

Instruction Manual

# Water Quality Module KAPTA™ 2000



Probe Kapta™ 2000-AC2

*Measurement of chlorine and temperature*



## Legal mention

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## 1. SENSOR SPECIFICATIONS

### 1.1. General specifications

- Detection of active chlorine (**HOCl ; HOBr or ClO<sub>2</sub>**)
- Integrated temperature sensor (Pt 1000) (0 – 40°C)
- Maintenance free for at least 9 months (continuous use) – depending on application.
- Reagent free
- Real in-situ, online active chlorine measurement
- Low power, small size

Measuring species	HOCl ; HOBr or ClO <sub>2</sub>
Operating range*	0 – 5 ppm or 0 – 2 ppm
Response time	< 30 s
Typical flow rate	500 L/h in pipe line 32 mm ext. diameter
pH range	5 – 9
Measurement accuracy	±2% and min. ±0.03 ppm at pH 7 in potable water
Min. pH	5 Lower pH can damage the sensor head irreversibly.
Maximum chlorine concentration	The lifetime of the sensor head can be reduced if higher concentration than 5 ppm is used.
Maximum pressure	10 bar
Min conductivity	100 µS/cm
[Cl-]	> 2 mg/L
Wetted material	PA and Viton® O-ring seals
Probe cable length*	3 m
Probe weight	210 g
Probe dimensions	See figure 2 on page 4

\*Specifications can be obtained upon request

### 1.2. Output specifications

Two versions are available for the internal electronic, a low power 0 – 5 V output or a 4 - 20 mA standard output

#### Option 1 : 4-20 mA Output

Input voltage: 10 – 24 VDC

Chlorine output: 4 – 20 mA

Chlorine sensitivity: 1.4 – 2.1 mA/ppm (for 0 - 5 ppm) or 3.5 – 5.2 mA/ppm (for 0 – 2 ppm)

Temperature output: 4 wires output for Pt1000

#### Option 2 : 0 – 5 V Output

Input voltage: 5.5 – 12 V

Output chlorine voltage: 0.5 V – 5 V

Chlorine sensitivity: 470 – 700 mV/ppm (for 0 – 5 ppm) or 1 – 1.6 V/ppm (for 0 – 2 ppm)

Output temperature voltage: 0 – 5 V

Temperature sensitivity: 20 ± 2 mV/°C



### 1.3. General sensor information



**Figure 1:** Schematic of NEROXIS sensor module

- Housing: PA (Max. Temperature 40°C)
- Sensing head: ENDETEC™ amperometric sensor
- Electronic: Potentiostat & amplifier
- Attached cable
- Compatibility with 3/4" thread (R BSPT or NPT) for direct connection to pipe line.



## 2. OPERATING PRECAUTIONS

### 2.1. Conditioning of the sensor

Before you operate the sensor for the first time or after long time storage in air, it is important to hydrate the sensor for at least 1 hour in tap water **WITHOUT CONNECTING THE SENSOR**. The response time of the sensor for chlorine when first hydrated can be longer typically half an hour.

Each time the sensor is left to dry, a minimum 1 hour hydration is required.

### 2.2. Measurement conditions

The sensor has to be used in stirred solutions (less accurate) or in a flow through system. If the hydration time is not respected or if the sensor is connected when not in solutions, the calibration of the sensor can be altered.

**IF THE SENSOR IS CONNECTED IN AN ON/OFF FLOWING WATER SOLUTION WHERE THE SENSOR WILL BE IN A CYCLE OF WATER AND NO WATER THE LIFETIME OF THE SENSOR WILL BE REDUCED.**



**WHEN CONNECTED, THE SENSOR SHOULD ALWAYS BE IN WATER.**

The sensor is sensitive to air bubbles. A minimum flow rate is required to avoid air bubbles.

**AIR BUBBLES SHOULD BE AVOIDED.**

The sensor is not suited for measurements in deionised water.  
The sensor is not certified to be in contact with drinking water.

### 2.3. Storage

If the sensor is not to be used for several weeks, it is better to store it dry, away from dust, light and heat. Otherwise it can be stored in tap water solution containing a small amount of chlorine.

### 2.4. Cross sensitivity

The sensor has a cross sensitivity with ozone and hydrogen peroxide.

**THE USE OF HYDROGEN PEROXIDE WILL CONSIDERABLY REDUCE THE LIFETIME OF THE SENSOR.**

The sensor is not suited for salt water electrolysis systems.



### 3. WIRING / CONNECTING THE SENSOR

#### 3.1. Wiring and connecting for the 0 – 5 V output option

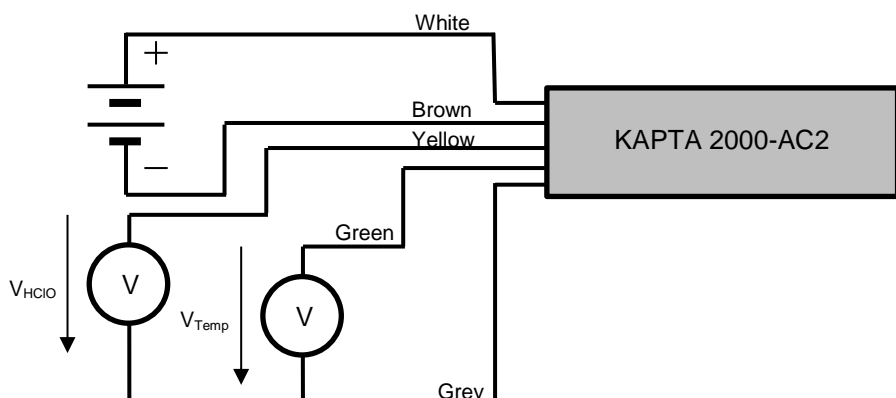
##### 3.1.1. Wiring description for the 0 – 5 V output option

