# D8.2– Sensors datasheets and features

## Project Information

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## Dissemination Level

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|---|---|---|
| PU | Public | ✓ |
| PP | Restricted to other program participants (incl. Commission Services) | |
| RE | Restricted to a group specified by the consortium (incl. Commission Services) | |
| CO | Confidential, only for the members of the consortium (incl. Commission Services) | |

## Document Log

| Version | Date | Author | Description of Change |
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# Table of Contents





"This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 958454".

# List of Tables



# List of Figures





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# 1 Executive Summary

This document refers to the deliverable D8.2 “Sensors datasheets and features”. It deals around the investigation of sensors properties, such as communication protocol, power supply, full scale, resolution etc. This report summarizes outputs from task T8.1 “Sensors development” (POLITO, M6-18) while considering data from D2.3 “Report on sensor requirements”.



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# 2 Introduction

This document aims to report commercial and custom made sensors features for physical/chemical parameters, which might be detected in control points of lab and pilot units' water streams. The control points and the key parameters were defined and reported in D2.3 "Report on sensor requirements".

This report relates to the information provided in the previous deliverable D8.1 "Report on sensors".

Any information regarding control points and key parameters can be retrieved from D2.3 and D8.1, and will not be reported here to avoid repetitions.



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# 3 Sensors features

As reported in D8.1 "Report on sensors", for the monitoring of specific physical and chemical parameters, such as temperature, pH, turbidity, electrical conductivity, a multiparametric probe is recommended.

