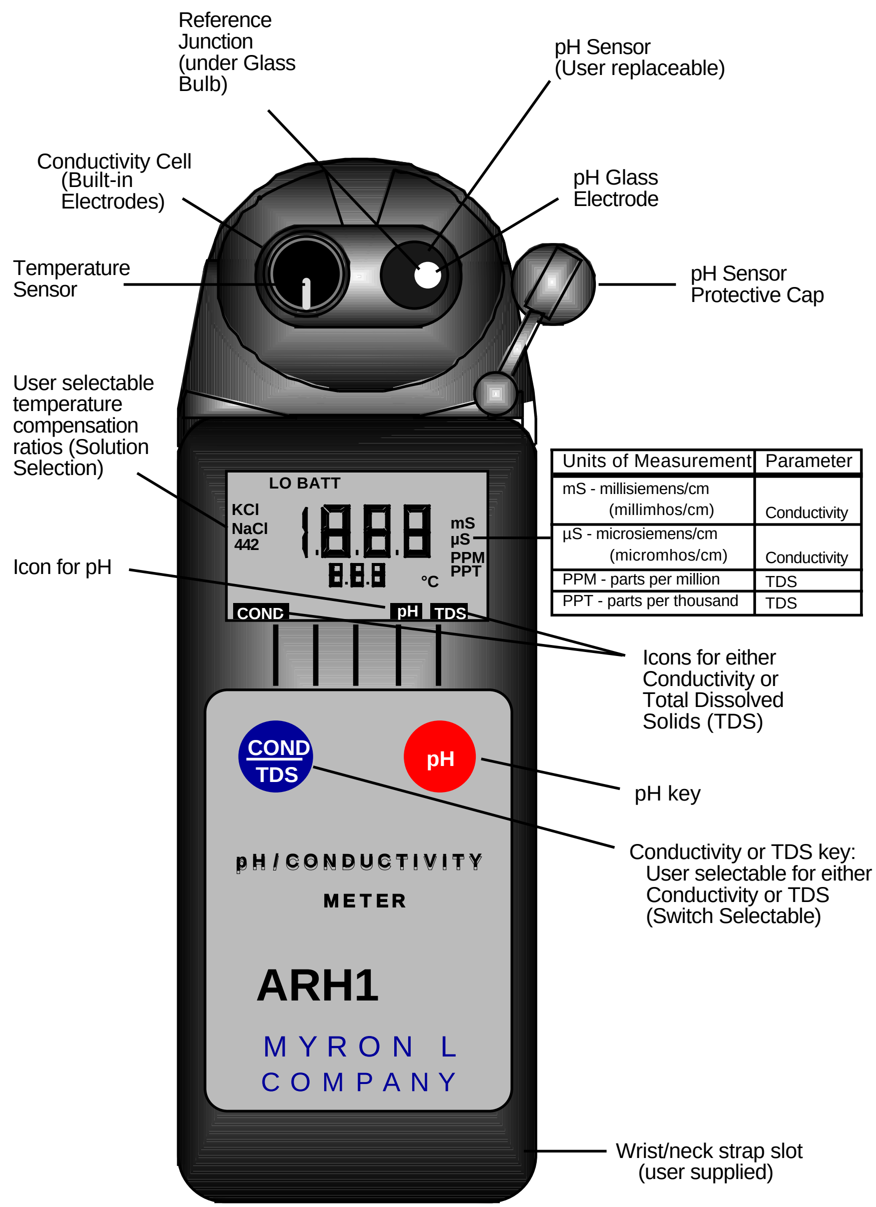
TechPro™ Operation Manual

Model ARH1

MYRON L
COMPANY

10-02 (WEB) EG

Instrument Illustration



Units of Measurement	Parameter
mS - millisiemens/cm (millimhos/cm)	Conductivity
µS - microsiemens/cm (micromhos/cm)	Conductivity
PPM - parts per million	TDS
PPT - parts per thousand	TDS

For detailed explanations, see Table of Contents

CE

1-12-99

FEATURES and SPECIFICATIONS

A. Features

- Superior resolution 3 1/2 digit LCD
- Conductivity/TDS accuracy of ±1% of full scale
- pH accuracy of ± .05 pH units
- All electrodes are internal for maximum protection
- Latest electrode cell technology
- Water resistant
- Autoranging Conductivity/TDS
- Easy Conductivity/TDS and pH calibration
- User selectable Conductivity/TDS modes
- 3 “User Selectable” solution conversions (tempcos)
- Temperature Accuracy of ±1° C/F

B. General Specifications

Display	3 1/2 Digit LCD
Dimensions (LxWxH)	7.7x2.7x2.5 in. 196x68x64 mm
Weight	11.2oz./320g
Case Material	ABS
Cond/TDS Cell Material	ABS
Cond/TDS Cell Capacity	0.2 oz./5 ml
pH Sensor Well Capacity	0.04 oz./1.2 ml
Power	9V Alkaline Battery
Battery Life	>100 Hours/5000 Readings
Operating/Storage Temperature	32-132°F/0-55°C
Protection Ratings	IP64/NEMA 3