The KAPTA™ 2000 AC2 is delivered with a 5 wire cable :

- 2 wires for the power supply (electrical ground and supply 5.5 to 12 V) which can be directly connected to a 9 V battery or DC decoupled power supply
- 1 wire for the analog output signal proportional to HOCl concentration, to be referenced to the input electric ground
- 1 wire for analog output signal for the temperature, to be referenced to the input electrical ground
- 1 ground wire (GND)

Description	Abbreviation	Color
Power supply -	Batt -	Brown
Power supply +	Batt +	White
Ground	GND	Grey
Chlorine Signal	Vcl	Yellow
Temperature signal	Vtemp	Green

##### 3.1.2. Basic connecting for the 0 – 5 V output option

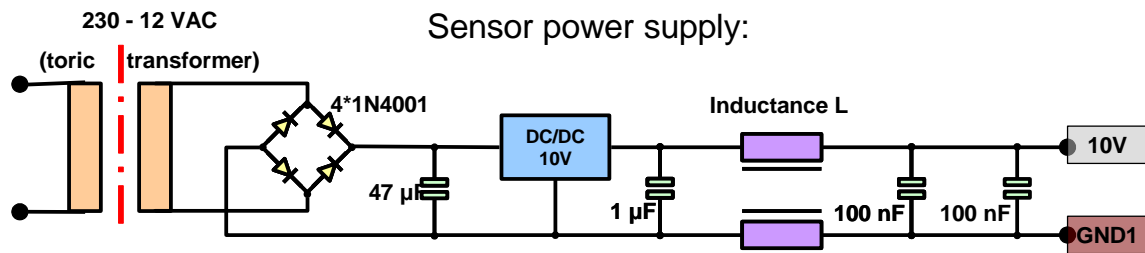


In the connections above the probe is powered by a battery, the Chlorine and temperature signals are measured by Floating voltmeter (device on battery). The power supply and metering instrument have to be electrical decoupled to avoid forcing the electrical potential of the probe. It is not always possible to use fully decoupled instrument. In this case see the two following examples.



### 3.1.3.Replacement of battery using electrical network

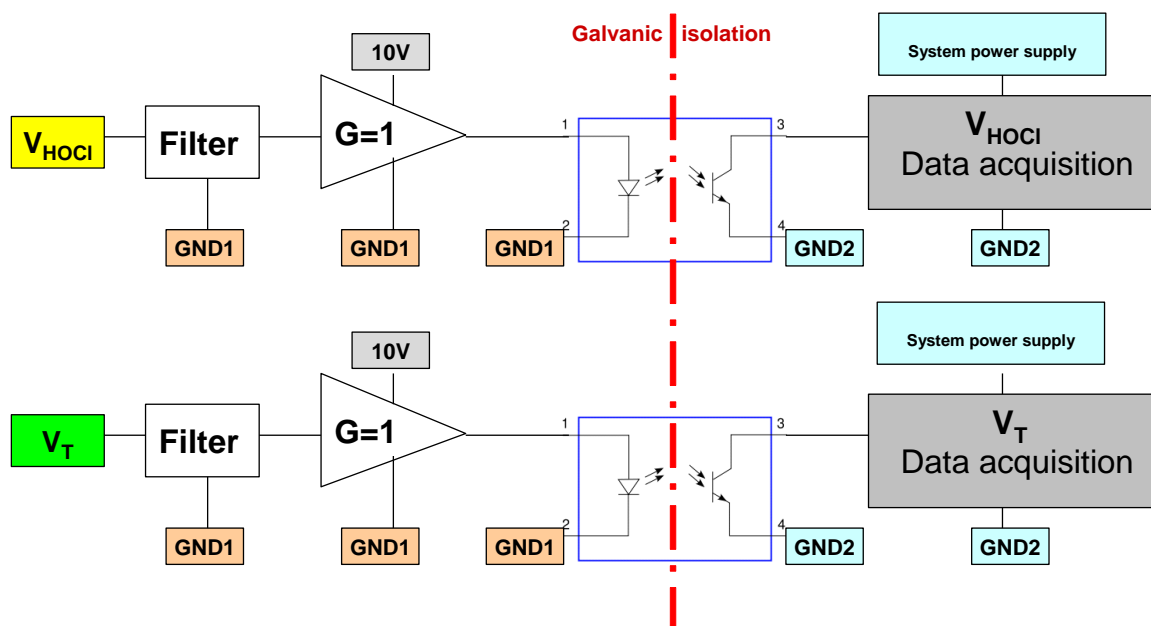
The power supply should have a good electrical isolation.



Switching power supply should not be used

### 3.1.4.Decoupling the sensor' signals $V_{HOCl}$ and $V_T$

The outputs measuring signal ( $V_{HOCl}$  and  $V_T$ ) should be also isolated from the data acquisition system.







