INSTRUCTION MANUAL

AquiStar® TempHion™

Smart Sensor (ph, ISE, Redox)

AquiStar™
Data Collection Systems

INW™

True data, measure by measure

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Introduction

What is the TempHion™ Smart Sensor?

The AquiStar® TempHion™ Smart Sensor is a submersible water quality sensor and datalogger capable of measuring pH, specific ions, redox, and temperature. Each unit comes with a thermistor based temperature element plus a combination of pH, ISE, or redox elements. (Contact INW for available combinations.)

The TempHion™ Smart Sensor is powered internally with two AA alkaline batteries or with an auxiliary 12VDC power supply for data intensive applications. The unit is programmed using a Windows® based computer and INW's easy-to-use Aqua4Plus software. Once programmed, the unit will measure and collect data on a variety of time intervals.

Several TempHions, or a combination of TempHions and other INW Smart Sensors, can be networked together and controlled from one location, either directly from a single computer or via a WaveData® Wireless Data Collection System.

The internal processor in the TempHion™ Smart Sensor allows for easy calibration, using the calibration utilities in Aqua4Plus. Once calibrated, this calibration data is stored in non-volatile memory within the Smart Sensor. When data is collected, this calibration information is applied to the data, resulting in highly accurate readings at a wide range of temperatures.

Initial Inspection and Handling

Upon receipt of your smart sensor, inspect the shipping package for damage. After opening the carton, look for concealed damage, such as a cut cable. If damage is found, immediately file a claim with the carrier. Check the label attached to the cable at the connector end for the proper cable length.

Do's and Don'ts

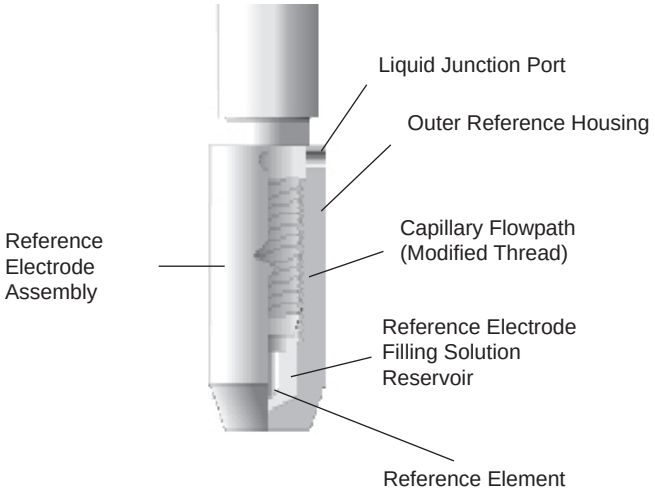
Do handle the device with care.
Do store in water or calibration solution and keep vertical once filled with reference solution.

Don't install the device so that the connector end is submerged.
Don't support the device with the connector or with the connectors of an extension cable. Use a strain relief device to take the tension off the connectors.
Don't allow the device to free-fall down a well as impact damage can occur.
Don't bang or drop the device on hard objects.

TempHion™ Reference Electrode

TempHion's patented reference electrode is the key to TempHion's superior downhole/ high pressure performance. TempHion uses a long capillary pathway, initially filled with reference electrode filling solution, to separate the reference electrode chamber from the solution being analyzed. In addition, TempHion's reference electrode is filled without *any* air (which is compressible). With this construction, the principle mechanism that will eventually allow test solution to enter the reference chamber and contaminate the reference electrode filling solution is diffusion - an exceedingly slow mechanism. Further, while the capillary pathway is narrow by garden hose standards, its open cross-section is huge compared to the microscopic openings in a conventional porous ceramic fluid/fluid junction. It is therefore much less susceptible to fouling. Fluid expansion and contraction caused by temperature variations can augment the effects of diffusion. Nevertheless, TempHion's proven stability under actual field conditions is measured in weeks or months, rather than hours or days!

The figure below illustrates the construction of the TempHion™ reference electrode. Please note that the capillary pathway between the reference and test solutions is established using a modified screw thread. This means that the capillary can be easily opened up for cleaning, refilling, or other maintenance.



Reference Electrode Assembly: The modified thread provides a continuous liquid path between the solution in which the instrument is immersed and the reference element.

Battery Life Note

The TempHion sensors are shipped from the factory with fresh internal AA batteries. These batteries should last several months to a year. Actual battery life may depend on battery brand, battery age, temperature of the environment, usage schedule, and other factors.

General Precautions

The rest of this manual includes step-by-step instructions for setting up the TempHion™, calibrating it, and using it in the field. When reading and following the instructions in these sections, keep these very important considerations in mind:

- Do not handle the surfaces of the sensing electrodes. Oils from fingers can "blind" the reactive surface. Rough handling can scratch the reactive surface.
- Avoid long-term exposure of silver-based sensing electrodes to bright sunlight.
- Use calibration standards that are accurately prepared. Discard standards after use. Do not return the used standards to the bottles of "fresh" solution.
- When TempHion's reference electrode contains filling solution, The o-ring at the top of the reference assembly must be in the upper position. (See further details under Field Deployment later in this manual.)
- For any step-change in temperature (e.g., where calibration standards are at a different temperature than water to be tested) allow the instrument to come to complete thermal equilibrium before making measurements. Up to 30 minutes may be required.

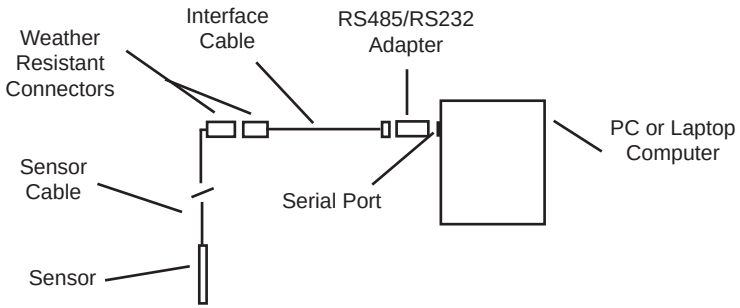
Installation and Operation

Connecting External Power

The TempHion™ comes with two AA internal batteries. If auxiliary power is desired, you can use a 6 - 13 VDC supply that can provide 15 mA. Connect to Vaux++ (white) and Ground (blue) or contact INW for auxiliary power connectors.

