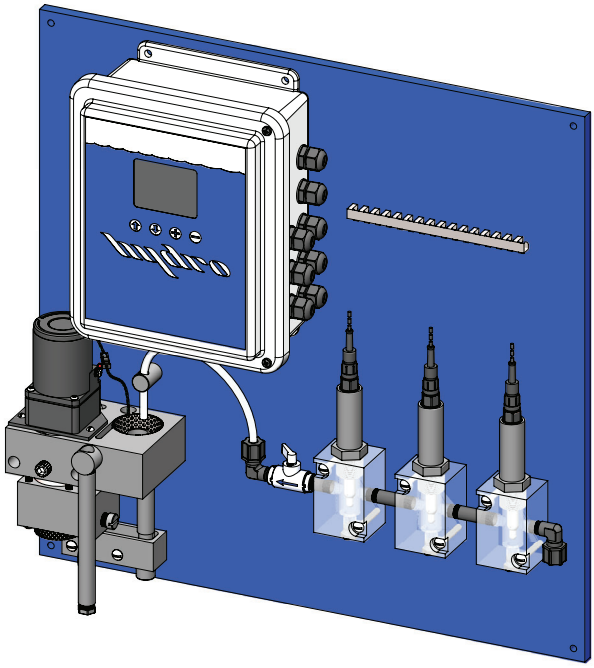
Series 280
Amperometric Residual Analyzer

Instruction Manual



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RAH-280 Rev. 1/19/2023

Hydro Instruments
Series 280 Amperometric Residual Analyzer

Table of Contents

I. FUNCTIONS AND CAPABILITIES

1. **Basic Concept Description:** The Series 280 Residual Analyzer uses a Galvanic measurement cell consisting of a Cathode and a Copper Anode with the sample water as the electrolyte. This measurement method is referred to as Amperometric and has been in use for over 50 years.

   As described below, the measurement cell can be used to measure the concentration of Free Chlorine, Total Chlorine, Chlorine Dioxide and other oxidants. Certain chemical species produce an electrical current in the cell that is proportional to their concentration in the sample water. This electrical current is read and manipulated by the Series 280 monitor circuit board. The system employs a motor to continuously clean the measurement cell by the abrasive action of Teflon balls. Sample water continuously flows through the measurement cell at a controlled rate. A Temperature sensor is employed to compensate for signal fluctuations caused by Temperature changes. The pH of the sample water is either manually entered for pH compensation in the software or else a pH buffer feed system is used to control the pH in the sample water. If Total Chlorine, Chlorine Dioxide, or some other oxidants are being measured, then another chemical will be continuously injected into the sample water prior to its entering the measurement cell.

   This analyzer is also equipped with a complete PID Control program, which can be enabled or disabled as desired. The program accepts a proportional (flow) analog 4-20 mA input and uses the residual value produced by the analyzer. This control program can be enabled as proportional (flow pacing), set-point (residual) or PID (compound loop) control.

2. **Galvanic Cell Theory:** Pure water has a relatively low conductivity. However, the presence of ionizing species increases the conductivity. If two electrodes are immersed in a solution containing chemical species (ions) capable of being reduced (gaining electrons) then this species can move toward the cathode where it can accept electrons from the cathode. To balance this flow of electrons (current), an oxidation reaction (where an oxidizable species loses electrons at the same rate) must simultaneously occur at the anode surface.

   As the reactions occur at the surface of each electrode, the local concentration of the reducible/oxidizable species drops, thus creating local concentration gradients. As a result of the concentration gradients, the process of diffusion moves more of these species toward the electrodes. The rate at which diffusion moves these species to the electrode surfaces is referred to as the rate of arrival.

   The electrical current produced in the cell is proportional to the rate of arrival of the reducible/oxidizable species at the electrodes. As the concentration of these species increases, so does the rate of arrival. Also, as the temperature increases, the rate of arrival increases for a given concentration. After some temperature compensation, the current is therefore an indication of species concentration. The current is read by electrically connecting the cathode and anode.

3. **Chlorine Chemistry:** When Chlorine dissolves in water it forms Hypochlorous Acid according to the following reactions:

   Chlorine Gas: Cl_2
   $Cl_2 + H_2O \leftrightarrow HOCl + HCl$

   Sodium Hypochlorite: NaOCl
   $NaOCl + H_2O \leftrightarrow HOCl + Na^+ + OH^-$

   Calcium Hypochlorite: $Ca(OCl)_2$
   $Ca(OCl)_2 + 2H_2O \leftrightarrow 2HOCl + Ca^{++} + 2OH^-$

Hypochlorous Acid is a weak acid that partially dissociates into a Hydrogen Ion and a Hypochlorite Ion as follows:

$$HOCl \leftrightarrow H^+ + OCl^-$$

The degree of dissociation depends on the pH and the Temperature. Regardless of Temperature, below a pH of 5 the dissociation of HOCl remains virtually zero and above a pH of 10 the dissociation of HOCl is virtually 100%. Figure 1 shows this dissociation curve at several Temperatures. The sum of Hypochlorous Acid and Hypochlorite Ion is referred to as Free Available Chlorine.

When Ammonia Nitrogen is present in the water, some or all of the Free Available Chlorine will be converted into Chloramine compounds according to the following reactions:

$$NH_3 + HOCl \longrightarrow H_2O + NH_2Cl \text{ (Monochloramine)}$$
$$NH_3 + 2HOCl \longrightarrow 2H_2O + NHCl_2 \text{ (Dichloramine)}$$
$$NH_3 + 3HOCl \longrightarrow 3H_2O + NCl_3 \text{ (Nitrogen Trichloride)}$$

The sum of the Chloramine compounds is referred to as “Combined Available Chlorine”. Also, the sum of Free Available and Combined Available Chlorine is referred to as “Total Available Chlorine”.

4. Measurement Chemistry:

Free Chlorine Measurements: As discussed above, Free Chlorine is the sum of Hypochlorous Acid and Hypochlorite Ion concentrations. Hypochlorous Acid is a reducible species in the Series 280 Residual Analyzer. Therefore the measurement cell can be used to measure the concentration of Hypochlorous Acid.

This measurement can be used to determine the concentration of Free Chlorine by one of two methods. Consider Figure 1 in the discussion of both methods.

First, an acidic buffer solution can be injected into the water sample stream to reduce the pH below 5, so that all of the Free Chlorine is in the form of Hypochlorous Acid.

Second, pH and Temperature measurements can be used to continuously determine the degree of Hypochlorous Acid dissociation through software. The instantaneous degree of dissociation value can then be used in conjunction with the Hypochlorous Acid concentration measurement to determine the Free Chlorine concentration. This method will be referred to as “pH Compensation”.