C. Specification Chart

ARH1	pH	Conductivity	TDS	Temperature
Ranges	0-14 pH	0-1999 µS 2-19.90 mS in 3 autoranges	0-1999 ppm 2-19.90 ppt in 3 autoranges	0-71° C 32 - 160° F
Resolution	.01 pH	0.1 (<200 µS) 1 (<2000 µS) 0.01 (>2 mS)	0.1 (<200 ppm) 1 (<2000 ppm) 0.01 (>2 ppt)	0.1° C/F
Accuracy	±.05 pH	±1% of Full Scale		±1.0° C/F
Auto Temperature Compensation	0-71° C 32 - 160° F	0-71° C 32 - 160° F		
Conductivity or TDS Ratios		KCl, NaCl or 442™		

D. Warranty/Service

The ARH1 has a 2 year warranty, excluding the pH sensor, which has limited 6 month warranty. If an instrument fails to operate properly, see the Troubleshooting Chart, pg. 17. The battery and pH sensor are user-replaceable For other service, return the instrument prepaid to the Myron L Company.

MYRON L COMPANY
6115 Corte Del Cedro
Carlsbad, CA 92009
USA
760-438-2021

If, in the opinion of the factory, failure was due to materials or workmanship, repair or replacement will be made without charge. A reasonable service charge will be made for diagnosis or repairs due to normal wear, abuse or tampering. This warranty is limited to the repair or replacement of the ARH1 only. The Myron L Company assumes no other responsibility or liability.

E. TechPro™ Series Models

TechPro Series Models	pH1	AR1	ARH1
Parameters	pH & Temperature	Conductivity or TDS, & Temperature	Conductivity or TDS, pH & Temperature

Additional information available on our web site at:
www.myronl.com

CE

TABLE OF CONTENTS

I. INTRODUCTION

Thank you for selecting the TechPro™ Series, Model ARH1, one of the Myron L Company's latest in a new line of digital instruments utilizing advanced circuitry. This circuitry makes it very accurate and easy to use (see pages 2 & 3 for Features and Specifications on this and other models). For your convenience, on the bottom side of your ARH1 is a brief set of instructions.

Special note ...... Conductivity/TDS require mathematical correction to 25°C values (ref. Temperature Compensation, pg. 19).

On the left side of the ARH1 liquid crystal display is shown an indicator of the salt solution characteristic used to model temperature compensation (Tempco) of conductivity or its TDS conversion. The indicator can be KCl, NaCl or 442. Internal selection affects the temperature correction of conductivity, and the calculation of TDS from compensated conductivity (ref. Conductivity Conversion to TDS, pg. 21).

The selection can affect the reported conductivity of hot or cold solutions, and will change the reported TDS of a solution. Generally, using KCl for conductivity and 442™ (Natural Water characteristic) for TDS will reflect present industry practice for standardization. NaCl may also be selected for either conductivity or TDS as is needed.

Your instrument, as shipped from the factory, is set for conductivity with the KCl tempco. However, if you are measuring natural waters and wish to have maximum accuracy, you may want to change it to the 442 tempco setting. To change the Tempco or to read in TDS/ppm, see Solution Selection on pg. 8.

II. RULES of OPERATION

A. Operation

Using the instrument is simple:

- Individual or dual parameter readings may be obtained by filling individual sensors or entire cell cup area.
- Rinse the Conductivity cell or pH sensor well with test solution 3 times and Refill.
- Pressing either measurement key starts a 20 second timer.
- Note the value displayed. It's that simple!

B. Characteristics of the Keys

- Your ARH1 is designed to provide quick, easy, accurate measurements by simply pressing one key.
- Both functions are performed one key at a time.

C. Operation of the Keys (See Instrument Illustration on page 1)

1. Measurement Keys in General

The measurement keys turn on the instrument in the mode selected.

The mode is shown at the bottom of the display, and the measurement units appear at the right.

2. COND/TDS Key

This key is used with solution in the Conductivity Cell.

Precautions:

- While filling cell cup ensure no air bubbles cling on the cell wall.
- If the proper solution is not selected (KCl, NaCl or 442), refer to Solution Selection on pg. 8.

Solution to be tested is introduced into the conductivity cell and a press of (COND/TDS) displays conductivity or Total Dissolved Solids (TDS) with units on the right. On the left is shown the solution type selected for conductivity. An overrange condition will show only [- - - -].

3. pH Key

Measurements are made on the solution held in the pH sensor well (ref. pH Measuring, pg. 23). The protective cap is removed, and the sensor well is filled and rinsed with sample enough times to completely replace the storage solution. After use, the pH sensor well must be refilled with Myron L Storage Solution, and the protective cap reinstalled securely (ref. Maintenance of the pH Sensor, below, and pH, pg. 15).

A press of (pH) displays pH readings. No units are displayed.

III. AFTER USING the ARH1

A. Maintenance of the Conductivity Cell

Rinse out the cell cup with clean water. Do not scrub the cell. For oily films, squirt in a foaming non-abrasive cleaner and rinse. Even if a very active chemical discolors the electrodes, this does not affect the accuracy; leave it alone (ref. Conductivity or TDS, pg. 15).

B. Maintenance of the pH Sensor

The sensor well must be kept wet with a solution. Before replacing the rubber cap, rinse and fill the sensor well with (in order of preference): Myron L Storage Solution, an almost saturated KCl solution, pH 4 buffer (ref. pH Buffer Solutions, pg. 18) or at least a strong table salt solution. Not distilled water (ref. pH, pg. 15).

