OPERATING INSTRUCTION MANUAL

65-Series

Differential 2-Wire (4-20 mA) pH & ORP Probes

N116-139 R4

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TABLE OF CONTENTS

1. GENERAL INFORMATION

This manual covers all AquaMetrix two-wire Series differential measurement pH and ORP probes.

The 65 series sensors feature the AquaMetrix differential design for long lifetime, user serviceability and more accurate readings. In typical installations these probes will last for years whereas the more common combination probe lasts only months. The "P" prefix refers to the pH probe while the "R" prefix refers to the ORP version. Figure 1 shows available configurations. If you can't find your part number here, it may have been obsoleted or replaced with a newer model – please contact your distributor for information.

P 65 R8 __ - 015

Application	
pH	**P**
ORP	**R**
Electronics	
Two wire transmitter, 4-20 mA output	**65**
Dual output transmitter pH/ORP and Temperature (R8 only)	**T65**
Body Type	
Fixed insertion, 1" NPT threaded ends, Ryton	**R5**
Fixed insertion, 1.5" NPT threaded ends, Ryton	**R8**
Enhanced Performance Options (R8 only)	
Standard electrode	
Hardened glass electrode for pH sensors	**H**
Flat faced glass electrode for pH sensors	**F**
Antimony electrode for pH sensors For up to 5% HF-acid applications	**A**
Gold electrodes for ORP sensors	**G**
Custom Cable Length	
Standard 15 ft (4.5m) cable	**015**
Extended 50 ft (15.24m) cable	**050**

Figure 1 - Part number decoding for 65-series differentials sensors

The 65 series sensor incorporates an encapsulated transmitter that outputs a 4-20 mA analog signal. It was designed to connect directly to a PLC or the AquaMetrix 2300 multi-input controller.

The PT65 and RT65 series sensors combine a separate temperature sensor with its own 4-20 mA transmitter. The PT sensors output a dual pH (or ORP) and temperature signal.

The output from a two-wire transmitter type is non-isolated and un-calibrated. The system must provide 24 VDC, with the "low" input isolated from earth ground, and a means of calibrating for offset and span.

NOTE: Do not discard the protective cap(s) that came with the sensor. If the sensor is removed from the process for an extended period of time, thoroughly clean the sensor, put a piece of cotton ball with few drops of water into the protective cap and replace it on the sensor. This keeps the junction from drying out which causes slow response when put back into operation or causes permanent damage to the sensor. **Sensors should not be left in dry lines or empty tanks for extended periods.**

Do not store the sensors in a dry or humid location. When storing, check the protective cap(s) regularly to make sure the cotton ball remains moist. Improper storage of sensors voids the warranty.

2. Specifications

	pH P65-series	**ORP R65-series**
Measurement Range	0 to 14.00	User selectable: 0 to 1000 mV or -500 to +500 mV
PT and RT Versions	Temperature output range: 0 – 100 °C (32 – 212F)	
Wetted Materials	R8: Ryton®, CPVC, glass, ceramic, titanium, Viton®, *PVC, Dynaflex® R5: Ryton®, glass, ceramic, titanium, Viton®, *PVC, Styrene® 110-55 *when fully submerged	R8: Ryton®, CPVC, glass, ceramic, titanium, Viton®, platinum or gold, *PVC, Dynaflex® R5: Ryton®, CPVC, glass, ceramic, titanium, Viton®, gold, *PVC, Styrene® 110-55 *when fully submerged
Stability	0.03 pH/day	2 mV/day
Resolution	0.01 mA	± the greater of 0.1% of range or 2 mA
Sensitivity	< 0.005 pH	< 0.5 mV
Output Span	1.143 mA/pH	1.6 mA/100 mV
Output Offset	12±1 mA @ pH 7	0 to 1000 mV: 12±1 mA @ 500 -500 to 500 mV: 12±1 mA @ 0
Mounting	R5 sensor fixed 1.0" NPT insertion R8 sensor fixed 1.5" NPT insertion	
Flow Rate	3 m/sec (10 ft/sec). Flow should be as low as possible in water with low conductivity water or suspended solids	

Maximum Load	450 Ω
Temperature Limits	-5 to 75°C (23 to 167°F)
Pressure Limits	100 psig @ 65 °C, 40 psig @ 75°C
Power Supply Limit	24±4 VDC, two 24±4 VDC for PT65 and RT65
Probe Cable	15 ft. (4.6 m) standard.
Transmission Distance	3000 ft (900 m)
Temperature Compensation	Automatic for pH, none for ORP Isolated Temperature Output in PT65 and RT65

3. INSTALLATION

3.1. General Instructions

Specific instructions for each type of probe are given in the following pages. Common to all probes are the following instructions:

1. If the distance between the probe and the instrument is such that a direct connection is not possible, the probe cable should be routed to a junction box with a terminal strip (AquaMetrix Part No. AM-JB2). The box should be well sealed and away from corrosion danger. Be sure that you have sufficient slack cable to allow for probe removal for calibration and servicing.
2. Route the interconnect cable from the junction box to the instrument, preferably in metal conduit. Do not run the power cable or control cables in the same conduit with the probe interconnect cable.
3. Remove the protective plastic caps from the end of the probe before placing in service.
4. For best results probes should always be mounted vertically with electrodes down. If this is not possible, the probe must be at least 15° above horizontal.

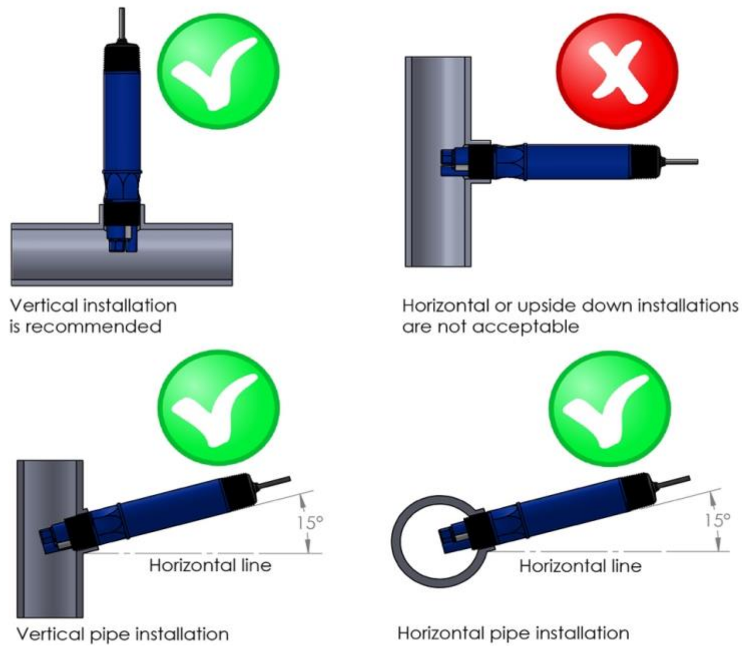


Figure 2 - General mounting instructions

3.2. Connecting to a PLC or AquaMetrix 2300 controller

P65 and R65 sensors have two wires:

- Red – 24VDC Power,
- Black – Signal GND

PT65 and RT65 sensors always have four wires:

- Red – process 24VDC power
- Green – temperature 24VDC power
- Black – process signal
- White – temperature signal.

1. Refer to the top half of Figure 3 for configuring the probe for operation with a PLC. For connecting to a current sinking PLC or ammeter a separate 24 VDC power supply is needed. The wiring between the PLC and power supply is in series as shown on the top left side of the Figure 3.

   Most PLC's have powered, i.e. current sourcing, inputs that eliminate the need for an external power supply. The top right side of to Figure 3 shows the connections to the analog connector of a PLC.

2. The AquaMetrix 2300 controller has both powered and unpowered inputs. The bottom left side of Figure 3 shows the connections of a probe to one of its four analog inputs and the 24 VDC power source.

3. For connecting the PT65 to a PLC or 2300 the temperature wires (Green and White) follow the same pattern. Refer to the bottom right of Figure 3.