The reaction at the cathode surface in this measurement is as follows:

$$HOCl + 2e^- \longrightarrow Cl^- + OH^-$$

Total Chlorine Measurements: As discussed above, Total Chlorine is defined as the sum of Free Available Chlorine and Combined Available Chlorine. Combined Available Chlorine species are not reducible in the Series 280 measurement cell. Therefore, the following technique must be employed to obtain a measurement.

First, Potassium Iodide (KI) is injected into the sample water so that all species comprising Total Chlorine react to form Potassium Chloride (KCl). The measurement cell then measures KCl concentration in the same fashion that it can measure HOCl concentration. Since KCl concentration is proportional to Total Chlorine concentration, the measurement of KCl is also a measurement of Total Chlorine concentration. The relevant reactions are as follows.

Free Chlorine Residual:

$$2H + 2HOCl + 2KI \leftrightarrow I_2 + 2KCl + 2H_2O$$

Combined Chlorine Residual:

$3H_2O + 2NH_2Cl + 2KI \leftrightarrow 2KCl + I_2 + 2NH_4OH + ½O_2$

$2H_2O + NHCl_2 + 2KI \leftrightarrow 2KCl + I_2 + NH_4OH + ½O_2$

$5H_2O + 2NCl_3 + 6KI \leftrightarrow 6KCl + 3I_2 + 2NH_4OH + 1.5O_2$

Second, the pH must be reduced to the range of 4.0 to 4.5 in order to prevent any dissociation of the Hypochlorous Acid or the Potassium Chloride (KCl).

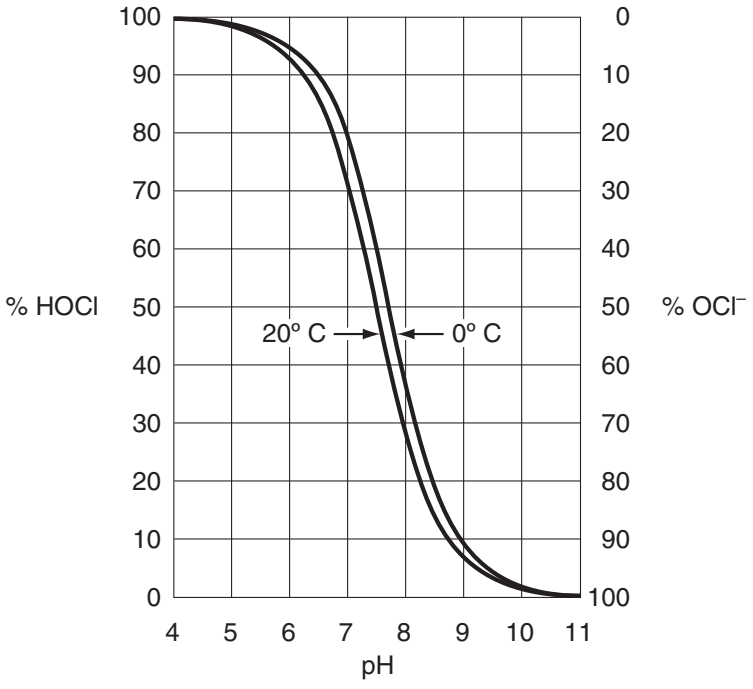
5. Basic Specifications

Temperature Range: 0º to 50º C (32º to 122º F).
Sample Water Flow Rate: 500 ml/min (8 gal/hr) ideal
150 ml/min (2.4 gal/hr) minimum
Sample Pressure: 5 psig (0.3 bar) maximum at inlet point.
Sample Supply: Continuous. Electrodes must be kept wet with fresh water.
Speed of Response: 4 seconds from sample entry to display indication.
T_{90}: Approx. 90 to 120 seconds
T_{100}: Approx. 10 minutes.
Sample Water: Metal ions or certain corrosion inhibitors may effect analyzer operation.
Residual Cl_2 Range: 0 to 0.1 to 0 to 20 mg/l (PPM). Field adjustable.
Power Consumption: 10 W max.
Power Requirements: 120VAC, 50/60 Hz or 240VAC, 50/60 Hz, single phase.
Residual Cl_2 Accuracy: 0.003 mg/l or +/-1% of range, whichever is larger.
Residual Cl_2 Sensitivity: 0.001 mg/l (1 PPB)
Input Signals: (5) Analog 4-20 mA.
Output Signals: (4) Isolated 4-20 mA Analog (Res, pH, Temp, Turbidity, or Control).
Digital Communication: Modbus RS-485 Two-Way
pH Sensor Input: Included.
Temperature Sensor Input: Included (for 10K Ohm thermistor).
Relay Contacts (4): 10 Amps @ 120 VAC or 24 VDC, resistive load, 5 Amps @ 240 VAC, resistive load.

Reagent Requirements

Free Chlorine (pH Compensated): None.
Free Chlorine (not pH Compensated):
pH Buffer or CO_2 gas.
Total Chlorine: pH Buffer or CO_2 gas
and Potassium Iodide.
Chlorine Dioxide: pH Buffer and Glycine.
Bromine Chloride: pH Buffer or CO_2
gas and Potassium Iodide.
Iodine: pH Buffer or CO_2 gas.

FIGURE 1



Hypochlorous Acid Dissociation Curves

II. SYSTEM COMPONENT DESCRIPTION

1. **Chlorine Measurement Cell:** Refer to Figure 2 for this section. The measurement electrodes consist of a cathode and a Copper anode. The measurement electrodes are mounted in a PVC housing assembly. The electrodes are in the shape of concentric cylinders. The cathode is the inner smaller cylinder and the anode is the outer larger cylinder. The sample water fills the gap in between the electrodes and continually flows in the upward direction. The detailed description of the electro-chemical process can be found in section I.

   The Series 280 Residual Analyzer also employs a continuous electrode cleaning method. The purpose of this method is to keep the electrode surfaces clean and free of chemical desposits to ensure consistent measurement readings. The cleaning is accomplished by filling the space between the electrodes with roughly 130 7⁄32" diameter PTFE cleaning balls and continuously driving them around the annular gap with a rotary motor. These balls and the electrodes require periodic maintenance and replacement as described in Section VI.

2. **Temperature Probe:** A Thermistor is used to continuously measure the sample water Temperature. The Temperature can be displayed and retransmitted by the Series 280 Residual Analyzer. It is also used in software for signal manipulation for the two following reasons:

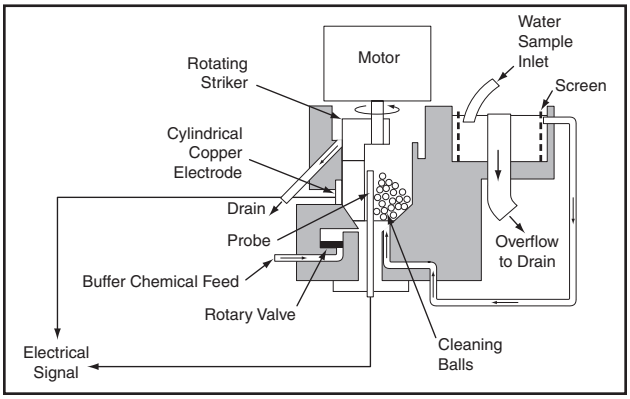
   Temperature compensation for the effects of Thermal Diffusion: As described in Section I, the rate of arrival at the electrode surfaces is dependent on the Temperature of the sample water. If the device is being used at a location with constant water Temperature, then this compensation is not necessary. However, if the sample water Temperature experiences significant fluctuations, then the raw signal will be affected and software Temperature compensation is necessary for accurate readings.

