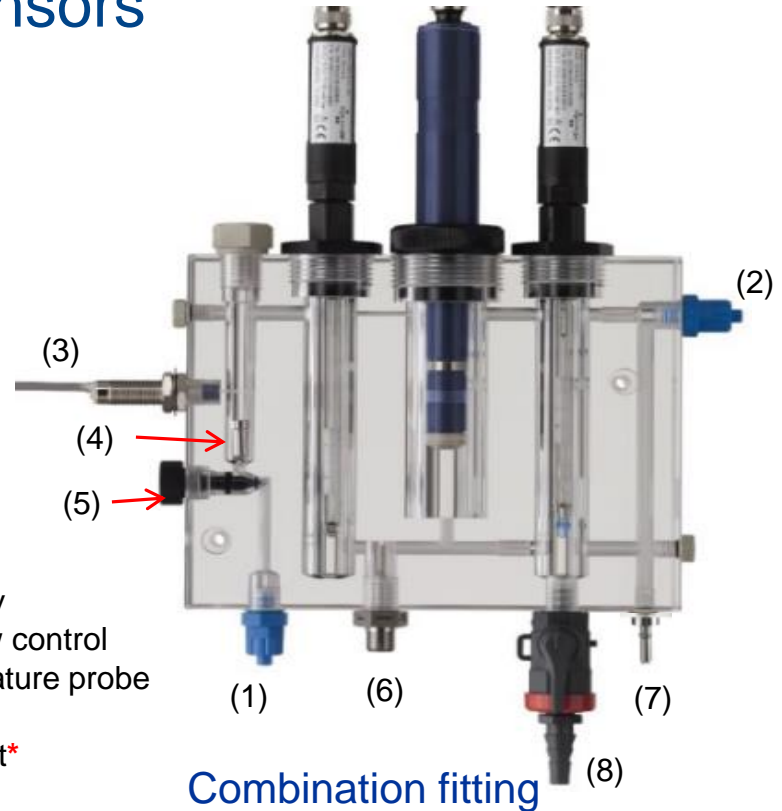**Flow monitor**

(1) Water Inlet
(2) Water outlet
(3) Flow monitor
(4) Floating body
(5) Valve for flow control
(6) RTD temperature probe
(7) Ground pin*
(8) Sampling unit*
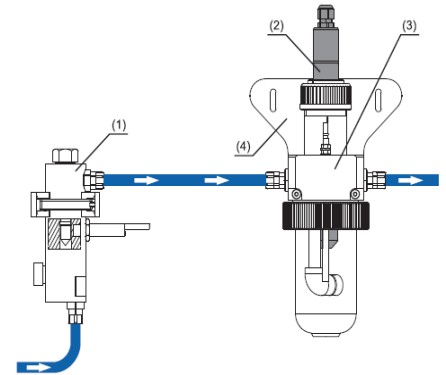* optional

(3)

(4)

(5)

(2)

(1)   (6)   (7)

(8)

Combination fitting

Fittings for Membrane covered Sensors

Requirements are fulfilled:

- Vertical installation

- Flow monitoring, min. flow of 30l/h is sufficient

- Constant water pressure (relative pressure of up to 1 bar or 3bar dependent on the sensor type)

- Easy installation and maintenance of the sensor

=> The sensor is usually installed in a bypass, and not directly into a pipe or tank

=> Fitting is a mechanical protection for the sensor!

Transmitters

Chlorine transmitter – Core Features

From a single parameter system …….