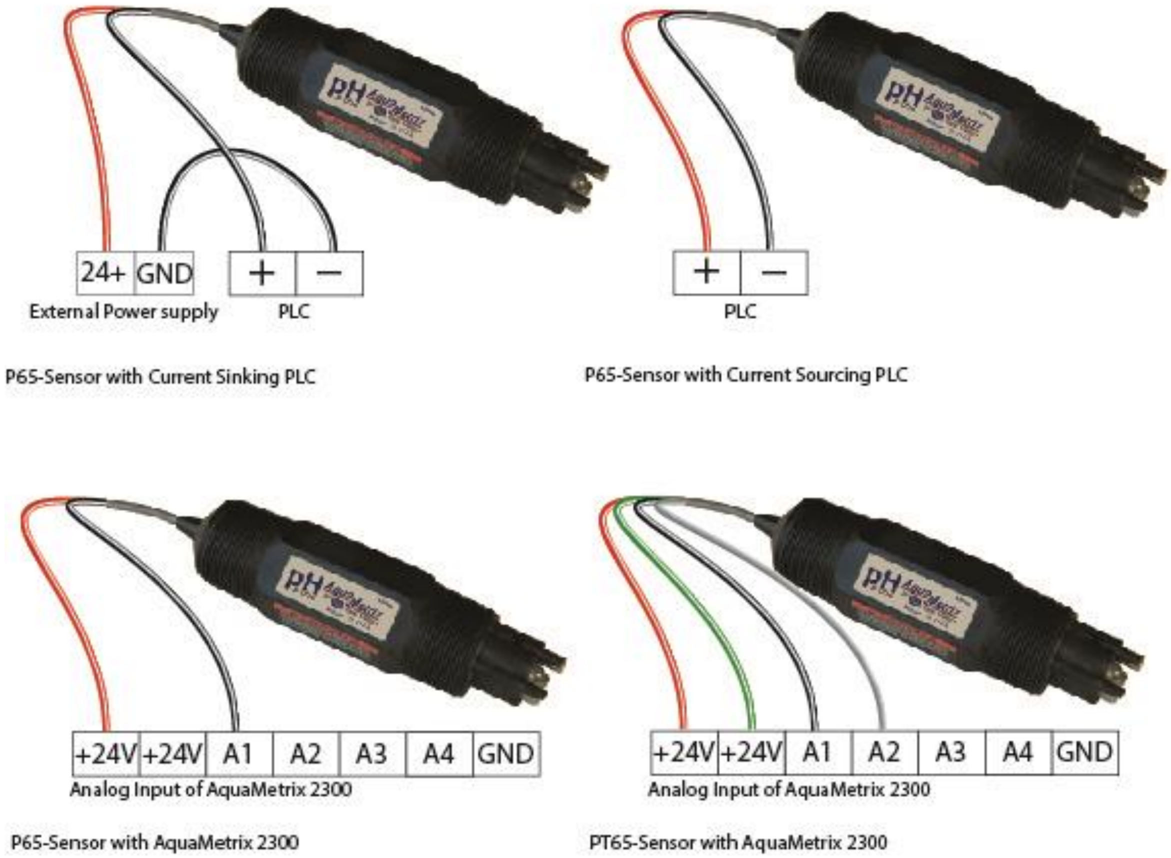


Figure 3 – Top left: Electrical connections for the 65 series sensors, with a 24 VDC power supply and a PLC. Top right: Electrical connections for the 65 series sensor with current sourcing PLC. Bottom left: Connections for a 65 series sensor with the AquaMetrix 2300 controller. Bottom right: Connections for a PT65 with the AquaMetrix 2300 controller.

3.3. Avoiding Isolation Problems

The 65-series doesn't have a built-in isolator, which means that it can run into a "ground loop" with any other equipment connected via the measured liquid if the controller is also not equipped with isolator. Ground issues can be some of the most difficult problems to detect, the symptom of an affected pH sensor is a constant signal at approximately 12 mA; for an ORP sensor the output is held near 0 mA or constantly moving. If the sensor reads accurately in an isolated container (beaker or a cup) but appears stuck when installed in a tank or a pipe with other equipment – this is a sign of the ground loop.

If one suspects that the process in which the probe is not isolated, then a galvanic isolator (ISO65-1CH or ISO65-2CH) installed between a sensor and the PLC (or AM-2300 controller) will solve the problem.

3.4. ORP (R65) Sensors Range Selection

R65 ORP sensors have a rocker switch for range selection, the options are -500 to +500mV or 0 to 1,000mV. Figure 4 shows the switch. If the switch needs to be cut, to fit the cable through a conduit for example, there are two wires that used in a switch for range selection:

- for R65R5 and R65R8: white and green wires. When open, the range is -500 to +500mV, when shorted – the range become 0 to 1,000mV.

- for RT65R8: yellow and blue wires. When open, the range is -500 to +500mV, when shorted – the range become 0 to 1,000mV.

  Avoid contacting range selection wires with any other wires as this may damage the sensor.

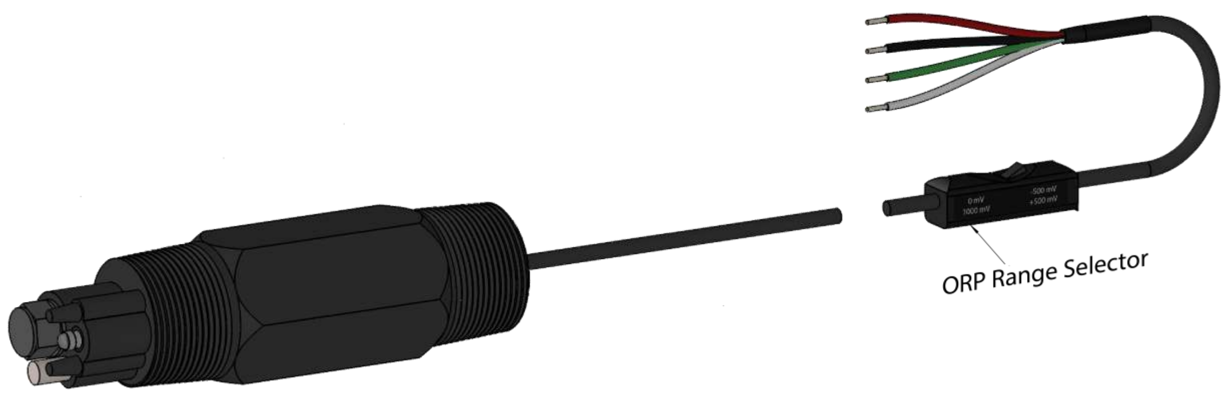


Figure 4 - Version of RT65R8 ORP sensors with rocker switch for range selection

3.5. Mounting Options for R8 sensors (P65R8, PT65R8, R65R8, RT65R8)

3.5.1. Submersion mounting

Refer to Figure 5 below.

1. A submersion mounting kit, AM-ARM-8, is available from Water Analytics which includes 4 ft. of 1" CPVC pipe, 1-1/2" x 1" reducer, a strain relief fitting and wire mounting bracket. Proceed as follows, either with the kit or with your own hardware.
2. Route the sensor cable through a pipe. Apply a thread sealant to the thread on the cable end of the sensor and screw it into a 1-1/2" fitting. Tight the strain relief. The cable end of the sensor should not be exposed to the process. A cable strain relief fitting should be used on the upper end of the pipe. In the kits a wire bracket is provided to aid in supporting the assembly.

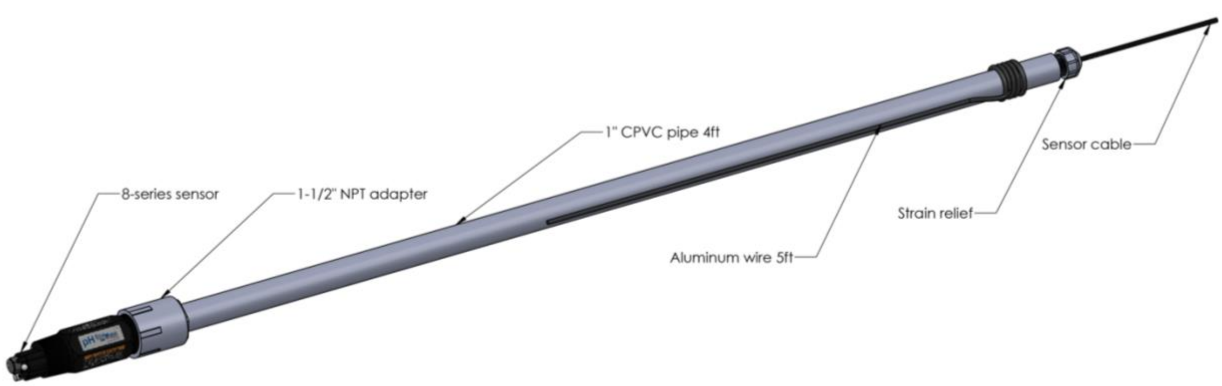


Figure 5 - Submersion mounting using AM-ARM-8

An optional protective shroud, Part No. AM-PTR-8 should be used on the electrode end of the sensor to protect the electrodes from accidental contact with the tank bottom, sides or objects in the process. See Figure 6 below.