   For use in pH compensation: As described in Section I, if the pH buffer is not being used to lower the sample water pH, then pH compensation is necessary to achieve accurate measurements.

3. **Optional Reagent Chemical Feed Pump:** The Series 280 Residual Analyzer can be fitted with a chemical reagent feed pump. The chemical reagent solution is continuously injected at a controlled rate. Section I.5 outlines the various reagent solutions that may be needed depending on the target measurement species and the measurement method. If operating properly, the reagent feed system should feed the solution at a rate of 3⁄4" to 1 1⁄8" (20 to 30 mm) level change in 24 hours.

4. **Optional pH Electrode:** If the unit is not fitted with the reagent feed system then it is recommend that the unit be equipped with an external pH electrode. This electrode is mounted in its own acrylic chamber located to the right of the measurement cell and used used to compensate for the effects of pH as described in section I. It is not recommended that this compensation method be used where the sample water being measured is consistently above pH 8.5. Should this be the case Hydro Instruments recommends utilizing the reagent feed system.

FIGURE 2



5. **Optional ORP Electrode:** The RAH-280 Residual Analyzer can can be fitted with an ORP electrode. This electrode is mounted in its own acrylic chamber located to the right of the chlorine measurement cell and used solely for ORP measurement.

6. **Optional Conductivity Electrode:** The RAH-280 Residual Analyzer can be fitted with a conductivity electrode. This electrode is mounted in its own acrylic chamber located to the right of the chlorine measurement cell and used solely for conductivity measurement.

III. INSTALLATION

Refer to Figure 3 for this section.

1. **Sample Water Connection and Control:** The following are some considerations relating to the sample water supply. The Series 280 Residual Analyzer requires a constant supply of sample water at a controlled rate and pressure. Precautions should also be taken to ensure that the sample water reaching the measurement cell is not altered as it passes through the sample water piping. Also, the connection to the sample point should be made in such a way to avoid receiving air or sediment from the pipe. Consider figure 4 when creating your sample water line

   Flow: As mentioned in the specifications in Section I, the sample water flow rate should be controlled at 500 ml/minute (8 GPH). A flow meter and rate control valve may be necessary to achieve and maintain this flow rate. This can be installed upstream from the measurement cell.

   > WARNING! Do not run analyzer without sample water running through! Lack of, or interruption of water flow to analyzer cell can overheat the motor and cause premature failure.

   Pressure: Where the sample point has a water pressure higher than 5 psig, a pressure-reducing valve must be employed to deliver the sample water to the measurement cell. The sample water entering the measurement cell should be at a pressure below 5 psig. If the sample point pressure is too low, then it may be necessary to use a sample pump to deliver the sample water to the measurement cell.

   Other Considerations: It should be considered, that any biological growth inside the sample piping system will have some chemical demand. This can cause the sample water reaching the measurement cell to not be an accurate sample. For example, the chlorine residual could fall as the sample water passes through the sample water piping system. For this reason, it may be necessary to periodically disinfect the sample water piping system to prevent any biological growth. Also, it is generally not recommended to use a filter in this piping system because as the filter collects particles it will develop a chlorine demand and therefore, the chlorine residual in the sample water will be reduced by the filter, leading to inaccurate readings. However, in certain installations with significant amounts of solids in the sample water (particularly iron and manganese) the use of sample water filters may be necessary.

2. **Sample Water Disposal Considerations:** If no reagent chemical is being injected, then the disposal of the water departing the measurement cell is usually not a significant concern. However, if some reagent chemicals are being injected, then all applicable regulations should be considered before making the decision of how and where to dispose of the wastewater exiting the measurement cell. Refer to the MSDS of the chemical in question for instructions on proper disposal.

3. **Sample Point Selection:** Consider Figure 5 for this section.

   There are at least two general concepts to consider when selecting the sample point location. First, is to select a point that allows reliable determination of the chemical residual concentration at the most critical point for the particular installation. Second, is to take into consideration the chemical injection control timing. A balance between these considerations must be reached.

   Each system is unique, however in general the goal of the chemical injection is to achieve some result by maintaining a certain chemical residual concentration at a particular point in the system. For example, to maintain a specific chlorine residual at the exit of the drinking water facility. The location should be selected so that the injected chemical is already fully mixed so that an accurate sample can be sent to the measurement cell.

It should also be considered that the sample point should be located such that the residual reading can be used as a control signal for the chemical injection. Especially, it should be considered that if there is a long time delay between chemical injection changes and the change being detected by the measurement cell, then chemical injection control is adversely affected. The delay time should be kept as short as possible. We recommend that the time be less than 5 minutes.

FIGURE 3 (Sampling Examples)

