Ultra-Pure Water Measurements

pH • CONDUCTIVITY

HACH®

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Introduction

The purpose of this document is to give you an overview of the main technical points regarding the pH and conductivity measurements in ultra-pure water. Ultra-pure water definition is reminded, general theoretical basis of pH and conductivity are presented and major influential parameters considered.

For pH, the ASTM D5128 is the standard test method for on line pH measurements of water of low conductivity (< 100µS/cm).

www.astm.org/Standards/D5128.htm

For conductivity, the ASTM D5391 is the standard test method for electrical conductivity and resistivity of a flowing high purity water sample.

www.astm.org/Standards/D5391.htm

This document highlights why Hach® pH and conductivity products fulfill the requirements of ultra-pure water measurements.

Chapter 1
OVERVIEW

In ultra-pure water, the only ionic species present are H_3O^+ (noted H^+ for simplifying) and OH^-, provided by the dissociation of the water.

Conductivity = 0.055 µS/cm at 25°C and Resistivity = 18.24 Mohm.cm

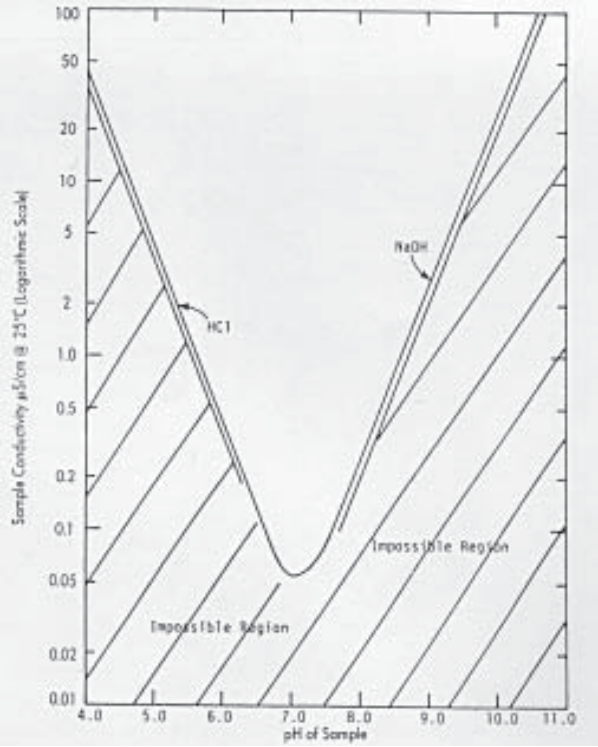
With resistivity= 1/ conductivity and 1µS/cm = 1/1 Mohm.cm

pH = 7.00 at 25°C

The pH/conductivity relationship has been described for ultra-pure water with traces of strong acid or base and ammonia (typical conditioning agent in the power plants)

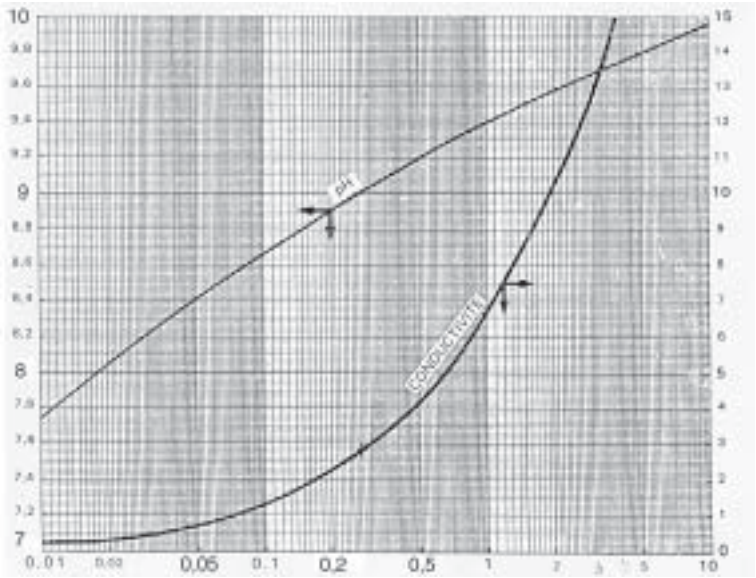
pH-conductivity relationship in ultra-pure water with acid-base contamination

For a conductivity of 0.06 µS/cm, the pH must be between 6.9 (traces of strong acid-HCl) and 7.2 (traces of strong base- NaOH)



pH-conductivity relationship in ultra-pure water with ammonia traces

Example: a conductivity of 0.2 µS/cm corresponds to a pH of 8.9



Conductivity measurements in ultra-pure water are much simpler to implement than pH ones. However, conductivity is non-specific and cannot predict the source of contamination (if it comes from acid, base, salts).That's why pH measurements remain necessary in some applications.

Chapter 2
pH Measurements

1- MAIN APPLICATIONS

Monitoring of the water conditioning quality of boiler systems and the effectiveness of demineralization plants, the source of impurity contamination demand accurate on-line pH measurements.

In steam power plant and industrial boilers, water is treated with traces of ammonia/amines in order to raise the pH and limit corrosion at high temperature and pressure.

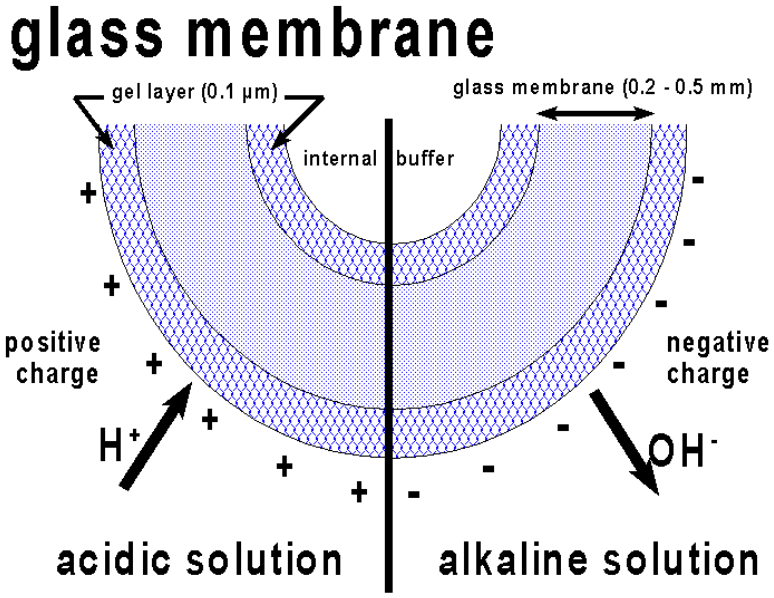
In pharmaceutical industries, the pH of purified water and water for injection must be between pH 5 and 7 at 25°C.

2- OPERATING PRINCIPLE

2.1 - pH electrode

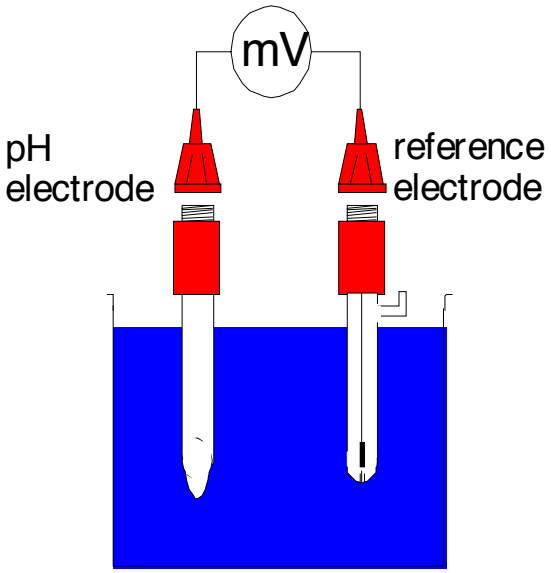
- A glass electrode acts as a sensitive element to hydrogen ions. The glass is made of SiO_2 with other positive metallic ions (Na^+, Ca^{2+}, ...). Immersed in a solution containing hydrogen ions, the glass exchanges its metallic cations with hydrogen ions through a hydrated gel layer at the surface of the glass membrane.
- A conductive solution is filled inside the glass bulb whose pH must be constant (usually equal to pH 7): it gives a stable potential at the inside surface of the membrane.
- An inner element (usually an Ag wire covered by AgCl) ensures the electrical connection with the inner solution.

The resulting differential potential depends on the ionic equilibrium between the glass and the solution in which the electrode is immersed. The corresponding voltage (mV) is generated to an amplifier. As it cannot be measured directly, a second connection is needed through the reference electrode.



2.2 - Reference electrode

- The reference electrode is made of a metallic element (Ag wire) with its insoluble metallic salt (AgCl) and a concentrated electrolyte solution (usually KCl, equal to pH 7). It provides a stable voltage at constant temperature.
- A porous diaphragm is used for ensuring a contact between the reference electrode and the sample.
- The reference electrode generates a voltage (mV) to an amplifier.



2.3 - Measured differential potential of the system

$E = E_{M, ext} + E_{M, in}t + E_{ref, int} - E_{ref, ext} + E_j$

With:

$E_{M, ext}$ = differential potential between sample and glass membrane

$E_{M, int}$ = differential potential between glass membrane and electrolyte of glass electrode

$E_{ref, int}$ = differential potential between electrolyte of glass electrode and reference inner element of glass electrode

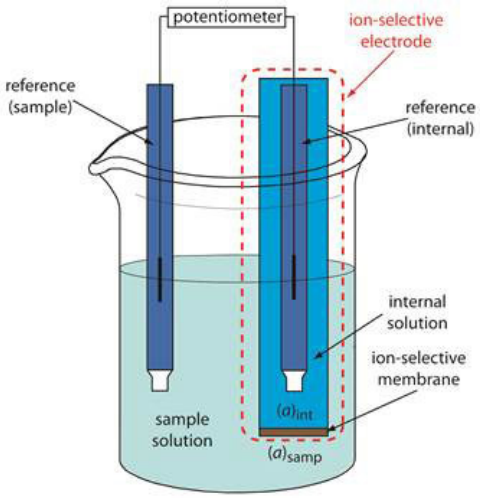
E ref, ext = differential potential between reference inner element of reference electrode and reference electrolyte

E j= junction potential between reference electrolyte of reference electrode and sample

The pH controller measures the potential difference E between the glass electrode and the reference electrode.

The glass electrode is obviously pH dependant ($E_{M, ext}$ and $E_{M, int}$)

The reference electrode isn't and must remain constant.



2.4 - pH calculation

- The differential potential between glass and reference electrodes is converted into hydrogen ion activity through the NERNST relation.

  $E = E_0 + 2.3\ RT/F\ \log (H^+)$

  With E0= standard potential with a H+ = 1 mol/L
  T= absolute temperature (Kelvin)
  R=8.32 J /°C/mol
  F=96500 C/mol
  Typically, 2.3 RT/F is equal to 59.16 mV at 25°C and corresponds to the change in potential per pH unit.

- The pH is calculated with the SÖRENSEN law.

  $pH = -\log (H+)$

  pH is equal to the negative logarithm of the hydrogen ion **activity**.

3- KEY PARAMETERS

3.1 - Activity and concentration

The H^+ **activity** corresponds to the **effective concentration**, taking into account the sample temperature and all **interactions with the other ions** of the sample. This relationship is expressed through **the activity coefficient "f"**.

$(H^+) = f*[H^+]$

with (H^+) = hydrogen ion **activity**
$[H^+]$ = hydrogen ion **concentration**

In very dilute solution (i.e. ultra-pure water), there are no ionic interactions between species: f=1 and $(H^+) = [H^+]$.

That means that any traces of ionic impurities in ultra-pure water (ultra-pure water is <1mS/cm) modify the $H^{\pm}$ activity. As glass electrodes respond to H^+ activity and not to their concentration, the pH measured in ultra-pure water in presence of ionic impurities is affected by these impurities and does not correspond to the pH of ultra-pure water.

3.2 - Source of drifting and noisy measurements

The pH measurement principle is based on ionic exchange in the gel layer of glass membrane. Its speed and stability of response depend upon the flow rate and the ionic strength of the solution (i.e. concentration of different ionic species) among other parameters.