IV. THE SPECIFIC RECOMMENDED MEASURING PROCEDURES

If the proper solution is not selected (KCl, NaCl or 442), see Solution Selection, Pg. 8.

***NOTE**: After sampling high concentration solutions or temperature extremes, more rinsing may be required. When sampling low conductivity solutions, be sure the pH cap is well seated so no solution washes into the conductivity cell from around the pH cap.*

A. Measuring Conductivity/Total Dissolved Solids (TDS)

1. Rinse cell cup 3 times with sample to be measured. (This conditions the temperature compensation network and prepares the cell).

2. Refill cell cup with sample.

3. Press COND/TDS.

4. Take reading. A display of [- - - -] indicates an overrange condition.

B. Measuring pH

1. Remove protective cap by squeezing its sides and pulling up.

2. Rinse sensor well 3 times with sample to be measured. Shake out each sample to remove any residual liquid.

3. Refill sensor well with sample.

4. Press pH.

5. Take reading.

6. **IMPORTANT**: After use, fill pH sensor well with Myron L Storage Solution, a strong KCl solution or pH 4 buffer, and replace protective cap. Do not allow pH sensor to dry out.

NOTE: If a storage solution, KCl or pH 4 solution is unavailable, use a saturated solution of table salt and water (ref. pH, pg. 15).

V. SOLUTION SELECTION

A. Why Solution Selection is Available

Conductivity and TDS require temperature correction to 25°C values (ref. Standardized to 25°C, pg. 19). Selection determines the temperature correction of conductivity and calculation of TDS from compensated conductivity (ref. Conductivity Conversion to TDS, pg. 21).

B. The 3 Solution Types

On the left side of the display is the salt solution characteristic used to

model temperature compensation of conductivity and its TDS conversion. Generally, using KCl for conductivity and 442 (Natural Water characteristic) for TDS will reflect present industry practice for standardization. Your instrument as shipped from the factory is set for conductivity with the KCl tempco. If you are measuring natural waters and wish to have maximum accuracy, it may be better to change it to the 442 setting. However, selecting NaCl for either conductivity or TDS may best reflect your specific specialized needs (ref. Solution Characteristics, pg. 21). **NOTE: Before opening instrument, Dry THOROUGHLY**.

C. Procedure to Select a Solution

NOTE: Check display to see if solution displayed (KCl, NaCl or 442) is already the type desired. If not:

1. Remove the 4 bottom screws and carefully open Instrument.

2. Locate dip switch labeled “TEMP COMP” on the right side of the circuit board. Switch positions are 1-4 (left to right).

3. Set switch numbers **1** and **2** to the desired position.
Note: Factory setting is for KCl - both switches UP or ON.

4. Carefully turn instrument over and press the COND/TDS key. The correct icon “KCl”, NaCl” or “442” should be shown on the left side of the display.

5. Replace bottom, ensuring the sealing gasket is installed in the groove of the top half of case. Tighten screws securely. (Do NOT overtighten)

6. Recalibrate as necessary. See Calibration, pg. 10.

D. Procedure to Select the Units of Measurement
i.e. µS to ppm

1. Remove the 4 bottom screws and open Instrument.

2. Locate dip switch labeled “TEMP COMP” located on the right side of the circuit board. Switch positions are 1-4 (left to right).

3. Set switch number **3** to the desired position - COND or TDS.
Note: Factory setting is for COND - DOWN or OFF.

4. Carefully turn instrument over and press the COND/TDS key. The

correct icon, "µS" or "ppm", should be shown on the right side of the display.

5. Replace bottom, ensuring the sealing gasket is installed in the groove of the top half of case. Tighten screws securely. (Do NOT overtighten)

6. Recalibrate as necessary. See Calibration, below.

In the first five sections, you have learned all you need to make accurate measurements. The following sections contain calibration, advanced operations, and technical information.

VI. CALIBRATION

A. Calibration Intervals

Generally, calibration is recommended about once per month with Conductivity or TDS solutions. Calibration with pH solutions should be checked twice a month.

B. Rules for Calibration of the ARH1

1. Calibration Steps

Each calibration is accomplished by a Calibration Control located under the respective cap plug on the bottom of the instrument.
After pressing the respective key, the reading is changed/adjusted to match the known standard or buffer value.
Depending on what is being calibrated, there may be 1, 2 or 3 steps to the calibration procedures.

2. Calibration Limits

In Conductivity or TDS, the inability to calibrate may indicate improper or contaminated calibration solution, or a damaged conductivity cell.
In pH, the inability to calibrate may indicate improper or contaminated buffer solution or a damaged pH Sensor.

C. Calibration Procedures

1. Conductivity /TDS Calibration

a. Rinse conductivity cell three times with proper standard (KCl, NaCl or 442) (ref. Conductivity/TDS Standard Solutions, pg. 18).

b. Refill conductivity cell with same standard solution.

c. Press COND/TDS key. If reading is acceptable, end procedure. If reading is unacceptable, continue.

d. Remove cap plug labeled COND CAL on bottom of Instrument.

e. Refill conductivity cell with same standard solution.

f. While pressing the COND/TDS key, adjust COND CAL Control with finger until the display agrees with the value on the standard solution bottle.

g. Repeat steps b. & c. to verify the setting.

h. Replace bottom cap plug securely to maintain water resistance. The COND/TDS Calibration procedure is now complete.