Connecting the TempHion™ to a Computer

The Smart Sensor cable is terminated with a weather resistant connector. Connect the weather resistant connector to your PC or laptop serial port via the interface cable and an RS485/RS232 adapter, as shown below. For USB connections, see Appendix E.



Connect the sensor to your computer using the interface cable and an RS485/RS232 adapter. See Appendix D for details on connecting using a USB Port.

Installing the Aqua4Plus Software

The TempHion™ comes with the Aqua4Plus host software to be installed on your PC or laptop. Use this software to calibrate the sensor, to program the datalogger, to retrieve data from the logger, to view collected data, and to export data to external files for use with spreadsheets or databases. Refer to the Aqua4Plus software manual for details on installing and using Aqua4Plus.

Calibration

The TempHion has two temperature channels and four millivolt channels. The millivolt channels can be configured to measure pH, redox, or various selected ions. Before leaving the factory, your sensor has been configured specifically for you. All unneeded channels have been disabled, and the active channels have been pre-configured. Disabled channels will not display in Aqua4Plus.

All active channels can be calibrated in the field. Temperature channels rarely need calibrating, however the millivolt channels should be calibrated before first use and periodically thereafter.

Environmental conditions of turbulence and temperature swings, as well as local likelihood for bio-fouling or mineral deposition, can vary considerably from site to site. Therefore, where the sensor is to be used for long-term monitoring, it is recommended that the calibration be initially checked frequently until a performance history is established.

See Appendix B for detailed calibration instructions.

Field Deployment

The black reference reservoir at the lower end of the TempHion™ Smart Sensor is shipped filled with INW reference solution. (If your reference reservoir is not filled, see the Maintenance section in this manual.) The black reference assembly has two grooves. The upper groove contains a small hole that forms the liquid junction port. During shipping and storage, an o-ring is located in the upper groove, preventing reference solution leakage and contamination. Be sure to move the o-ring to the lower groove before deploying, thus exposing the liquid junction port. If the o-ring continues to cover the opening, readings will not be representative or accurate.

Be sure to move the o-ring to the lower groove before deploying, thus exposing the liquid junction port.

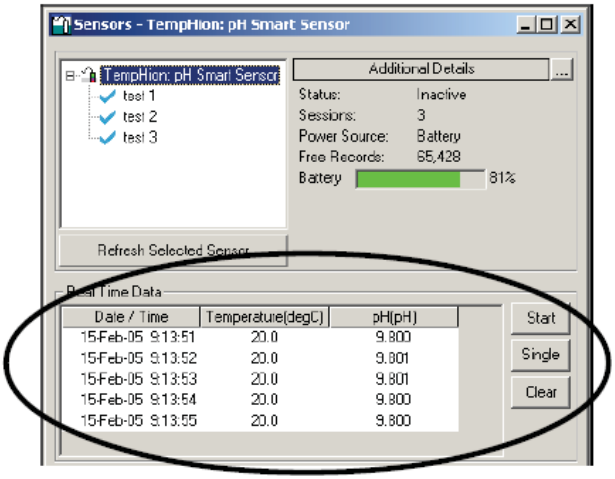
Lower the sensor to the desired depth. Fasten the cable to the well head using tie wraps or a weather proof strain-relief system. (Note that for shallow installations the liquid in which the sensor is submerged must, at all times, reach high enough to touch the metal tubing on the sensor.)

Be sure the supplied cap is securely placed on the weather-resistant connector at the top of the cable. Do not install such that the connector might become submerged with changing weather conditions. The connector can withstand incidental splashing but is not designed to be submerged.

Collecting Data

Following is a brief overview on using Aqua4Plus to collect data. Please refer to the *Aqua4Plus Instruction Manual* for further details on configuring and using Aqua4Plus.

Real Time Monitor



The Real Time Monitor gives a snapshot of the current readings on the sensor.

Click Single to get a single reading.

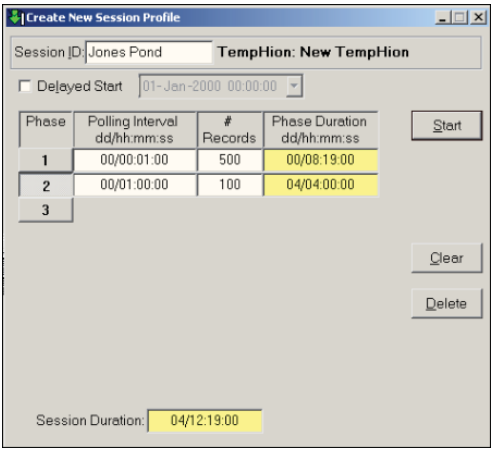
Click Start to get a reading once a second.

Click Stop to stop the reading.

Note: These are snapshot readings and are not recorded on the sensor.

Setting up a Data Recording Session

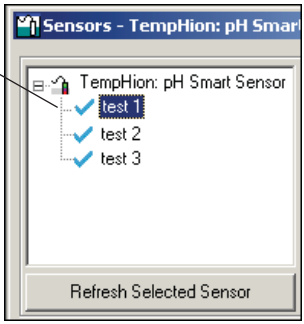
Click the tool button. A Session Profile Window will open. Refer to the *Aqua4Plus Instruction Manual* for details in describing your session profile. Click the Start button to save the session to the sensor and begin recording.



Using the Session Profile Window, describe the test steps for your particular test.

Retrieving Data from the Sensor/Datalogger

- Click on the session you want to upload.
- Click the  tool button.
- Select a file location.
- Click Save.
- Click Start.



Select the data session you are ready to upload.