3.2.1- Flow rate

If too low, a flow rate can accentuate the degradation of the glass membrane (see 3-2-4).

If too high, a flow rate can edge up the diffusion potential (see 3-2-3)

It is generally difficult to predict the effect of flow variation, it's also better to maintain a stable flow rate. In the same way, it is recommended to maintain a fixed sample stream pressure by an atmospheric discharge.

OUR SOLUTION

We recommend a stable flow rate of 10 L/h.

3.2.2 - Ionic strength

An excessive KCl electrolyte leakage from the pH reference half cell obviously increases the conductivity of ultra-pure water .

Therefore it artificially improves the response time and the stability of the pH electrode since the ionic exchange through the gel layer of the glass membrane is boosted.

But the key point is that it alters the pH of the ultra-pure water sample! (see 3.1)

Likewise, a pH electrode with a flowing reference electrode must not be installed upstream of a conductivity cell.

OUR SOLUTION

8362 probe: We use a non-flowing reference electrode.

3.2.3 - Liquid junction potential (diffusion potential)

The liquid junction potential occurs when the reference electrolyte solution meets the sample solution.

With a flowing type reference electrode, KCl electrolyte slowly bleeds through the junction. With a non flowing type reference electrode, KCl electrolyte and process sample diffuse together.

In ultra-pure water, there is an important concentration gradient between the sample (low conductivity, high resistivity, concentration about 10^{-7} mole/L) and the KCl electrolyte (high conductivity, low resistivity, concentration about 1 mol/L or more).

Ionic mobilities are different and charges separation in the diaphragm can occur if the pore diameter is too small. It can become highly resistive if it is completely rinsed with ultra-pure water (about 10 Mohm).

These potentials can represent an important unknown value acting as a zero offset. It mainly depends on the junction design of the reference electrode, temperature, flow rate and pressure of the sample.

OUR SOLUTION

8362 probe: Use of a sealed reference half cell demanding no electrolyte replenishment to minimize variation in the liquid junction potential. The reference electrode resists dilution over several months due to its high viscosity electrolyte.

Hach standard controller.

3.2.4 - Degradation of the glass membrane

The hydrated gel layer (0.1 µm) can be damaged by the corrosive ultra-pure water and does not permit the ionic exchange anymore.

Moreover the great solubility energy of water dissolves alkali components of the glass.

OUR SOLUTION

We recommend to store the electrode in KNO_3 solution to avoid this damage during long-term storage.

3.2.5 - Streaming potential

The electrode glass membrane is non-conductive and usually shows a high resistivity about 200-250 Mohm.

The ultra-pure water sample, being highly resistive, creates static electrical charge while flowing across the membrane of the pH electrode.

Noisy and drifting pH readings may appear.

OUR SOLUTION

8362 probe: Use of a conductive flow cell to minimize the streaming potentials, connected to the earth/ground. It decreases this streaming potential due to the water flow by leading the external noise induction to the earth.

3.2.6 - Electrical noise

The high impedance of glass and reference electrodes are very sensitive to any electromagnetic fields from any other equipment. This leakage current can shift the measurements if glass and reference electrodes are not isolated. It preferentially passes through the reference electrode (weakest impedance) and reduces its span life by electrolyzing it.

It could be the case with a single amplifier (the reference electrode is connected to the earth) if the isolation between the earth and the reference electrode is inaccurate.

It's also essential that the reference electrode is connected to a high impedance preamplifier since the resistance of the junction diaphragm can reach more than 10 Mohm in ultra-pure water.

The electronic treatment of the signal must eliminate any risk of ground loop.

OUR SOLUTION

Hach standard controller (sc): We use a differential amplifier with high impedance inputs for glass and reference electrodes.

If there is a disturbance, both glass and reference electrodes will be affected. As we measure the potential difference (i.e.differential amplifier) between the glass electrode and the reference electrode, we eliminate this noisy signal and can measure this potential (converted in H^+ activity see 2-4) without being influenced by the external environment.

To avoid any ground loop, there must be only one connection point to the earth. With the sc200, the grounding issues are solved.

OUR SOLUTION

We use a galvanic insulation between all these three different internal power supplies to allow only one contact to the earth and to avoid any ground loop.

Furthermore, the pH electrode can be connected to the earth through the sample and is physically linked to the pH module. The pH module communicates with the CPU board for calculating the pH from the potential measured.

However, there must not be a ground loop between the pH module and the CPU board (already connected to the earth).

OUR SOLUTION

We use an isolated ground to avoid any ground loop.

3.3 - Source of interferences

Ultra-pure water is easily contaminated since there is no buffer capacity.

Water is a very well-known solvent and is able to dissolve a lot of compounds.

The level of contamination is very low: about 1 ppb of salts

Examples:

- solution of 1ppb of NaOH (0.055µS/cm ; pH 7.05): addition of 1ppm NaOH increases the pH by pH 2.35
- solution of 1ppm NaOH (6.229µS/cm ; pH 9.4): addition of 1ppm NaOH increases the pH by pH 0.30

The pH of the less concentrated solution (1ppb NaOH) is much affected by the addition of 1ppm NaOH since the buffer capacity is lower than that of the solution containing 1 ppm NaOH.

Atmospheric contamination

Effect of carbon dioxide (CO_2 gas)
The atmosphere is made of 79% N^2, 21% oxygen and some 0.03% (300 mg/L) CO_2

This addition of 0.2 mg/L of CO_2 into a ultra-pure water sample at 25°C shifts the pH by pH 1.11 (pH of the solution is pH 5.89)

Comparing with a solution containing 0.51 mg/L of ammonia (pH 9.2), the effect of CO_2 contamination is much lower

The addition of 0.2 mg/L of CO_2 shifts the pH by pH 0.08 (pH of the solution is 9.09)

Note that ultra-pure water in equilibrium with air absorbs CO_2 so that it shifts the pH from 7 to between 5 – 6 at 25°C.

An ultra-pure water sample must not be held in an open container but in a closed sampling system.

OUR SOLUTION

8362 system: we offer a closed sampling system with our built-in, gas-tight, stainless steel and acrylic flow-through chamber.

Any contaminants present in the samples such as iron oxide deposits, resin fines:

Absorb or adsorb ionic impurities.

Can mask real change in the water loop: if conductivity rises, they will trap the ionic impurities and will free them when water becomes cleaner.

Likewise, after immersing electrodes in calibration buffers, the liquid junction is modified and the offset shifted.

Electrodes require a long rinse time to cancel the high ionic effect of buffer solution in the junction path.

Reminder that it is impossible to predict the error on the pH measurements due to unstable junction potentials.

The wetted parts should not represent any leakage risk of contaminants (plastic parts for example), the sampling system should minimize air entrapment and solid deposits accumulation.

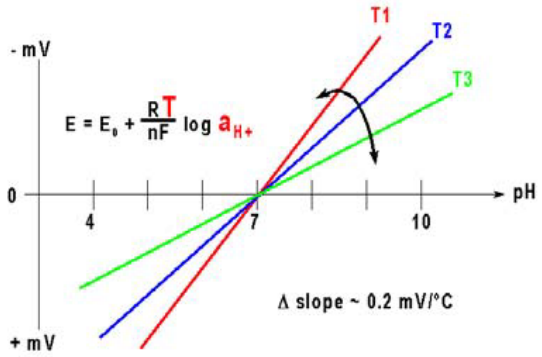
OUR SOLUTION

The stainless steel/acrylic flow-through chamber was designed to eliminate both the influence of air bubbles and the accumulation of particles at the surface of the electrodes. The small section increases the flow velocity inside and contributes to remove solid deposits.

3.4 - Temperature effects onto pH

3.4.1 - Standard NERNST effect

The output signal of the electrode varies with temperature according to the NERNST factor: RT/F. The slope of the electrode increases if the temperature does.



Graph output signal of pH electrode (mV) at different temperature
Example: at 25°C, the slope is 59.16 mV
At 80°C, the slope is 70.1 mV

Therefore, this temperature compensation curve is well established. It compensates the effect of the temperature on the intrinsic characteristics of the electrode but does not take into account the temperature variation of the pH of the solution.

In wastewater, drinking water or other conductive process water, the buffer capacity due to the presence of all dissolved compounds is enough to avoid any temperature dependency of the pH of the solution.

The pH of ultra-pure water having no buffer capacity depends completely upon the temperature of the solution and the other ionic traces.

3.4.2 - pH of ultra-pure water

It's due to the dissociation of the ultra-pure water with temperature
$Kw = (H^+)x\ (OH^-)$
Kw: dissociation constant of water

With an increase of temperature, the dissociation constant of water increases as well. It means that both the concentration of H^+ and OH^- grows in the same proportion. Ultra-pure water is always neutral.

However, since pH is only a measurement of H^+ through a negative log function, the pH of water decreases with a raise of temperature.

Example: At 100°C, pH of ultra-pure water is 6.14, slightly acid but still neutral (equal concentration of H^+ and OH^-)

3.4.3 - pH of ultra-pure water solutions with ionic species

Small quantities of acid/alkaline solutions modify the behavior of the ultra-pure water temperature curve. The determination of the theoretical pH behavior with temperature change is quite complex .

The temperature coefficient predicting the pH of the sample at whatever temperature it might be depends upon the exact composition of the sample. 4 tables have been established showing the variation of the pH, function of the temperature.

.For example, with these tables, it is possible to determine the theoretical pH of a sample at 25°C whereas it has been measured at 30°C.

Temperature	Sulfate Curve	Ammonia + Hydrazine	Ammonia + Morpholine + Hydrazine	Ammonia + Phosphate
5	4.004	9.719	10.294	10.178
10	4.004	9.525	10.108	9.981
15	4.005	9.342	9.932	9.795
20	4.005	9.169	9.765	9.619
25	4.006	9.002	9.604	9.451
30	4.007	8.847	9.456	9.296
35	4.008	8.699	9.312	9.148

Temperature coefficient of ultra-pure water and 4 matrixes

Temperature	Sulfate Curve	Ammonia + Hydrazine	Ammonia + Morpholine + Hydrazine	Ammonia + Phosphate
5	+0.002	-0.717	-0.690	-0.727
10	+0.002	-0.524	-0.504	-0.530
15	+0.001	-0.340	-0.327	-0.343
20	+0.001	-0.167	-0.160	-0.168
25	0.000	0.000	0.000	0.000
30	-0.001	0.154	0.149	0.155
35	-0.002	0.303	0.292	0.304

If the formulation of the sample does not correspond exactly to those of the solutions described in table, the temperature coefficient may be different.

In this case, it may be necessary to calculate it by measuring the pH of the sample at two ten degree increments (for example: 20 and 30 degrees). However, this temperature coefficient is linear and some errors could occur if it is determined for temperature never reached by the process. The best way is to determine it for temperature near the process temperature.

OUR SOLUTION

The different temperature compensation modes described above are available:

- *NERNST curve: solutions enough conductive for having an important buffer capacity and not to be influenced by a temperature variation. The only temperature effect is the slope modification of the electrode.*
- *Ultra-pure water curve: the water must be exempt of any impurities.*
- *Matrixes 1,2,3,4: they are dedicated to the solutions described. If the customer application is slightly different, the temperature coefficient may change. In this case, it is better to use the fixed coefficient mode.*
- *Coefficient: In the Hach standard controller (sc), it corresponds to the pH variation for a 10°C change.*

The sign of the coefficient depends on the pH variation with temperature.

The temperature compensation curve follows: pH(25°C) = pH(T) + coef x (T-25)

Example: process temperature stable at 30°C.
Determine the pH of the sample at 25°C and at 35°C.
Note the difference equal to the absolute temperature coefficient (for 10°C variation)
If pH(35°C) >pH(25°C): coef is <0 You should enter in the controller: - coef.
If pH(35°C)<pH(25°C): coef is >0 You should enter in the controller: + coef

3.4.4 - pH of buffer solutions

The pH of buffer solutions also changes with temperature variation.

During the calibration, it is essential to disable the ultra-pure water temperature compensation mode whatever it is since buffer solutions have temperature behavior completely different from that of high purity water.