Figure 6 - Electrode protector AM-PTR-8 installation

3.5.2. Flow-through mounting in a TEE

Refer to Figure 7 below

1. Apply pipe sealant to the electrode end of the sensor and screw it into the 1-1/2" NPT bushing.
2. Slide bushing into modified TEE
3. Secure sensor by tighten the lock nut
4. Install retaining ring

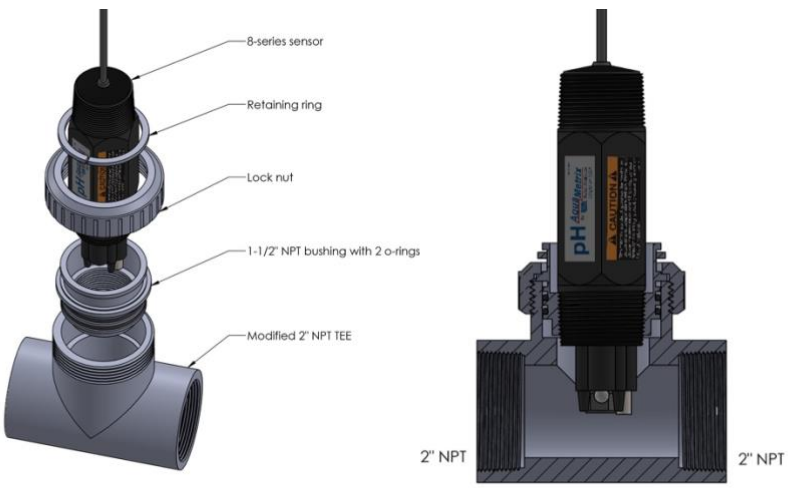


Figure 7 - Flow through installation using AM-TEE-8

3.5.3. Sanitary fitting for R8-series

The R8-series can be installed in 2" sanitary fitting using sanitary flange (part AM-SFL-8). Refer to Figure 8 below.

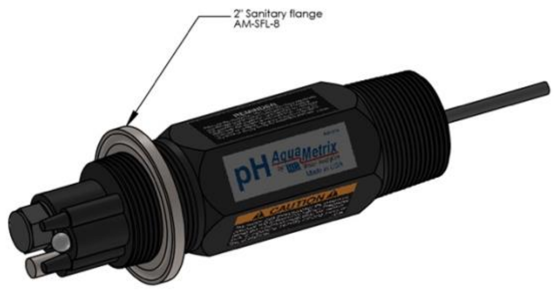


Figure 8 - Installation of AM-SFL-8 sanitary fitting

Please note that the sanitary fitting doesn't make sensor suitable for sanitary application.

3.6. Mounting options for R5 sensors

3.6.1. Submersion mounting

1. A submersion mounting kit, AM-ARM-5, is available from Water Analytics which includes 4 ft. of 1" CPVC pipe, 1" adapter, a strain relief fitting and wire mounting bracket. Proceed as follows, either with the kit or with your own hardware.
2. Route the sensor cable through a pipe. Apply a thread sealant to the thread on the cable end of the sensor and screw it into a 1" fitting. Tight the strain relief. The cable end of the sensor should not be exposed to the process. A cable strain relief fitting should be used on the upper end of the pipe. In the kits a wire bracket is provided to aid in supporting the assembly.

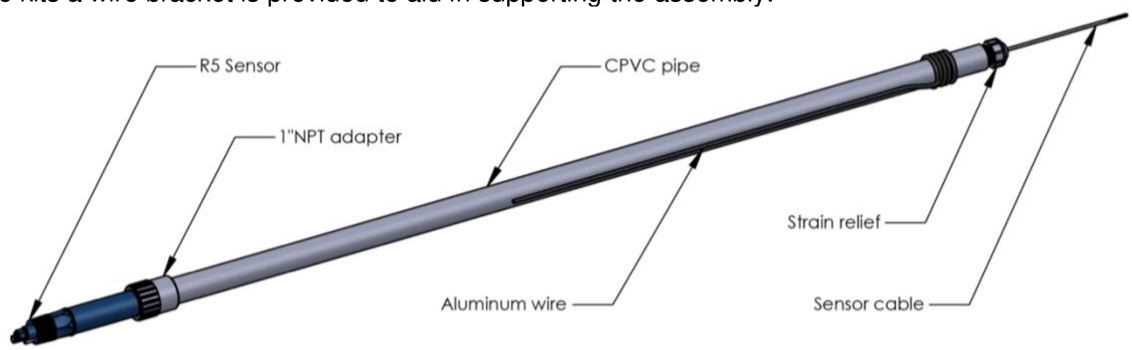


Figure 9 - Submersion mounting using AM-ARM-5

An optional protective shroud, Part No. AM-PTR-5 should be used on the electrode end of the sensor to protect the electrodes from accidental contact with the tank bottom, sides or objects in the process. See Figure 10 below.

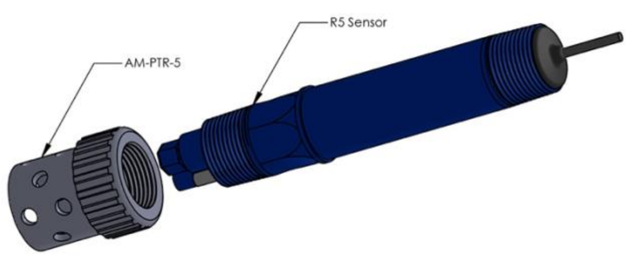


Figure 10 - Electrode protector AM-PTR-5 installation

3.6.2. Flow-through tee mounting R8-series Differential Sensors

Refer to Figure 11 below

1. Apply pipe sealant to the electrode end of the sensor and screw it into the 1” NPT bushing
2. Slide bushing into modified TEE
3. Secure sensor by tighten the lock nut
4. Install retaining ring

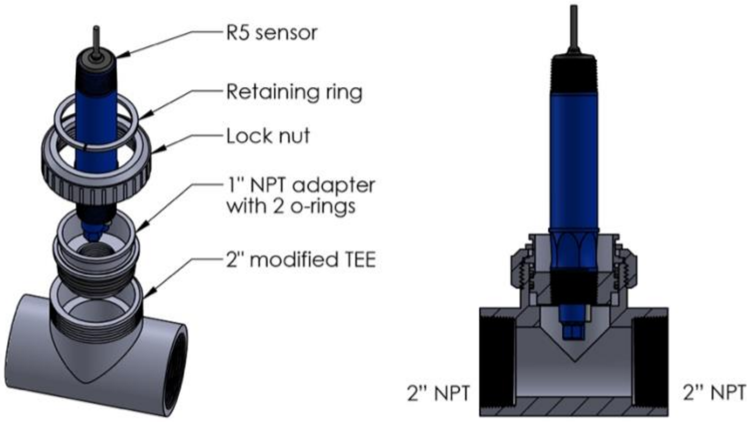


Figure 11 - Flow through installation using AM-TEE-5

3.6.3. Sanitary fitting

The R5-series can be installed in 2” sanitary fitting using sanitary flange (part AM-SFL-5). Refer to Figure 12 below.

Figure 12 - 2in sanitary flange AM-SFL-5

Please note that the sanitary fitting doesn’t make sensor suitable for sanitary application.

3.6.4. Variable insertion (R5-series only)

Refer to Figure 13 below.

1. Mount the attachment on the sensor from the cable side.
2. Take the compression fitting apart. Apply pipe sealant to the 1-1/2” NPT thread and screw this part into a 1-1/2” tee or nipple. A larger fitting with an appropriate reducer may be used.
3. Put the compression fitting components on the sensor in the order shown in the figure below.

4. Remove the protective cap from the sensor and place the sensor in the tee. The sensor must be in such a position that the electrodes will be in the pipe stream but not touching the opposite side of the tee.
5. Now tighten the nut by hand as much as possible, then turn 1/2 turn with a wrench.