2. pH Calibration

IMPORTANT: Always "zero" your ARH1 with a pH 7 buffer solution before adjusting the gain with acid or base buffers, i.e., 4 and/or 10, etc.

a. pH Zero Calibration

1. Remove protective cap.

2. Rinse sensor well 3 times with 7 buffer solution.

3. Refill sensor well with 7 buffer solution.

4. Press pH to verify the pH calibration. If the display reads 7.00, skip the pH Zero Calibration and proceed to section b. pH Gain Calibration. If reading is not acceptable, continue.

5. Remove cap plug labeled ZERO CAL on bottom of Instrument.

NOTE: If the pH reading displayed will not adjust to the proper reading, the sensor well needs additional rinsing or fresh buffer solution, or the pH sensor is bad and needs to be replaced (ref. Troubleshooting Chart, pg. 17).

6. Refill sensor well again with 7 buffer solution.

7. While pressing the pH key, adjust ZERO CAL Control with finger until the display reads 7.00.

8. Replace bottom cap plug securely to maintain water resistance.

The pH ZERO Calibration procedure is now complete. You may continue with pH Gain Calibration or stop and replace storage solution & pH cap.

b. pH Gain Calibration

IMPORTANT: Always calibrate or verify your ARH1 with a pH 7 buffer solution before adjusting the gain with acid or base buffers, i.e., 4 and/or 10, etc. The pH gain calibration is performed in the same manner as the ZERO. For maximum accuracy use a buffer value closest to instrument's normal area of use, i.e., if you normally measure acidic solutions, use "4" buffer.

1. Rinse the sensor well 3 times with acid or base buffer solution.
2. Refill sensor well again with same buffer solution.
3. Press (**pH**) key. If reading is acceptable, end procedure. If not, continue.
4. Remove cap plug labeled GAIN CAL on bottom of Instrument.
5. Refill sensor well again with same buffer solution.
6. While pressing the (**pH**), adjust GAIN CAL Control with finger until reading agrees with buffer solution.
7. If the instrument will be used to read both acids and bases, repeat steps 1 and 6 using opposite buffer solution.
8. If reading is different by more than is acceptable, split the difference with the previous setting. (If it is not possible to adjust Gain, it is an indication of bad buffers or a deteriorating or damaged pH sensor.)
9. Replace bottom cap plug securely to maintain water resistance. The pH **GAIN** Calibration procedure is now complete.

VII. CALIBRATION INTERVALS

There is no simple answer as to how often one should calibrate an instrument. The ARH1 is designed to not require frequent recalibration.

The most common sources of error were eliminated in the design, and there are simple electromechanical adjustments. Still, to ensure specified accuracy, any instrument has to be checked against chemical standards occasionally.

A. Suggested Intervals

On the average, we expect calibration need only be checked monthly for the Conductivity or TDS functions. The pH function should be checked every 2 weeks to ensure accuracy. Measuring some solutions will require more frequent intervals.

B. Calibration Tracking Records

To minimize your calibration effort, keep records. If adjustments you are making are minimal for your application, you can check less often. Changes in conductivity calibration should be recorded in percent. Changes in pH calibration are best recorded in pH units.

Calibration is purposely limited in the ARH1 to ±8% for the conductivity cell because more than that indicates damage, not drift. Likewise, pH calibration changes are limited to ±1 pH unit because more than that indicates the end of the sensor lifetime, and it should be replaced.

C. Conductivity or TDS Practices to Maintain Calibration

1. Clean oily films or organic material from the cell electrodes with foaming cleaner or mild acid. Do not scrub inside the cell.
2. Calibrate with solutions close to the measurements you make. Readings are compensated for temperature based on the type of solution. If you choose to measure tap water with a KCl compensation, which is often done (ref. Temperature Compensation, pg. 19), and you calibrate with 442 solution because it is handy, the further away from 25°C you are, the more error you have. Your records of calibration changes will reflect temperature changes more than the instrument's accuracy.
3. Rinse out the cell with pure water after making measurements. Allowing slow dissolving crystals to form in the cell contaminates future samples.
4. For maximum accuracy, keep the pH cell cover on tight so no fluid washes into the conductivity cell.

D. pH Practices to Maintain Calibration.

1. Keep the sensor wet with Myron L Storage Solution.

2. Rinse away caustic solutions immediately after use.

VIII. CHANGING from CENTIGRADE to FAHRENHEIT

(Note: °F to °C is the reverse)

1. **Dry Instrument THOROUGHLY**.

2. Remove the 4 bottom screws and carefully open Instrument.

3. Locate dip switch labeled "TEMP COMP" on the right side of the circuit board. Note: Factory setting is degrees "C".

4. Set switch number **4** to the down position.

5. Carefully turn instrument over and press the (pH) key. The displayed reading will be in Fahrenheit "°F".

6. Replace bottom, ensuring the sealing gasket is installed in the groove of the top half of case. Tighten screws securely. (Do NOT overtighten)

IX. CARE and MAINTENANCE

The ARH1 should be rinsed with clean water after each use. Solvents should be avoided. Shock damage from a fall may cause instrument failure.

A. Temperature Extremes

Solutions in excess of 160°F/71°C should not be placed in the cell cup area; this may cause damage. The pH sensor may fracture if the ARH1 temperature is allowed to go below -10°C (14°F). Care should be exercised not to exceed rated operating temperature. Leaving the ARH1 in a vehicle or storage shed on a hot day can easily subject the instrument to over 150°F. This will void the warranty.