Basic functionalities

- Voltage supply for the sensor (DC12-30V)

- Outputs 4-20mA / 0-10V

- Calibration menu / calibration logbook

- Flow monitoring

- Controller functions

- Data logging/Recording function

(1) JUMO dTRANS AS 02
(2) Measuring cell for free chlorine, type 202630
(3) Flow monitor, type 202811/20

Chlorine transmitter – Core Features

.......to a multiparameter system

- Up to 15 analytical parameters are connectable

- Multi-channel, multi-controller facilities

- Intuitive user-interface via TFT touchscreen

- Modular expandable with in/outputs, serial interfaces as RS 422/485 Modbus RTU, Profibus, Profinet

- Math/Logic formulas

- Extensive data recorder with manipulation-safe protocolling

- Web-browser and Online-visualisaton

JUMO AQUIS touch S/P

Calibration

- **One point calibration** of the Slope

- The reference value for chlorine is the chlorine concentration in the medium

- **Reference Test equipment required:** Photometer + DPD colorimetric kit

- **Recalibration** after appr. time of 1 to 4 month provided constant operation conditions

Photometer, DPD-Method

A Zero – Point/Span calibration is not necessary!

Chlorine Measurement System – Premounted on panels

Source:
Witty GmbH & Co. KG, Germany

- Compact solution

- Easy to install

- Space-saving

- Readily accessible

- Calibration is simply to perform

Chlorine Measurement System – Premounted on panels

- Accurate control of Chlorine concentration and pH value

- Remote display via web browser

- With connection to the central control station

=> Practice-oriented solution, according to customer specific requirements
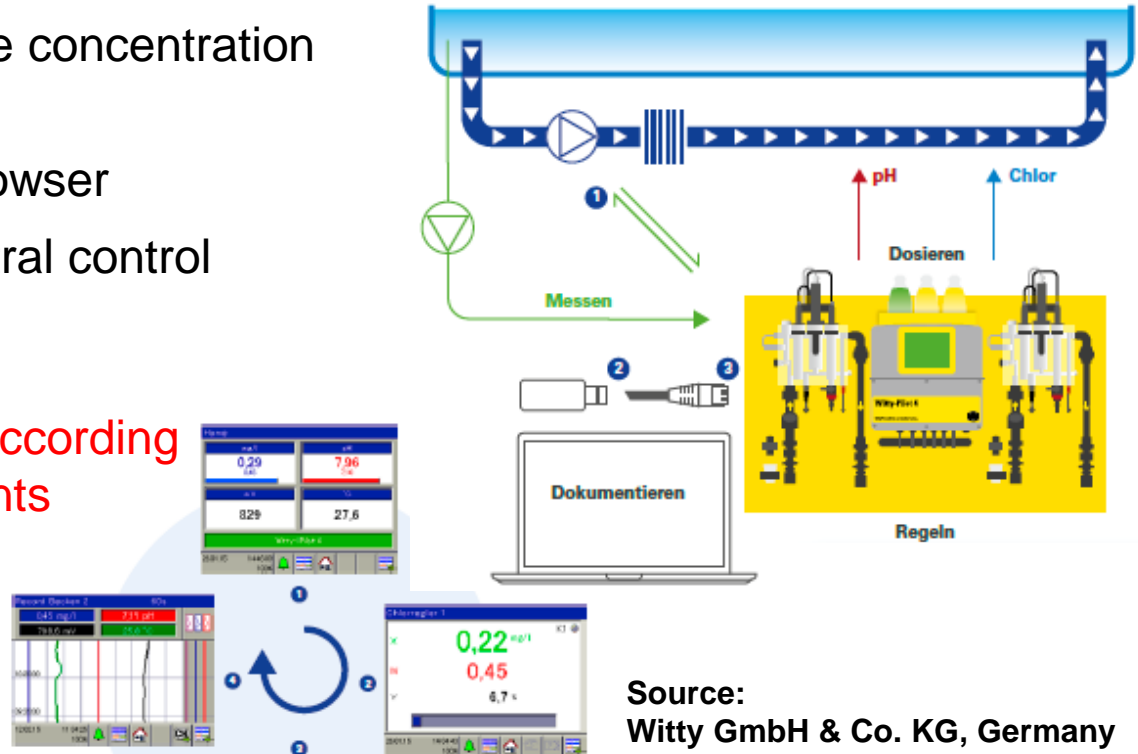
Source:
Witty GmbH & Co. KG, Germany