The pH of the temperature solution needs to be adjusted to the true pH value of the buffer at its temperature, indicated on the buffer bottle.

pH Values of Calibration Buffers vs. Temperature

Temperature °C	Buffer A pH 6.86	Buffer B pH 4.01	Buffer C pH 9.18
10	6.923	3.998	9.332
15	6.900	3.999	9.276
20	6.881	4.002	9.225
25	6.865	4.008	9.180
30	6.853	4.015	9.139
35	6.844	4.024	9.102
40	6.838	4.035	9.068
45	6.834	4.047	9.038
50	6.833	4.060	9.011

OUR SOLUTION

In the Hach sc controller, the auto calibration mode selects automatically the NERNST temperature compensation curve and the right Hach buffer pH with regards to the temperature measured.

3.4.5 - Others temperature effects

The pH electrode should be located near the temperature sensor in order to measure the temperature at which the pH electrode is.

The useful life of electrodes is reduced at high temperature. The solubility of Ag/AgCl reference elements increases with temperature..

At 10°C, the potential of a reference electrode is 231.4 mV whereas at 30°C it's 219 mV and at 90°C it's 161.5 mV.

As 60 mV is about pH 1, it's important to use the same reference elements in pH and reference half cells.

OUR SOLUTION

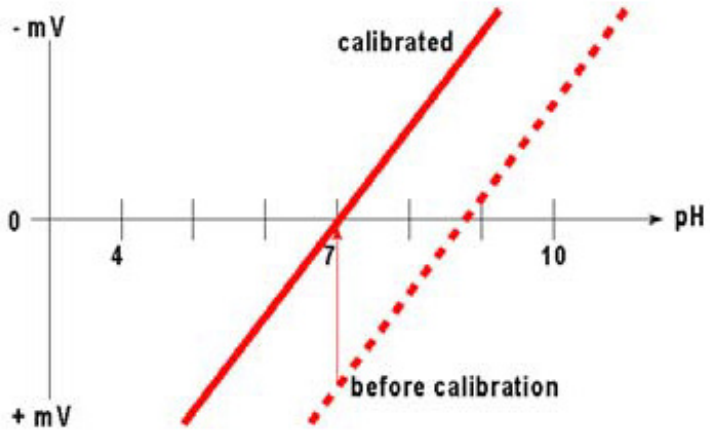
8362 model: The temperature sensor is PT100 Grade A and installed closely to the pH sensor.

4- CALIBRATION PROCEDURE

4.1 - Zero calibration

Each electrode has a non ideal behavior. Therefore when placing a glass electrode in a solution corresponding exactly to the formulation of the internal electrolyte of the glass electrode, a asymmetry potential exists. It mainly appears if internal and external side of the glass membrane have different structure, if the conductive elements of the reference and glass electrodes are at different temperature.

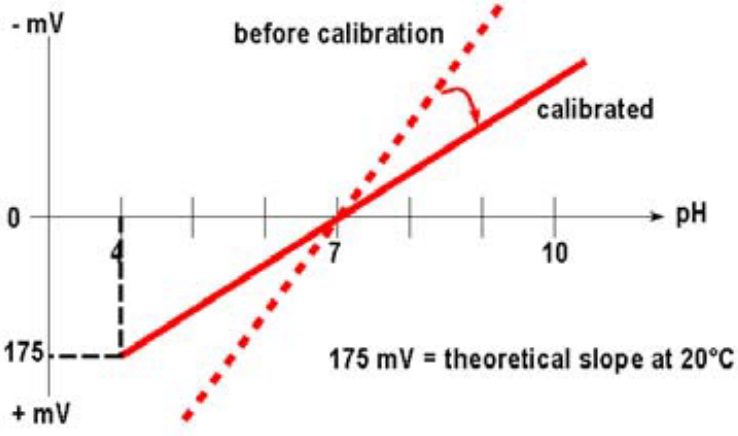
The zero calibration allows to correct this isopotential offset by immersing the pH electrode in a pH 7 buffer corresponding to the internal electrolyte of the pH electrode.



4.2 - Slope adjustment

The slope of the pH electrode corresponds to the NERNST factor: 2.3RT/F. Ideally, it is equal to 177 mV at 25°C in a pH 4 buffer. But pH electrodes show imperfect behavior because of ageing, fouling among others.

The slope calibration allows to adjust it to its theoretical value at the temperature of the buffer.



4.3 - Calibration procedure

It is given for a 8362 probe associated to a Hach standard controller.

About sensor calibration

- The sensor characteristics slowly shift over time and cause the sensor to lose accuracy.
- The sensor must be calibrated regularly to maintain accuracy.
- The calibration frequency varies with the application and is best determined by experience.
- Calibration adjusts the sensor reading to match the value of one or more reference solutions.

For pH sensors, a temperature element is used to provide pH readings which are automatically adjusted to 25 °C for temperature changes that affect the active and reference electrode. This adjustment can be manually set by the customer if the process temperature is constant.

Calibration slope and offset limits

A calibration will fail if the new slope value is < -20% or > 10% of the original slope value, or if the new offset value is ± 3 pH of the original offset value. If the new slope and offset values are within these limits the calibration will pass. However, if the new slope value is < -10% or > 5% of the original slope value, or if the new offset value is ± 2 pH of the original offset value, a warning will be generated, and a warning icon displayed on the measurement screen. To remove the warning icon from the display, push the enter key, select the sensor and acknowledge the warning.

pH calibration

In calibration mode, the temperature compensation of the electrodes is systematically according to the Nernst law (non ultra-pure water mode), whatever is the measurement temperature matrix selected.

The temperature measurement remains active. If the automatic temperature compensation is selected, be sure to have the Pt100/1000 immersed in the calibration solution.

Buffer solutions

The pH of buffer solutions depends on temperature. The nominal pH values are referred to a temperature of 20°C.

For temperatures different from 20°C, NIST standard buffer solutions, DIN buffers (DIN 19267 or DIN 19266), and pH values are indicated in the table below.

NIST (National Institute of Standards and Technology) - IUPAC pH 4.00-6.88-9.22 at 20°C

These pH 6.88 & 9.22 buffers are classified in Primary Standard Reference Solutions and pH 4.00 buffer is classified in Operational Reference Solutions and described in the Standard documents as:

Buffer	4.00 @20°C	6.88 @20°C	9.22 @20°C
Recipe	Potassium Hydrogen phthalate 0.05 $mol.kg^{-1}$	Di-Sodium hydrogen phosphate + Potassium dihydrogen phosphate 0.025 $mol.kg^{-1}$ each	Di-Sodium Tetraborate 0.01 $mol.kg^{-1}$
T°C	NIST	NIST	NIST
0	4.000	6.984	9.464
5	3.998	6.951	9.395
10	3.997	6.923	9.332
15	3.998	6.900	9.276
20	4.000	6.881	9.225
25	4.005	6.865	9.180
30	4.011	6.853	9.139
35	4.018	6.844	9.102
37	4.022	6.841	9.088
40	4.027	6.838	9.068
50	4.050	6.833	9.011

DIN 19266

Buffer	1.68	4.01	6.86	9.18
T°C range	0-95°C	0-95°C	0-95°C	0-95°C
Recipe	Potassium tetraoxalate 0.05 mol.kg-1	Potassium hydrogen phthalate 0.05 mol.kg-1	Phosphate 0.025 / 0.025 mol.kg^{-1} KH_2PO_4 / Na_2HPO_4	Sodium tetraborate 0.05 mol.kg^{-1}
T°C				
-10	1.672	3.994	7.010	9.631
0	1.671	3.996	6.980	9.462
10	1.670	4.001	6.922	9.331
20	1.676	4.003	6.880	9.228
30	1.685	4.015	6.853	9.144
40	1.697	4.036	6.837	9.076
50	1.712	4.064	6.833	9.018
60	1.723	4.091	6.836	8.962
70	1.743	4.126	6.845	8.921
80	1.766	4.164	6.859	8.885
90	1.792	4.205	6.877	8.850
100	1.821	4.255	6.898	8.820
110	1.852	4.309	6.920	8.793

DIN 19267

Buffer	1.09	3.06	4.65	6.76	9.23	12.75
Recipe	HCl 0.1 M	Glycine	Acetate	Phosphate + Citric acid	Boric Acid + NaOH	NaOH
T°C						
0	1.08		4.67	6.89	9.48	
10	1.09	3.10	4.66	6.84	9.37	13.37
20	1.09	3.07	4.65	6.80	9.27	12.96
25	1.09	3.06	4.65	6.79	9.23	12.75
30	1.10	3.05	4.65	6.78	9.18	12.61
40	1.10	3.04	4.66	6.76	9.09	12.29
50	1.11	3.04	4.68	6.76	9.00	11.98
60	1.11	3.04	4.70	6.76	8.92	11.69
70	1.11	3.04	4.72	6.76	8.88	11.43
80	1.12	3.05	4.75	6.78	8.85	11.19
90	1.13	3.07	4.79	6.80	8.82	10.99

pH 4.00-7.00-10.00 at 20°C

Buffer	4.00 @25°C	7.00 @25°C	10.00 @25°C
Recipe	Potassium Hydrogen phthalate 0.05 mol.kg^{-1}	KH_2PO_4 / Na_2HPO_4 phosphate 0.020 / 0.0275 mol.kg^{-1}	$NaHCO_3$ / Na_2CO_3 carbonate 0.025 / 0.025 mol.kg^{-1}
T°C			
-10.0°C	4.02	7.17	10.38
0.0	4.00	7.10	10.26
10.0	3.99	7.06	10.15
20.0	3.99	7.02	10.05
30.0	4.00	6.99	9.96
40.0	4.02	6.97	9.87
50.0	4.05	6.98	9.80
60.0	4.08	6.98	9.73
70.0	4.12	6.97	9.68
80.0	4.15	6.99	9.63
90.0	4.20	7.01	9.59
100.0	4.23	7.04	9.55
110.0	4.27	7.07	9.51

The temperature of the buffer solution needs to be entered only if the transmitter is operated in the manual temperature-compensation mode.

- In the « automatic calibration » mode the transmitter determines the pH value according to the temperature.
- In the other calibration modes, the nominal pH values must always be considered.
- For a precise calibration of the pH electrode, 2 buffer solutions are required one of which should have a pH close to the sample pH.
- The pH 7 buffer solution (or 6.88 at 25°C) is recommended for a first standardization and a pH 4 buffer solution (or 4.01 at 25°C) or pH 10 (or 9.22 at 25°C) is required to calibrate the electrode slope.

For calibration procedure details, please refer to the pH manual: DOC024.52.93063

4.3.1 - Advice

The calibration frequency depends upon the customer's tolerances onto the drift of the measurements and the accuracy required. Generally, we do recommend a calibration every 2 or 3 weeks but it can be done once a month or less.

A grab sample must not be taken with regards to CO_2 contamination, and temperature coefficient change.

The electrode must not dry. Therefore the flow-through chamber must not be kept leer. If it happens, immerse the electrode in pH 7 solution to hydrate the glass membrane again. Bear in mind that ultra-pure water is corrosive and can dissolve the glass of the electrode. If you need to store the electrode during a long period of time it's better to immerse it in a KNO_3 1M solution at 25°C.

5- ASTM REGULATIONS : D5128-14

Standard test method for on line pH measurement of water low conductivity

www.astm.org/Standards/D5128.htm

Chapter 3
CONDUCTIVITY MEASUREMENTS

1- MAIN APPLICATIONS

The conductivity measurement is a reliable indicator for monitoring ionic impurities in the water.

It monitors any change in the solution:
Traces of salts, acids, base, impurities will increase the conductivity

It is mainly used to control:

- The performance and cost effectiveness of demineralization plants
- The ionic contaminants level in boiler feed water and condensate, in microelectronics rinse water, in pharmaceutical process water.
- The chemical treatment for conditioning the boiler feed water accurately.

Power plants, microelectronics and pharmaceutical industries must ensure the quality of their process water and require accurate conductivity or resistivity measurements in order to avoid any production loss or corrosion problems.

2- OPERATING PRINCIPLE

Conductivity characterises the ability of an aqueous solution to carry an electric current, conducted by the ion's movement.