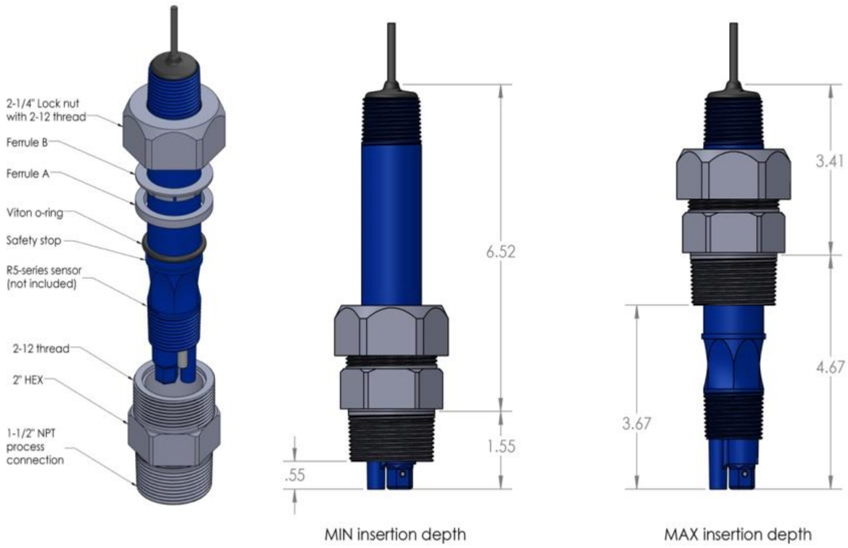


Figure 13 - Variable insertion using AM-CFT-R5 compression fitting.

Using attachment AM-CFT-R5 the standard R5 series sensor can be used in applications that require variable insertion. AM-CFT-R5 has 1-1/2" NPT process connection and allow to vary insertion depth from .55" to 3.67"

3.6.5. Hot Tap (Wet Tap) insertion mounting R5-series

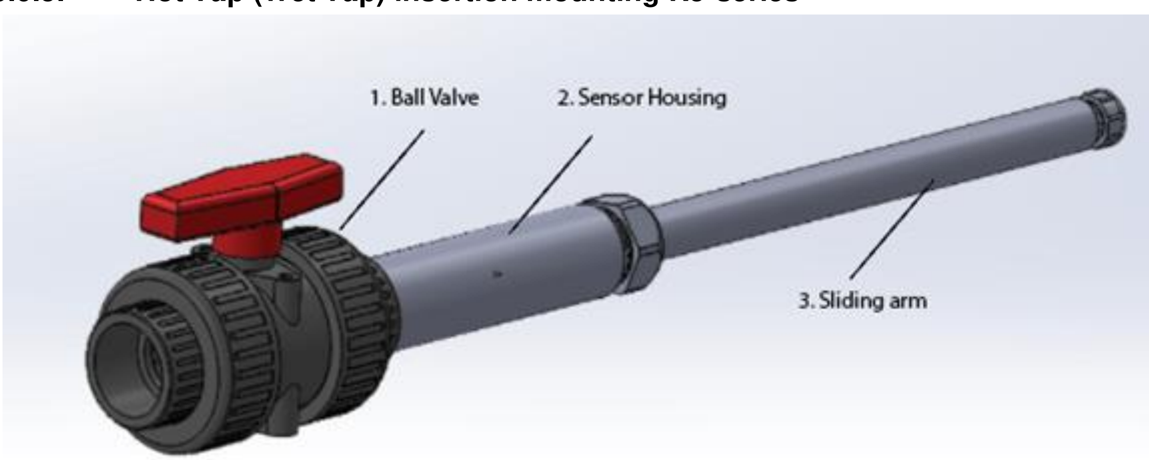


Figure 14 - AM-HTA-R5 Hot Tap assembly

1. A ball valve assembly, AM-HTA-R5 (or a shorter version AM-HTA-R5S), is available from AquaMetrix which includes the 2" ball valve, sensor housing, and a sliding arm with cable compression fitting.
2. Take union ball valve apart from both ends.
3. Mount the 2" fitting in a desirable location on a tank or pipe. The assembly comes with a field selectable, 2" FNPT or socket adaptor. Add the ball valve to the union, make sure ball valve is in the closed position.
4. Take the compression fitting at the end of a sliding arm apart.

5. Insert sensor cable into the sliding arm from the 1” adapter side and run it through cable gland.
6. Apply sealant to the back end of the R5-series probe and screw the sensor into the 1” sensor adapter.
7. Re-assemble compression fitting at the end of the sliding arm with the cable installed.
8. Loosen the compression fitting of the sensor housing. Slide the sensor into the sensor’s housing fully.
9. Place the union body, with the probe attached, back into the ball vale assembly and tighten union nut.
10. Open ball valve & slide the probe into the process.
11. Tighten the compression fitting nut of the sensor housing by hand as much as possible, then turn 1/2 turn with a wrench to keep probe in place.

4. CALIBRATION

All 65-series sensors are calibrated to output 4-20 mA signal over the entire measuring range. The 65-series sensors have non-adjustable outputs.

Note that current output probes cannot be characterized by the same efficiency value as the “raw” 60 series probes. That’s because the current output of the former is a function of the probe efficiency **plus** the transfer efficiency of probe voltage to current output.

Calibration for direct output probes is the process by which the current output of the probe is mapped to the value of the calibration solution in which the probe is immersed. This mapping is assumed to be linear so, typically, one calibrates using two points. Non-linear output in pH probes caused by alkaline error or acid error will result in a non-linear current response. In addition, the mapping of probe voltage to current output always has some non-linear component. Some PLC’s allow for calibration using more than two points. Under the assumption that the current output is approximately linear with process value the result of two-point calibration is a slope and offset.

4.1. Calibration of pH sensors (P65R5, P65R8, PT65R8)

The ideal value of the mA value can be calculated from:

$$Output\ (mA) = pH\ x \left(\frac{16}{14}\right) + 4\ mA$$

Table 1 lists nominal outputs for pH and pH + Temperature sensors. Please note that a brand-new sensor can deviate by as much as ±1mA for the offset due to the unique tolerances of a probe.

Table 1 - Nominal outputs for pH sensors

Output (mA)	pH	Temp. (°C) (for PT65R8)
4.00	0	0
8.57	4	
7.20		20
12.00	7	50
15.43	10	
20.00	14	100
Ideal Slope	1.143 mA/pH	0.16 mA/°C
Acceptable Slope (83%)	0.989 mA/pH	0.14 mA/°C
Acceptable Offset	±1 mA	±1 mA

One should check an offset (difference from an ideal mA output) and a span (difference between two pH solutions) to validate calibration.

An acceptable offset can't exceed ±1.0mA for new probes, a lager value usually indicates reference solution poisoning (refer to chapter 6 for service and maintenance). Slope is measured by the difference between two solutions (for example pH4 and pH7) and it should be in the range of 0.948 to 1.143 mA/pH for a new sensor. A higher value doesn't always indicate a better performance as there are factors unique to each sensor. Once the slope drops below 0.932 mA/pH for a probe in service, it is recommended to perform maintenance (cleaning and/or salt-bridge replacement).

Slope can also be expressed as efficiency, which is a percentage value of the nominal (ideal) slope.

$$Efficiency = \frac{Calculated\ Slope}{Ideal\ slope}\ x\ 100\%$$

Efficiency is an easier to understand slope value, where 100% is ideal theoretical slope and low value (0-30%) indicates faulty probe. Acceptable efficiency for a brand new 65-series probe is 83%. An efficiency of 75% or lower is a flag for maintenance – see chapter 6.

Figure 15 displays the acceptable range of current output from the P65, dark blue area indicates an acceptable tolerance for a brand-new sensor, light blue area shows an acceptable tolerance for a sensor that was in service. Note that the desired accuracy is unique for each process, and it can be improved by calibration.