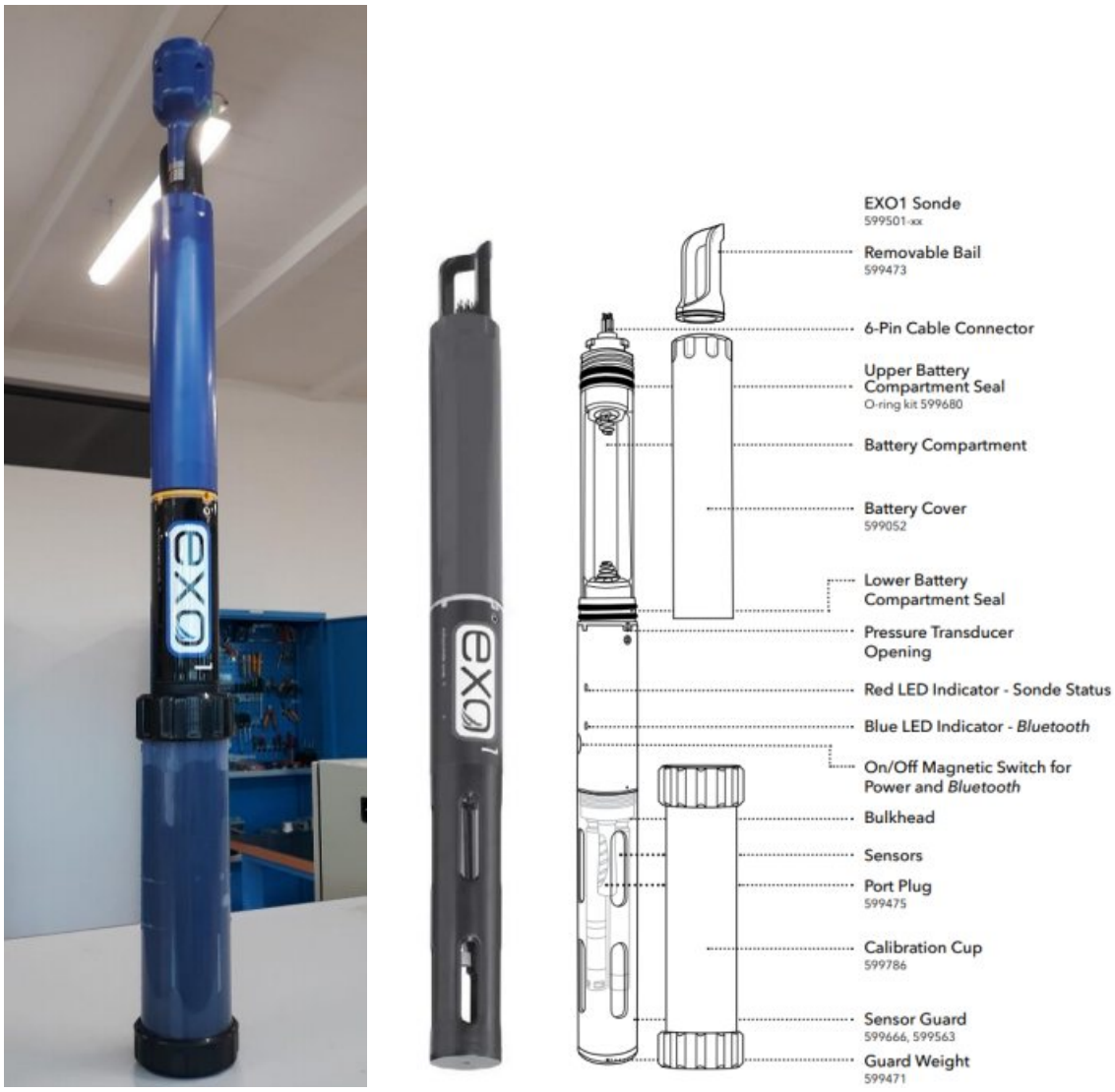


Figure 1. EXO 1 multiparametric probe.

The YSI multiparametric probe model EXO1 specifications are reported in Table1.

Table 1. Multiparametric probe specifications

| Name | Power supply | Dimensions | Communication protocols |
|---|---|---|---|
| EXO 1 Multiparametric probe | 9-16 or 24 VDC or Batteries | Diameter 10 cm<br>Length 64.77 cm<br>Weight 1.42 Kg | Rs-485 or Rs -232<br>Mod-bus or Sdi-12 |

Multiparametric probe EXO1 includes titanium universal sensors, that detect a variety of physical, chemical, and biological properties of water.



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Table 2. Multiparametric prob Sensors specifications

| Parameter | Full scale | Accuracy | Response time | Resolution | Sensors type |
|---|---|---|---|---|---|
| Conductivity | 0 to 200 mS/cm | 0-100 mS/cm: ±0.5% of reading or 0.001 mS/cm, 100-200 mS/cm: ±1% of reading | T63<2 sec | 0.0001 to 0.01 mS/cm range-dependent | 4-electrode nickel cell |
| Temperature | -5 to +50°C | -5 to 35°C: ±0.01°C 35 to 50°C: ±0.05°C | T63<1 sec | 0.001°C | Thermistor |
| Depth and level | Shallow: 0 to 10 m Medium: 0 to 100 m Deep: 0 to 250 m Vented: 0 to 10 m | Shallow: ±0.04% FS ±0.004 m Medium: ±0.04% FS ±0.04 m Deep: ±0.04% FS ±0.10 m Vented: ±0.03% FS ±0.003 m | T63<2 sec | 0.001 m | Stainless steel strain gauge |
| Ammonium | 0 to 200 mg/L-N | ±10% of reading or ±2 mg/L-N | T63<30 sec | 0.01 mg/L | Ion-selective electrode |
| Nitrate | 0 to 200 mg/L-N | ±10% of reading or ±2 mg/L-N, | T63<30 sec | 0.01 mg/L | Ion-selective electrode |
| Chloride | 0 to 18000 mg/L-Cl | ±15% of reading or ±5 mg/L-Cl, | T63<30 sec | 0.01 mg/L | Ion-selective electrode |
| pH | 0 to 14 | ±0.1 pH units within ±10°C of calibration temperature. ±0.2 pH units for entire temp range | T63<3 sec | 0.01 | Glass combination electrode |
| ORP | -999 to +999 mV | ±20 mV in Redox standard solution | T63<5 sec | 0.1 mV | Platinum button |
| Turbidity | 0 to 4000 FNU | 0-999 FNU: 0.3 FNU or ±2% of reading, whichever is greater; 1000-4000 FNU: ±5% of reading | T63<2 sec | 0-999 FNU: 0.01 FNU 1000-4000 FNU: 0.1 FNU | Optical, 90° scatter |



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For Calcium detection, an electro-chemical device, Model S80 of ECD, was identified.

Figure 2. Model S80 sensor for calcium ion detection.