### 3.2. Wiring and connecting for the 4 – 20 mA output option

#### 3.2.1. Wiring description for the 4 – 20 mA output option

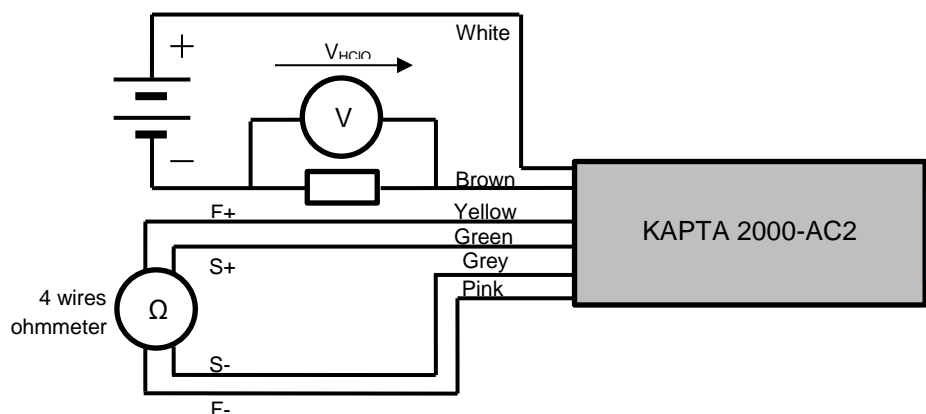
The KAPTA™ 2000-AC2 is delivered with a 7 wire cable :

- 2 wires for the power supply (electrical ground and supply 10 to 24 V)
- 1 ground wire (shield)
- 4 wires for the Pt1000 temperature sensor

Nr.	Description	Abbreviation	Color	Connection to ENDETEC™ controller terminal box
1	Negative pole	4-20_NEG-	Brown	4
2	Positive pole	4-20_POS	White	5
3 & 4	Temperature 1	PT1	Yellow	34
			Green	35
5 & 6	Temperature 2	PT2	Grey	36
			Pink	37
7	Shield	Shield	Black	44

The 4 – 20 mA can be connected to ENDETEC™ standard controller. *See specific application note.*

#### 3.2.2. Basic connecting for the 4 – 20 mA output option



Typical measuring resistor = 100 Ohms.

The current is measured through the measuring resistor ( $U=R \cdot I$ ).

As the 0 – 5 V output version, the power supply and the voltage measurement have to be decoupled from the electrical network, but it is not necessary for the temperature measurement. The schematic examples shown at the points 3.1.2 and 3.1.3 can be used.

On the schematic above, the Pt1000 measurement is performed with 4 wires measurement. It is possible to measure the Pt1000 also with 2 wires (less accurate).



### **3.2.3.Connection to a controller**

In the case where the KAPTA™ 2000-AC2 probe 4 – 20 mA output is used with a controller, it is necessary to ensure that the power supply and the measurement acquisition provided by the controller is electrically decoupled (galvanic isolation) from the electrical network, as explain above. The sensor is electrically isolated when it has not common wire with the electricity network. Both for the power part that for the measurement part.

ENDETEC™ provides a controller that includes all these solutions to ensuring the proper functioning of the KAPTA 2000-AC2 probe.

We recommend avoiding all switching power supplies that will inevitably cause noise on the chlorine measurement.



#### 4. INSTALLATION OF THE SENSOR IN THE SAMPLE STREAM

##### Sensor positioning in pipe line:

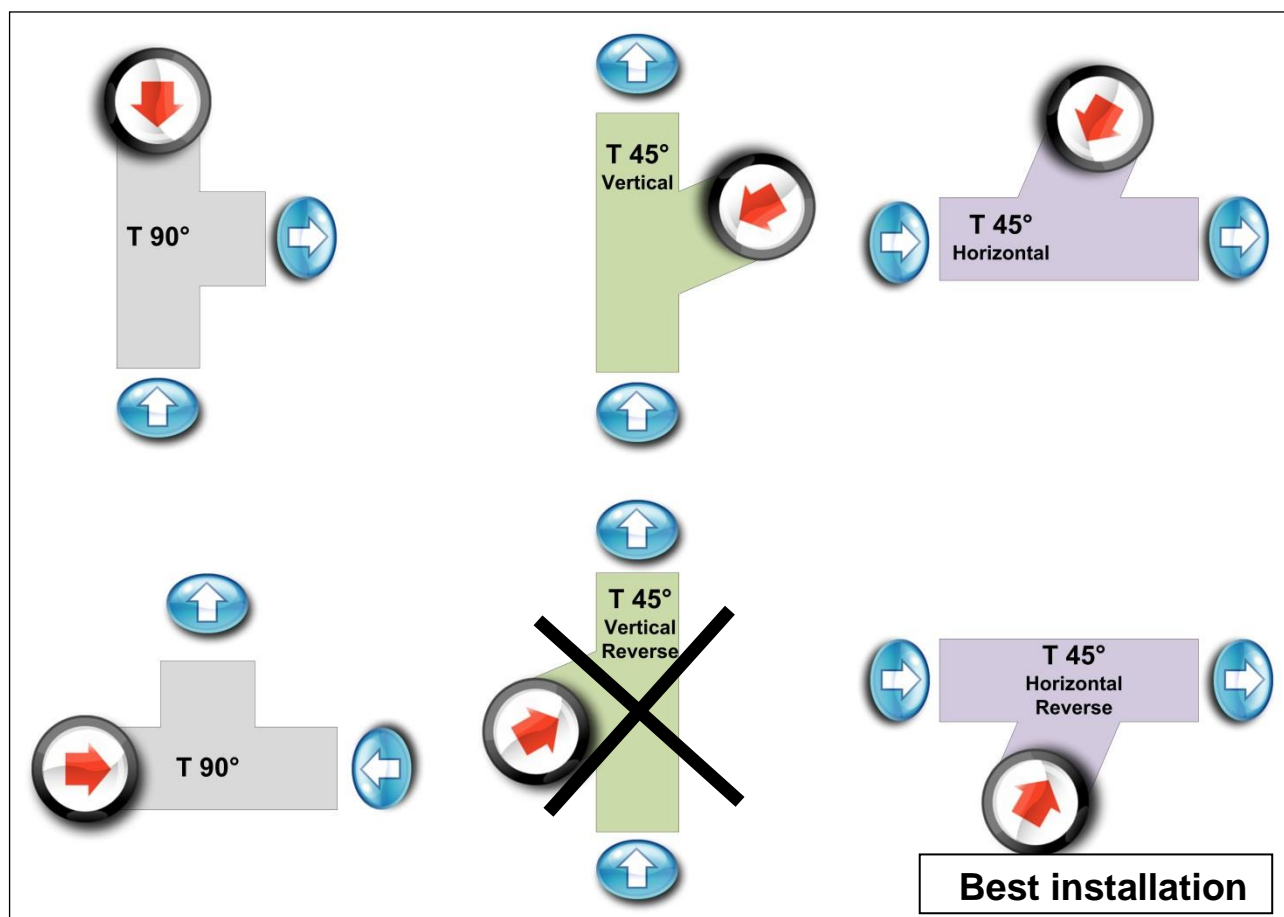
The sensor can be placed directly in the fluidic line. The position of the sensor is critical to avoid air bubbles. **THE BEST POSITIONING OF THE SENSOR IS T45° HORIZONTAL REVERSE**, especially at very low flow rate. It is also recommended to better protect the sensor from particles which could be present in the flow stream.