Viewing Data

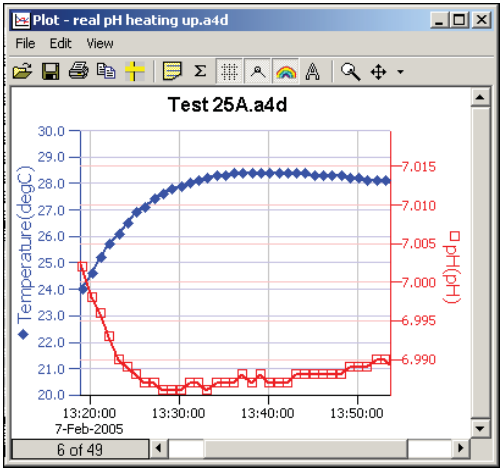
- Click the  tool button to view data as a table.
- Click the  tool button to view data as a graph.
- Navigate to the desired file, then click the Open button. (If the File Open box does not appear, click the File Menu, then select Open.)

File Display - real pH heating up.a4d

Sensor SN	Sensor Type	Sensor Name	Session Name
2452034	TempHion	pH Smart Sensor	Test 25A

		Temperature(degC)	pH(pH)
	Sensor Range	-40 - +125 degC	0-14 pH
	Minimum	22.0	6.986
	Maximum	28.4	7.019
	Mean	27.0	6.992
	Variance	4.02	0.0001
	Std Deviation	2.00	0.0091
	Element	30K type 5 thermistor	
	Cal Date	7-Feb-05	7-Feb-05
Rec#	Date/Time	Temperature(degC)	pH(pH)
1	07-Feb-05 13:13:03	22.0	7.018
2	07-Feb-05 13:14:03	22.0	7.018
3	07-Feb-05 13:15:03	22.0	7.019
4	07-Feb-05 13:16:03	22.2	7.016
5	07-Feb-05 13:17:03	22.7	7.013
6	07-Feb-05 13:18:03	23.3	7.005
7	07-Feb-05 13:19:03	24.0	7.002
8	07-Feb-05 13:20:03	24.6	6.998
9	07-Feb-05 13:21:03	25.2	6.996
10	07-Feb-05 13:22:03	25.7	6.993

The File Display Window displays your data in a tabular format.



The Graph Window displays your data on an X Y coordinate graph.

Exporting Data to .csv or .xls Files

- Using the File Display window, open the file you want to export.
- Click on the tool button.
- Select a file location and enter a name for the file.
- Select a file type.
- Click Save.

A Word About Units

Readings from the TempHion™ Smart Sensor can be displayed in various units. Select the units you want from the Options | Units menu.

pH:	pH or mV
ISE:	ppm or mV
Redox:	mVH or mV
Temperature:	Degrees Celsius, Fahrenheit, or Kelvin

When using pH, ppm, or mVH units, all readings are automatically compensated for temperature and all field calibration factors are applied. When using millivolts or ohms, only the actual millivolt or resistance values are displayed - no adjustments are made.

Maintenance

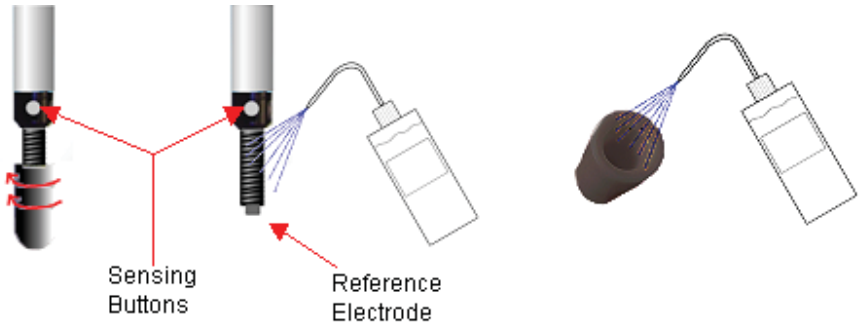
Care and Filling of Reference Solution Reservoir

The TempHion's patented reference electrode is key to the TempHion's superior performance. The TempHion uses a long capillary pathway, filled with reference solution, to separate the reference electrode from the solution being analyzed. Proper care and filling of this reference solution reservoir is essential to accurate functioning of the sensor.

Your TempHion is normally shipped from the factory already filled with reference solution. However, from time to time you will need to replace the reference solution. If you notice you are getting erratic readings, this is an indication that the filling solution may need to be replaced. We also recommend replacing the filling solution when doing periodic calibrations.

The TempHion is normally shipped with a bottle of INW Reference Solution. If you will be using a different solution, contact INW for any adjustments that may be needed.

Emptying and Cleaning the Reservoir



Rinse the reference electrode and the inside of the cap with distilled or de-ionized water.

- Unscrew the reservoir cap. **Do not touch or scratch the sensing buttons or the reference electrode!**
- Empty any remaining filling solution from the cap.
- Thoroughly rinse the reference electrode and the inside of the cap with distilled or de-ionized water.
- There may be some crystallized residue inside the cap, on the electrode screw path, or on the electrode itself. If rinsing does not clear this away, then gently use a cotton swab or a soft toothbrush to remove the residue.
- Rinse the electrode assembly and cap thoroughly again after cleaning with the swab or brush.
- Gently, pat dry with a clean paper towel.

Filling the Reservoir

Once the reservoir has been emptied and cleaned, you are ready to fill the reservoir with reference solution.

- Rinse the reference electrode assembly and the inside of the cap with a small amount of the reference solution.
- Empty any remaining solution from the cap.
- Fill cap about half full with reference solution.
- Holding sensor vertically, replace reservoir cap. Some solution should spill from the top as you screw the cap on. This assures that no air bubbles are trapped inside.
  If any air bubbles are trapped, a proper electrical connection cannot be made and the sensor may read erratically!

Excess filling solution spills over, forcing out any air bubbles.

CAUTION: Filling solutions are not considered hazardous, but they can be irritating to the skin. Protective gloves are advised. Rinse hands or gloves with fresh water.