B. Battery Replacement (LO BATT)

Dry Instrument THOROUGHLY. Remove the 4 bottom screws. Open instrument. Carefully detach battery from circuit board. Replace with 9 volt alkaline battery. Replace bottom, ensuring the sealing gasket is installed in the groove of the top half of case. Tighten screws evenly

and securely. (Do NOT overtighten)

C. pH Sensor Replacement

Order model RPG. When ordering, be sure to include the model and serial number of your instrument to ensure receiving the proper type.

Complete installation instructions are provided with each replacement sensor.

D. Cleaning Sensors

1. Conductivity or TDS

The cell cup should be kept as clean as possible. Flushing with clean water following use will prevent buildup on electrodes. However, if very dirty samples — particularly scaling types — are allowed to dry in the cell cup, a film will form. This film reduces accuracy. When there are visible films of oil, dirt, or scale in the cell cup or on the electrodes, use a foaming non-abrasive household cleaner. Rinse out the cleaner, and your ARH1 is ready for accurate measurements.

2. pH

The unique pH sensor in your ARH1 is a nonrefillable combination type which features a porous liquid junction. It should not be allowed to dry out. If it does, the sensor can sometimes be rejuvenated by first cleaning the sensor well with a liquid spray cleaner such as Windex™ or Fantastic™ and rinsing well. Do not scrub or wipe the pH sensor.

Then use one of the following methods:

1. Pour a HOT salt solution ~60°C (140°F), preferably potassium chloride (KCl) solution — HOT tap water with table salt (NaCl) will work fine — in the sensor well and allow to cool. Retest.

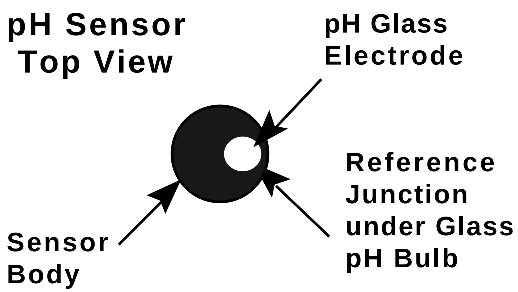
Or

2. Pour DI water in the sensor well and allow to stand for no more than 4 hours (longer can deplete the reference solution and damage the glass bulb). Retest.

If neither method is successful, sensor must be replaced.

"Drifting" can be caused by a film on the pH sensor bulb. Spray a liquid cleaner such as Windex™ or Fantastic™ into the sensor well to clean it. The sensor bulb is very thin and delicate. Do not scrub or wipe the pH sensor.

Leaving high pH (alkaline) solutions in contact with the pH sensor for long periods of time can damage it. Rinsing such liquids from the pH sensor well and refilling well with Myron L Storage Solution, a saturated KCl solution, pH 4 buffer, or a salty tap water, will extend the useful life.



Samples containing chlorine, sulfur, or ammonia can "poison" any pH electrode. If it is necessary to measure the pH of any such sample, thoroughly rinse the pH sensor well with clean water immediately after taking the measurement. Any sample element which will reduce (add an electron to) silver, such as cyanide, will attack the reference electrode.

Replacement pH sensors are available only from the Myron L Company or our authorized distributors.

X. TROUBLESHOOTING CHART

Symptom	Possible Cause	Corrective Action
No **display**, even though measurement key pressed.	Battery weak or not connected.	Check connections or replace battery (ref. Battery Replacement, pg. 14).
Inaccurate **pH** readings	1. pH calibration needed (ref. pH Cal., pg. 11). 2. Cross-contamination from residual pH buffers or samples in sensor well. 3. Calibration with expired pH buffers.	1. Recalibrate instrument. 2. Thoroughly rinse sensor well. 3. Recalibrate using fresh buffers (ref. pH Buffer Solution, pg. 18).
No response to **pH** changes	Sensor bulb is cracked or an electro-mechanical short caused by an internal crack.	Replace pH sensor (ref. pH Sensor, pg. 15).
Will not adjust down to **pH** 7.	pH sensor has lost KCl.	Clean and rejuvenate sensor (ref. pH, pg. 15) and recalibrate. If no improvement, replace pH sensor (ref. pH Sensor Replacement, pg. 15).
pH readings drift or respond slowly to changes in buffers/samples.	1. Temporary condition due to “memory” of solution in pH sensor well for long periods. 2. Bulb dirty or dried out. 3. Reference junction clogged or coated.	Clean and rejuvenate sensor (ref. pH, pg. 15) and recalibrate. If no improvement, replace pH sensor (ref. pH Sensor Replacement, pg. 15).
Unstable **Conductivity** or **TDS** readings.	Film or deposits on electrodes.	Clean cell cup and electrodes (ref. Conductivity or TDS, pg. 15).
Unable to calibrate **Conductivity** or **TDS**.	Film or deposits on electrodes.	Clean cell cup and electrodes (ref. Conductivity or TDS, pg. 15).

XI. ACCESSORIES

A. Conductivity/TDS Standard Solutions

Your ARH1 has been factory calibrated with the appropriate Myron L Company NIST traceable standard solution. Most Myron L conductivity standard solution bottles show three values referenced at 25°C: Conductivity in microsiemens/micromhos and the ppm/TDS equivalents based on our 442 Natural Water™ and NaCl standards. All standards are within ±1.0% of reference solutions.