KAPTA™ 2000 AC2  
representation



Water flow  
representation



The position T45° vertical reverse should not be used.

A bad positioning of the sensor in the flow stream can lead to a lower lifetime of the sensor head.



## 5. CALIBRATION

### 5.1. One point calibration procedure for the 4 – 20 mA output

Follow the controller instructions used.

### 5.2. One point calibration procedure for the voltage output sensor

For best accuracy, the calibration of the sensor should be carried out at a pH of 7.0. This can be achieved with the addition of dilute sulfuric acid to a tap water solution. **The pH should never be lower than 5.**

#### **DO NOT USE PURE DIIONISED WATER FOR CALIBRATION.**

1. Place the sensor in a flow through pipe line without connecting it.

- Typical external pipe diameter 32 mm; typical flow rate 500 L/h

- Typical external pipe diameter 1 1/4"; typical flow rate 2 GPM

2. Leave the sensor to hydrate 1 hour in flowing condition.

3. Connect the sensor to the power supply.

4. Add dilute sulfuric acid to shift the pH toward 7.0.

5. Leave the sensor stabilize to its zero value.

If the zero cannot be achieved, you probably have a small amount of chlorine in your solution (use the zero measurement given in the certificate of conformity given with the sensor: Zero without chlorine).

6. Note the value  $V_{\text{zero without chlorine}} = \text{_____ V}$

7. Add approximately 2 ppm of chlorine.

8. Leave the sensor stabilize 15 min.

9. Note the value of  $V_{\text{HOCl}} = \text{_____ V}$

10. Make an accurate measurement of HOCl or free chlorine DPD1 measurement for example (DPD 1 measurement should be converted to HOCl concentration with the following relationship:

$$[\text{HOCl}] = \frac{[\text{FAC}]}{1 + 10^{(\text{pH} - \text{pKa})}} \quad \text{pKa} = 7.54 \text{ at } 25^\circ\text{C}$$

Note the value  $[\text{HOCl}] = \text{_____ ppm}$

Careful, if your pipeline is rapidly consuming chlorine, the measurement will be less accurate. To verify, it might be best to note the  $V_{\text{HOCl}}$  before and after DPD measurement.

11. Calculate the sensitivity of the sensor  $S = ((V_{\text{HOCl}} - V_{\text{zero without chlorine}}) * 1000) / [\text{HOCl}]$  in  $\text{mV/mg L}^{-1}$ .

The calibration should obviously be close enough to the value given in the certificate of conformity.

**COC information given**

<b>COC information given</b>					<b>HOCl measurement</b>	
<b>Inc.</b>	<b>Sensor N°</b>	<b>Head N°</b>	<b>Electronic Zero (V)</b>		<b>Sensitivity (mV/mg<sup>-1</sup>)</b>	<b>Zero without chlorine (V)</b>
			<b>Gain / nA/mV</b>	<b>Zero / V</b>		
<b>1</b>	C12508	T12508	46.91	0.523	563	0.518

<b>Inc.</b>	<b>Sensing head N°</b>	<b>Sensitivity nA/mg<sup>-1</sup></b>	<b>Zero without chlorine / nA</b>	<b>Noise (nA)</b>
<b>1</b>	T12508	12.0	-0.110	0.04

$$S_{\text{sensor}} (\text{mV/ppm}) = S_{\text{head}} (\text{nA/ppm}) \times \text{Gain}_{\text{electronic}} (\text{nA/mV})$$

$$V_{\text{zero without chlorine}} (\text{V}) = V_{\text{electronic zero}} + (I_{\text{zero without chlorine}} \times \text{Gain}_{\text{electronic}})$$

$$V_{\text{zero without chlorine}} = 0.523 + (-0.110 \times 46.91)/1000 = 0.518 \text{ V}$$

$$S = 12.0 \times 46.91 = 563 \text{ mV/mgL}^{-1}$$

[HOCl] : HOCl concentration in ppm or mg/L

$V_{\text{HOCl}}$  : HOCl output voltage (V)

$V_{\text{zero without chlorine}}$  : HOCl output voltage without chlorine (V)

$V_{\text{electronic zero}}$  : Zero of the electronic potentiostat

$S_{\text{sensor}}$  : Sensitivity of the chlorine sensor (mV/mg<sup>-1</sup>)

$$[\text{HOCl}] = ((V_{\text{HOCl}} - V_{\text{zero without chlorine}}) \times 1000) / S_{\text{sensor}}$$

**Example:**

$$V_{\text{HOCl}} = 1.925 \text{ V}$$

$$[\text{HOCl}] = 2.5 \text{ ppm}$$

$$S_{\text{sensor}} = ((1.925 - 0.518) \times 1000) / 2.5 = 563 \text{ mV/mgL}^{-1}$$

During field measurements, the sensor does not require further calibration.