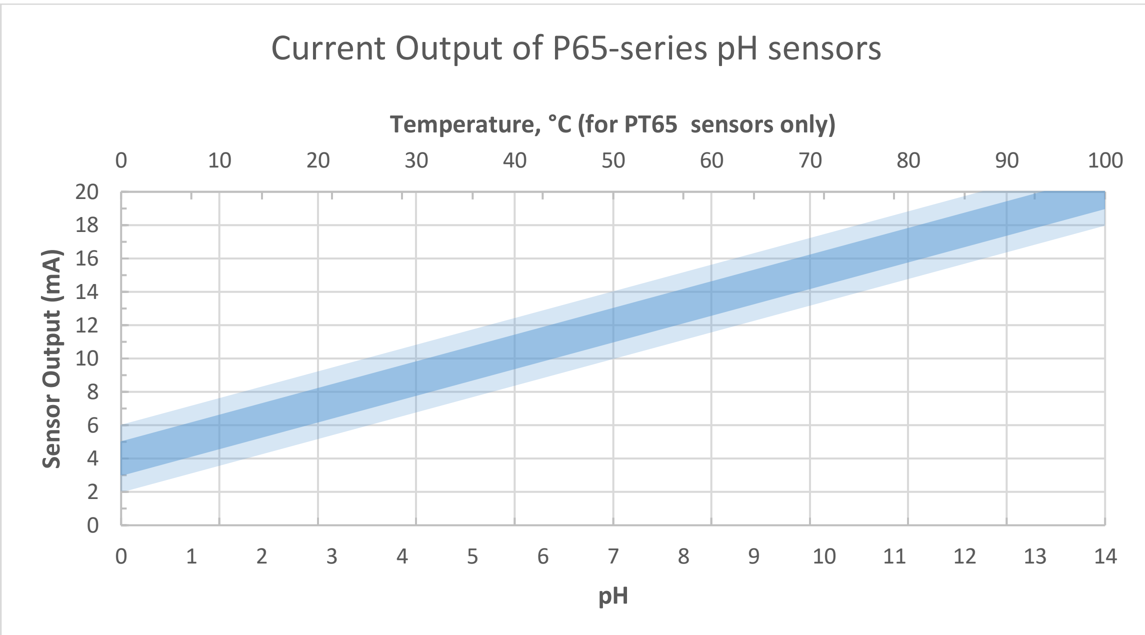


Figure 15 – Range of acceptable output for new P65 (pH) and PT65 (pH and temperature) probes. The dark blue middle band is for new probes and represents the acceptance criteria for new probes. The light blue outer band shows the acceptance criteria for working probes.

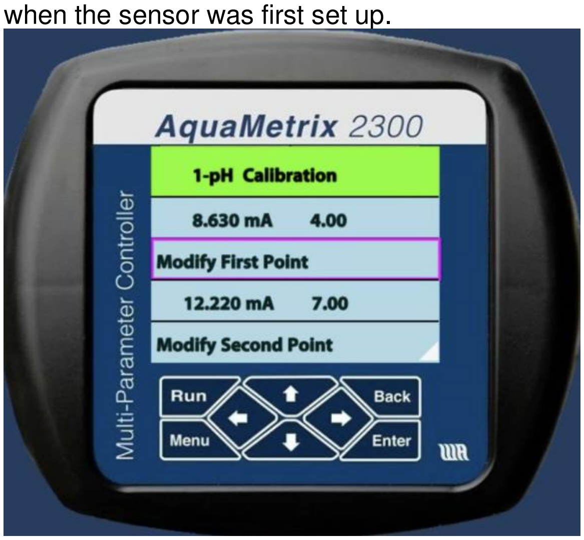
4.1.1. Calibration using AM-2300 Controller

Calibration using the AM-2300 can be done two ways, via the front panel or via the web interface. For the most accurate calibration, two calibration standards are necessary. If most cases, pH4 & pH7 buffer solutions are recommended due to their wide availability and fast response time. If the process operates in high pH - use pH10 buffer.

In extreme situations, one can substitute calibration solution(s) with a factory default values: 4mA = 0pH, 20mA = 14pH. This method is not recommended as standard calibration practice as accuracy can be much lower, and there is no good way of calculating important metrics like slope and offset.

Front Panel.

1. Press the Menu button.
2. Select Calibrate/Disable Probe.
3. Select the sensor ("meter") from the list of sensors using ↑ and ↓ buttons.
4. Select Perform Calibration.
5. The current calibrations values will be displayed. These are the values that were defined when the sensor was first set up.



6. Select Modify First Point.
7. Insert the pH probe into the lower pH solution (for example, pH4 buffer). The live mA reading will appear on the line Use Measured mA. Depending on the probe condition, it may take up to 2 minutes for the reading to stabilize. When the reading is stable select Use Measured mA and press Enter.

8. In case a pH solution was different from the one stored in previous calibration, update the solution value. Select Enter Solution Value. Using the numeric keypad, enter the value of the pH standard—in this example, 4.
9. Confirm the first point calibration by selecting Confirm Calibration.
10. Repeat for the second calibration standard (pH7 or pH10 buffer).
11. When both points are updated, leave the calibration menu by either pressing Run or selecting Done

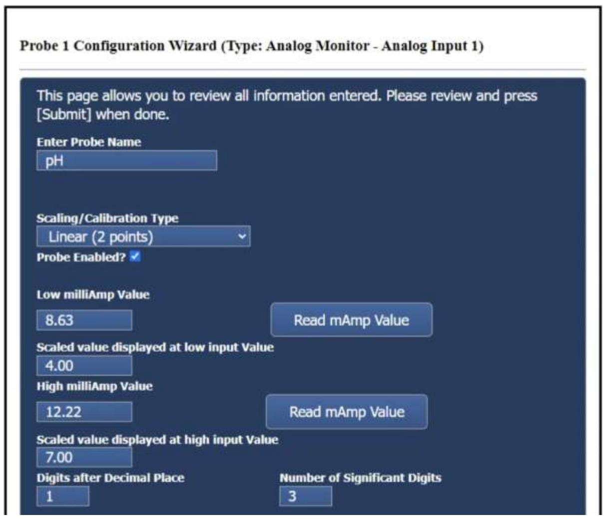
If you only have one standard, then you must assume the value of the other, using Table 1. For instance, if you only have pH 10 solution then you can assume 8.57 mA for pH 4.

Web Interface

Calibration is part of the probe setup process. However, it can (and should) be done on a periodic basis without going through the entire setup process:

1. The default screen is Probe Status. On the top-level menu select Setup.

2. On the Main Setup screen select Probe Configuration.
3. On the Probe Configuration screen select the pH probe from the list of probes.
4. The first page of the Setup Wizard will appear. Since you are not going through the entire setup process you will select Summary.



5. Immerse the probe in the first calibration solution. Enter the value of the first standard in the field Scaled value displayed at low input value. For the case of pH 4 standard that value is 4.00.
6. Click on Read mAmp Value.
7. Repeat for the second calibration standard.

   If you only have one standard, then you must assume the value of the other. For instance, if you only have pH 10 solution then you can assume 8.57 mA for pH 4.

4.1.2. Calibration using PLC

The AM-2300 is a user-friendly PLC. The process of calibration is essentially the same for PLC's. A custom calibration routine that allows enter two mA values for standard buffer solution (pH4, pH7, and pH10) is ideal.

Some PLCs only allow calibration at 4 and 20 mA. The default settings are: 4mA = 0pH and 20mA = 14pH. Without calibration in buffer solutions, the error may be as high as ±1.0pH.

The example of PLC logic that only allows 4&20mA points adjustment is shown below:

1. Enter first calibration [for example, pH = 4]
2. Enter mA of first calibration solution [for example, mA = 8.9]
3. Enter second calibration [for example, pH = 7]
4. Enter mA of first calibration solution [for example, mA = 12.1]
5. Calculate Slope (pH/mA): △pH/△mA [in the example, (7 - 4) / (12.1-8.9) = 0.94]
6. Calculate Offset (pH): 7 – (mA@pH7 x Slope) [In the example, 7 – (12.1 x 0.94) = -4.34]

7. Calculate pH for 4mA point: (4 x Slope)+ Offset [(4 x 0.94) – 4.34 = -0.59]
8. Calculate pH for 20mA point: (20 x Slope) + Offset [(20 x 0.94) – 4.34 = 14.41]

4.2. Calibration of ORP sensor (R65R5, R65R8, RT65R8)

R65 sensors have user selectable output range. Before proceeding with a calibration, confirm the switch position. If the range selection switch was removed, refer to section 3.4.