1. Potassium Chloride (KCl)

The concentrations of these reference solutions are calculated from data in the International Critical Tables, Vol. 6. The 1800 µS or 18,000 µS are the recommended standards. Order KCl-1800 or KCl-18,000.

2. 442 Natural Water™

442 Natural Water Standard Solutions are based on the following salt proportions: 40% sodium sulfate, 40% sodium bicarbonate, and 20% sodium chloride which represent the three predominant components “anions” in freshwater. This salt ratio has conductivity characteristics approximating fresh natural waters and was developed by the Myron L Company over three decades ago. It is used around the world for measuring both conductivity and TDS in drinking water, ground water, lakes, streams, etc. The 1500 ppm or 15,000 ppm are the recommended standards. Order 442-1500 or 442-15,000.

3. Sodium Chloride (NaCl)

This is especially useful in sea water mix applications, as sodium chloride is its major salt component. Most Myron L standard solution labels show the ppm NaCl equivalent to the conductivity and to ppm 442 values. The 14.0 mS is the recommended standard. Order NaCl-14.0.

B. pH Buffer Solutions

pH buffers are available in pH values of 4, 7 and 10. Myron L Company buffer solutions are traceable to NIST certified pH references and are color-coded for instant identification. They are also mold inhibited and accurate to within ±0.01 pH units @ 25°C. Order 4, 7 or 10 buffer.

C. pH Sensor Storage Solution

Myron L Storage Solution prolongs the life of the pH sensor. It is available in quarts and gallons. Order SSQ or SSG.

D. Soft Protective Case

Padded Cordura® Nylon carrying case features a belt clip for hands-free mobility. Order Model: UCC

® Registered trade mark of DuPont

E. Replacement pH Sensor

Model RPG is gel filled and features a unique porous liquid junction. It is user-replaceable and comes with easy to follow instructions.

XII. TEMPERATURE COMPENSATION (Tempco) of Aqueous Solutions

Electrical conductivity indicates solution concentration and ionization of the dissolved material. Since temperature greatly affects ionization, conductivity measurements are temperature dependent and are normally corrected to read what they would be at 25°C.

A. Standardized to 25°C

Conductivity is very accurately measured in the ARH1 by a method that ignores fill level, electrolysis, electrode characteristics, etc., and uses a unique circuit to perform temperature compensation. In simpler instruments, conductivity values are usually assigned an average correction similar to KCl solutions for correction to 25°C. The correction to an equivalent KCl solution is a standard set by chemists. It standardizes the measurements and allows calibration with precise KCl solutions, recognized for stability. In the ARH1, this correction can be set to either KCl, NaCl or 442 to best match your applications.

B. Tempco Variation

Most conductivity instruments use an approximation of the temperature characteristics of solutions, perhaps even assuming a constant value. The value for KCl is often quoted simply as 2%/°C. In fact, KCl tempco

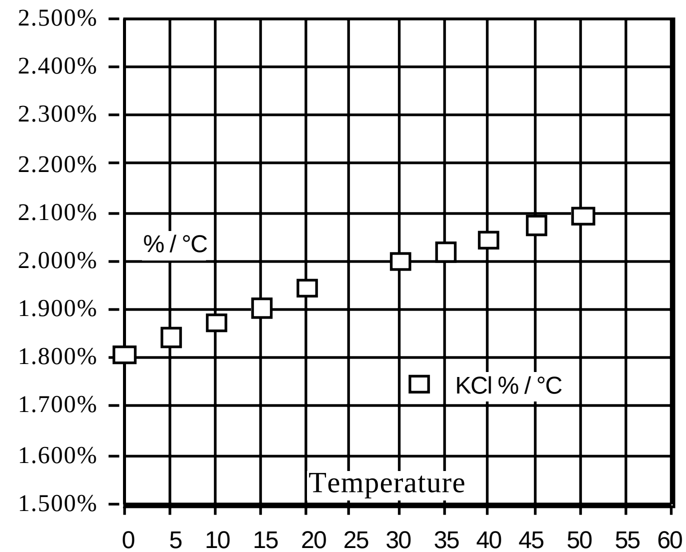


Chart 1

varies with concentration and temperature in a non-linear fashion. Other solutions have more variation still. The ARH1 uses corrections that change with concentration and temperature instead of single average values (see Chart 1, pg. 19).

C. An Example of 2 different solution selections and the resulting compensation:

How much error results from treating natural water as if it were KCl at 15°C?

A tap water solution should be compensated as 442 with a tempco of 1.68 %/°C, where the KCl value used would be 1.90 %/°C.

Suppose a measurement at 15°C (or 59°F) is 900 microsiemens of true uncompensated conductivity.

Using a 442 correction of 10 (degrees below 25) x 1.68% indicates the solution is reading 16.8% low. For correction, dividing by (.832) yields 1082 microsiemens as a compensated reading.

A KCl correction of 10 (degrees below 25) x 1.9% indicates the solution is reading 19% low. Dividing by (.81) yields 1111 microsiemens for a compensated reading. The difference is 29 out of 1082 = 2.7%.

D. A Chart of Comparative Error

In the range of 1000 µS, the error using KCl on a solution that should be compensated as NaCl or as 442, is shown in the graph below.