## 6. PROCEDURE TO RAPIDLY TEST THE SENSOR

### Installation

1. Take the sensor from its package.
2. Take a beaker of 250 mL.
3. Fill the beaker with 200 mL of tap water and add a magnetic stir bar.
4. Place the sensor on the magnetic stirrer.
5. Place the sensor head using a holder in the beaker.
6. Turn on the magnetic stirrer.
7. Leave the sensor hydrating 1 hour.

### Connecting the sensor

1. Take a standard rectangular 9V battery.
2. Connect the white wire to the positive pad of the battery.
3. Connect the brown wire to the negative pad of the battery.
4. Take a voltmeter with 3 digits for the measurement of the output voltage for chlorine ( $V_{\text{HOCl}}$ ).
5. Connect the yellow wire to the voltage input of the voltmeter.
6. Connect the brown wire to the ground of the voltmeter.

### Measurement

The sensor should read a voltage around 0.5 V (zero without chlorine voltage written in the certificate of conformity given with the sensors) if no chlorine, if the sensor reads a higher voltage, your tap water contains chlorine and the pH of your solution is probably higher than 7.5.

Check the pH of your solution. If the pH is higher than 7.5, leave the sensor to stabilize 1 hour, the voltage should have dropped to a value around 0.5 V.

If the pH of the solution is lower than 7.5 add 10 microliters of hypochlorous acid from a commercial 13-14% concentration solution. The HOCl voltage output should increase and indicate a value around 3V depending on the sensitivity of the sensor and the exact pH of your solution. If left the HOCl voltage signal will decrease in time.

An addition of 10 microliters of hypochlorous acid will again increase the HOCl output voltage. After several addition of hypochlorous acid the signal will saturate at a voltage slightly higher than 5 V.

If the pH of the solution is higher than 7.5, to check more easily the response of the sensor it will be best to acidify the solution to a pH around 7 by adding 100 microliters of a standard solution of sulfuric acid 0.5 mol/l.

An addition of 10 microliters of hypochlorous acid should increase the voltage around 1.2 V.

An addition of 10 microliters of hypochlorous acid will again increase the HOCl output voltage. After several addition of hypochlorous acid the signal will saturate at a voltage slightly higher than 5 V.

Take the certificate of conformity given with the sensor in order to calculate the concentration of HOCl in your solution.

**COC information given**

<b>COC information given</b>					<b>HOCl measurement</b>	
<b>Inc.</b>	<b>Sensor N°</b>	<b>Head N°</b>	<b>Electronic Zero / V</b>		<b>Sensitivity mV/mg<sup>-1</sup></b>	<b>Zero without chlorine / V</b>
			<b>Gain / nA/mV</b>	<b>Zero / V</b>		
<b>1</b>	C12508	T12508	46.91	0.523	563	0.518

<b>Inc.</b>	<b>Sensing head N°</b>	<b>Sensitivity nA/mg<sup>-1</sup></b>	<b>Zero without chlorine / nA</b>	<b>Noise / nA</b>
<b>1</b>	T12508	12.0	-0.110	0.04

[HOCl] : HOCl concentration in ppm or mg/l

V<sub>HOCl</sub> : HOCl output voltage (V)

V<sub>zero without chlorine</sub> : HOCl output voltage without chlorine (V)

V<sub>electronic zero</sub> : Zero of the electronic potentiostat

S<sub>sensor</sub> : Sensitivity of the chlorine sensor (mV/mg<sup>-1</sup>)

S<sub>sensor</sub> = S<sub>head</sub> x Gain<sub>electronic</sub>

V<sub>zero without chlorine</sub> = V<sub>electronic zero</sub> x (I<sub>zero without chlorine</sub> x Gain<sub>electronic</sub>)

$$[\text{HOCl}] = ((V_{\text{HOCl}} - V_{\text{zero}}) \times 1000) / S_{\text{sensor}}$$

**Example:**

$$V_{\text{zero without chlorine}} = 0.523 + (-0.11 \times 46.91)/1000 = 0.518 \text{ V}$$

$$V_{\text{HOCl}} = 1.925 \text{ V}$$

$$S_{\text{sensor}} = 12.0 \times 46.91 = 563 \text{ mV/mgL}^{-1}$$

$$[\text{HOCl}] = ((1.925 - 0.518) \times 1000) / 563 = 2.5 \text{ ppm}$$

**REMARKS**

To accurately calibrate the sensor, it should be placed in a water flow line and the pH should be adjusted at 7 (Follow the instructions of § 6). The pH compensation should be taken into account.