An alternating current (I, provided by a controller) is applied to a precise volume of the solution to be analyzed, represented by the **conductivity cell**. The resulting voltage (V) is measured and converted into a conductivity measurement, compensated or not in temperature:

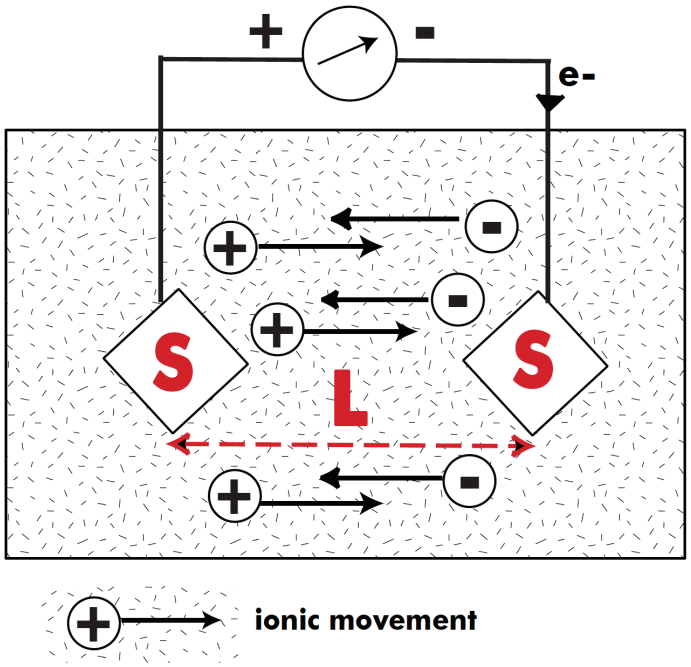
V = R I (ohm law)
R(Ω) is the resistance of the sample between the opposite face of the electrode (surface S(cm^2), distance L(cm))
ρ is the resistivity(Ω.cm) with **R=ρ L/S**
κ is the conductivity (S/cm) and is the reciprocal of the resistivity.

The ratio L/S (cm^{-1}) represents the cell constant of the conductivity probe with K=L/S.
ρ = R/K and κ = K/R

The controller measures the resistance (R) and calculates the uncompensated resistivity which depends upon the value of the cell constant (K) according to: **ρ = R/K**.

Afterwards, it measures the temperature and compensates the resistivity with the appropriate temperature compensation algorithm.

It displays the resistivity or conductivity at the referenced temperature if any.



3-KEY PARAMETERS

3.1 - Overview

Many factors contribute to the variation of conductivity affecting the mobility of the ions:

- The valency of the ions will determine the quantity of electricity that an ion is able to carry (i.e Z)
- The permittivity of the solvent (i.e. water in ultra-pure water systems)
- The dissociation rate, the viscosity of the electrolyte (i.e. water and acid, bases or neutral salts impurities)
- The temperature, the concentration and the size of the ions (i.e. C, **Λ**)

Among others parameters, the measurements accuracy depends upon:

- The precision of the real cell constant value
- The ability of the controller to measure a ultra-pure resistance (R) accurately
- The accuracy of the temperature sensor

The calibration of the controller in temperature and conductivity, and the determination of the real cell constant are essential to ensure high-accurate measurements.

3.2 - Conductivity probe

3.2.1 - The cell constant

The electrical contact with the water occurs through conducting surfaces: the electrodes

They are covered by an insulated body with a precise geometrical form (subjected to manufacturing variations) defined by the cell constant (K)

If the cell constant changes ,the resistance seen by the circuitry does as well.
With concentric electrodes, the cell constant is difficult to determine depending upon the inside diameter of outer electrode, the outside diameter of inner electrode, the length of innerelectrode and their concentricity.

In practice, cell constants are not calculated from dimensions but by comparison with the reference probe which has the same designed cell constant.

The cell constant of this reference probe is determined according to the resistance measured (i.e. resistivity or conductivity displayed by the controller with a cell constant of 1) in a potassium chloride standardized solution (whose resistivity/conductivity value is known)

$$K = \frac{\kappa KCl}{\kappa controller}$$

With:
K = cell constant of the reference probe
κKCl = Potassium chloride conductivity
κcontroller = Conductivity displayed by the controller with a cell constant of 1 cm^{-1}.

By this mean, the cell constant can be determined within 2% accuracy .

As this value is essential for ensuring precise measurements, it is mandatory to set in the controller the real value of the cell constant which is not strictly equal to 0.01.

OUR SOLUTION

First, we define the cell constant of our reference probe (k=0.01 8310 or 8315 model) whose cell constant corresponds to that of currently manufactured probes. The reference probe remains at our facility and is checked once a year.

Second, we use this reference probe to determine the cell constants of all 8310 or 8315 probes (same design cell constant of 0.01) manufactured at our facility.

On the left top of the certificate is indicated our reference related to your order.

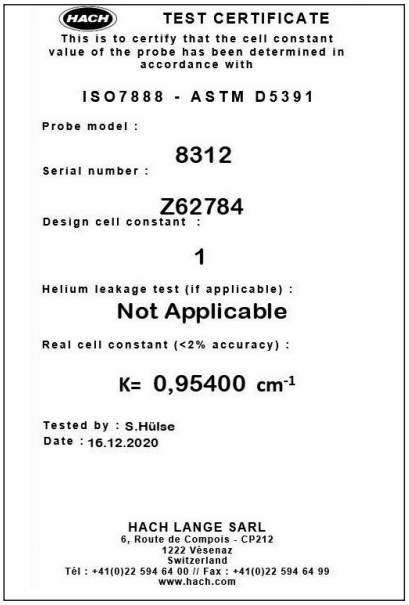
Moreover, this certificate specifies the model, the serial number, the design cell constant and the real cell constant of the probe.

In the attached example, a 8312 probe, whose serial number is Z62784 and design cell constant is equal to 1 has been tested according to ISO7888 and ASTM D1125. The real cell constant has been calculated and is 0.95400 cm-1+/- 2%.

We remember that we test each 8314, 8315, 8316, 8317 with helium under 25 bar pressure at 25°C for eliminating any risk of fluid leakage since probes must operate at this level of pressure.

Each probe tested must have a leakage rate less than 10^{-4} atm.cm^3/s for design cell constant of 1 and 0.1 and 10^{-6}atm.cm^3/s for that of 0.01.

It's an important safety feature to promote!



TEST CERTIFICATE

This is to certify that the cell constant value of the probe has been determined in accordance with

ISO7888 - ASTM D5391

Probe model : 8312

Serial number : Z62784

Design cell constant : 1

Helium leakage test (if applicable) : Not Applicable

Real cell constant (<2% accuracy) : K= 0,95400 cm^{-1}

Tested by : S.Hülse

Date : 16.12.2020

HACH LANGE SARL
6, Route de Compois - CP212
1222 Vésenaz
Switzerland
Tél : +41(0)22 594 64 00 // Fax : +41(0)22 594 64 99
www.hach.com

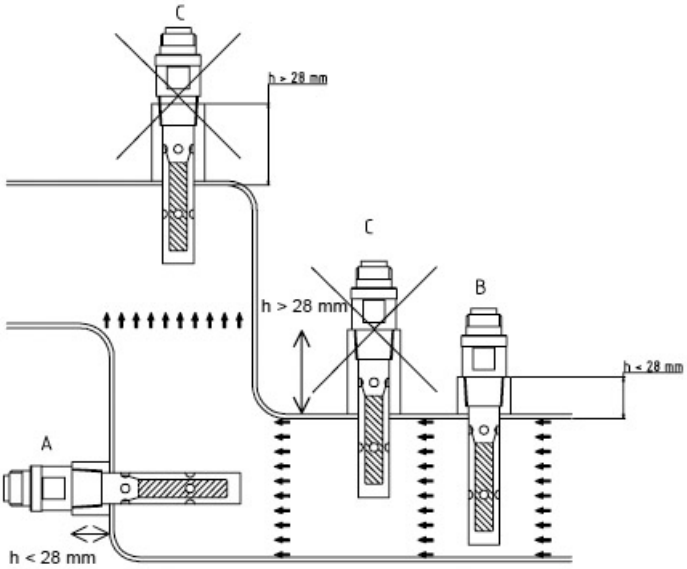


Figure 3-5 - Electrode 8315

A Very good installation:
Perfect immersion of the electrode surfaces.

B Correct installation:
Satisfactory immersion of the electrode surfaces.

C Poor installation:
Incomplete immersion of the electrodes, the conductivity will be too low.

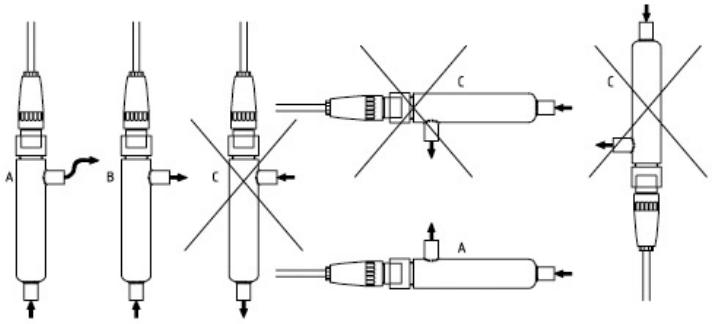


Figure 3-7 - Circulation chamber

A Very good installation:
Perfect immersion of the electrode surfaces.

B Correct installation:
Satisfactory immersion of the electrode surfaces.

C Poor installation:
Incomplete immersion of the electrodes, the conductivity will be too low.

3.2.2 - Surface electrode and materials

The surface finish of the electrodes must be without any porosity and active.

The wetted material must withstand acid and caustic solutions used in ion exchange regeneration and resists to sterilization.

OUR SOLUTION

Our probes dedicated to ultra-pure water measurements use stainless steel electropolished electrodes.

The installation of probes must avoid any dead leg which can be created in a tee if the diameter of the probe fittings is smaller than that of the pipe. We recommend placing the probes in an elbow of a pipe or in a tee.

Be careful that the flow rate is high enough to eliminate any air bubbles. If a flowthrough chamber is used, install the inlet at the bottom and the outlet at the top. Indeed, air bubbles reduce the active surface of the electrodes and decrease the value of conductivity displayed (i.e. increase the resistivity).

3.2.3 - Cable capacity

The cell of the electrode is not a ultra-pure resistance. The measurement is affected by inter-wire capacitance, wire resistance, pickup of unwanted signals among others.

The cable induces a capacitance in parallel which produces an alternative current, decreasing the resistivity read by the controller (i.e. positive error on conductivity, increase of its value).

OUR SOLUTION

The use of a low frequency (i.e. Impedance = C/ j 2πf) is recommended to minimize this effect which can be quite important if the cable is long .

4 - TEMPERATURE EFFECT

4.1 - Overview

The temperature affects the ion's mobility and densities. With an increase of temperature, the dissociation constant of water increases implying an increase of conductivity (i.e. a decrease of resistivity).

In general aqueous salt solutions, the temperature coefficient is about 2%/°C (Conductivity greater than 10µS).

Depending upon concentrations and the ion's nature, it can reach up to 7%/°C in ultra-pure water.

The temperature compensation adjusts the resistivity to what it would be at 25°C. Conductivity measurements are quite often referenced to the international standard @ 25°C as following:

$$\text{Conductivity Compensated @T Reference} = \text{Conductivity Uncompensated @T, Temperature of the Solution} \times \frac{1}{1 + 0.0X\ *(T\text{-}Tref)}$$

**With 0.0X = temperature coefficient in %/°C*

The precision of the temperature compensation is dependent upon the location and the accuracy of the PT100 sensor.
A minimum thermal inertia is required.