Calcium Ion Electrode is a combination electrode with a sensing element made of a PVC membrane containing an ion exchanger and a double junction reference electrode. The Calcium Ion Selective Electrode cartridge develops a millivolt potential proportional to the concentration of calcium ions in the measured solution. The typical output is 25mV to 30 mV per decade of change in concentration.

Table 3. Calcium ion sensors specifications

| Parameter | Full scale | Response time | Resolution | Sensors type | Communication | Power supply |
|---|---|---|---|---|---|---|
| Calcium | 20 ppb to 40,000 ppm | T90 in 10 seconds | Depends on range<br>Electrode Slope<br>26 ± 3 mV per decade of concentration change | ion exchange sensor | 4-20 mA outputs, | 110/220 VAC, 24<br>VDC |



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For $SO_4^{2-}$ another continuous monitoring sensor was identified (also available for Calcium or Barium).

Figure 3. Sulphate monitoring apparatus.

ScaleSense was developed to operate on the most challenging flows (e.g. high-TDS range).

Applications:

- Reverse osmosis: real-time scaling ion control to maximize recovery while protecting membranes
- Cooling tower blowdown minimization: reduce freshwater withdrawal on a scale-limited tower
- Barium, sulfate precipitation and chemical softeting process control: ensure your phys-chem process is meeting treatment goals for $Ca^{2+}$, $Ba^{2+}$, $SO_4^{2-}$, $SiO_2$
- Oil & gas: sulfate monitoring, protect disposal wells, maximise nanofiltration recovery in enhanced oil recovery (EOR)

Table 4. $SO_4$/Calcium ion sensors specifications

| Parameter | Full scale | Response time | Resolution | Sensors type | Communication | Power supply | Dimensions |
|---|---|---|---|---|---|---|---|
| Sulphate | ND | 5 mins | 2-5 % | ion specific sensor | Digital outputs not specified | 120 VAC, 10A (customizable) | 0.53*0.76*2.03 m<br>Weight 113 Kg |

Moreover, another optical sensor for continuous Sulphate detection in water was identified which required further testing for the challenging flows of intelWATT applications.



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Figure 4. EZ1000 Series sulphate/ EZ2000 Series Iron analyser

Table 5. Sulphate/Iron optical sensor specifications

| Parameter | Full scale | Response time | Precision | LOD | Sensor type | Communication | Power supply | Dimensions |
|---|---|---|---|---|---|---|---|---|
| Sulphate | 10 - 40 mg/L SO4<br>Optional:<br>40 - 160 mg/L SO4 (with internal dilution)<br>80 - 320 mg/L SO4 (with internal dilution)<br>1000 - 4000 mg/L SO4 (with internal dilution) | 10 mins | Better than 3% full scale range for standard test solutions | ≤ 10 mg/L | Colorimetric | Analog 4 - 20 mA max. 500 Ohm load, standard 1, max. 8 (option)<br>Optional digital output:RS232, Modbus(TCP/IP, RS485) | 220 VAC, | 690 mm x 465 mm x 330 mm<br>Weight 25 Kg |
| Iron | Total Iron<br>0.01 - 1 mg/L Fe<br>Optional:<br>0.002 - 0.1 mg/L<br>0.005 - 0.25 mg/L<br>0.005 - 0.5 mg/L<br>0.08 - 4 mg/L (with internal dilution) | 20 mins | Better than 2% full scale range for standard<br>test solutions | ≤ 2 µg/L | Colorimetric | Analog 4 - 20 mA max. 500 Ohm load, standard 1, max. 8 (option)<br>Optional digital output:RS232, Modbus(TCP/IP, RS485) | 220 VAC | 690 mm x 465 mm x 330 mm<br>Weight 25 Kg |



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| | 0.16 - 10 mg/L (with internal dilution)<br>2 - 20 mg/L (with internal dilution) | | | | | | | |

For online, continuous density measurement a device available from Parisa Technology is considered to be the most suitable.

Figure 5. DENSITRAK® D625 Liquid Density Meter

Table 6. Density sensor specifications

| Parameter | Full scale | Accuracy | Resolution | Sensors type | Communication | Power supply |
|---|---|---|---|---|---|---|
| Density | 0.40 – 2.00 [gr/cm3] | 0.0001 gr/cm3 | 0.00001 gm/cm3 | Spring mass | Analog output 4-20 mA<br>Digital I/O USB, RS232, and RS485 (2- WIRE) protocols | VOLTAGE: 24 VD CURRENT: 50 to 150 mA nom |

For Solar radiation a photovoltaic silicon diode is selected, which converts incoming solar radiation (W/m2), in the wavelength interval between 0.36µm and 1.1µm, in to an electrical signal.