- Once filled, besure the o-ring is in the upper groove to prevent reference solution leakage and contamination. **Before deploying be sure to move the o-ring to the lower groove to expose the liquid junction port.**

Be sure to move the o-ring to the lower groove before deploying, thus exposing the liquid junction port.

Storing Sensor

For long-term storage, the sensor should be stored dry.

- Unscrew and empty the reservoir cap. **Do not touch or scratch the sensing buttons or the reference electrode!**
- Clean the cap and electrode assembly as detailed earlier in this application note.
- Let cap and electrode assembly dry thoroughly.
- Replace cap to protect electrode from scratching.

Changing Batteries

Because changing the batteries involves opening the water-tight seal, **this must be done in a clean, dry environment to avoid contamination or moisture damage to the circuitry.**

Battery Type: Two standard AA Alkaline batteries.

Opening the Housing

Open the housing by removing the top cap, as outlined below. The top cap is the connector between the tube housing, the sensor, and the cable. There is a waterproof gasket between the sensor body and the top cap. Compress sensor housing against top cap by pushing from both ends and gently twisting the top cap. (You may need a pair of pliers.)

1. Carefully separate the top cap from the body of the sensor. Top cap remains attached to the body via several colored wires.
2. Disconnect the black service connector. (See photos)

Caution! Pulling forcefully on the top-cap can pull the insides out of the sensor or snap the connections inside. Removing the circuit board or pushing on the surface of the pressure element **may void your warranty**.

Note: O-rings provide a water-tight seal for the sensor housing. Take care not to nick or otherwise damage these O-rings.

Replacing the Batteries

3. Tip housing over and gently slide batteries out.
4. Insert new batteries - **positive terminals towards the top-cap**.

Re-sealing Housing

5. Gently twist the wires into a bundle. Carefully wrap the wires around the slot in the connector board. (See photo.)

6. Replace service connector. Note: this connector is keyed and can only be connected in one direction.
7. Replace top-cap, twisting until you hear a click.

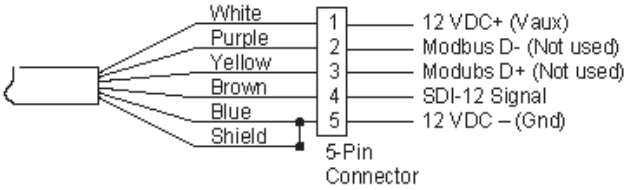
Appendix A: Technical Specifications

Wiring Information

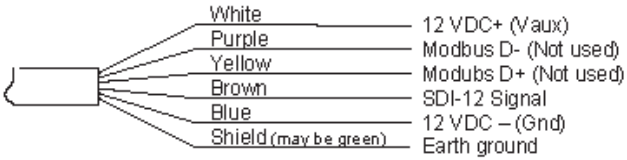
Cable Type: 9-conductor, shielded

Shield	=	Ground
White	=	Vaux (6 to 13 VDC)
Brown	=	SDI-12
Orange	=	Vbat+ (1.8 to 3.3 VDC)
Blue	=	Ground
Yellow	=	Comm D+
Purple	=	Comm D-

For SDI-12 with firmware 2.0 or higher — with 5-pin connector



For SDI-12 with firmware 2.0 or higher — without connector



Dimensions and Specifications

SENSOR

Length	13.25” – 17.25” (33.7 – 42.8 cm) (varies by parameters)
Diameter	0.75” (1.9 cm)
Weight	0.85 lb (0.4 kg)
Body Materials	Delrin® & 316 stainless steel or titanium
Wire Seal Materials	Viton® and Teflon®
Submersible Cable	Polyurethane, polyethylene, FEP or Tefzel®
Cable Weight	4 lbs/100 ft (1.8 kg/30 m)
Communication	RS485 Modbus®
Available Channels	3 pH/ISE/Redox, 1 temperature
Operating Temperature Range	0° C to 50° C
Storage Temperature Range[1]	-20° C to 80° C
Reference	
Electrode	Ag/AgCl solid-state electrode
Junction	Patented capillary liquid junction
Electrolyte	TempHion™ reference solution
Maximum Operating Pressure	100 PSI (70 H2O)
Burst Pressure	200 PSI (140 H2O)

LOGGING

Memory	250,000+ records
Logging Rate	2x/sec
Resolution	16 bit
File Formats	.xls / .csv / .a4d

POWER

Internal Battery	2x1.5V AA Alkaline[2]
Auxiliary Power	12 VDC – Nominal 6V-15VDC – Range

TEMPERATURE

Element Type	30K ohm thermistor
Element Material	Epoxy bead/external housing
Accuracy	± 0.5° C
Resolution	0.01° C
Units	Celsius, Fahrenheit, Kelvin

ION SPECIFIC ELECTRODE

Chloride/Bromide

Measurement Principle	Ion electrode method
Probe Material	Ag/AgCl solid-state electrode
Range	0-10,000 ppm
Typical Accuracy	± 2.0% of measured value
Resolution	0.1 ppm
Thermal Compensation	Isopotential point characterization
Calibration	1-2 point method w/ ionic strength adjustment
Reference Solution	Potassium Nitrate - (KNO_3)

pH/REDOX

Sensor Type/Material	
pH	Glass combination electrode
Redox	Platinum ring
Ranges	
pH	0-14 pH units / -538mV to 260mV
Redox	± 1200mV
Units	
pH	pH, mV
Redox	mVH, mV
Typical Accuracy	
pH	± 0.2 pH units
Redox	0.1 mVH
Resolution	
pH	0.01 pH units
Redox	0.01 mVH
Calibration	
pH	1 and 2 point w/ pH buffers (7 & 4 or 10)
Redox	1 point
Compensated Range	0° C to 40° C
Reference Solution	Potassium Nitrate - (KNO_3)

[1] Storage without batteries

[2] Lithium available upon request

Appendix B: Field Calibration

Calibration Overview

The TempHion should be calibrated before first use and periodically thereafter. It should also be calibrated if moving to a different sampling environment where readings will be significantly different than the current environment.