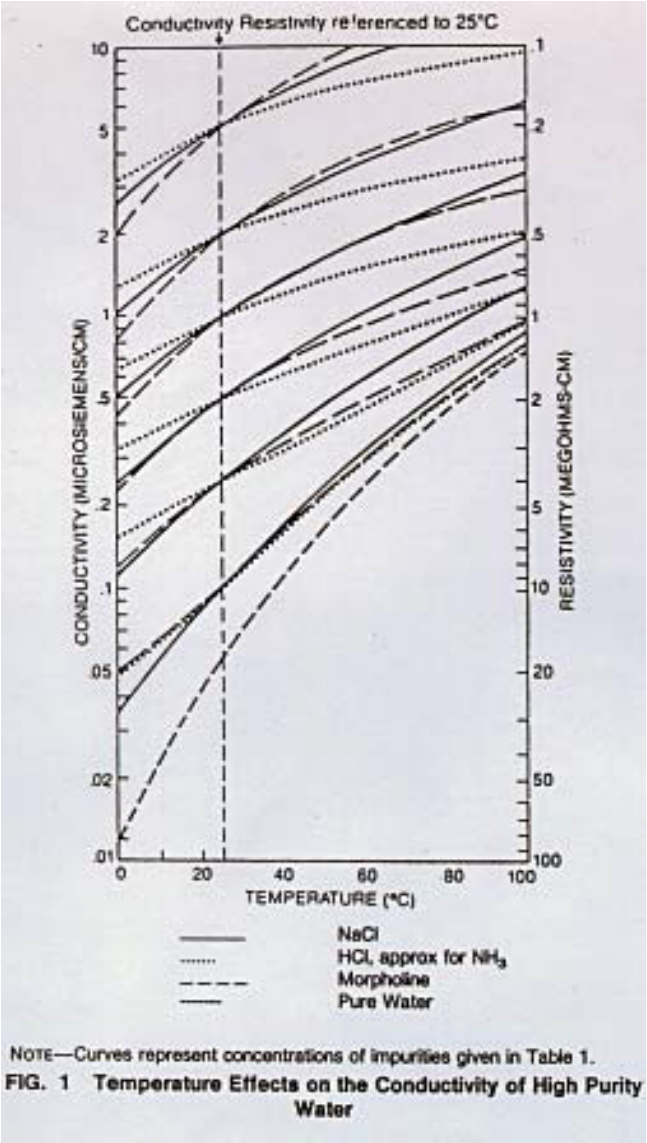
OUR SOLUTION

We use accurate sensors (Pt100 grade A) on all our conductivity probes and our controllers to allow calibration of the temperature loop electrically or according to a comparative value from an external certified thermometer (ie process calibration).

Note:
accurate compensation = accurate temperature measurement + knowledge of specific impurity

4.2 - Temperature effect in ultra-pure water

4.2.1 - Ultra-pure water



NOTE—Curves represent concentrations of impurities given in Table 1.

FIG. 1 Temperature Effects on the Conductivity of High Purity Water

TABLE 1 Concentrations of Trace Contaminants Plotted in Fig. 1

	Concentration (pg/L)			
Conductivity pS/cm at 25°C	NaCl	HCl	NH_3	Morpholine
5.00	2295	430	638	13.755
2.00	903	172	177	2632
1.00	439	86	76	837
0.500	207	42.6	34.4	298
0.250	91	20.7	16.1	117
0.100	21.0	6.5	5.4	34.6
0.055	0.0	0.0	0.0	0.0

In ultra-pure water, the ionic contribution is mainly due to the self ionization of the water.

Conductivity is calculated as following:

$$k = 10^{-3} d_t (L_{H+} + L_{OH-}) (K_w)^{1/2}$$

with

k=conductivity in S/cm

dt = density of water in g/mL

$L_{H+} = L_{OH-}$ = equivalent conductance in $S.m^2.mol^{-1}$

K_w= dissociation constant of water

Example:

At 25°C, Kw =10^{-14} ; L_{H+} = 349.8 and L_{OH-}=197.8; d_t =0.99707; **k=0.055 µS/cm**

4.2.2 - Ultra-pure water with impurities

If the conductivity of ultra-pure water is different from this value at 25°C, there are some other ions present (traces Na^+; Cl^-; Ca^{2+}; Mg^{2+}....)

In this case, the non-linear behavior of the dissociation of the water is associated to the linear behavior of the contaminants. The conductivity is calculated according to:

$$k = C * å ((Z xL)/M) + k_{H2O}$$

with
C= concentration of impurity(kg/L)
Z= electronic charge
M= molar mass(g/mol)
L =equivalent conductance in $S.m^2.mol^{-1}$

Example: At T=25°C with NaCl impurity present in ultra-pure water sample.

* NaCl=100ppb = 0.1 mg/l= 0.1.10-6 kg/L
L_{Na+}=50.1 $S.m^2.mol^{-1}$ with Z_{Na+}= =1 and M_{Na+}=23 g/mol
L_{Cl}-= 76.35 $S.m^2.mol^{-1}$ with Z_{Cl}- = 1 and M_{Cl}-=35.5g/mol
k_{H2O}= 0.055 µS/cm = 0.055 10^{-6} S/cm

k = 0.1 10^{-6} ((50.1+76.35)/(23+35.5) + 0.055 10^{-6} =0.271 µS/cm (solution of 100ppb NaCl)
r=1/0.271=3.69 Mohm

**A 1ppb NaCl solution has a resistivity of 17.5 Mohm and a 10ppb one a resistivity of 13.1Mohm.*

The higher the concentration of impurity is, the lower the resistivity is.

If it's a neutral salt, the ionization is independent from that of the water: The temperature compensation of each of them is correct. However, acid or basic impurities have different ionization proprieties from a neutral salt and it is necessary to compensate each of them. Indeed, if there is an acid or base, their contribution removes the ionization of the water (less ions present).

Different curves have been established :

- NaCl for effluent of classical deionizer
  Typical of that of many other inorganic solutions.
  Example NaCl=1ppb
  25°C=17.6Mohm
  50°C=5.87 Mohm
  100°C=1.3 Mohm
- Ammonia for conditioning water in power plants
  HCl for sample with cationic conductivity and cation exchangers effluents, cheap rinse water
  As acid and ammonia curve are quite similar, HCl curve is considered as a good approximation for NH_3 solution.
- USP regulations consider that it's impossible to compensate correctly for all possible compositions of the water
  (Cl^-; NH_4^+; HCO_3^-; H^+; OH^-: cation Na^+)
  In addition, the influence of CO_2 complex the temperature properties.
  Therefore they recommend uncompensated conductivity measurements.

OUR SOLUTION

In the Hach standard controller, we offer 3 types of temperature compensation:
Type: NO for uncompensated conductivity measurement (USP application in ultra-pure water)
Type: AUTO (Mode NaCl or HCl)
Type: Fixed coefficient = for in other applications than that of ultra-pure water)

5 - CALIBRATION

5.1 - Standard Solution

In order to calibrate accurately conductivity measurements, it is usually recommended to use a calibration solution whose conductivity is near the average values measured on-line. Generally, the conductivity probe is fitted into a beaker containing a KCl solution of known conductivity standards. The value displayed is adjusted to the conductivity of this standard.

This method cannot be performed for conductivity measurements dedicated to pure or ultra-pure water because pure water standards do not exist.

The lowest available NIST (National Institute of Standards and Technology) standards is equal to 25 µS/cm +/- 2% uncertainty.

Due to potential carbon dioxide contamination from the surrounding air, residues in the samples beaker and traces of chemicals, it is impossible to guarantee the quality of ultra-pure water standards lower than 100 µS/cm. Therefore, the lowest stable and accurate conductivity NIST standards is 100 µS/cm+/-0.25%.

5.2 - How to calibrate

The key parameter to validate is the accuracy of the cell constant. Because we declare cell constant in the controller, the new cell constant will need to be re-calibrated yearly.

First available calibration method: Performing a process calibration by online comparison with a reference measuring loop.

This method is generally enough for most of the applications and is valid if the cell constant is stable enough (+/- 5% of the factory value).

- f your sensor is out of that acceptance range, you may need to clean up the sensor (refer to cleaning section of the sensor manual) and validate the integrity of the electrodes surface.
- If the electrodes are damaged or corroded, please change the sensor.
- To perform the process calibration, you need a sampling point as close as possible from the measuring point and a validated measuring loop (i.e. Hach Purecal 9526).
- Run the reference system in parallel with the process unit on the same sample
- Wait for reference temperature measurement stabilizing to process temperature +/- 0.1°C
- Read the conductivity value on your reference system
- Enter that value into the process controller

Second available calibration method: Performing a calibration according to ASTMD 1125

- Step 1: use traceable resistors within 0.1% accuracy to calibrate both temperature sensor and the electrical loop (controller + cables) to consider lead wire characteristics (i.e. parallel and serial capacitance) ...
- Step 2: plunge your sensor connected to the measuring loop to be calibrated in a reference KCl standard (at least 100 µS/cm) at 25°C (77°F).
- Step 3: enter the reference conductivity solution value into the controller

Third available calibration method: Performing a calibration utilizing a reference loop according to ASTMD 1125

Using the 9586 Purecal, which is a reference loop certified according to ASTMD 1125 that is connected to the process, the cell constant can be redefined or validated.

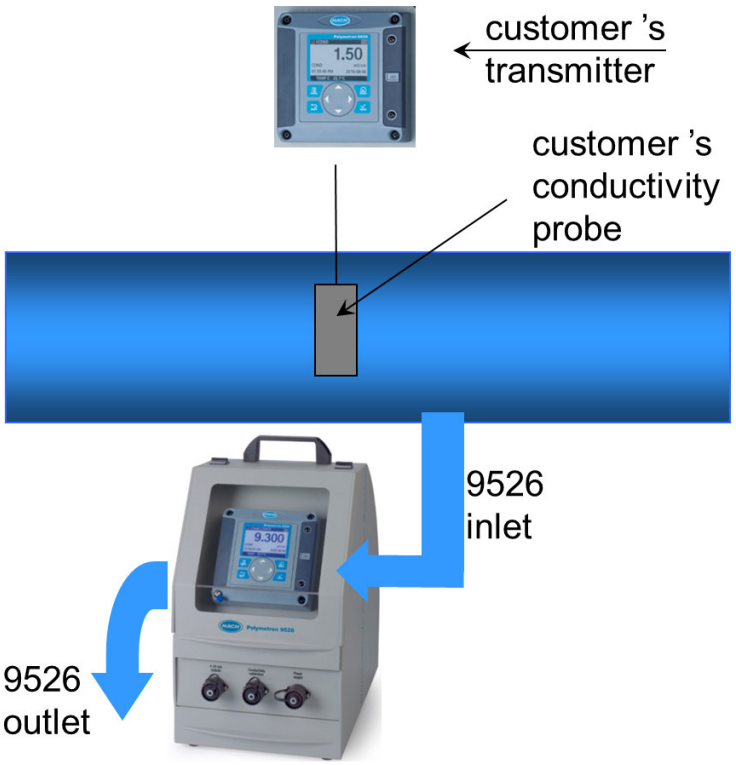
As for the process calibration, you need a sampling point as close as possible from the measuring point.

- Run the reference system in parallel with the process unit on the same sample
- Wait for reference temperature measurement stabilizing to process temperature +/- 0.1°C
- Read the conductivity value on your reference system
- Enter that value into the process controller

In addition, thanks to the NIST traceable resistors available on the Hach 9526 Purecal system, you can also validate your cell constant once a year (quality control) with:

- Calibration of both temperature sensor and the electrical loop (controller + cables) to consider lead wire characteristics (i.e. parallel and serial capacitance)...
- Cell constant validation by reading comparison between the online system and the Hach 9526 Conductivity Certification System

Note:
This third calibration/validation method is only appliable with Hach conductivity measuring loops.



PLEASE NOTE

The quality of ultra-pure water must be guaranteed and in compliance with international regulations.

Conductivity is a reliable indicator.

Periodical calibrations must be performed for maintaining the performance of the conductivity system.

Regulations (ASTM, USP) demands a certified conductivity certification system for validating conductivity loops installed on ultra-pure water process.

PURECAL matches these needs!

6- ASTM REGULATIONS : D5391-14

Standard test method for electrical conductivity and resistivity of a flowing high purity water sample
www.astm.org/Standards/D5391.htm

8362 ULTRAPURE WATER pH/ORP SENSORS

Applications
- Power

Simple to Integrate. Simple to Operate.

An integral part of the most complete water analytics system for the Power industry. Hach provides a broad range of product options designed to work together into flexible solutions to meet your unique needs. Hach's comprehensive approach saves you time on design, installation, training, maintenance, and operation.

Save time on design

A single design source and one product platform means you spend less time searching for design files or configuring components. Create and reuse your optimal design templates. The compact design saves valuable space.

Accelerate your installation

One source, interchangeable components, a common user interface, and one support team make installation faster and less complicated. Quickly and easily transfer user settings between pH/ORP loops. The self-pressurizing electrode is ready to operate and requires no maintenance or refilling of electrolyte reservoirs between normal electrode replacements

Reduce training complexity

A single platform minimizes time required to teach and learn product operations, getting new systems in use faster.