Figure 6. Silicon solar radiation sensor



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Table 7. Solar irradiance sensor specifications

| Parameter | Full scale | Accuracy | Resolution | Sensors type | Communication | Power supply |
|---|---|---|---|---|---|---|
| Solar Irradiance | 0-1600W/m² | ±5% | 0,1mV/(W/m²) | Silicon photodiode | Output<br>0 … 160mV; 4 … 20mA; 0 … 1V; 0 … 2V; 0 … 5V; RS485 Modbus | Voltage<br>9 … 24Vdc<br>Consumption<br>≤10mA @ 12Vdc |

Regarding the RED unit voltage and current motoring, two commercial devices from LEM meet the required specifications.


Figure 7. IT 205-S Current transducer and CV 3-500 Voltage transducer

Table 8. Voltage and Current sensors specifications

| Parameter | Full scale | Accuracy | Sensors type | Communication | Power supply | Dimensions |
|---|---|---|---|---|---|---|
| Current | Primary<br>0 -200 A<br>Secondary<br>0-200 mA | 0.01 | Closed loop Fluxgate | Analog output depending on power supply voltage | Voltage<br>5-24 V | 76.6x77.7x47 mm |



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|---|---|---|---|---|---|---|
| Voltage | Primary<br>0 -±500 V<br>Secondary<br>10 V | ±0.6 % | Closed Loop | Analog output depending on power supply voltage | ± 15V | 77.5*64*65.5 mm<br>Weight 560 g |

For pressure measurement in all the 36 control points, we identified a family of devices (**3100 Series and 3200 Heavy Duty Series)** from GEMS, and WIKA (**A-10**) with appropriate full scales and resolutions.

Figure 8. 3100 Series pressure sensors

Table 9. Pressure sensors specifications

| Parameter | Full scale | Accuracy | Response time | Communication | Power supply | Dimensions |
|---|---|---|---|---|---|---|
| Pressure | 0-4 bar and 0-200 bar | 0.25% FS<br>0.5% FS | 1 ms | Analogue Output<br>4-20 mA or<br>0-10 V (see datasheet) | Voltage<br>9 … 24Vdc<br>Consumption<br>≤10mA @ 12Vdc | Max 45*26 mm<br>Weight 35 g |



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Moreover, also for Flow measure, which are very different for every control point, we identify a device family (**Vortex flow sensors A00X from Autosen**)


Figure 9. Autosen vortex flow meters

Table 10. Flow sensors specifications

| Parameter | Full scale | Accuracy | Response time | Communication | Power supply | Dimensions |
|---|---|---|---|---|---|---|
| Flow | 0.9...15 l/min<br>1.8...32 l/min<br>3.5...50 l/min<br>5...85 l/min<br>9...150 l/min | Q < 50 % MEW: < 1 % MEW / Q > 50 % MEW: < 2 % MW; (water) \| ± 0,5 °C ± 0,005 x T<br>* MV = measured value, MREV = measurement range end value | 0.5 s<br>Delay < 2 s | Analogue Output<br>4-20mA | Voltage<br>10 ... 33 V DC | Depends on Full scale. Connector type for piping G1/2 , G1 and G1,5 |

The features of custom-made Chromium sensor developed by Politecnico di Torino, are already reported in D8.1.