If the sensor stays at a value close to 0.5 V or 5V and does not increase or decrease respectively, or gives a voltage lower than 0.5 V after 1 night stabilization, please contact our technical support by email to [kaptasupport.vws@veolia.com](mailto:kaptasupport.vws@veolia.com)



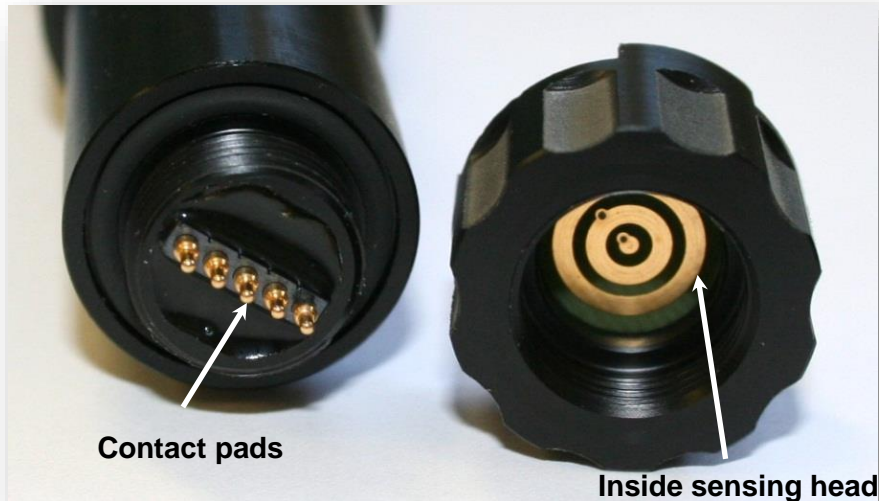
## 7. MAINTENANCE

No chemical or physical maintenance should be used on the sensor head.

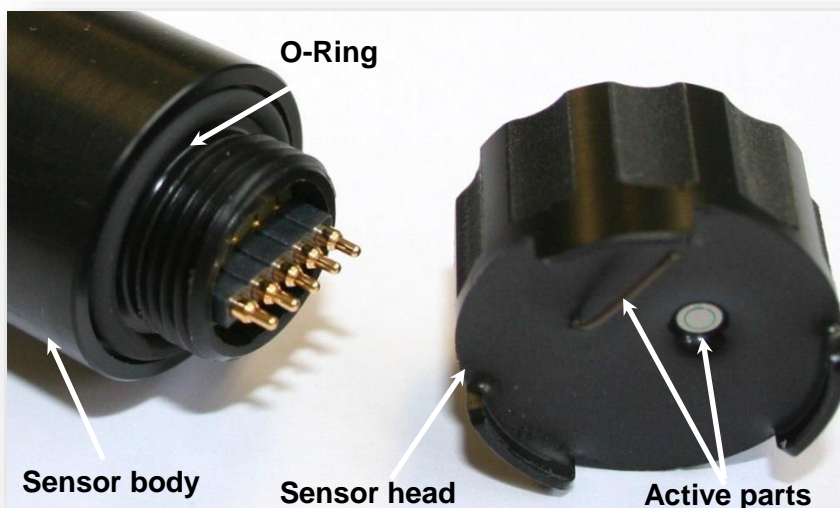
### 7.1. Replacement of the sensing head

During this process it is important not to touch the contact pads and the active part of the sensor. And it is also important not to put water on the contact pads of the head.

**NO WATER SHOULD ENTER INSIDE THE SENSING HEAD OR INSIDE THE CONTACT PADS.**



- Disconnect the sensor.
- Take the sensor out of the flow line.
- Dry it without touching the sensor active part.
- It is important to dry the sensor properly and have dry hands as no water should enter in the sensing head.
- Unscrew the head.
- Change the O-ring and check that it is properly installed.
- Take a new sensing head.
- Screw it on the sensor body.
- Make sure you have screw the head to the maximum to assure water tightness.

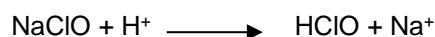
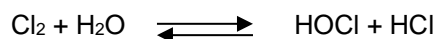






## APPENDIX 1: PRINCIPLE OF CHLORINE

Many techniques are used for the chlorination of water either using dissolved chlorine ( $\text{Cl}_2$  gas), sodium hypochlorite ( $\text{NaOCl}$ ) or calcium hypochlorite ( $\text{Ca}(\text{OCl})_2$ ). Either way, hypochlorous acid is formed by hydrolysis of  $\text{Cl}_2$  or acidification of hypochlorite.

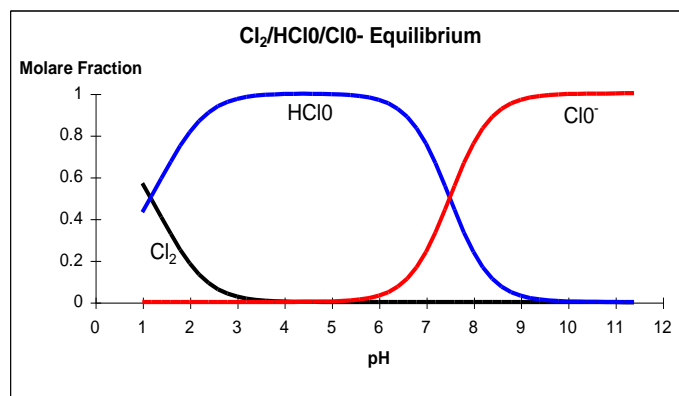
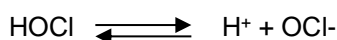


Ammonia when present or added reacts with hypochlorous acid to form the chloramines  $\text{NH}_2\text{Cl}$ ,  $\text{NHCl}_2$  or  $\text{NCl}_3$ . The first two are known to have a disinfecting action that lasts longer than that of chlorine.

The chlorinated compounds are separated into two groups the free chlorine and the bonded chlorine.

Depending on the pH-value of the water, the free chlorine can be: dissolved chlorine  $\text{Cl}_2$  (gas), hypochlorous acid  $\text{HOCl}$  or the hypochlorite ion  $\text{OCl}^-$ .