Simplify maintenance

Common menu guides reduce variability and provide step-by-step procedures for maintenance and calibration. Standard visual alerts across parameters notify operators when troubleshooting is required.

Optimize operation

Self-pressurizing electrodes and platinum RTD temperature sensor ensures accurate measurement. Hach's unique conductive flow chamber and stainless steel sheath reduces drift common to less sophisticated probes.

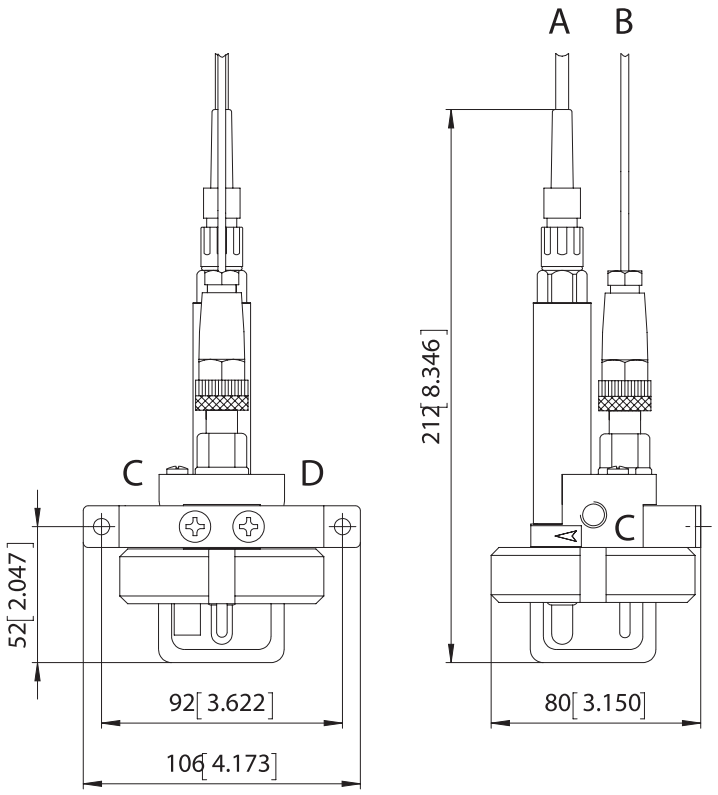
HACH®
Be Right™

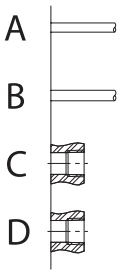
Specifications*

Prod. No.	08362=A=0000	08362=A=1111
	8362 Ultrapure Water pH Sensor	8362 Ultrapure Water ORP Sensor
Range	2 to 12 pH	-1500 to 1500 mV
Flow	100 to 400 mL/min	100 to 400 mL/min
Operating Temperature Range	-20 to 60 °C	-20 to 60 °C
Pressure Limit	Maximum Pressure: 16 bar at 25 °C, 6 bar at 100 °C	Maximum Pressure: 16 bar at 25 °C, 6 bar at 100 °C
Temperature Sensor	Pt 100	Pt 100
Temperature Compensation	-20 to 200 °C (-4 to 392 °F) Nernst special compensation for ultra pure water, different tables or linear coefficient	-20 to 200 °C (-4 to 392 °F)
Cable Length	3 m	3 m
Weight	1.98 lbs. (0.9 kg)	1.98 lbs. (0.9 kg)

**Subject to change without notice.*

Dimensions





A pH SENSOR, cable length 3000 [118], ∅ 5.3 [0.208]. Connect to pH/ORP Meter.

B TEMPERATURE SENSOR, cable length 3000 [118], ∅ 4.5 [0.177]. Connect to pH/ORP Meter.

C SAMPLE INLET: Female NPT 1/8",
0° to 80°C (32° to 176°F), Pressure: 4 bar [58 psi] max., Flow: 5 to 25l/h.

D SAMPLE OUTLET: Female NPT 1/8", atmospheric pressure.

All dimensions are in mm[inches].

Ordering Information

pH/ORP Electrodes

08362=A=2100	ORP Electrode for 8362 Ultrapure Water Sensor
08362=A=2000	pH Electrode for 8362 Ultrapure Water Sensor
08362=A=1001	Temperature Sensor for 8362 Ultrapure Water Sensor

pH/ORP Accessories

08362=A=4000	Stainless Steel Fittings, 1/8 NPT, pack of 2
08362=C=4000	Clear Flow-Through Chamber for 8362 pH/ORP electrode
08362=A=3001	Cable for 8362 Temperature Sensor, 3m
08362=A=3002	Cable for 8362 Temperature Sensor, 10m
08362=A=3003	Cable for 8362 Temperature Sensor, 20m
359016,10120	Cable for 8362 Ultrapure pH/ORP Electrode, 10m
359016,10122	Cable for 8362 Ultrapure pH/ORP Electrode, 20m

HACH COMPANY World Headquarters: Loveland, Colorado USA

United States: 800-227-4224 tel 970-669-2932 fax orders@hach.com
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CONTACTING CONDUCTIVITY SENSORS MODELS 8310, 8311, 8312

Applications
- Power

Simple to Integrate. Simple to Operate

An integral part of the most complete water analytics system for the Power industry. Hach provides a broad range of product options designed to work together into flexible solutions to meet your unique needs. Hach's comprehensive approach saves you time on design, installation, training, maintenance, and operation.

Save time on design

A single design source and one product platform means you spend less time searching for design files or configuring components. Create and reuse your optimal design templates. Each sensor has a unique four-digit cell constant determined according to ISO 7888 and ASTM D 1125 standards.

Accelerate your installation

One source, interchangeable components, a common user interface, and one support team make installation faster and less complicated. Quickly and easily transfer user settings between conductivity loops.

Reduce training complexity

A single platform minimizes time required to teach and learn product operations, getting new systems in use faster.

Simplify maintenance and operation

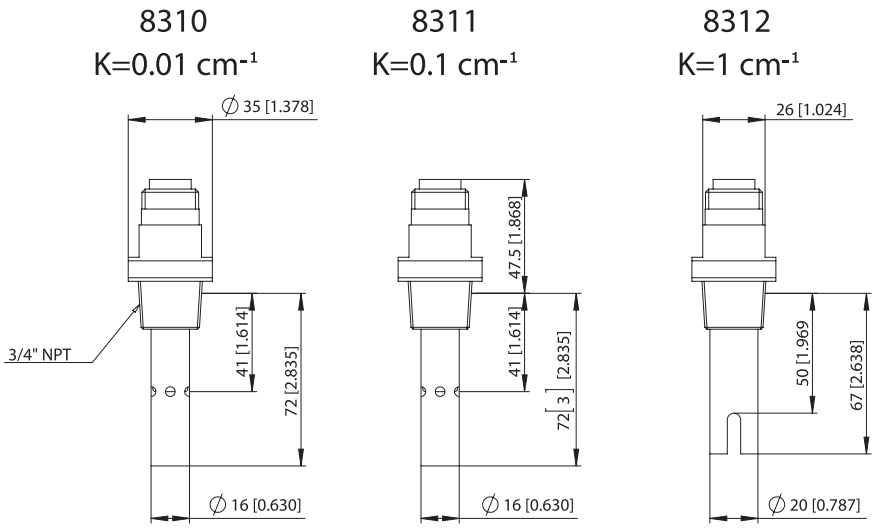
Common menu guides reduce variability and provide step-by-step procedures for maintenance and calibration. Robust construction with 316 Stainless Steel and a sturdy industrial design ensures the product can withstand even the most demanding conditions. Hach's contacting conductivity sensors measure a broad range (pure water 0.057 µS/cm up to 20,000 µS/cm) with high accuracy.

Specifications*

Prod. No.	08310=A=0000	08311=A=0000	08312=A=0000
Cell Constant k	0.01 cm^{-1}	0.1 cm^{-1}	1.0 cm^{-1}
Range	0.01 to 200 µS/cm	0.01 to 2000 µS/cm	0.01 to 20000 µS/cm
Operating Temperature Range	Maximum Temperature: 125 °C at 10 bar	Maximum Temperature: 125 °C at 10 bar	Maximum Temperature: 125 °C at 10 bar
Pressure Limit	10 bar at 25 °C	10 bar at 25 °C	10 bar at 25 °C
Material	Black PSU upper body with a 316L Stainless steel electrode	Black PSU upper body with a 316L Stainless steel electrode	Black PSU upper body with a graphite electrode
Temperature Sensor	PT100	PT100	PT100

**Subject to change without notice.*

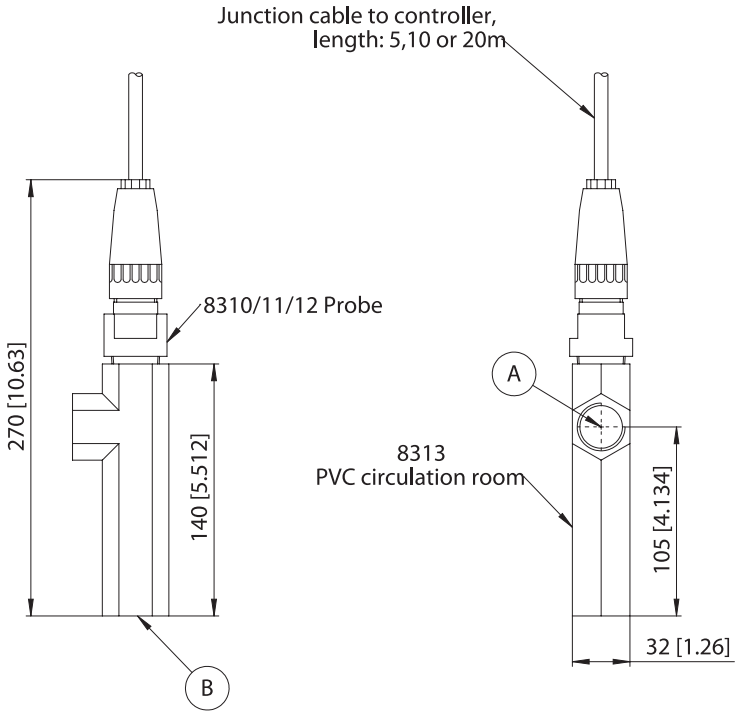
Dimensions



Psu PROBES

T Max: 125°C (257°F) / P Max: 10 bar (145 psi)

All dimensions are in mm[inches].



A SAMPLE OUTLET: Female NPT 3/4".

B SAMPLE INLET: Female NPT 3/4",
0° to 60°C (32° to 140°F), P: 10 bars max. (145 psi)

All dimensions are in mm[inches].

Ordering Information

Conductivity Electrodes

08310=A=0000	8310 Conductivity Sensor, K= 0.01 cm^{-1}
08311=A=0000	8311 Conductivity Sensor, K= 0.1 cm^{-1}
08312=A=0000	8312 Conductivity Sensor, K= 1 cm^{-1}

Conductivity Accessories

08313=A=0001	PVC Flow Chamber with 3 X 3/4 FNPT Bores
08319=A=0005	Cable for 831x Conductivity Probes, 5m
08319=A=0010	Cable for 831x Conductivity Probes, 10m
08319=A=0020	Cable for 831x Conductivity Probes, 20m

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CONTACTING CONDUCTIVITY SENSORS MODELS 8315, 8316, 8317

Applications
- Power

Simple to Integrate. Simple to Operate.

An integral part of the most complete water analytics system for the Power industry. Hach provides a broad range of product options designed to work together into flexible solutions to meet your unique needs. Hach's comprehensive approach saves you time on design, installation, training, maintenance and operation.

Save time on design

A single design source and one product platform means you spend less time searching for design files or configuring components. Create and reuse your optimal design templates. Each sensor has a unique four-digit cell constant determined according to ISO 7888 and ASTM D 1125 standards.

Accelerate your installation

One source, interchangeable components, a common user interface, and one support team make installation faster and less complicated. Quickly and easily transfer user settings between conductivity loops.

Reduce training complexity

A single platform minimizes time required to teach and learn product operations, getting new systems in use faster.