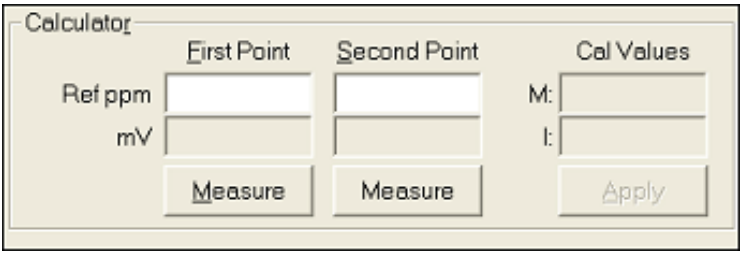
Environmental conditions of turbulence and temperature swings, as well as local likelihood for bio-fouling or mineral deposition, can vary considerably from site to site. Therefore, where the sensor is to be used for long-term monitoring, it is recommended that the calibration be initially checked frequently until a performance history is established.

Aqua4Plus provides an easy-to-use calibration calculator for performing one- or two-point in-field calibrations. Two-point calibrations are more accurate and should be used whenever possible. A Calibration Kit is available from INW, which includes a beaker, pipette, measuring beaker, and stand.

- In order for the TempHion Smart Sensor to calibrate and function correctly, the filling solution reservoir must be properly filled with reference solution. For details, see earlier in this manual.
- Be sure the o-ring on the black reference housing has been moved to the lower groove, exposing the liquid junction port.
- For best results, the filling solution reservoir should be filled at least 16 hours before calibrating.
- The sensor and all calibration buffers and solutions should be at the same temperature before and during calibration.
- Calibration can only be done when there are no sessions stored on the sensor. If there are any sessions stored on the sensor, upload any data you want and then erase the sessions before continuing. (Sessions Menu | Erase All Sessions).

Field Calibration Window and Calculator

Field calibration is performed on each channel separately. To calibrate a specific channel, select Field Calibration from the Configure Menu, and then click on the channel to be calibrated. Refer to Appendix B in the *TempHion Smart Sensor Instruction Manual* for general use of the field calibration window and the calculator. Follow directions below for each specific channel type.



Use the Aqua4Plus calibration calculator to perform one- and two-point calibrations.

Temperature Channel Calibration

The temperature channel rarely needs calibration. If needed, select Field Calibration from the Configure Menu. Click on Temperature, and then follow the instructions on the screen.

pH Channel Calibration

Preparing

- INW recommends pH buffers of 4, 7, and 10 for calibration. For a one-point calibration, select the buffer closest to the expected values in your samples. For a two-point calibration, select the two buffers that most closely bracket the expected values in your samples.
- For best results, look up the buffer's actual pH for the temperature closest to the buffer temperature during calibration. This information is available from the buffer manufacturer.

One-Point Calibration

— First Calibration Point —

- Prepare the buffer.
- Rinse sensor first with distilled water and then with small amount of the buffer.
- Place sensor in buffer. (Buffer must be deep enough to cover the sensing bulb in the slot in the black module on the sensor.)
- Allow time for sensor to stabilize.
- In the ***Ref pH*** box for the first point, enter the reference pH as noted in the preparation section above.
- Click first ***Measure*** button.
- When readings have stabilized to your satisfaction, click the ***OK*** button in the pop-up box.

— Applying Calibration Values —

- Observe ***I*** value in the right hand section of the calculator. This should be between 180 and 300.
- Click the ***Apply*** button to apply calibration values.
- The reference value, the computed I, and the sample temperature will be transferred to the calibration fields.
- Click ***OK*** to save the values to the sensor.

— Verifying Calibration Values —

- Using the Real Time Monitor, take a few readings while the sensor is still in the buffer. Be sure units are set to pH. Readings should be very close to your selected buffer.

Two-Point Calibration

— First Calibration Point —

- Prepare first buffer.
- Rinse sensor first with distilled water and then with small amount of first buffer.
- Place sensor in buffer. (Buffer must be deep enough to cover the sensing bulb in the slot in the black module on the sensor.)
- Allow time for sensor to stabilize.
- In the ***Ref pH*** box for the first point, enter the reference pH as noted in the preparation section above.
- Click first ***Measure*** button.
- When readings have stabilized to your satisfaction, click the ***OK*** button in the pop-up box.

— Second Calibration Point —

- Prepare the second buffer.
- Rinse sensor first with distilled water and then with small amount of second buffer.
- Place sensor in second buffer. (Buffer must be deep enough to contact stainless steel tube above the sensor section.)
- In the ***Ref pH*** box for the second point, enter the reference pH as noted in the preparation section above.
- Click second ***Measure*** button. (Note: measured temperature must be +/- 1 degree of first measured temperature or calibration will not be accurate!)
- When readings have stabilized to your satisfaction, click the ***OK*** button in the pop-up box.

— Applying Calibration Values—

- Observe the ***M*** and ***I*** values in the right hand section of the calculator. ***M*** should be between -50 and -60, and ***I*** should be between 180 and 300.
- Click the ***Apply*** button to apply calibration values.
- The reference values, the computed M and I, and the sample temperature will be transferred to the calibration fields.
- Click ***OK*** to save the values to the sensor.

— Verifying Calibration Values—

- Using the Real Time Monitor, take a few readings while the sensor is still in the buffer. Be sure units are set to pH. Readings should be very close to your selected buffer.

ISE Channel Calibration

Introduction to ISE Calibration

INW recommends using the "known addition method" for preparing calibration solutions. Using this method, the sensor is placed in 100 mL of distilled or de-ionized water. A small amount of standard is added to create a known concentration. The first point is measured. An additional amount of the same standard is added to create a second known concentration. The second point is measured.

INW recommends the calibration standards listed below. The following instructions are based on using one of these standards. If you use different standards or prefer not to use the known addition method, you must use some other method to determine the concentration used for the first and second point when calibrating.