Dissolved chlorine is in equilibrium with hypochlorous acid ( $K^{25^\circ\text{C}} = 4 \times 10^{-4}$ ). Likewise,  $\text{HOCl}$  is in equilibrium with hypochlorite ions ( $K^{25^\circ\text{C}} = 2.9 \times 10^{-8}$ )



**Figure 1:** Molar fractions of the three compositions of free chlorine in water as a function of pH.

**Figure 1** shows that at a typical pH for drinking water of about 7.5 both  $\text{HOCl}$  and  $\text{OCl}^-$  are present in solution. As  $\text{HOCl}$  is much better disinfectant (x100) than  $\text{OCl}^-$ , the disinfecting effect depends strongly on the pH. Therefore, the measurement of  $\text{HOCl}$  gives the correct disinfecting power of the water.



## Chlorine measurement

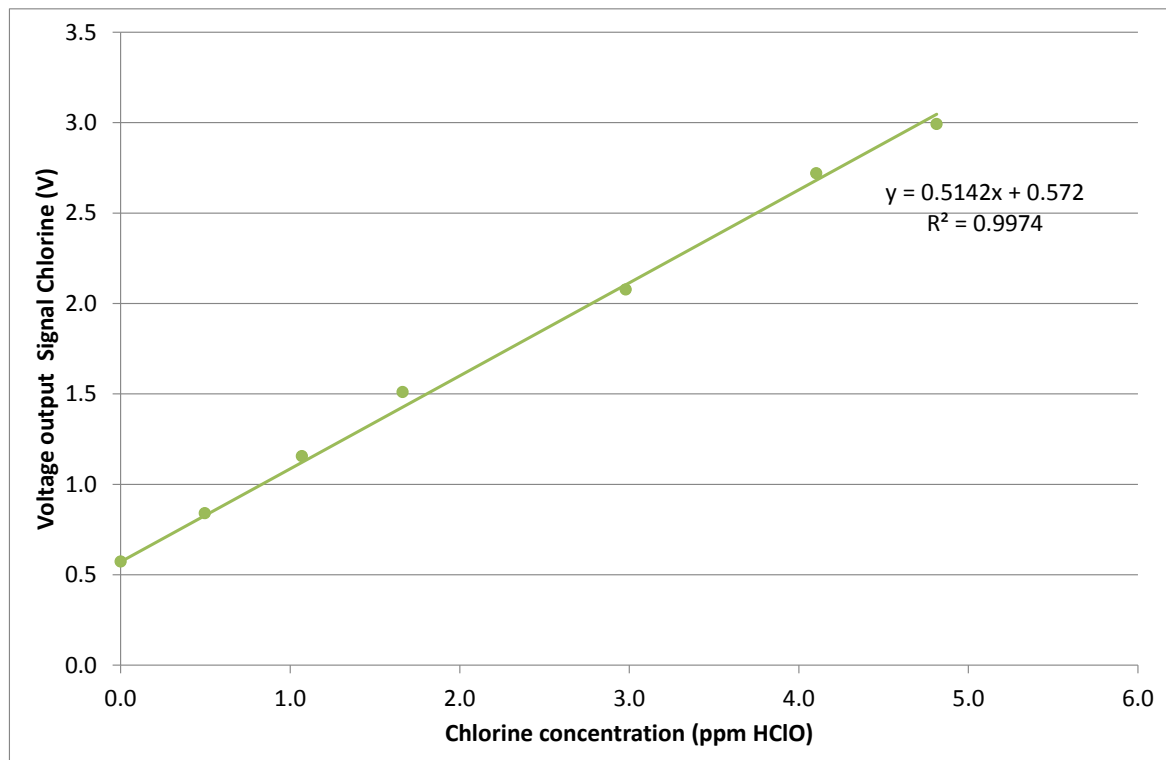


Figure 2: Chlorine sensitivity

## pH dependence

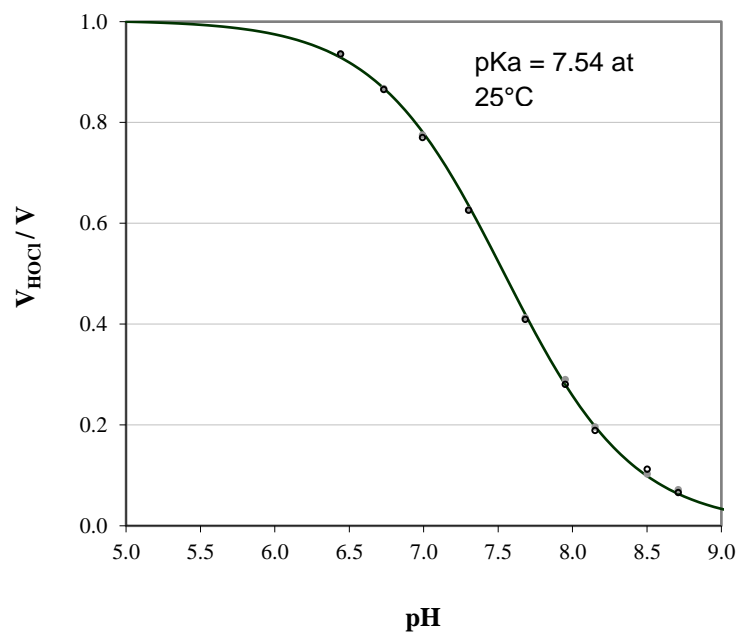


Figure 3: HOCl pH dependence



## APPENDIX 2: TEMPERATURE COMPENSATION

### Influence of the temperature on chlorine measurement

General influence of temperature

The chlorine measurement depends on the temperature as the kinetic of the equilibrium HOCl/OCl<sup>-</sup> and the electrochemical reaction are functions of the temperature.