Simplify maintenance and operation

Common menu guides reduce variability and provide step-by-step procedures for maintenance and calibration. Robust construction with 316 Stainless Steel and a sturdy industrial design ensures the product can withstand even the most demanding conditions. Hach's contacting conductivity sensors measure a broad range (pure water 0.057 µS/cm up to 20,000 µS/cm) with high accuracy.

Specifications*

Prod. No.	08315=A=0000	08316=A=0000	08317=A=0000
Cell Constant k	0.01 cm^{-1}	0.1 cm^{-1}	1 cm^{-1}
Range	0.01 to 200 µS/cm	0.1 to 2000 µS/cm	1 to 20000 µS/cm
Operating Temperature Range	Maximum Temperature: 150 °C (302 °F) at 25 bar (362.5 psi)	Maximum Temperature: 150 °C (302 °F) at 25 bar (362.5 psi)	Maximum Temperature: 150 °C (302 °F) at 25 bar (362.5 psi)
Pressure Limit	25 bar Maximum Pressure	25 bar Maximum Pressure	25 bar Maximum Pressure
Material	Stainless Steel 316L with Viton O-Ring Gaskets, Stainless Steel 316L Internal Electrode	Stainless Steel 316L with Viton O-Ring Gaskets, Stainless Steel 316L Internal Electrode	Stainless Steel 316L with Viton O-Ring Gaskets, Graphite Internal Electrode
Measurement Method	Two-Electrode Sensor	Two-Electrode Sensor	Two-Electrode Sensor
Temperature Sensor	PT100 Integrated Sensor	PT100 Integrated Sensor	PT100 Integrated Sensor

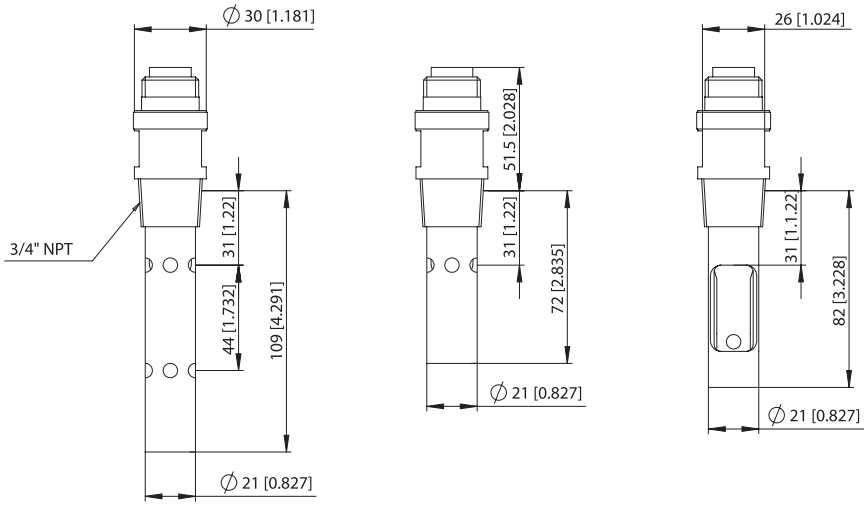
**Subject to change without notice.*

Dimensions

8315
K=0.01 cm^{-1}

8316
K=0.1 cm^{-1}

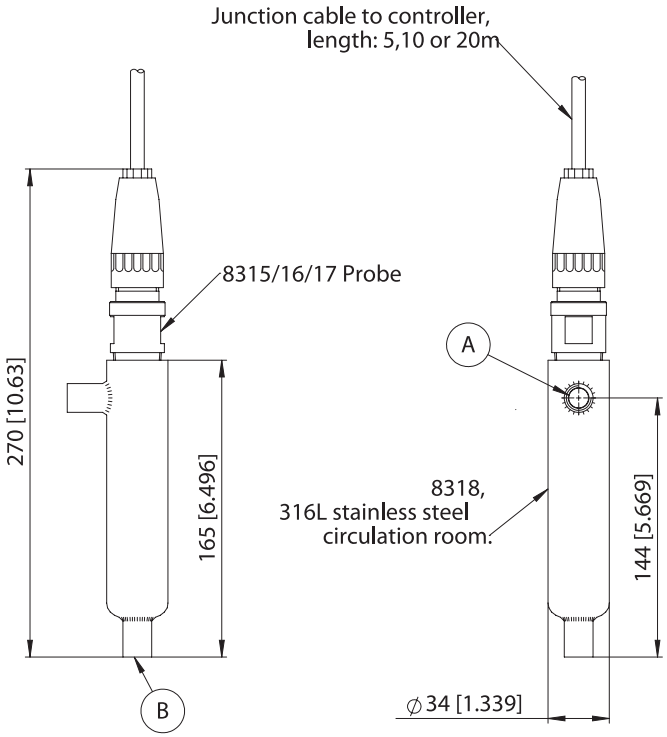
8317
K=1 cm^{-1}



316L STAINLESS STEEL PROBES

T Max: 150°C (302°F) / P Max: 25 bar (362 psi)

All dimensions are in mm[inches].



Ordering Information

Conductivity Electrodes

08315=A=0000	8315 Conductivity Sensor, K = 0.01 cm^{-1}
08316=A=0000	8316 Conductivity Sensor, K = 0.1 cm^{-1}
08317=A=0000	8317 Conductivity Sensor, K = 1 cm^{-1}

Conductivity Accessories

08318=A=0001	Stainless Steel Flow Chamber for 831x Sensors
08319=A=0005	Cable for 831x Conductivity Probes, 5m
08319=A=0010	Cable for 831x Conductivity Probes, 10m
08319=A=0020	Cable for 831x Conductivity Probes, 20m

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9525sc Degassed Cation Conductivity System

Applications
- Power
- Steam Systems

Service

Simple to Integrate. Simple to Operate.

An integral part of a complete Power water analytics system, Hach®'s degassed cation conductivity (DCCP) system measures specific conductivity (SC), cation conductivity (CC), and degassed cation conductivity (DCC) and helps to reduce plant start-up time. This comprehensive approach saves you time on design, installation, training, maintenance, and operation.

Reliable measurements

Hach's newly redesigned Degassed Cation Conductivity Analyzer efficiently removes CO_2 from the sample to deliver fast reliable results that save you critical time and effort.

Space-Saving Design

Compact, wall mounted footprint to allow for easy integration into existing or new SWAS systems.

Easy and Safe Handling

The new 9525sc requires no additional cooling water supply but instead allows for a regenerative cooling option and condenses the steam to allow for safe discharge via a vent drain.

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Technical Data*

Dimensions (H x W x D)	Degas System: 910 mm x 450 mm x 380 mm DCCP System (optional): 910 mm x 620 mm x 380 mm
Weight	27.7 kg (61 lbs) 50 kg (110 lbs for DCCP system)
Power Requirements (Voltage)	110 - 120 V AC
Power Requirements (Hz)	60 Hz
Main Supply Voltage Fluctuation	±10 % of nominal voltage
Power Consumption	1.6 k VA
Operating Temperature Range	Recommended operating temperature: 23 - 27 °C (75 - 80 °F)
Ambient Temperature	2 - 50 °C (36 - 122 °F)
Storage Conditions	0 - 50 °C (32 - 120 °F) 0 - 85 % relative humidity, non-condensing
Cell Constant k	0.01 cm^{-1}
Measuring Range Conductivity	0.01 - 200 µS/cm
Accuracy	< 2%
Power Requirements Controller	100 - 240 V AC ±10 %, 50/60 Hz
Enclosure Rating	IP66 / NEMA 4X
Flow	100 - 150 cc/min (mL/min); 6 - 9 L/h
Fitting Type	Sample inlet/outlet connections: ¼ inch tube fitting
Sample Cooler Type	DTC-DCCP
Cooling Water	0.8 L/min (0.2 gpm)
Certifications	CE, UL, CSA

Detailed specifications for the system components are available on hach.com & in the appropriate manuals:

SC200 Ultrapure Controller - DOC023.97.80040

8315sc Conductivity Sensor - DOC023.97.80083

**Subject to change without notice.*

Principle of Operation

The Hach DCCP Reboiler is designed to optimize the analytical results for degassed cation conductivity. First, the panel uses an oversized heater and baffled vapor discharge chamber, which assures complete boiling and provides a steam blanket over the sample to eliminate any sample contamination that might occur due to discharge piping backflow. The vapor is then condensed and removed via a vent drain. After the sample is degassed, it is cooled with an additional sample cooler so that chemistry deviations in analyzer temperature compensation curves are reduced. This unit operates in accordance to ASTM D4519.

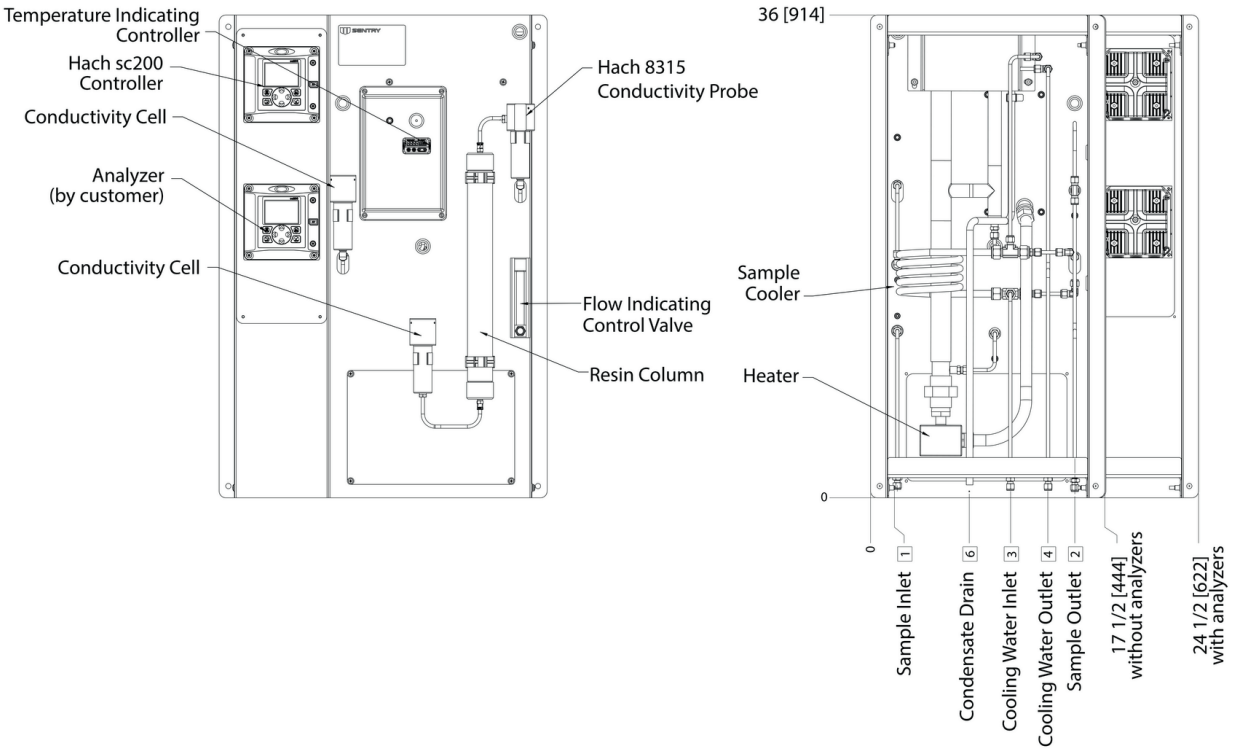
Benefits:

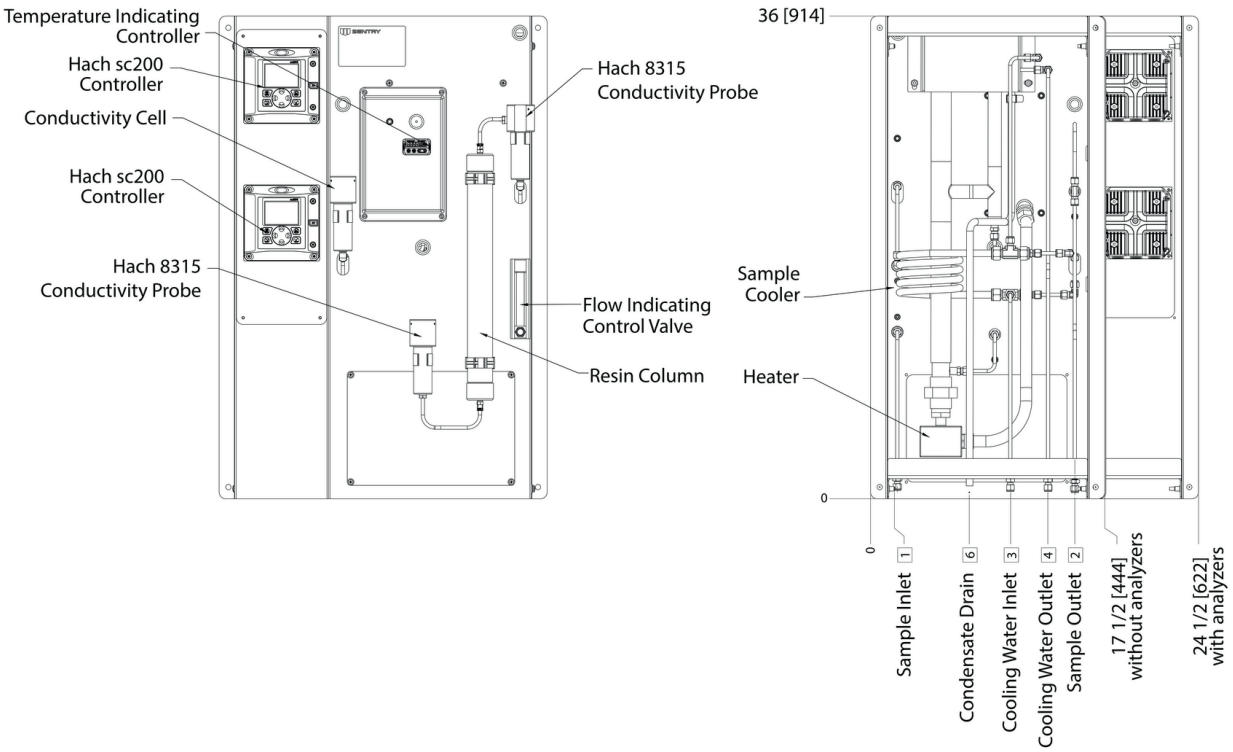
The Hach DCCP reboiler is a complete panel that efficiently removes CO_2 from the sample to measure degassed cation conductivity.

1. Capable of measuring (SC), Cation Conductivity (CC), Calculated pH and degassed cation conductivity (DCC)
2. No cooling water required with regenerative cooling option
3. Operates in accordance with ASTM D4519
4. Sample cooler ensures CC and DCC probes receive identical sample temperatures, eliminating errors

Dimensions

In millimeters.





Order Information

Degas System

9525.99.0010	Hach 9525sc System, Degassed Cation Conductivity only
9525.99.10CC	Hach 9525sc System, Specific Conductivity, Cation Conductivity, Calculated pH and Degassed Cation Conductivity
9525.99.0011	Hach 9525sc System, Degassed Cation Conductivity only, with Regenerative Cooler
9525.99.10CCR	Hach 9525sc System, Specific Conductivity, Cation Conductivity, Calculated pH and Degassed Cation Conductivity, with Regenerative Cooler

Accessories

9525.99.7030	Degas System Heater, 120 V
9525.99.7050	Degas Temperature Controller
9525.99.7060	Degas System Sample Cooler
4643600	Flow meter, 1.2 to 18 L/h, with ¼" OD tubing fittings
694=000=001	Adjustable flow meter, 0 to 16 L/h
8617600	Resin Column for 9525sc DCCP
8617700	Resin Column Refill Bag for 9525sc DCCP
8617800	Resin Column Refill Bulk for 9525sc DCCP, 18.9 L

Service

With Hach Service, you have a global partner who understands your needs and cares about delivering timely, high-quality service you can trust. Our Service Team brings unique expertise to help you maximize instrument uptime, ensure data integrity, maintain operational stability, and reduce compliance risk.

Visit hach.com/service

DOC053.53.35109.Sep19

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HQ Series Portable Meters

Applications

- Drinking Water
- Wastewater
- Food and Beverage
- Industrial Water
- Power
- Source Water

Service Protected

A robust and intuitive range of portable meters, instilling confidence in reporting and managing your results.

Performing a successful calibration has never been so simple

Most measuring issues are due to incorrect calibration procedures. With our illustrated, step-by-step on-screen calibration and troubleshooting procedures, water quality professionals can succeed every time.

Deliver your daily activity in just a few clicks

Whether you are at your facility or working in the field, the Hach® HQ Series portable meter ensures your data will be safely transferred via USB or optional Bluetooth*. Take advantage of additional data validation when you connect your field meter to Claros™ Data Management software.

*Bluetooth connectivity currently available in North America and selected European countries.

Sensors designed for every application

We offer standard laboratory and rugged field Intellical™ smart sensors available with the HQ Series to measure a wide variety of parameters including:

- Total Dissolved Solids (TDS)
- Optical Dissolved Oxygen (DO)
- Biochemical Oxygen Demand (BOD)
- Temperature,
- Conductivity
- pH.

ntellical smart probes are automatically recognized by HQ meters, retain calibration history and method settings to minimize errors and setup time. They incorporate proven technology to deliver superior accuracy and response times – even when measuring challenging samples or challenging operating environments.

Peace of mind: Hach service and support will be there for you

Our Technical Support, Field Service, and Central Service Teams work together with over 80 years of electrochemistry expertise to help you maximize instrument uptime, ensure data integrity, maintain operational stability, and reduce compliance risk. Never feel alone when you need support.

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Be Right™

Parameter Table*

Model	HQ1110 pH/ ORP/ 1 Channel	HQ1130 DO/ 1 Channel	HQ1140 EC/ TDS/ 1 Channel	HQ2100 pH/EC/ TDS/Salinity/ DO/ORP/ 1 Channel	HQ2200 pH/EC/ TDS/Salinity/ DO/ORP/ 2 Channel	HQ4100 pH/EC/ TDS/Salinity/ DO/ORP/ISE/ 1 Channel	HQ4200 pH/EC/ TDS/Salinity/ DO/ORP/ISE/ 2 Channel	HQ4300 pH/EC/ TDS/Salinity/ DO/ORP/ISE/ 3 Channel
Temperature	•	•	•	•	•	•	•	•
pH	•			•	•	•	•	•
mV	•			•	•	•	•	•
Conductivity			•	•	•	•	•	•
TDS			•	•	•	•	•	•
Salinity			•	•	•	•	•	•
Resistivity				•	•	•	•	•
Dissolved Oxygen		•		•	•	•	•	•
Luminescent (LDO)		•		•	•	•	•	•
BOD Sensor (with LDO)		•		•	•	•	•	•
ORP/Redox	•			•	•	•	•	•
Ion Selective Electrodes						•	•	•
Ammonia						•	•	•
Ammonium						•	•	•
Chloride						•	•	•
Fluoride						•	•	•
Nitrate						•	•	•
Sodium						•	•	•

Subject to change without notice.

Technical Data*

Model	HQ1110 pH/ ORP/ 1 Channel	HQ1130 DO/ 1 Channel	HQ1140 EC/ TDS/ 1 Channel	HQ2100 pH/EC/ TDS/Salinity/ DO/ORP/ 1 Channel	HQ2200 pH/EC/ TDS/Salinity/ DO/ORP/ 2 Channel	HQ4100 pH/EC/ TDS/Salinity/ DO/ORP/ISE/ 1 Channel	HQ4200 pH/EC/ TDS/Salinity/ DO/ORP/ISE/ 2 Channel	HQ4300 pH/EC/ TDS/Salinity/ DO/ORP/ISE/ 3 Channel
Data Memory	5000 data points			10,000 data points		100,000 data points		
Display Type	536x336 Mono-TFT			536x336 Mono-TFT		640x480 Color TFT		
Inputs	1			1	2	1	2	3
Weight (Meter only)	519 g			519 g	541 g	530 g	550 g	570 g
Warranty	EU: 2 years US and other geographies: 1 year			EU: 2 years US and other geographies: 1 year		3 years		
Dimensions (H x W x D)	63 mm x 97 mm x 220 mm							
Enclosure Rating	IP67 (with battery compartment installed)							
Data Storage	Automatic in Press to Read Mode and Interval Mode. Manual in Continuous Read Mode.							
Data Export	USB connection to PC or USB storage device (limited to the storage device capacity).							
Software available	Claros							
Display	Up to 3 parameters at a time, dependent on HQ model							
Backlight	Yes							
Lock Function	Continuous / Auto-stabilization (“press to read”) / At Interval							
Languages	English, Chinese - Simplified, Spanish, French, German, Italian, Japanese, Turkish, Dutch, Portuguese (PT & BR), Korean, Danish, Swedish, Polish, Norwegian, Hungarian, Greek, Finnish, Czech, Romanian, Croatian, Bulgarian, Slovak, Lithuanian, Estonian, Slovenian, Russian							
Certifications	CE, FCC, ISED, RCM, KC, ETL Verified: US DOE/ NRCan Energy Efficiency, RoHS							
GLP Features	Date; Time; Sample ID; Operator ID, Calibration							
Power Supply	Rechargeable lithium-ion battery 18650 (internal) Class II, USB power adapter: 100 - 240 VAC, 50/60 Hz input; 5 VDC at 2 A USB power adapter output (external)							

**Subject to change without notice.*

Order Information

HQ Series Portable Standard Sensor Kits

LEV015.53.11101	HQ1110 Portable Dedicated pH/ORP/mV Meter with Gel pH Electrode, 1 m Cable
LEV015.53.22004	HQ2200 Portable Multi-Meter with pH and Dissolved Oxygen Electrodes, 1 m Cables
LEV015.53.11301	HQ1130 Portable Dedicated Dissolved Oxygen Meter with Dissolved Oxygen Electrode, 1 m Cable
LEV015.53.42001	HQ4200 Portable Multi-Meter with Gel pH and Conductivity Electrode, 1 m Cable
LEV015.53.42005	HQ4200 Portable Multi-Meter with Gel pH and Dissolved Oxygen Electrode, 1 m Cables
LEV015.53.43001	HQ4300 Portable Multi-Meter with Gel pH, Conductivity, and Dissolved Oxygen Electrode, 1 m Cable

HQ Series Portable Rugged Sensor Kits

LEV015.53.11103	HQ1110 Portable Dedicated pH/ORP/mV Meter with Gel pH Electrode, 5 m Rugged Cable
LEV015.53.11302	HQ1130 Portable Dedicated Dissolved Oxygen Meter with Dissolved Oxygen Electrode, 5 m Rugged Cable
LEV015.53.22006	HQ2200 Portable Multi-Meter with pH and Dissolved Oxygen Electrode, 5 m Rugged Cables
LEV015.53.42006	HQ4200 Portable Multi-Meter with Gel pH and Dissolved Oxygen Electrode, 5 m Rugged Cables
LEV015.53.42002	HQ4200 Portable Multi-Meter with Gel pH and Conductivity Electrode, 1 m Cable

Additional Standard and Rugged Sensor Kits are available. Please contact Hach for more information.

Accessories and Consumables

LEZ015.99.A001A	Portable HQ Series Standard Field Case for Standard Probes
LEZ015.99.A002A	Portable HQ Series Field Case for Rugged Probes with Extended Cable Lengths
LEZ015.99.A003A	Kick Stand and Hand Strap for Portable HQ Series Meter
LEZ015.99.A004A	Protective Glove for Portable HQ Series Meter
LZE015.99.A005A	Wrist Strap and Dust Plugs for Portable HQ Series Meter
LEZ015.99.00001	Li-Ion Battery Replacement, HQ Series Meter
LEZ015.99.00002	USB Cable for Portable HQ Series Meter
LEZ015.99.00006	Replacement Power Supply for HQ Series Meter, US
LEZ015.99.00004	Replacement Power Supply for HQ Series Meter, EU

Service Protected

With Hach Service, you have a global partner who understands your needs and cares about delivering timely, high-quality service you can trust. Our Service Team brings unique expertise to help you maximize instrument uptime, ensure data integrity, maintain operational stability, and reduce compliance risk.

DOC052.53.25026.Aug20

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