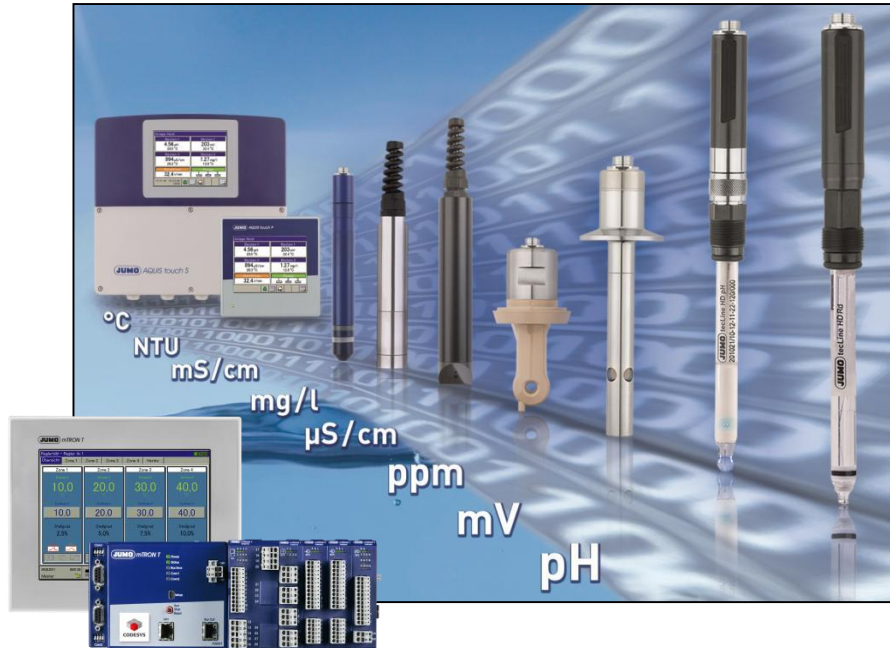# JUMO digiLine

JUMO digiLine for the Water Technolgy

Intelligent, bus-capable connection system for digital sensors in liquid analysis with integrated sensor management

digiLine

Digital sensors/measurands:

- pH-value

- Redox voltage (ORP)

- Temperature

- Conductivity (conductive/inductive)

- Dissolved Oxygen (DO)

- Turbidity

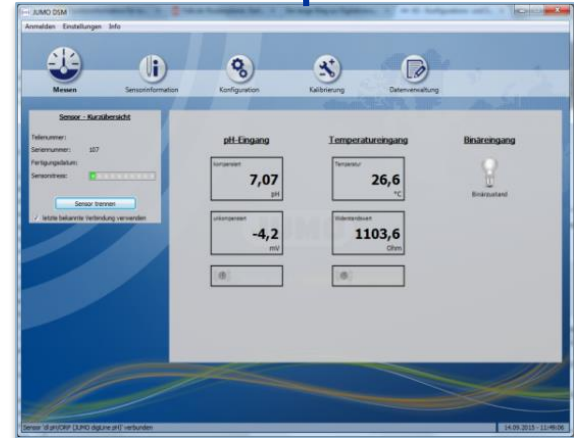- Desinfectants as Free Chlorine, Chlorine dioxide, Ozone, etc.

digiLine

JUMO AQUIS touch S/P
JUMO mTRON T

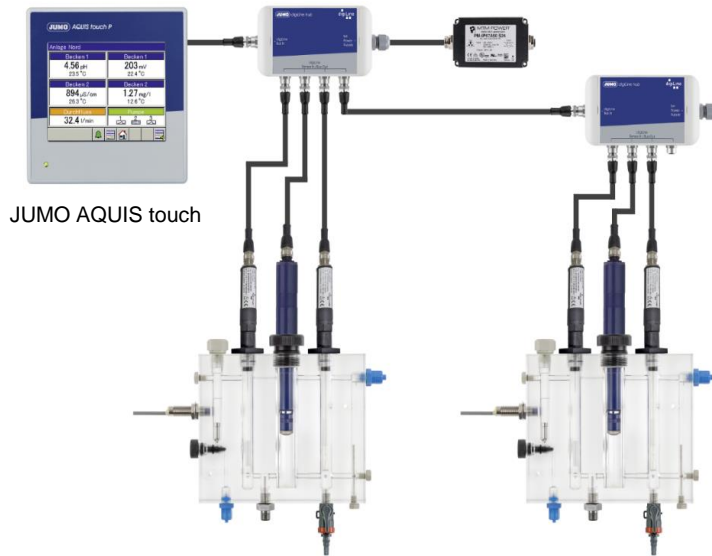JUMO **D**igital **S**ensor **M**anagement
(DSM)