### HOCl measurement

For the measurement of HOCl, the temperature effect on the equilibrium HOCl/OCl<sup>-</sup> does not have to be taken in account. On the contrary the temperature effect on the electrochemical reaction has to be considered and compensated if required.

### Free chlorine measurement (HOCl + OCl<sup>-</sup>)

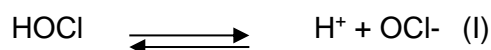
For the measurement of HOCl + OCl<sup>-</sup> by measuring the pH, both variations have should be considered.

In both cases, the compensation should be considered depending on the accuracy required.

### Temperature compensation

Influence of the temperature on the kinetic of the equilibrium HOCl/OCl<sup>-</sup>

In aqueous solutions, HOCl is in equilibrium with hypochlorite ions OCl<sup>-</sup> according to the following reaction:



The HOCl concentration varies as a function of pH as follows:

$$[\text{HOCl}] = \frac{1}{1 + 10^{\text{pH} - \text{pKa}}} \quad (\text{II})$$

$$K_a^{25^\circ\text{C}} = 2.9 \times 10^{-8}$$

Where  $T = 273 + \text{degrees centigrade}$

From this information, a first compensation can be done for the measurement of free chlorine FAC (HOCl + OCl<sup>-</sup>).

$$\text{Then: } [\text{FAC}] = [\text{HOCl}] \times (1 + 10^{\text{pH} - \text{pKa}})$$

With:

$$\text{pKa} = \frac{3000}{T} - 10.0686 + 0.0253 T \quad (\text{III})$$

**Influence of the temperature on the electrochemical reaction**

The temperature dependency is defined by the Arrhenius law:

$$\log\left(\frac{C}{C_0}\right) = -\frac{A}{T} + B \quad (\text{IV})$$

This is mainly due to the variation of the diffusion coefficient as a function of temperature:

$$D = D_0 \exp\left(-\frac{E}{kT}\right) \quad (\text{V})$$

An experimental temperature study at a pH 5 (100% HOCl) study can define the compensation. It shows that the chlorine concentration increases by ca. 1.5% per °C.

Then:  $S_{HOCl}^{T=25^\circ C} = \frac{S_{HOCl}}{1+1.5/100(T-25)}$  Electrochemical compensation.

**Calibration**

After calibration the sensitivities can be calculated as follows:

$$S_{HOCl} = \frac{V_{HOCl} - V_{HOCl}^0}{[HOCl]_{Ref}} \quad \text{and} \quad S_{HOCl}^{T=25^\circ C} = \frac{S_{HOCl}}{1+1.5/100(T-25)}$$

$$S_T = \frac{V_T - V_T^0}{T_{Ref}}$$

Constants obtained from the sensor calibration:

$S_{HOCl}^{T=25^\circ C}$ : Sensitivity of the chlorine sensor compensated at 25°C

$V_{HOCl}^0$ : Offset voltage of the chlorine sensor

$S_T$ : Sensitivity of the temperature sensor

$V_{T}^0$ : Offset voltage of the temperature sensor

Variables:

$S_{HOCl}$ : Sensitivity of the chlorine sensor at T

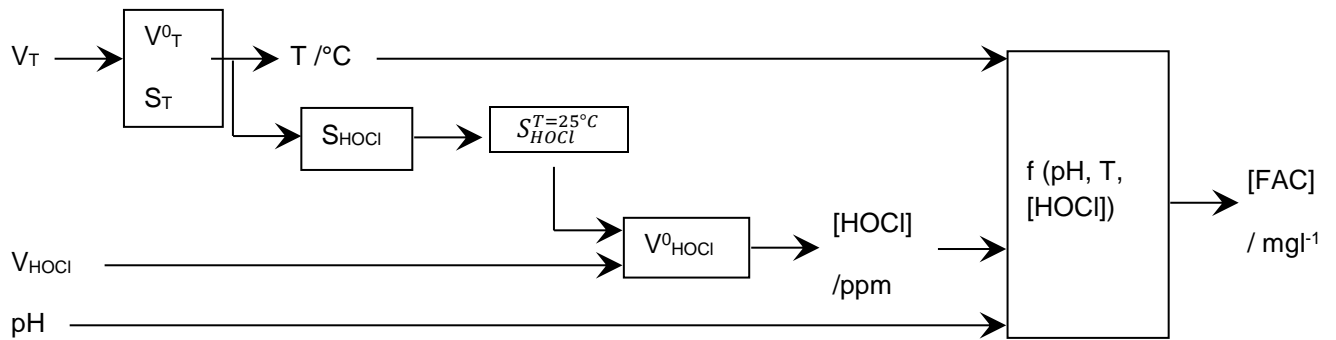
$V_{HOCl}$ : Output voltage of the chlorine sensor

$V_T$ : Output voltage temperature sensor

$[HOCl]$ : HOCl concentration

$[FAC]$ : Free chlorine concentration (HOCl + OCl<sup>-</sup>)

pKa: Equilibrium constant for the reaction (III) à T

**Flow chart of the compensation**

With:

$T = \frac{V_T - V_T^0}{S_T}$  gives the temperature from the calibration parameters of the T sensor.

$[HOCl] = \frac{V_{HOCl} - V_{HOCl}^0}{S_{HOCl}^{T=25°C}}$  gives the HOCl concentration compensated as a function of T.

With:

$$S_{HOCl}^{T=25°C} = \frac{S_{HOCl}}{1 + 1.5 / 100(T - 25)} \quad \text{Electrochemical compensation}$$

From equation (III):

$$pKa = \frac{3000}{T} - 10.0686 + 0.0253 T$$

Then the free chlorine is:  $[FAC] = [HOCl] \times (1 + 10^{pH - pKa})$

# Resourcing the world

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