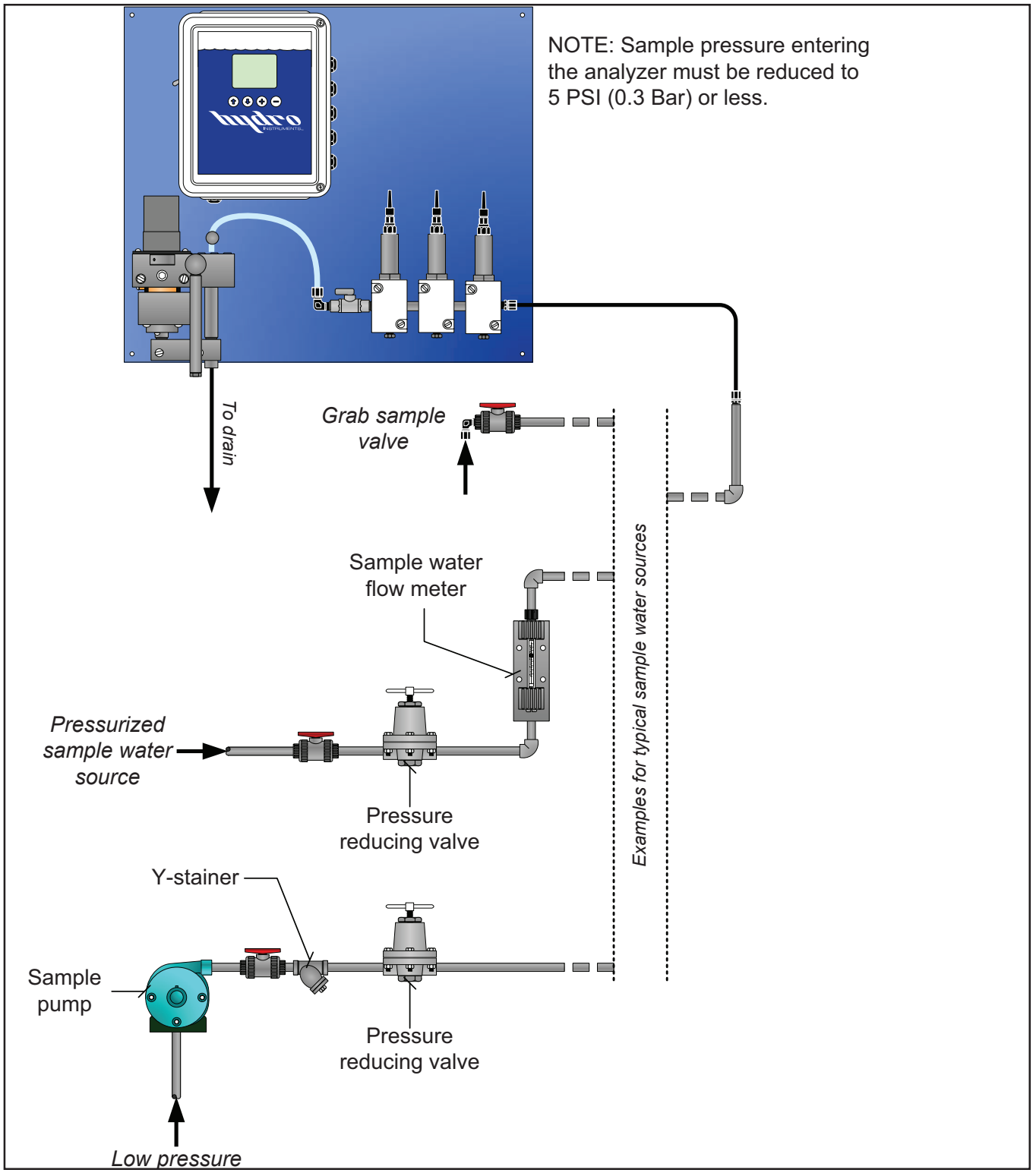


FIGURE 4 (Sample Sources)

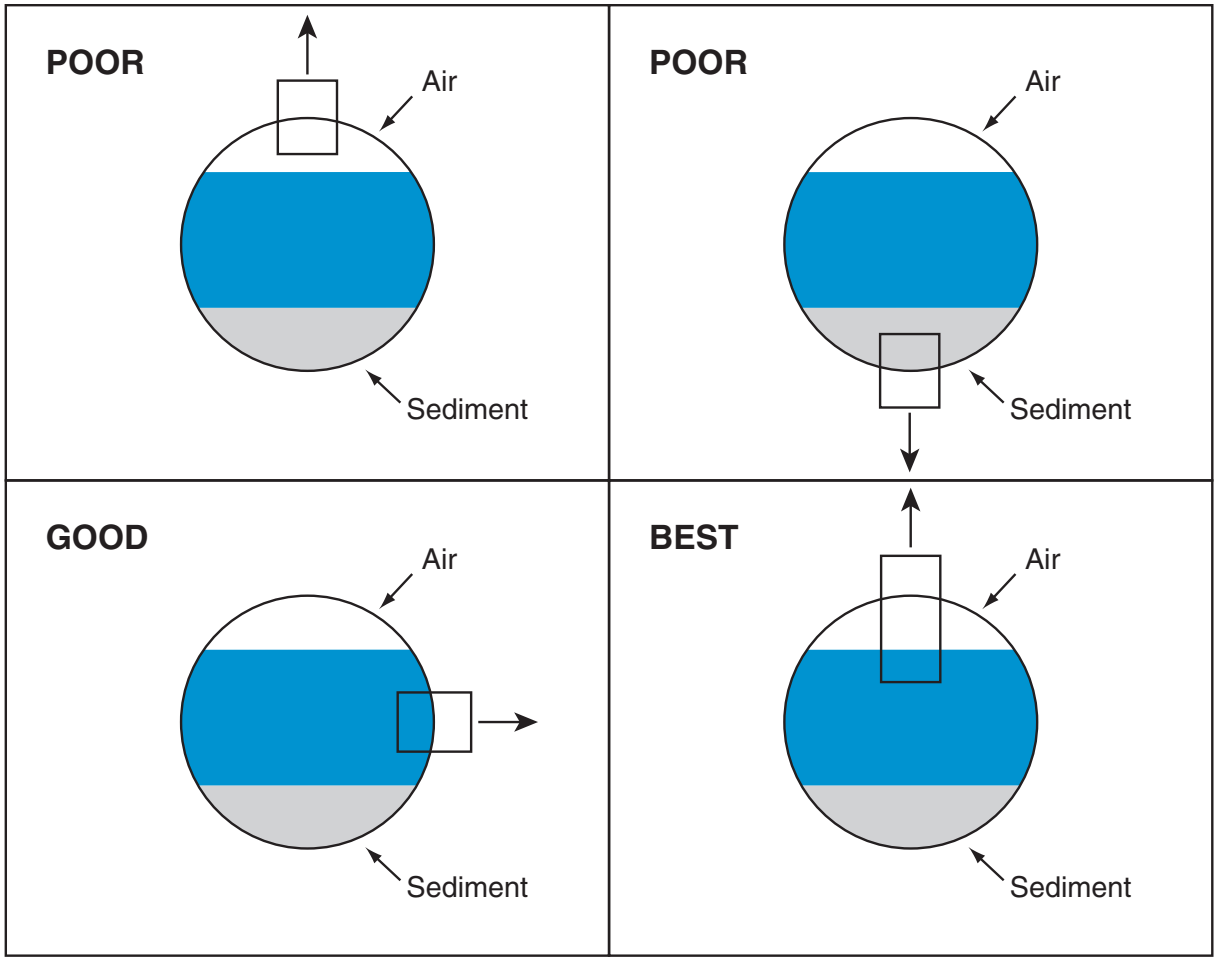
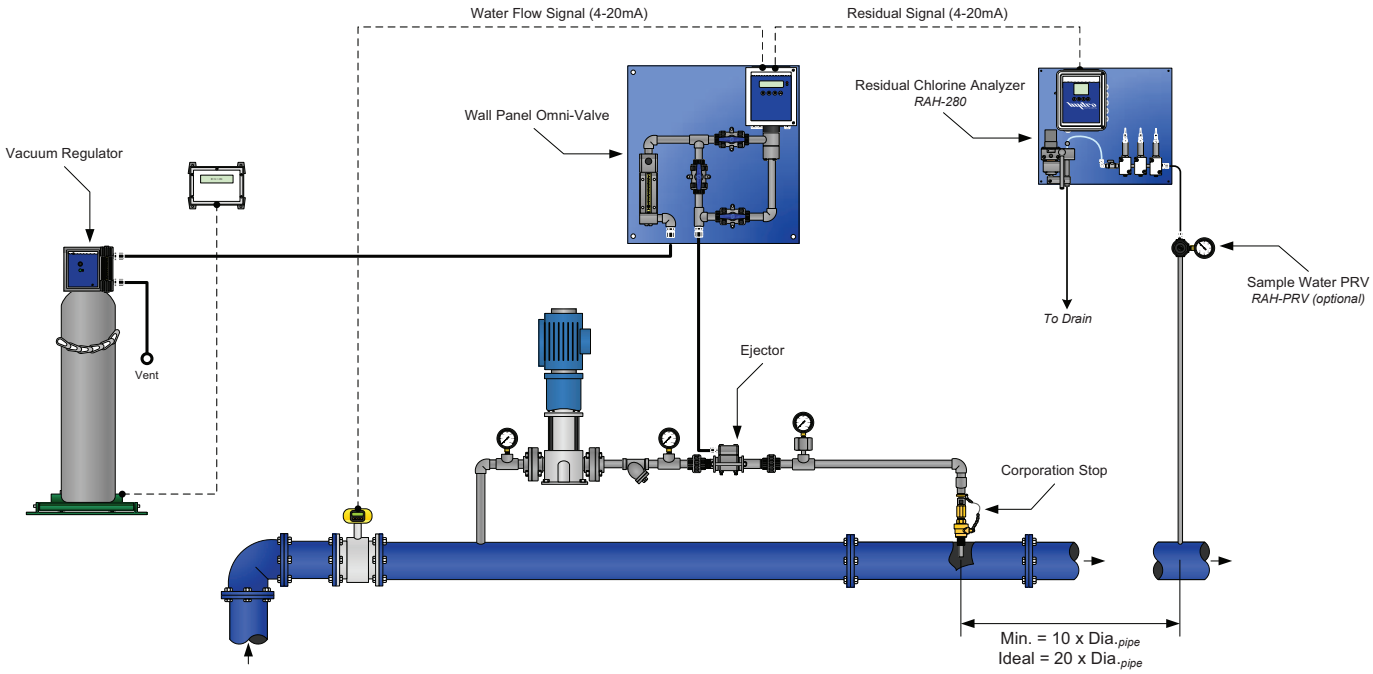