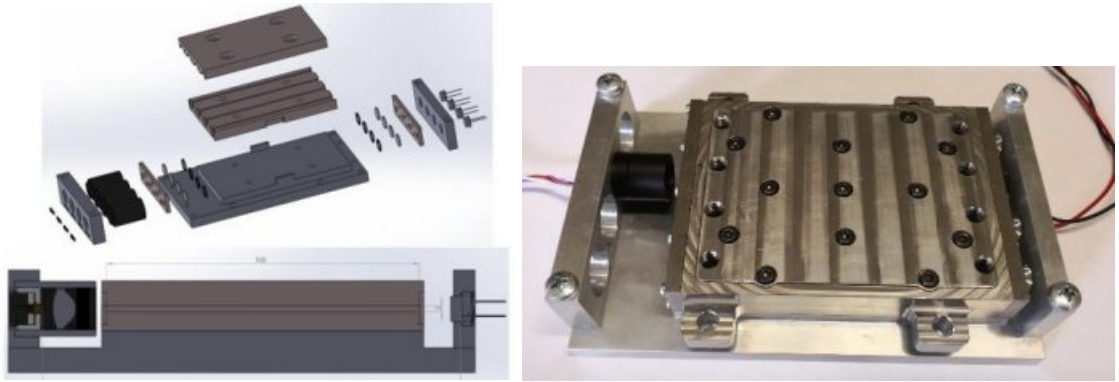

Figure 10. Chromium sensor, developed by Politecnico di Torino

From Case study 3, an updated specification database was created with additional control points for key parameters. In the table the new special sensors requirements are presented (Cr, Ni, Cu).



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Table 11. Updated special sensors requirements for CS3

| Stream | Chromium | Precision | Nickel | Precision | Copper | Precision |
|---|---|---|---|---|---|---|
| **Rinsing bath chromium** | 100-1000 ppm | 10 ppm | 0-15 ppm | 0.5 ppm | 0-5 ppm | 0.1 ppm |
| **Rinsing bath nickel** | not required | not required | 1000-50000 ppm | 500 ppm | 0-10 ppm | 0.05 ppm |
| **Rinsing bath copper** | not required | not required | not required | not required | 1000-10000 ppm | 100 ppm |
| **Wastewater (feed water)** | 100-1000 ppm | 10 ppm | 1000-10000 ppm | 100 ppm | 0-10 ppm | 0.05 ppm |
| **Water after pretreatment** | 100-1000 ppm | 10 ppm | 1000-10000 ppm | 100 ppm | 0-10 ppm | 0.05 ppm |
| **RO permeate** | 0-10 ppm | 0.1 ppm | 0-10 ppm | 0.1 ppm | 0-10 ppm | 0.1 ppm |
| **RO concentrate (brine)** | 1000-10000 ppm | 100 ppm | 1000-150000 ppm | 1000 ppm | 1000-80000 ppm | 1000 ppm |
| **Water after posttreatment** | 0-10 ppm | 0.1 ppm | 0-10 ppm | 0.1 ppm | 0-10 ppm | 0.1 ppm |
| **Concentrate after posttreatment** | 1000-10000 ppm | 100 ppm | 1000-100000 ppm | 1000 ppm | 1000-100000 ppm | 1000 ppm |
| **Recirculating water** | not required | not required | not required | not required | not required | not required |
| **Batch water** | not required | not required | not required | not required | not required | not required |



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Commercial optical devices (W600 controllers from Welchem) for Nickel and Copper high concentrations detection are identified below.


Figure 11. W600 series for Nickel and Copper detection

These in-line optoelectronic analyzers are designed for use in copper or nickel baths without electrical current (and micro etching baths) that contain more than 0.10 g/l of copper or nickel ions.


Figure 12. Immersible copper sensors (A) are available for direct monitoring of solutions inside the tank or continuous flow through sensors (B) designed for monitoring outside the tank.



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For Nickel only one continuous flow model variant is commercially available.

For Copper an immersion as well as continuous flow model can be used; in the latter case there are 3 different options depending on the copper concertation:

- Optical path length 0.1" Low conc. Cu (0-25 g/l)
- Optical path length 0.025" Medium conc. (15-50 g/l)
- Optical path length 0.015" High conc.

For the detection of both Nickel and Copper no reagents are required, as the measurement is colorimetric.

**Table 12. Copper and Nickel sensors specifications**

| Parameter | Full scale | Accuracy | Resolution | Communication | Power supply | Dimensions |
|---|---|---|---|---|---|---|
| Copper | 100-99000 ppm<br>100-5500 ppm | ±10 ppm | ±10 ppm | Analogue Output<br>4-20 mA<br>Provided accuracy ± 0.5% of reading | Voltage<br>100 -240 VAC, 50 or 60 Hz, 7 A maximum | 241x203x102 mm |
| Nickel | 100-25000 ppm | | | | | |



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