Recommended Standards

Bromide

- 0.1 Molar NaBr (equates to 7990 ppm)

Chloride

- 0.1 Molar NaCl (equates to 3550 ppm)
- 100 ppm
- 1000 ppm

Preparing

- Select a standard that you will be using for calibration.
- Place 100 mL of distilled water in a beaker.
  Note: Temperature of the water ***must remain the same*** *throughout the calibration. Temperature of the sensor must also be this temperature prior to calibration.*

One-Point Calibration

— Computing Calibration Value—

- Rinse sensor with distilled water and pat dry.
- Place sensor in beaker of distilled water, as prepared above. (Solution must be deep enough to cover the sensing buttons.)

- Add 1 cc of selected standard to the water. Depending on which solution you are using, this will result in a concentration as shown below:
  - 0.1 Molar NaBr (Bromide) = 79.10 ppm
  - 0.1 Molar NaCl (Chloride) = 35.15 ppm
  - 100 ppm (Chloride) = 0.99 ppm
  - 1000 ppm (Chloride) = 9.90 ppm
- Stir to distribute standard evenly.
- Allow time for sensor to stabilize (15 - 20 minutes).
- In the ***Ref ppm*** box for the first point, enter the concentration you have chosen.
- Click the first ***Measure*** button. (Readings will be in mV).
- When readings have stabilized to your satisfaction, click the ***OK*** button on the pop-up box.

— Applying Calibration Values—

- Observe the ***I*** value in the right hand section of the calculator. For Bromide, ***I*** should be between 0 and 40. For Chloride, ***I*** should be between 120 and 160.
- Click the ***Apply*** button to apply calibration values.
- The reference value, the computed I, and the sample temperature will be transferred to the calibration fields.
- Click ***OK*** to save the values to the sensor.

— Verifying Calibration Values—

- Using the Real Time Monitor, take a few readings while the sensor is still in the standard. Be sure units are set to ppm. Readings should be very close to your selected concentration.

Two-Point Calibration

— First Calibration Point—

- Rinse sensor with distilled water and pat dry.
- Place sensor in beaker of distilled water, as prepared above. (Solution must be deep enough to cover the sensing buttons.)
- Add 1 cc of selected standard to the water. Depending on which solution you are using, this will result in a concentration as shown below:
  - 0.1 Molar NaBr (Bromide) = 79.10 ppm
  - 0.1 Molar NaCl (Chloride) = 35.15 ppm
  - 100 ppm (Chloride) = 0.99 ppm
  - 1000 ppm (Chloride) = 9.90 ppm
- Stir to distribute standard evenly.
- Allow time for sensor to stabilize (15 - 20 minutes).
- In the ***Ref ppm*** box for the first point, enter the concentration you have chosen.
- Click the first ***Measure*** button.
- When readings have stabilized to your satisfaction, click the ***OK*** button on the pop-up box.

— Second Calibration Point—

- Add 10 cc of the ***same*** standard to the water. Depending on which solution you are using, this will result in a concentration as shown below:
  - 0.1 Molar NaBr (Bromide) = 791.8 ppm
  - 0.1 Molar NaCl (Chloride) = 351.8 ppm
  - 100 ppm (Chloride) = 9.9 ppm
  - 1000 ppm (Chloride) = 99.0 ppm
- Stir to distribute standard evenly.
- Allow time for sensor to stabilize (15 - 20 minutes).
- In the ***Ref ppm*** box for the second point, enter the concentration you have chosen.
- Click the second ***Measure*** button.
- When readings have stabilized to your satisfaction, click the ***OK*** button on the pop-up box.

— Applying Calibration Values—

- Observe the ***M*** and ***I*** values in the right hand section of the calculator. ***M*** should be between -50 and -60. For Bromide, ***I*** should be between 0 and 40. For Chloride, ***I*** should be between 120 and 160.
- Click the ***Apply*** button to apply calibration values.
- The reference values, the computed M and I, and the sample temperature will be transferred to the calibration fields.
- Click ***OK*** to save the values to the sensor.

— Verifying Calibration Values—

- Using the Real Time Monitor, take a few readings while the sensor is still in the standard. Be sure units are set to ppm. Readings should be very close to your selected concentration.

Redox Channel Calibration

Note on units: The unit “Eh” refers to readings in millivolts referenced to a hydrogen electrode. In other words, Eh represents millivolt readings that would have been obtained if using a hydrogen electrode. The units “mV” are direct millivolt readings from the sensor.

— For Calibration You Will Need—

- A beaker or bucket of a sample that is representative of what will be measured with the sensor.
- An alternate redox meter - such as an Orion or YSI meter.
- Distilled or deionized water.
- Paper towels.

— Computing Calibration Value—

Note: When calibrating a redox channel, do not use the built-in calculator in the Field Calibration Window. Instead, follow the instructions below.

1. Rinse sensor with distilled or deionized water, and then pat dry with clean paper towels.
2. Place the sensor in sample. (Solution must be deep enough to cover the sensing bulb.)
3. Using the alternate meter, take a redox measurement of that sample. Use either plain mV or Eh, whichever you normally use.
4. In Aqua4Plus - set display units to either mV or Eh, whichever you used for the above step.
5. Scan for and click on the sensor.
6. Open the field calibration window (***Configure*** | ***Field Calibration***).
7. Click on the redox channel, and then enter a zero in the offset box.
8. Click ***OK***
9. Take two or three single readings using the Real Time monitor and note the redox value.
10. Subtract this value from the value read in the step 3.

— Applying Calibration Value—

11. Open the field calibration window.
12. Click on the redox channel, and then enter this value in the offset box.
13. Click ***OK***.