FIGURE 5 (Installation Example)



IV. SETUP, REAGENTS & CONDITIONING THE ANALYZER

IMPORTANT NOTE: Prior to starting the analyzer, turn the striker with your thumb (from left to right) to be sure the motor turns freely. If the motor becomes stuck or is difficult to turn by hand, the problem must be identified and corrected prior to starting the analyzer. See Section X (Troubleshooting).

1. **Reagent Chemical Setup and Requirements:** This section pertains to systems using the reagent feed pump. The following explains what reagents are to be used depending on the measurement method.
   a. Free Chlorine with pH compensation in software – No reagents required.
   b. Free Chlorine without pH compensation – Requires pH buffer solution.
   c. Total Chlorine – Requires pH buffer and potassium iodide.
   d. Chlorine Dioxide – Requires pH buffer and glycine.
   e. Bromine Chloride – Requires pH buffer and potassium iodide.
   f. Iodine – Requires pH buffer.

   NOTE: A 2 liter reagent bottle will last for approximately one week of continuous use.

   Use of pH buffer: It should be noted that the pH buffer feed pump is designed to reduce pH in the sample cell in order to minimize or eliminate the effects of dissociation.

   The following pH buffer is recommended:

   Sodium acetate trihydrate and glacial acetic acid can be mixed with distilled deionized water as follows:

   a. Add 850 mL of distilled deionized water to a ½ gallon (2L) bottle.
   b. Add 486 grams sodium acetate trihydrate crystals and mix until all the crystals are dissolved.
   c. Add 952 grams or 907 mL of glacial acetic acid to the bottle.
   d. Fill the bottle to the top with distilled deionized water. Mix thoroughly.
   e. If necessary check the pH of the solution (pH = 4). If not, add more acetic acid to lower the pH.
   f. To conserve buffer you may also dilute 50:50 with distilled deionized water in a separate ½ gal (2 L) container and store the remaining solution for later use. However, please be aware that doing this will lower the buffering capacity of the solution.

   Use of Potassium Iodide reagent: This reagent is always used together with the above mentioned pH buffers. To prepare the combined reagent solution, follow this procedure:

   a. Fill a ½ gallon (2 L) bottle half way with distilled deionized water.
   b. Add potassium iodide crystals as follows to the ½ gallon bottle.
   c. Shake the bottle until the crystals are all dissolved completely.
   d. Fill the ½ gallon bottle to the top with the pH buffer solution.

TABLE 1

Potassium Iodide (KI) (grams)	Analyzer Range (ppm) (mg/l)
2.65	0 to 0.2
5.3	0 to 0.5
21	0 to 2.0
32	0 to 3.0
53	0 to 5.0
105	10 or 20

NOTE: Due to the nature of the potassium iodide (KI), the above solution will have a shelf life of approximately 15 days. This is because of the oxidation of the KI in solution. As this occurs, the solution will turn a golden color. Adding a drop of a reducing agent such as 0.02N sodium thiosulfate or 0.00564N phenylarsine oxide to the reagent can reverse the oxidation process. After the reducing agent has been added, the solution should turn clear again. If the solution turns dark brown or black color, then the KI has oxidized and a new reagent solution must be prepared. It is suggested that this reducing agent be added once every 14 days or as needed to preserve the solution.

Use of Glycine reagent: This reagent is always used together with the above mentioned pH buffers. To prepare the combined reagent solution, follow this procedure:

a. Fill a ½ gallon (2 L) bottle with 500 mL of distilled deionized water.

b. Add 190 to 210 grams of glycine crystals as follows to the ½ gallon bottle.

c. Fill the ½ gallon bottle to the top with the pH buffer solution and shake to mix thoroughly. Ensure that the glycine crystals are dissolved completely.

2. Conditioning the Analyzer: Before calibration is carried out, the analyzer must be operated for at least 24 hours to allow the readings to stabilize. If the reagent feed system is being used, then the following procedure must be followed also.

a. Holding the full reagent bottle upright, pull the tapered plug upward until the hole in the cap is plugged. Turn the bottle upside down and install in the reagent feeder body. The bottle will seal against the o-ring and the tapered plug will open due to gravity.

b. Start the sample water flow to the measurement cell. Water must be flowing over the weir in the sample filter chamber to the drain.

c. An ideal flow rate of 500 ml/minute (8 GPH) should be provided. When set properly, the sample water level in the inlet weir should be close to or slightly overflowing the inner drain lip. Under all circumstances, the electrodes must be kept wet, even if the sample water flow must stop periodically. Maximum sample water pressure is 5 psig. See Figure 3.

d. Turn on the power to the analyzer.

e. Check for air bubbles in the sample line and reagent line. Remove any air bubbles.

f. Allow the analyzer to operate with the reagent feeding and the sample water flowing for at least 24 hours. After this, the analyzer can be calibrated.