The ideal value of the mA value can be calculated from:

$$Output\ (mA) = ORP\ x \left(\frac{16}{1000}\right) + 4\ mA$$

Table 2 - ORP nominal outputs

Output (mA)	ORP Range 0 to 1000mV	ORP Range -500 to +500	Temp. (°C) (for RT65R8)
4.00	0	-500	0
7.20	200		20
12.00			50
13.60	600		
15.20		200	
20.00	1000	500	100
Ideal Slope	0.016 mA/mV		0.16 mA/°C
Acceptable Slope (83%)	0.013 mA/mV		0.14 mA/°C
Acceptable Offset	±1 mA		±1 mA

Table 2 lists nominal outputs for ORP and ORP + Temperature sensors. Please note that a brand-new sensor can deviate by as much as ±1mA for the offset due to the unique tolerances of a probe.

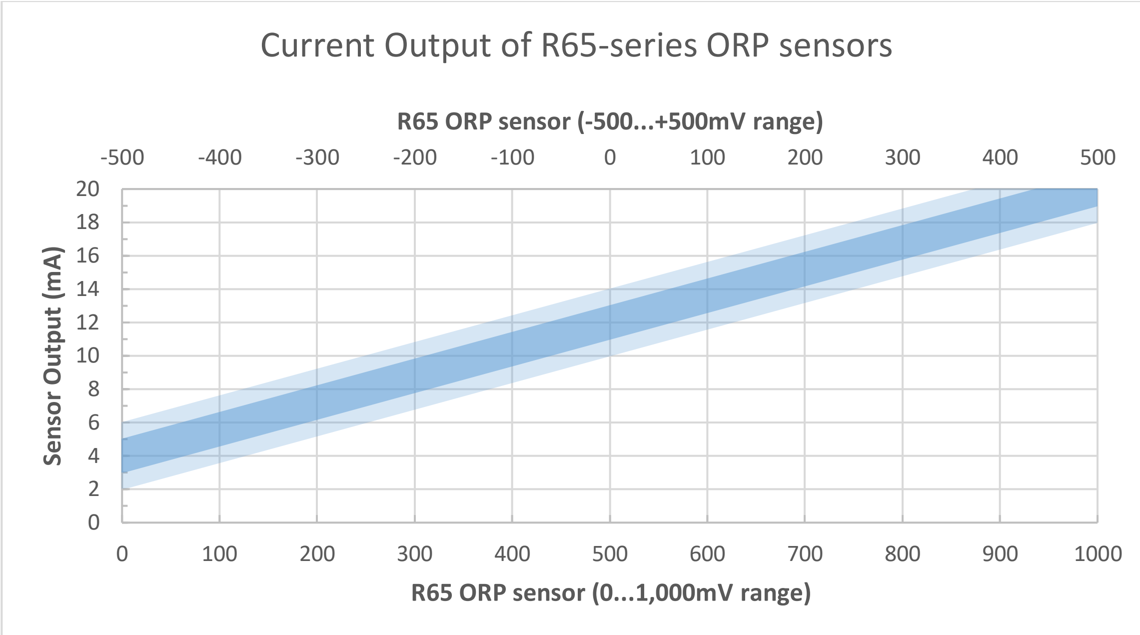


Figure 16 - Range of acceptable output for new R65 (ORP) probes. The dark blue middle band is for new probes and represents the acceptance criterion for new probes. The light blue outer band shows the acceptance criteria for working probes.

ORP calibration standards are not buffered like pH standards so the former do not maintain their values as tightly as the latter. Exposure to air will react with chemicals and result in a rising ORP value. Full, sealed containers of standards have shelf lives of approximately one year. Partially full containers have shelf lives of only several weeks. Higher ORP standards (e.g., 600 mV) have shorter shelf lives.

4.2.1. Calibration using AM-2300 controller

Calibration using the AM-2300 can be done two ways, via the front panel or via the web interface. Both methods assume that you have two calibration standards that span as much of the 4 to 20 mA range as possible. For ORP solutions that can be Light's and Zobell calibration standards.

Front Panel.

1. Press the Menu button.
2. Select Calibrate/Disable Probe.
3. Select the sensor ("meter") from the list of sensors.
4. Select Perform Calibration.
5. The current 4 and 20 mA process values will be displayed. These are the values that were defined when the sensor was first set up.
6. Select Modify First Point.
7. Insert the ORP probe into the lower pH solution. For the example above that is 200 mV. The live mA reading will appear on the line, Use Measured mA. When the reading is stable select Use Measured mA.
8. Select **Enter Solution Value**. Using the numeric keypad, enter the value of the pH standard—in this example, 4.
9. Repeat for the second calibration standard (in this example, 10.

If you only have one standard, then you must assume the value of the other. For instance, if you only have pH 10 solution then you can assume 8.57 mA for pH 4.

4.2.2. Calibration using PLC

Table 2 lists outputs for standard calibration solutions for ORP sensors (200 and 600 mV) and acceptable minimum values of the slope. These values are equal to 83% of the ideal slope. The acceptable offset for all probes is ±1 mA. Every probe that leaves the factory must meet exceed the minimum slope stated in the table. Keep in mind that the minimum current outputs and maximum output of ±1 mA are for new probes only. As probes age the output drifts. When the slope reaches approximately 75% of the ideal slope, a maintenance is recommended. If the efficiency can't be recovered, the probe should be replaced and set aside for emergency use.

Note: Using the ORP probe without calibration, i.e. with nominal 4&20mA values can result in an error as big as ±63mV.

Figure 16 shows the range of acceptable output for R65 (ORP) and RT65 (ORP and temperature) probes. The dark blue band in the figures shows acceptable output for new 65-series sensors based on the 83% acceptance criterion. The wider light blue shaded band shows the acceptance for a 75% acceptance criteria of working probes.

5. TROUBLESHOOTING AND SERVICE

5.1. Connecting a 65-Series Sensors to an Ammeter

The 2300 and most PLC's can display a raw mA signal. If you are using a PLC that does not display the loop current, then insert an ammeter as shown in Figure 17.

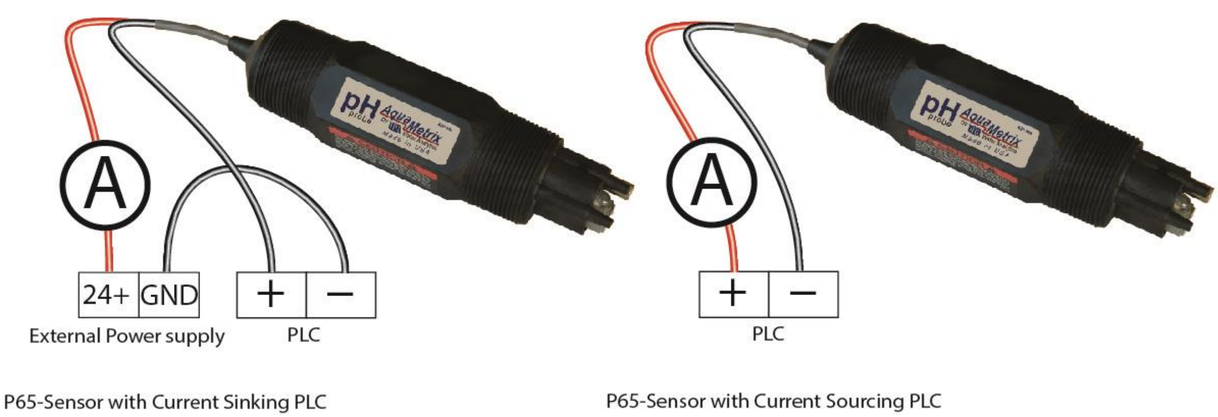


Figure 17 – Connecting a PLC/2300 or an ammeter for sensor diagnostics.

5.2. Diagnosing a P65 series pH sensor

1. Rinse the probe and place it in pH 7 buffer. Allow the temperature of the buffer and probe to stabilize at room temperature.
2. Note the current reading for pH 7. This is the offset of the probe. The reading should be between 11 and 13 mA. If it is not then the probe needs maintenance or is defective. If the offset is within these limits then note the exact reading and proceed to the next step.