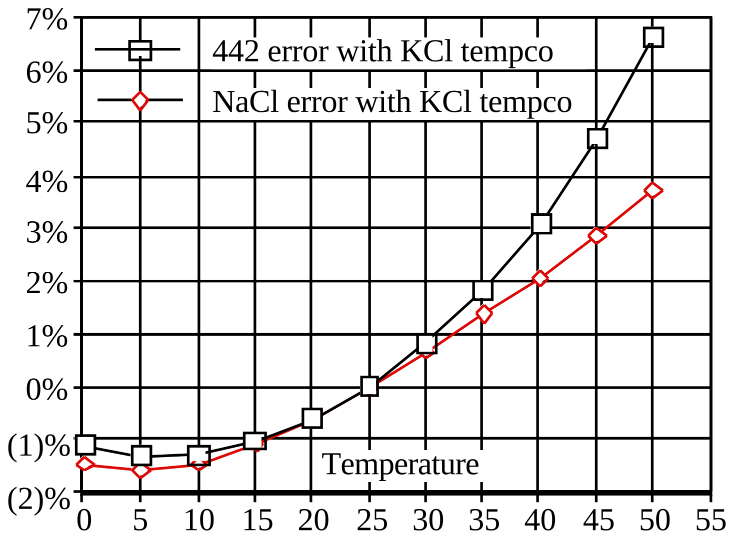


Chart 2

Users wanting to measure natural water based solutions to 1% would have to alter the internal compensation to the more suitable preloaded “442” values or stay close to 25°C. Some who have standardized to KCl based compensation may want to stick with it, regardless of increasing error as you get further from 25°C. The ARH1 will provide the repeatability and convertibility of data needed for relative values for process control.

E. Other Solutions

A salt solution like sea water or liquid fertilizer acts like NaCl. An internal correction for NaCl can be selected for greatest accuracy with such solutions. Many solutions are not at all similar to KCl, NaCl or 442. A sugar solution, or a silicate, or a calcium salt at a high or low temperature may require a value peculiar to the application to provide readings close to the true compensated conductivity.

Clearly, the solution characteristics should be chosen to truly represent the actual water under test for rated accuracy of ±1% of full scale. Many industrial applications have always been relative measurements seeking a number to indicate a certain setpoint or minimum concentration or trend. The ARH1 gives the user the capability to take data in “KCl conductivity units” to compare to older published data, as in terms of NaCl or 442, or as may be appropriate.

XIII. CONDUCTIVITY CONVERSION to TOTAL DISSOLVED SOLIDS (TDS)

Electrical conductivity indicates solution concentration and ionization of the dissolved material. Since temperature greatly affects ionization, conductivity measurements are temperature dependent and are normally corrected to read what they would be at 25°C (ref. Temperature Compensation, pg. 19).

A. How it’s Done

Once the effect of temperature is removed, the compensated conductivity is a function of the concentration (TDS). Temperature compensation of the conductivity of a solution is performed automatically by the internal processor, using data derived from chemical tables. Any dissolved salt at a known temperature has a known ratio of conductivity to concentration. Tables of conversion ratios referenced to 25°C have been published by chemists for decades.

B. Solution Characteristics

Real world applications have to measure a wide range of materials and mixtures of electrolyte solutions. To solve this problem, industrial users commonly use the characteristics of a standard material as a model for their solution, like the KCl favored by chemists for its stability.

Users dealing with sea water, etc., use NaCl as the model for their concentration calculations. Users dealing with freshwater work with mixtures including sulfates, carbonates and chlorides, the three predominant components (anions) in freshwater that Myron L Company calls “natural water”. These are modeled in a mixture called “442” which the Myron L Company markets for use as a calibration standard, as it does standard KCl and NaCl solutions.

C. When does it make a lot of difference?

First, the accuracy of temperature compensation to 25°C determines the accuracy of any TDS conversion. Assume we have industrial process water to be pretreated by R.O. Assume it is 45°C and reads 1500 µS uncompensated.

1. If NaCl compensation is used, an instrument would report 1035 µS compensated, which corresponds to 510 ppm NaCl.

2. If 442 compensation is used, an instrument would report 1024 µS compensated, which corresponds to 713 ppm 442.

The difference in values is 40%.

In spite of such large error, some users will continue to take data in the NaCl mode because their previous data gathering and process monitoring was done with an older NaCl referenced device.

Those who want true TDS readings that will correspond to evaporated weight will select the correct Solution Type.

The ARH1 contains circuitry for the 3 most commonly referenced compounds — KCl, NaCl and 442. In the LCD display, the solution type being used is shown on the left.

XIV. TEMPERATURE COMPENSATION (Tempco) and TDS DERIVATION

When making conductivity measurements, the Solution Selection determines the characteristic assumed as the instrument reports what a measured conductivity would be if it were at 25°C. The characteristic is represented by the tempco, expressed in %/°C. If a solution of 100 µS at 25°C increases to 122 µS at 35°C, then a 22% increase has happened over this change of 10°C. The solution is said to have a tempco of 2.2 %/°C.

Another solution would have a different tempco because of its ionization activity. And, that tempco may be a little different at a different concentration or temperature. This is why the ARH1 uses mathematically generated models for known salt characteristics that vary with concentration and temperature.