V. CALIBRATION AND PROGRAMMING

1. Programming the RAH-280 Residual Analyzer

a. ***Operation (See Section VII):*** This is the normal operation state of the RAH 280 Analyzer. It provides a display of the current residual reading, (optional) pH, (optional) ORP, (optional) Conductivity, Live Charts and any alarm conditions that may exist.

b. ***Configuration and Calibration (Programming) (See Section VIII):*** These screens are used to set up the display options, operational parameters and other features.

c. ***PID Control (See Section IX):*** These parameters configure the PID Control program in the software. These parameters perform proportional, set-point (residual) or compound loop control. One or more of the analog outputs (AO1 through AO4) can be programmed to transmit a 4-20 mA control signal.

2. Programming Access

a. ***Operation Mode:*** This is the standard operatonal state during initial powering of the device. To return to this mode from any other screen simply press the ⬆ button repeatedly.

b. ***Configuration and Calibration:*** This is accessed from the Operation screen by pressing the ⬇ button until the password screen is reached. Then enter the password “280” and then press the ⬇ button.

c. ***PID Control:*** These parameters will display several general status and control screens in the Operation Mode. Access to the screens which allow this program to be set-up are listed among the other operational parameters in the Configuration menus. Press the ⬇ button (in the Operation Mode) until the password screen is reached. Then enter the password “280” and press the ⬇ button.

3. Operating the keypad

1. ***Navigation:*** To move from one screen to another, simply press the ⬆ and ⬇ buttons to reach the desired screen. Navigation between screens is possible in either direction.

2. ***Adjustment of Displayed Parameters:*** To adjust a displayed parameter in the Configuration Mode, simply use the ⊕ and ⊖ buttons to increase or decrease. Once a parameter has been set to the desired position, pressing either ⬆ or ⬇ button to leave the screen will cause the new parameter to be stored. To select a blinking option (such as “Temperature Cal – Yes/No”), use the arrow buttons as needed to make the desired selection blink then press the ⊕ button.

FIGURE 6 (Operation Menu Flow Chart)

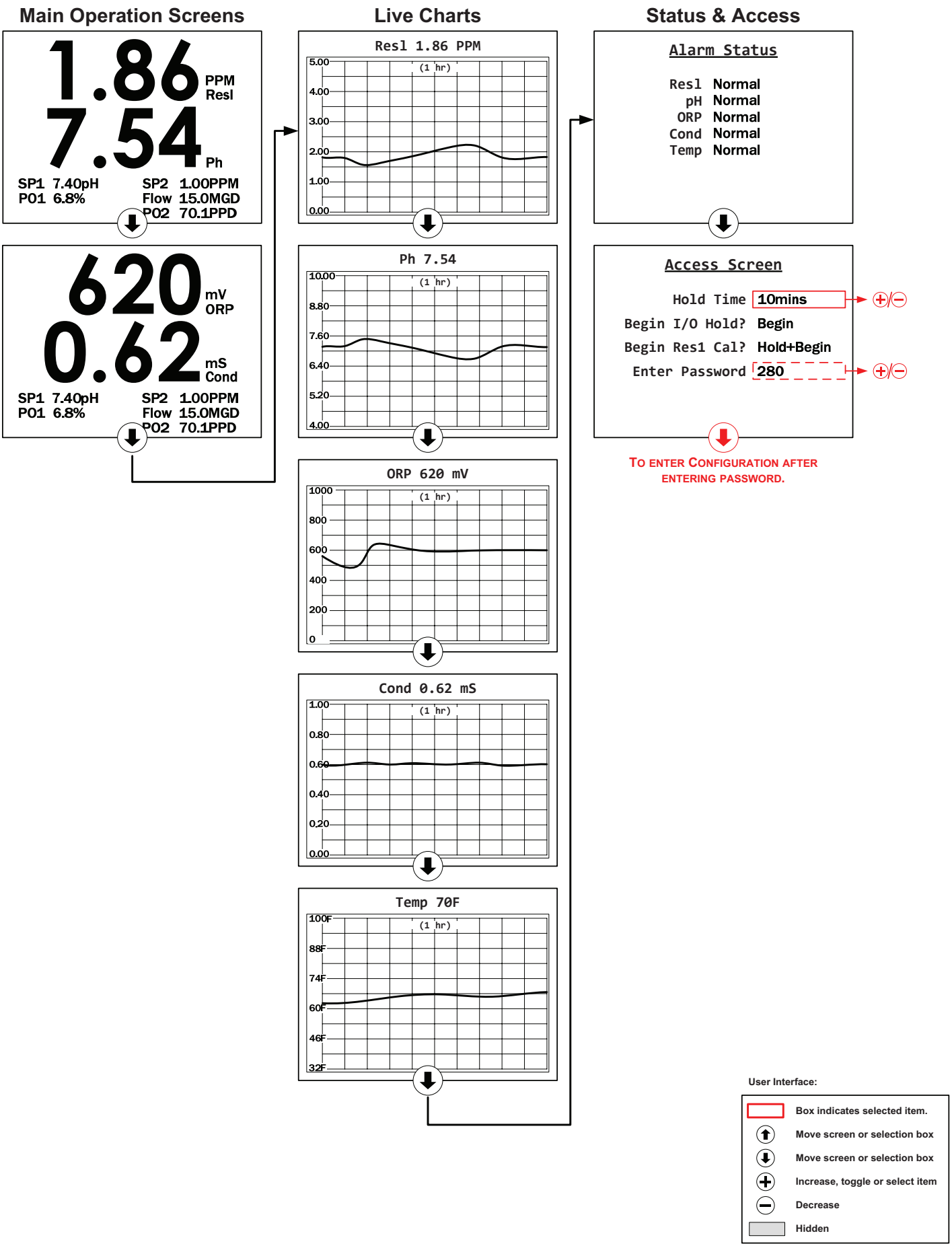
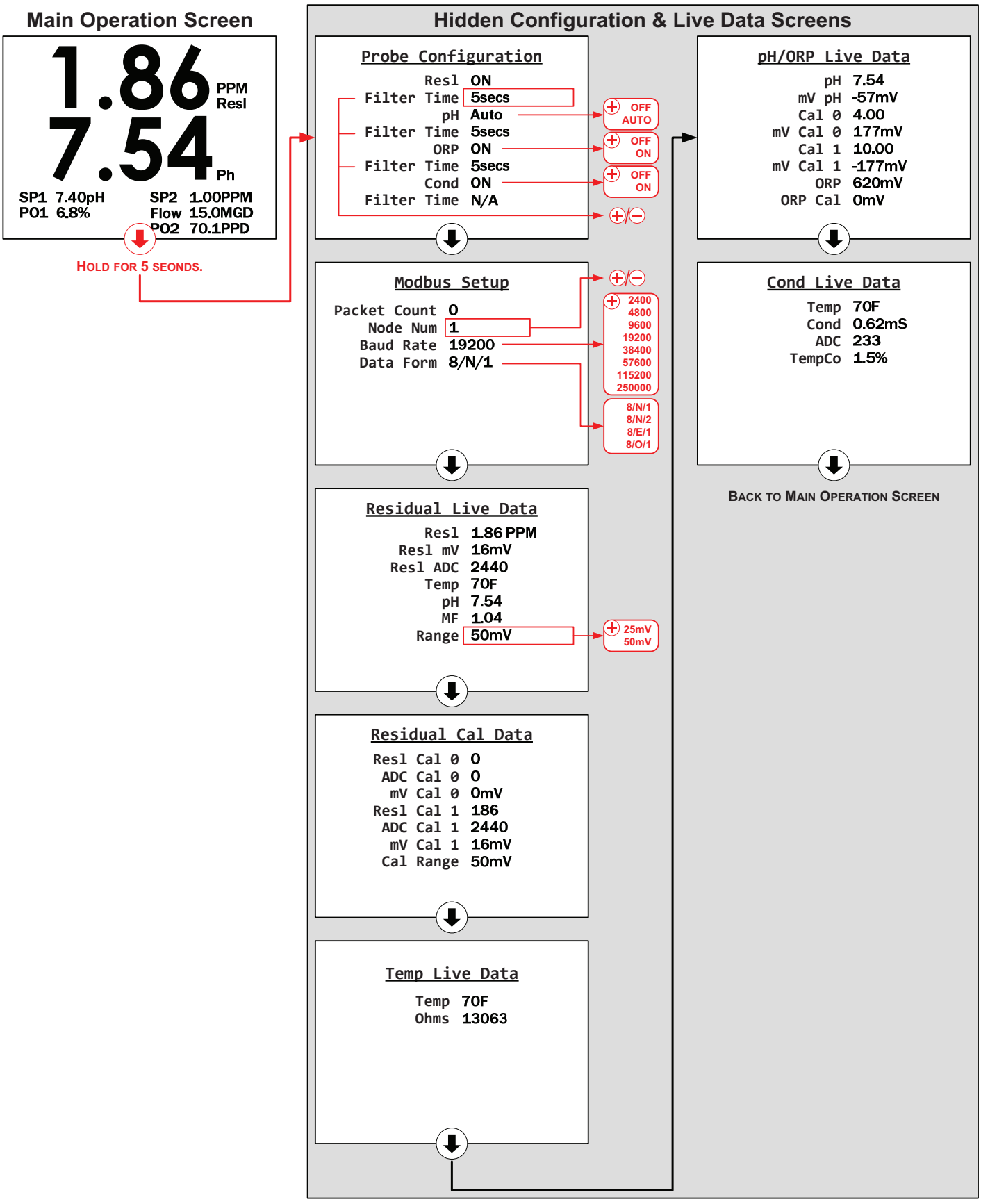
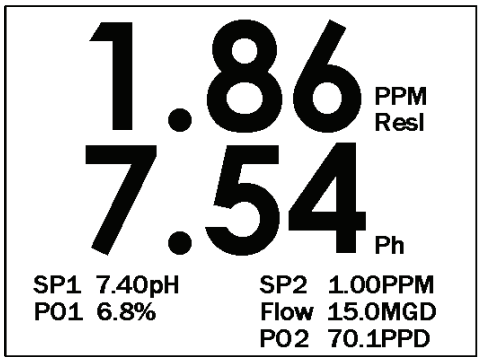