3. Rinse the probe and place it in pH 4 or pH 10 buffer. Allow the current of the probe to stabilize. Check the span of the probe by reading the ammeter. If the probe is in pH 4 buffer, the reading should be between 2.85 and 3.99 mA lower (pH 4) or higher (pH 10) than the reading obtained in pH 7. A perfect reading is 3.43 mA and one can assign an efficiency rating to the probe by dividing the actual span by 3.43. (Note that this is not the same as efficiency of a pH probe, which takes into account only the voltage output of the probe with pH.)
4. If the span of the probe drops below 2.85 mA than the efficiency is less than 83%. The probe still can be used with proper calibration but its accuracy will be compromised. If the output is less than 2.23 mA the probe should be replaced.
5. To check the operation of the temperature compensation in the probe, heat the buffer to about 50°C. The ammeter reading should be within ±0.2 mA of the reading observed in the same buffer at room temperature. This tolerance is approximate as different buffers exhibit pH values that differ with temperature.

5.3. R65 series ORP sensors

1. Set the probe range to 0 to 1000 mV. For probes made in 2017 or later switch in position set the position of the switch to 0-1000mV, For older probes short the white and green wires together.
2. Rinse the probe and place it in the 200 mV solution. The ammeter should read between 6.2 and 8.2 mA.
3. Rinse the probe and place it in the 600 mV solution. The meter should read 6.4 ±0.6mA higher than the reading obtained in ORP 200mV solution.
4. As explained for pH probes, a smaller difference can still enable the probe to be used with calibration.

5.4. Temperature check for PT65 and RT65 Probes

1. Insert the probe into a mixture of ice and water. The meter should read between 4 and 5 mA.
2. Insert the probe into a sample of water at 50 °C. The meter should read between 11 and 13 mA.

6. SERVICE AND MAINTENANCE

There are three sensor components that require routine maintenance:

1. **Process electrode**. The process electrode of a pH probe is pH-sensitive glass whereas the process electrode of an ORP probe is a platinum or gold band wrapped around a plain glass envelope. Both need to kept clean, which usually means free of biofilms and/or scaling.
2. **Reference Solution**. The reference solution in either a pH or ORP probe is typically pH 7 buffer. As the probe ages reference solution flows out of the salt bridge while the process flow into the junction and into the reference chamber. The result is a steady contamination of reference solution. The pH trends toward 7 as the reference solution more closely resembles the process.
3. **Salt Bridge**. The salt bridge will foul over time through the accumulation of suspended solids and organic matter. The result is that the probe responds increasingly sluggishly and erratically.

The frequency of maintenance depends strongly on the application. Probes in clean water can go for months without the need for cleaning and recalibration but only two weeks in a metal plating operation. Fortunately, by calibrating on a regular basis, one can determine when maintenance is due. The following rules of thumb are useful.

1. If calibration shows a pattern of decreasing span then the probe needs to be cleaned. This is why it is important to record the efficiency at every calibration. Probes that leave the factory have an efficiency

of at least 83%. Probes in service can have a span as low as 50% and still be usable though their accuracy will diminish as the span drops. In general, a probe with a span less than 65% should be replaced and set aside for emergency use. A probe with a span less than 50% should be discarded.

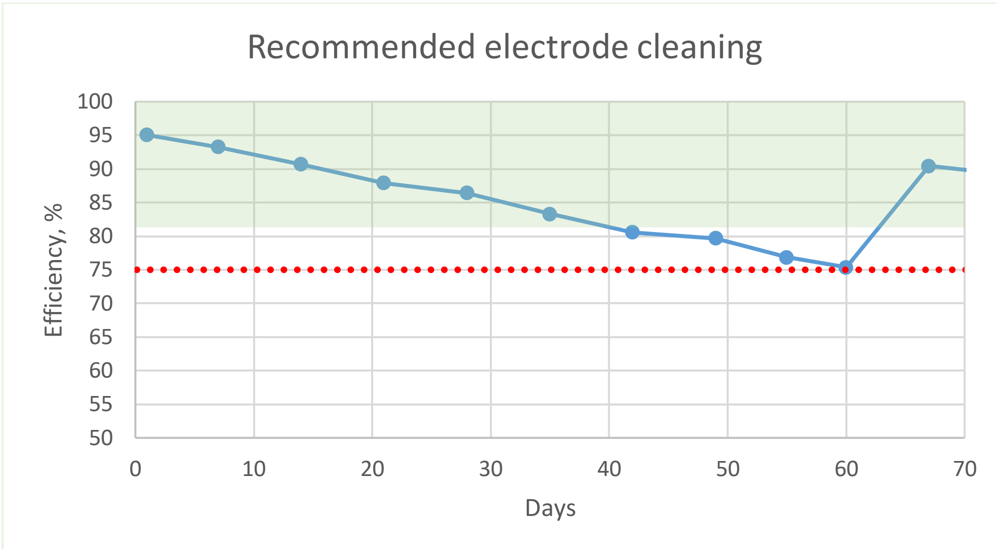


Figure 18 – Efficiency before and after electrode cleaning.

2. If the calibration shows a pattern of increasing offset, then the reference solution needs to be replaced. An offset greater than 2 mA indicates need of replacing salt bridge.

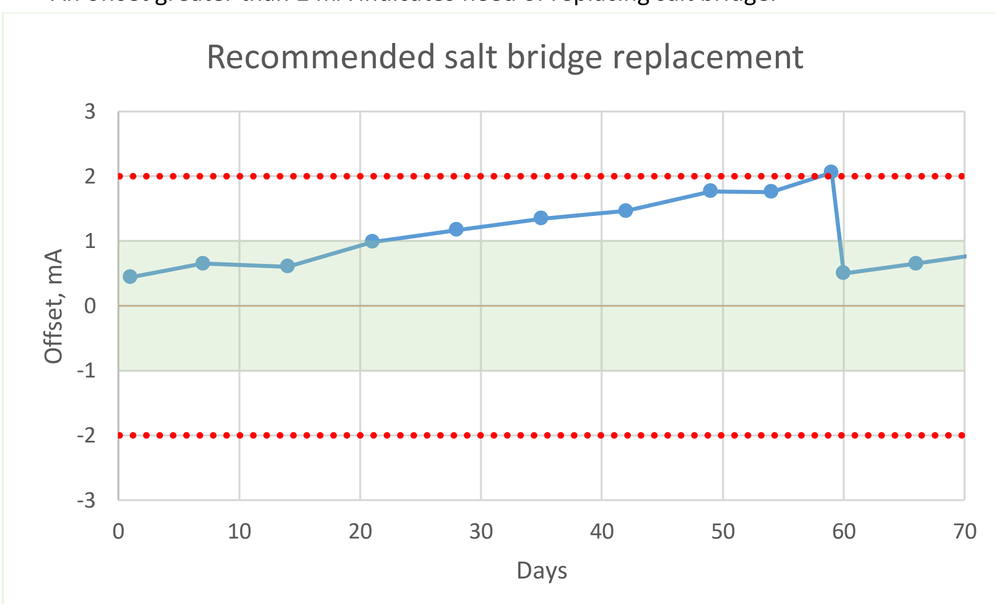


Figure 19 - Offset improvement after replacement of salt bridge.

3. If the probe takes more than about 15 seconds to fully respond to a change in pH then the salt bridge should be replaced. Of course that also requires replenishing the reference solution.

6.1. Probe Cleaning

1. Rinse the probe and use a soft brush, e.g. a soft toothbrush, and detergent to gently remove loose debris. Be careful: *The process electrode of a pH probe is comprised of very thin glass and breaks easily. Breaking it is the death of the probe.*
2. Rinse with clean warm water. Tap water is fine.
3. For scaling (calcium carbonate deposits) soak the probe in a weak acid for about an hour. White vinegar works great. Hydrochloric or sulfuric acid diluted ten-fold will do the job in about 10 minutes.
4. For biofilm fouling soak the probe in bleach for about 20 minutes.
5. Rinse the probe again in water.
6. Calibrate the probe in accordance with the instrument instruction manual.

6.2. Replacement of Salt Bridge

6.2.1. For R5 Series, Differential Probes

1. If the system cannot be calibrated after cleaning the probe, it may be necessary to replace the reference solution. A kit is available from Water Analytics for this purpose (Part No. AM-SBK3-R5). Proceed as follows:
2. Hold the probe vertically with the sensor face up. Insert Phillips #3 in the salt bridge and turn counter-clockwise taking care not to damage the glass electrode. Discard the used salt bridge.
3. Up-end the probe and pour out the contents of the standard electrode chamber. Flush the chamber with a small amount of pH 7 buffer or clean water.
4. Refill the chamber with 7pH buffer solution up to the tip of the electrode inside the chamber. DO NOT OVERFILL. It is important to leave space for the salt bridge thread and a small amount of air.
5. Screw the new salt bridge into the cavity until finger tight. Now turn 1/4 turn with long nose pliers. The front face of the salt bridge should be flush with the electrode face.