The ARH1 contains circuitry for characteristics of the 3 most commonly referenced compounds — KCl, NaCl and 442. In the display, the solution type being used is shown on the left.

XV. pH MEASURING

A. pH as an Indicator

pH is the measurement of Acidity or Alkalinity of an aqueous solution. It is also stated as the Hydrogen Ion activity of a solution. pH measures the effective, not the total, acidity of a solution.

A 4% solution of acetic acid (pH 4, vinegar) can be quite palatable, but a 4% solution of sulfuric acid (pH 0) is a violent poison. pH provides the needed quantitative information by expressing the degree of activity of an acid or base.

In a solution of one known component, pH will indicate concentration indirectly. However, very dilute solutions may be very slow reading, just because the very few ions take time to accumulate.

B. pH Units

The acidity or alkalinity of a solution is a measurement of the relative availabilities of hydrogen (H^+) and hydroxide ($0H^-$) ions. An increase in (H^+) ions will increase acidity, while an increase in (OH^-) ions will increase alkalinity. The total concentration of ions is fixed as a characteristic of water, and balance would be 10^{-7} mol/liter (H^+) and (OH^-) ions in a neutral solution (where pH sensors give 0 voltage).

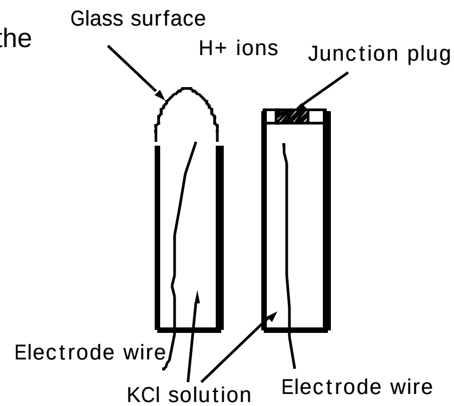
pH is defined as the negative logarithm of hydrogen ion concentration. Where (H^+) concentration falls below 10^{-7}, solutions are less acidic than neutral, and therefore are alkaline. A concentration of 10^{-9} mol/liter of (H^+) would have 100 times less (H^+) ions than (OH^-) ions and be called an alkaline solution of pH 9.

C. The pH Sensor

The active part of the pH sensor is a thin glass surface which is selectively receptive to hydrogen ions. Available hydrogen ions in a solution will accumulate on this surface and a charge will build up across the glass interface. The voltage can be measured with a very high impedance voltmeter circuit; the trick is to connect the voltmeter to solution on each side.

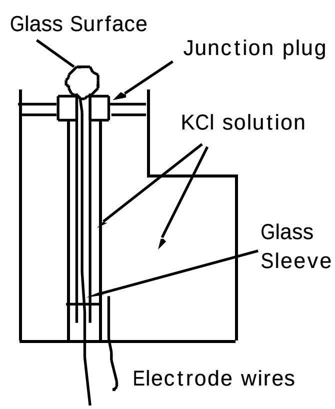
The glass surface encloses a captured solution of potassium chloride holding an electrode of silver coated with silver chloride. This is as inert a connection as can be made from metal to an electrolyte. It still can produce an offset voltage, but using the same materials to connect to the solution on the other side of the membrane allows the 2 equal offsets to cancel.

The problem is... the other side of the membrane is some test solution, not potassium chloride. The outside electrode, also called the Reference Junction, is of the same construction with a porous plug in place of a glass barrier to allow the junction fluid to contact the test solution without significant migration of liquids through the plug material. The figure to the right shows a typical 2 component pair. Migration does occur, and this limits the lifetime of a pH junction from depletion of solution inside the reference junction or from contamination. The junction is damaged by drying out because insoluble crystals may form in a layer, obstructing contact with test solutions. See pH, pg. 15.



D. The Myron L Integral pH Sensor

The sensor in the ARH1 (figure at right) is a single construction in an easily replaceable package. The sensor body holds an oversize solution supply for long life. The reference junction "wick" is porous to provide a very stable, low permeability interface. It is formed in a ring around the pH sensing electrode. The construction combines all the best features of any pH sensor known.



E. Sources of Error

The basics are presented in pH, pg. 15.

1. Reference Junction

The most common sensor problem will be a clogged junction because a cell was allowed to dry out. The symptom is a drift in the "zero" setting at 7 pH. This is why the ARH1 does not allow more than 1 pH unit of offset during calibration. At that point the junction is unreliable.

2. Sensitivity Problems

Sensitivity is the receptiveness of the glass surface, which can be diminished by a film on the surface, or a crack in the glass. These problems also cause long response time.

3. Temperature Compensation

pH sensor glass changes its sensitivity slightly with temperature, so the further from pH 7 one is, the more effect will be seen. A pH of 11 at 40°C would be off by 0.2 units. The ARH1 senses the cell temperature and compensates the reading.

XVI. GLOSSARY

Anions - Negatively charged ions.
See Solution Characteristics, pg. 21.

Algorithm - A procedure for solving a mathematical problem.
See Temperature Compensation and TDS Derivation, pg. 22.

Logarithm - An arithmetic function. See pH Units, pg. 23.

TDS - Total Dissolved Solids or the Total Conductive Ions in a solution. See Conductivity Conversion to TDS, pg. 21.

Tempco - Temperature Compensation
See Temperature Compensation, pg. 19.

For details on specific areas of interest refer to Table of Contents.

NOTES