FIGURE 7 (Hidden Configuration & Live Data Screens)



VI. EXPLANATION OF OPERATION MODE SCREENS

Main Screen: This screen will display the live readings for installed and active disinfectant sensors, pH electroides, ORP electrodes, and conductivity electrodes. The values shown in small font size are live values for PID control, using user-specified units. A value may show in red color if there is an active Alarm condition for the respective value.



Residual Chart: This screen shows curves which graphically depict residual values for active probes over a user-adjustable time period.

pH Chart: This screen shows curves which graphically depict pH values for active pH sensors over a user-adjustable time period. The pH chart will not be present if neither channel 1 nor channel 2 is set for pH.

ORP Chart: This screen shows curves which graphically depict ORP values for active ORP electrode over a user-adjustable time period. The ORP chart will not be present if neither channel 1 nor channel 2 is set for ORP.

Conductivity Chart: This screen shows curves which graphically depict conductivity values for active conductivity electrodes over a user-adjustable time period. The Conductivity chart will not be present if no conductivity electrodes are present.

Temperature Chart: This screen shows curves which graphically depict temperature values for active thermistors over a user-adjustable time period.

Alarm Status Screen: This screen will show a list of current alarm conditions for active probes and sensors. Typically, a non-normal alarm condition will be shown in red color.

Access Screen: In addition to allowing access to the RAH-280 Configuration screen (after adjusting the password value to “280”), users can initiate an “I/O Hold” or jump to residual calibration prompts from this screen.

FIGURE 8A (Configuration Menus)