— Verifying Calibration Values—

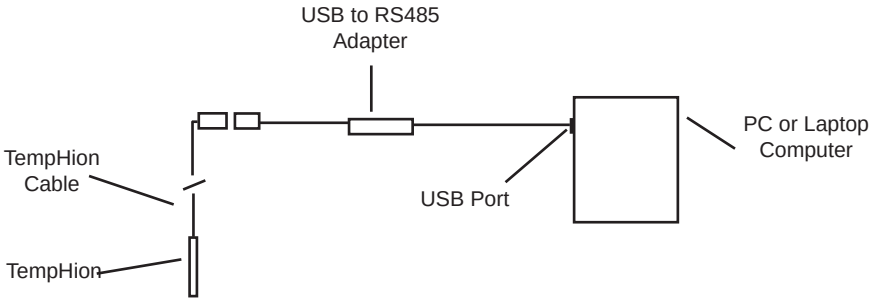
14. Take another couple single Real Time readings. These should be close to the reading taken with the other meter.

Appendix C: Using a USB Port

If you do not have or do not want to use a 9-pin serial port for connecting your sensor to your PC, you can connect to your sensor using a USB port.

Connecting with INW's USB to RS485 Adapter

If using INW's USB to RS485 adapter, connect as shown in figure below. Drivers and installation instructions come with the adapter.

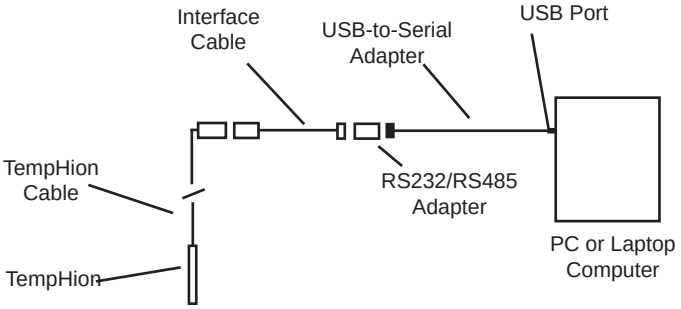


Connection using INW's USB to RS485 Adapter

Connecting with a USB/Serial Adapter

USB-to-Serial cables are readily available from many electronics and computer stores, as well as numerous sites on the Internet. INW has tested and recommends the Keyspan USA-19HS. It is available from INW as well as from many sites on the Internet. Install as follows:

- Plug into USB port.
- Install the drivers provided with the particular unit.
- Determine the port number to which the adapter is assigned.
  - Right-click on My Computer.
  - From the popup menu, select Manage to open the Computer Management window.
  - On left panel, click on Device Manager.
  - On right panel, double-click on Ports.
  - A list of active COM ports will be displayed. Note the COM number assigned to the adapter you just installed.
    For example: Keyspan USB Serial Port (COM4)
  - Close Manager.
- Connect to the sensor.
- On the Aqua4Plus software, select the COM port noted above. (If you do not see your new COM port in the dropdown box, open the Communications dialog box from the Options menu. Increase the Highest COM port number, up to a maximum of 15.)



Connection using a USB to Serial Adapter

Appendix D: Reading the TempHion™ via Direct Read

While the TempHion comes with INW's easy to use Aqua4Plus software, you can also use standard Modbus® RTU or SDI-12 equipment to easily take readings, so as to tie into your existing equipment or networks.

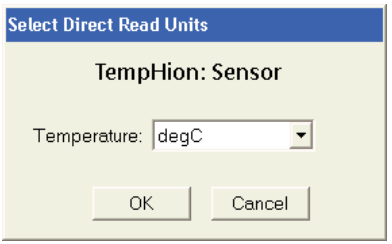
You may need to use Aqua4Plus to make a few settings, prior to directly reading the TempHion with your equipment. For one thing, you may want to change the units for returned values. If reading via Modbus, you may also need to set the baud rate. (You do not need to set the baud rate for SDI-12). These are described in the following sections.

For Modbus you must have TempHion firmware version 1.1 or higher. For SDI-12 you must have version 2.0 or higher.

Setting Units for Direct Read

The TempHion has up to five data channels. The first channel is always temperature. The Temperature channel, by default, uses degrees Celsius. If you want to change to different units, for example, degrees Fahrenheit, set these units using Aqua4Plus.

- Click on the Configure menu, and then select Advanced.
- From the flyout menu, select Direct Read Units. If you do not see this option, be sure your sensor is running the correct firmware.
- On the popup box, click the down-arrows next to Temperature, and then select the units you want.
- Click OK.



Use Aqua4Plus to select the units for your direct read measurements, whether Modbus or SDI-12

The remaining channels are mV channels and can be configured at the factory as pH, ISE, Redox, or ISE 3-Point channels. Each of the mV channels return two direct read values. The first is always mV. The second is either pH, ppm, or Eh, depending on the channel type.

Once set, these units are saved on the sensor and direct readings, either via Modbus or via SDI-12, will return values using these units. (Note: These settings do not affect the units used on the Aqua4Plus display. Refer to the Aqua4Plus software manual for details on using Aqua4Plus.)

Reading Via Modbus® RTU

Setting Baud Rate

Your TempHion comes configured to communicate at 38,400 baud, with 8 data bits, one stop bit, and no parity. The sensor can also be set to 19,200 or 9600 baud, if needed for your application.

If needed, set your TempHion to the desired baud rate as follows:

- Click on the Configure menu, and then select Advanced.
- From the flyout menu, select Sensor Baud Rate. (You may be asked for a password. Enter admin.)
- On the popup box, click the down-arrow and select the baud rate you need, and then click OK.

Once you have changed the baud rate on the TempHion, you will not be able to talk to it with Aqua4Plus until you change the baud rate for Aqua4Plus, as follows:

- Click the Options menu, and then select Baud Rate.
- On the popup box, click the down-arrow, select the baud rate you need, and then click OK.

The current Aqua4Plus baud rate is displayed in the lower right corner of the main Aqua4Plus window.

Taking Measurements

Reading Registers

Read measurements using Modbus function 03 – Read Holding Registers.
Readings are located in two registers each, starting at address 62592. (TempHion register addressing is zero based, i.e., starts at zero. If your equipment uses one based addressing, you will need to add one to the register addresses.)