6.2.2. For Series 8 Differential Probes

1. If the system can't be calibrated after cleaning the probe, it may be necessary to replace the standard cell solution and/or the salt bridge. A salt bridge kit is available from Water Analytics for this purpose (Part No. AM-SBK3-8R). Proceed as follows:
2. Hold the probe vertically electrodes up. Remove the used salt bridge. For the -8 probe the salt bridge is a hexagonal-shaped capsule that can be removed using a 9/16" socket wrench. Discard the used salt bridge.
3. Dispose of the used solution inside the bridge chamber and flush with pH 7 solution or distilled water.
4. Refill the chamber with 7pH buffer solution, up to the tip of the electrode, inside the chamber. DO NOT OVERFILL. It is important to leave space for the salt bridge thread and a small amount of air.
5. Screw the new salt bridge into the cavity until finger tight. Now perform a 1/4 turn with a 9/16" socket wrench. The salt bridge edges should be flush with the front of the probe face.

6.3. Storage

1. Do not discard the protective cap(s) that came with the sensor. If the sensor is removed from the process for an extended period of time, thoroughly clean the sensor, put a piece of cotton ball with few drops of water into the protective cap and replace it on the sensor. This keeps the junction from drying out which causes slow response when put back into operation or causes permanent damage to the sensor. **Sensors should not be left in dry lines or empty tanks for extended periods.**

2. Do not store the sensors in a dry or humid location. When storing, check the protective cap(s) regularly to make sure the cotton ball remains moist. Improper storage of sensors voids the warranty.

6.4. Maintenance messages in PLC (optional)

For advanced users, PLC can be trained to predict maintenance and display messages for operators.

A calibration log, as shown in Table 3, can be incorporated in PLC logic. Once continuing loss of efficiency noted (see weeks 1-5) and/or efficiency falling below the threshold of 75% - there could be a popup message about an immediate need of cleaning glass electrode and recalibration. If efficiency of the sensor remains in >80% range and the offset gradually increases (by more than 2mA) – the message should ask to replace the salt bridge and recalibrate.

Table 3 - Weekly Calibrtation Log for pH sensor

	pH7, mA	pH4 (or pH10), mA	Slope, mA/pH	Offset	Efficiency
Initial Calibration	12.04	8.78	1.09	0.43	95%
1 WEEK Calibration	12.14	8.92	1.07	0.63	94%
2 WEEK Calibration	11.99	8.87	1.04	0.71	91%
3 WEEK Calibration	11.58	8.70	0.96	0.86	84%
4 WEEK Calibration	11.33	8.59	0.91	0.94	80%
5 WEEK Calibration	10.89	8.35	0.85	0.96	74%
After Cleaning	12.36	9.24	1.04	1.08	91%
6 WEEK Calibration	12.31	9.26	1.02	1.19	89%
7 WEEK Calibration	12.12	9.21	0.97	1.33	85%
8 WEEK Calibration	12.12	9.24	0.96	1.40	84%
9 WEEK Calibration	12.36	9.51	0.95	1.71	83%
10 WEEK Calibration	12.59	9.81	0.93	2.10	81%
Replaced Salt Bridge	11.25	8.34	0.97	0.46	85%

$$\boldsymbol{Slope} = \frac{\text{mA@pH7} - \text{mA@pH4}}{\Delta\text{pH}}$$

$$\boldsymbol{Offset} = \text{mA@pH7} - (\text{slope} * 7) - 4$$

$$\boldsymbol{Efficiency} = \frac{Measured\ Slope}{Ideal\ Slope}$$

6.5. Troubleshooting

A pH or ORP probe is a simple instrument. As a potentiometric device, it outputs a voltage in response to a change in pH or ORP. The built-in transmitter converts the voltage to a current. A probe that is not functioning properly will output a current that is out of range of the specifications listed in Section 5.1

The change in output with calibration standard constitutes the span.

For a pH probe: The span between pH 4 and pH 7 or between pH 7 and pH 10 should be between 2.85 and 3.99 mA.

The ORP sensor is unique in that the voltage is the ORP reading. There is no span between readings of two calibration solutions. However, mA readings should be within the ranges stated in Section 5.1.

If the span of a pH probe or the absolute mA readings of an ORP probe do not satisfy these criteria then the cause of the problem may be one of the following:

1. The process electrode is coated with scaling or biofouling.
2. The process electrode is inoperable (likely broken).
3. The reference solution has been contaminated with the process to the point that it is no longer pH 7.
4. The salt bridge has fouled to the point that reference solution cannot pass through that is needed to complete the potentiometric circuit.
5. The printed circuit board (PCB) has shorted out by ingress or the op-amp on the board has failed.

The manifestations of these different sources are as follows:

1. A coated electrode (1) will create a narrower span or reduced ORP readings. If the coating is from scaling, then soaking the probe in a weak acid (e.g. vinegar or 0.1M HCl) will remove the scale. If the coating is from fouling, then soaking the probe in bleach will clear it.
2. Either problems 2 or 5 If the pH or ORP reading does not change when changing from one calibration solution to another then either the cause is a failed PCB (5) or broken electrode (2).
3. A contaminate reference solution (3) will result in both a lower span and higher offset for pH probes or an erroneous ORP reading.
4. A fouled salt bridge (4) will result in a slower response but not necessarily a narrower span or inaccurate ORP readings. AquaMetrix sells replacement salt bridges at very modest pricing.

6.6. Customer Service

If a problem has not been resolved with the above procedures, a telephone consultation with your AquaMetrix representative, or directly with Water Analytics will provide the answer.

978-749-9949
www.AquaMetrix.com
support@WaterAnalytics.net

If you are returning a probe for inspection, enclose description of the problem. Pack the probe adequately to avoid damage to the glass electrode and ensure that it will not be exposed to temperatures below –5°C. Water Analytics cannot be responsible for shipping damage nor for damage due to frozen electrodes. For safety reasons, Water Analytics cannot accept probes which have not been thoroughly cleaned to remove all process material.

6.7. Warranty

Warranty statement is available on www.AquaMetrix.com and www.wateranalytics.net.

7. Probe and Accessory Photographs

P65R8-015 R65R8-015 PT65R8-015 RT65R8-015		P65R5-015 R65R5-015	
2" Sanitary Flange -R8: AM-SFL-8 -R5: AM-SFL-5		Union Tee with adapter -R8: AM-TEE-8 -R5: AM-TEE-5	
Protectors -R8: AM-PTR-8 -R5: AM-PTR-5		Jet Cleaners -R8: AM-JET-8 -R5: AM-JET-5	
Salt Bridge Kit (3-pack) -R8: AM-SBK3-R8 -R5: AM-SBK3-R5		Salt Bridge Kit (10-pack) -R8: AM-SBK10-R8 -R5: AM-SBK10-R5	
Hot Tap Assembly -R5:AM-HTA-R5		Submersion Hardware -R8: AM-ARM-8 -R5: AM-ARM-5	
Junction box AM-JB2		Interconnect cable: AM-CBL	
pH Calibration Solutions (500ml) pH4: AM-PH4-1P pH7: AM-PH7-1P pH10: AM-PH10-1P		ORP Calibration Solutions (500ml) 200 mV: AM-R200-1P 600 mV: AM-R600-1P	

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	REVISION:	4	
	PAGE:	0 OF 24	

DOC. NO.	N116-139
DESC.	OPERATING INSTRUCTIONS FOR 65-SERIES DIFFERENTIAL PH/ORP (TEMPERATURE) PROBES

CONTENTS

REV. NO.	DESCRIPTION OF CHANGE	AUTHOR	CHECKED	APPROVED
0	Created from the N116-19 that covered both 2-wire and 5-wire probes	JA, MNS	MNS	MNS
1	Added drawings for probe dimensions and pictures of accessories	MNS	MNS	MNS
2	Added PT (dual output) probes	MNS		
3	Fixed specs section, Added rocker switch for R65, Added calibration section, Added charts to maintenance section, Updated all pictures and part numbers to 2017	AD	MNS	
4	Changed temperature rating to 0-75C, updated information with R5-series	AD		