Smart Sensors

JUMO digiLine - Characteristic

digiLine

JUMO AQUIS touch

- Faile-Safe bus communication
- Plug and play at JUMO AQUIS touch; up to 6 digital sensors easily connectable
- „Lifecycle-Management" through the smart sensor „intelligence"
- Less wiring and cost reduced installation
- Asset management via PC-software

At JUMO mTRON T up to **62** digiLine-sensors are connectable

Smart Sensors - Features

- „Intelligent" electronic, stored data can be „carried" for evaluation.

- Calibration of the sensor can be performed in the office.

- Separable/Reusable sensor electronic

  ⇒ pH Sensors e.g. have a limited lifetime, and have to be replaced after a while.

  ⇒ The only replacment is still the pH sensor itself and not the elctronic as in combined systems

=> Economical and Ecological way of thinking

Consumable-parts

Smart Sensors

Required maintenance/calibration

Reinstall „Smart sensor"

Sensor
- **cleaning**
- **regeneration**
- **calibration**
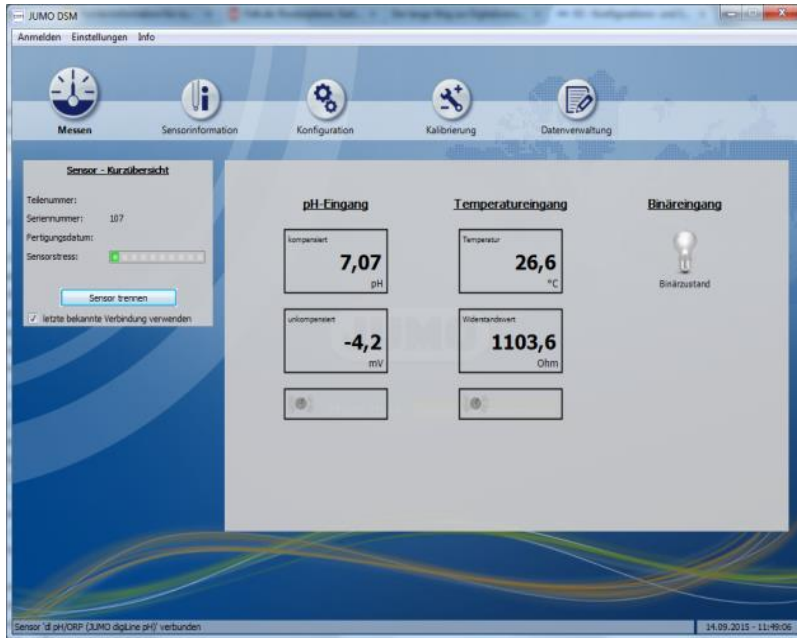- **evaluation**
- **doumentation**

When changing of the sensor is necessary the smart electronic is reusable!

JUMO digiLine – Asset Management

JUMO Digital Sensor Management (DSM)

- Userfriendly Software
- Calibration on PC*
- Measurement documentation (life cycle management)
- Predictive maintenance

*Not for desinfectant sensors which have to be calibrated in the measuring media!

State-of-the-art measuring and controlling system meets professional requirements

digiLine

- Modern, bus-compatible measurement instrumentations for liquid analysis

- Measuring System is expandable according to the customers requirements

- Simplified and safe point meter operation (Plug and Play)

- Easy sensor management for complex applications

- Economical and Ecological way of technology

Your contact

More than sensors + automation

JUMO

Ulrike Storm

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Thank you for your attention!