Register Addresses for the TempHion

	Zero-Based	One-Based
Temperature	62592	62593
mV 1 (mV value)	62594	62595
mV 2 (mV value)	62596	62597
mV 3 (mV value)	62598	62599
mV 1 (pH, ppm, or Eh)	62600	62601
mV 2 (pH, ppm, or Eh)	62602	62603
mV 3 (pH, ppm, or Eh)	62604	62605

Measurement Timing

When you request a reading via Modbus, the sensor wakes up, returns the current values in the registers, and then starts taking new readings and updating the registers. After approximately 10 seconds, if no more readings have been requested, the sensor goes back to sleep.

Because of this, the first reading you get will be old. If you are taking readings at intervals of less than 10 seconds, simply ignore the first reading — all remaining readings will be current. On the other hand, if you are taking readings at intervals of greater than 10 seconds, take a reading, ignore it, wait one second, take another reading. Record this second reading.

Data Format

The data is returned as 32-bit IEEE floating-point values, high word first, also referred to as big-endian or float inverse.

For further information and detailed Modbus examples, see INW application note, "*Modbus Direct Read on AquiStar Smart Sensors*" available from our web site at www.inwusa.com/technical-library/application-notes.

Reading Via SDI-12

Note: The default units for temperature is Celsius. To change this, use the Direct Read Units option under the Configure | Advanced menu in the Aqua4Plus Control Software. When using the M!, MC!, C!, or CC! command, all mV channels will report in mV. When using the M1!, MC1!, C1!, or CC1! command, all mV channels will report in either pH, ppm, or Eh, depending on the channel type. (pH = pH, ISE = ppm, Redox = Eh)

Addressing
Default SDI-12 Address: 0

SDI-12 Command Nomenclature
<a> = Sensor address
{crc} = SDI-12 compatible 3-character CRC
<cr> = ASCII carriage return character
<lf> = ASCII line feed character
highlighted values indicate variable data

SDI-12 Commands

```
//*** Sensor Identification
<a>I! <a>13  INWUSA  TempHi2.0ssssssssss<cr><lf>
                                        // note: 2.0 will change to reflect current
                                        // firmware revision
                                        // sssssssss = device serial #
//*** Acknowledge Active, Address Query
<a>! <a><cr><lf>
?! <a><cr><lf>

//*** Change Address
<a>A<b>! <b><cr><lf>                    // change address from <a> to <b>


//*** Request measurement
<a>M! <a>0024<cr><lf>                   // request all measurements
<a>D0! <a>+74.6128+73.2412+109.862+145.077<cr><lf>
                                        // read: temperature, 1st mV channel (mV),
                                        // 2nd mV channel (mV), 3rd mV channel (mV)

<a>M1! <a>0024<cr><lf>                  // request measurements
<a>D0! <a>+74.6182-.535585+.339544+.000503<cr><lf>
                                        // read: temperature, 1st mV channel (pH/ISE/
                                        // Redox*), 2nd mV channel (pH/ISE/Redox*),
                                        // 3rd mV channel (pH/ISE/Redox*)
                                        // *Units on mV channels depend on channel
                                        //   type. (pH = pH, ISE = ppm, Redox=Eh)

//*** Request measurement with CRC
<a>MC! <a>0024<cr><lf>                  // request all measurements w/CRC
<a>D0! <a>+74.6128+73.2412+109.862+145.077{crc}<cr><lf>
                                        // read: temperature, 1st mV channel (mV),
                                        // 2nd mV channel (mV), 3rd mV channel (mV)
```

<a>MC1! <a>**0024**<cr><lf> // request measurements w/CRC
<a>D0! <a>**+74.6128-.535585+.339544+.000503{crc}**<cr><lf>
// read: temperature, 1st mV channel (pH/ISE/
// Redox*), 2nd mV channel (pH/ISE/Redox*),
// 3rd mV channel (pH/ISE/Redox*)
// *Units on mV channels depend on channel
// type. (pH = pH, ISE = ppm, Redox=Eh)

//*** Concurrent measurement
<a>C! <a>**00204**<cr><lf> // request all measurements
<a>D0! <a>**+74.6128+73.2412+109.862+145.077**<cr><lf>
// read: temperature, 1st mV channel (mV),
// 2nd mV channel (mV), 3rd mV channel (mV)

<a>C1! <a>**00204**<cr><lf> // request measurements
<a>D0! <a>**+74.6128-.535585+.339544+.000503**<cr><lf>
// read: temperature, 1st mV channel (pH/ISE/
// Redox*), 2nd mV channel (pH/ISE/Redox*),
// 3rd mV channel (pH/ISE/Redox*)
// *Units on mV channels depend on channel
// type. (pH = pH, ISE = ppm, Redox=Eh)

//*** Concurrent measurement with CRC
<a>CC! <a>**00204**<cr><lf> // request all measurements w/CRC
<a>D0! <a>**+74.6128+73.2412+109.862+145.077{crc}**<cr><lf>
// read: temperature, 1st mV channel (mV),
// 2nd mV channel (mV), 3rd mV channel (mV)

<a>CC1! <a>**00204**<cr><lf> // request measurements w/CRC
<a>D0! <a>**+74.6128-.535585+.339544+.000503{crc}**<cr><lf>
// read: temperature, 1st mV channel (pH/ISE/
// Redox*), 2nd mV channel (pH/ISE/Redox*),
// 3rd mV channel (pH/ISE/Redox*)
// *Units on mV channels depend on channel
// type. (pH = pH, ISE = ppm, Redox=Eh)

For further information and SDI-12 examples, see the INW application note, "*TempHion Interface Specification (SDI-12)*" available from our web site at www.inwusa.com/technical-library.

Reordering Information

For sales & service offices, please contact:

INW
www.inwusa.com
800-776-9355

LIMITED WARRANTY/DISCLAIMER - AquiStar® TempHion™ Smart Sensor

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INW
8902 122nd Avenue NE
Kirkland, WA 98033 USA
425-822-4434
FAX 425-822-8384 / info@inwusa.com

1-800-PRO-WELL
WWW.INWUSA.COM