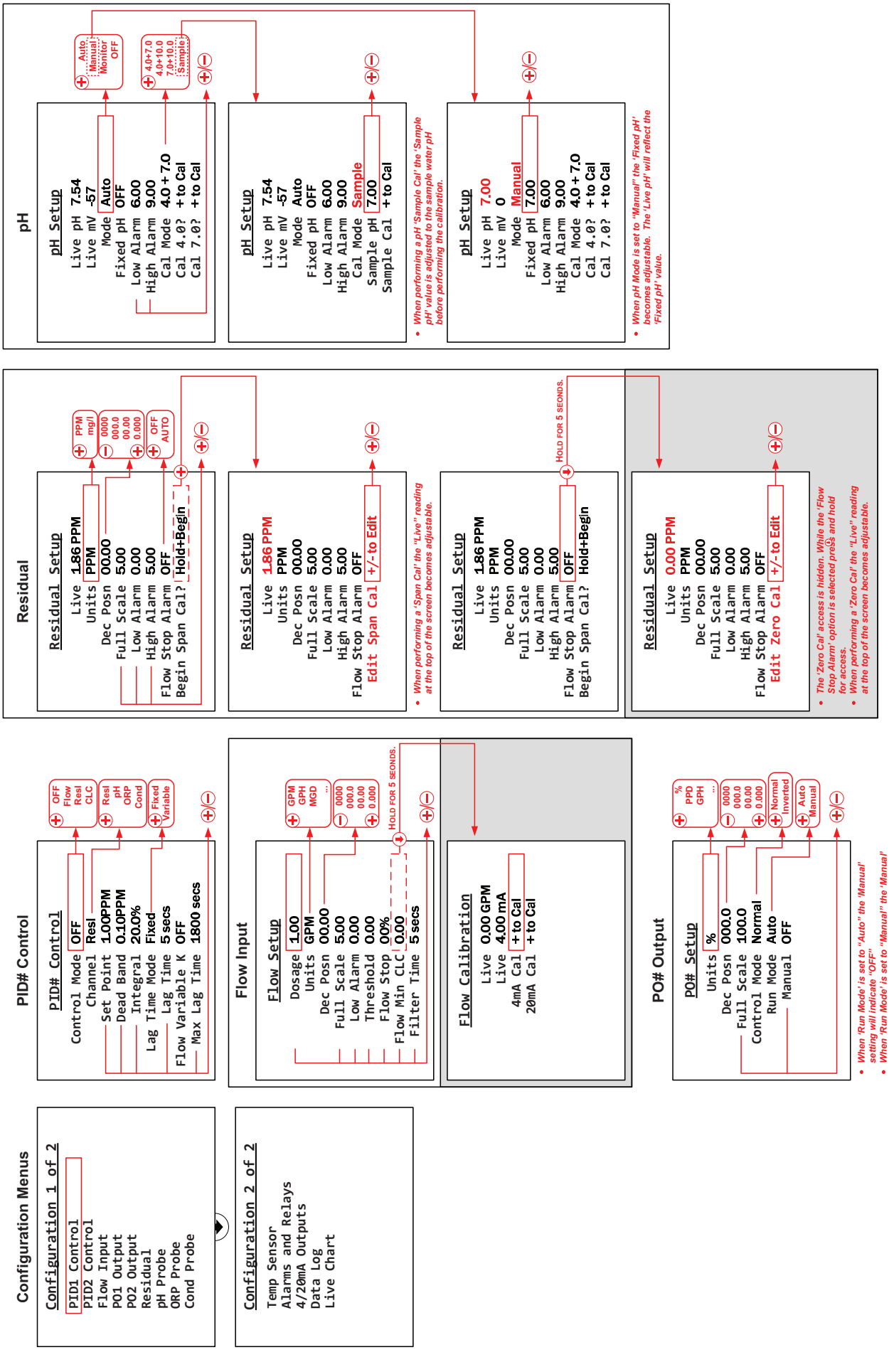
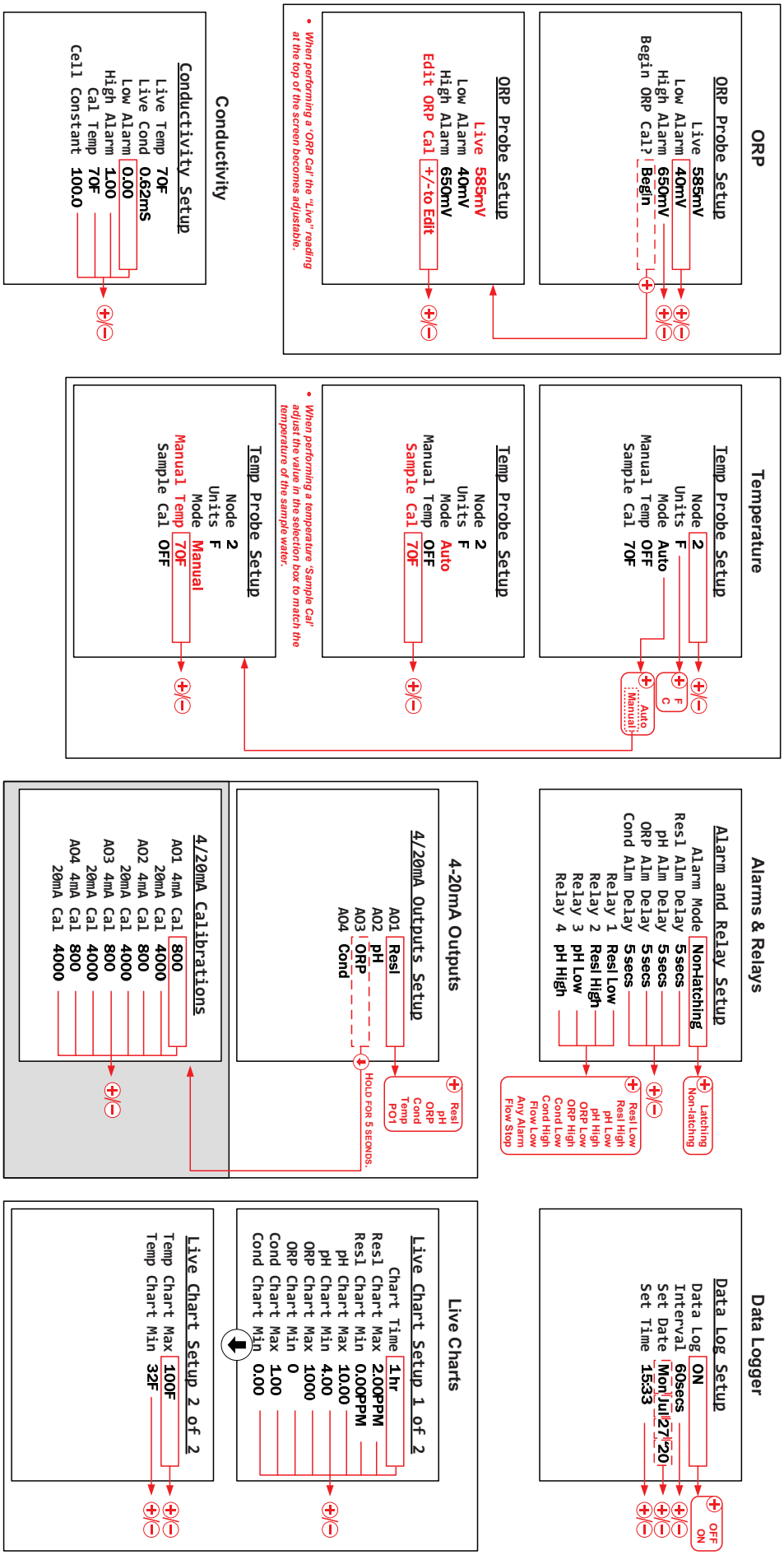


FIGURE 8B (Configuration Menus)



VII. EXPLANATION OF CONFIGURATION MODE SCREENS

RAH-280 Configuration Screen: This screen lists titles of accessible Setup screens for active probes, sensors, outputs, data logging, and charting. Use the ⬇ button to select a screen title, and then press the ⊕ button to jump to that screen.

Residual Setup: This screen shows the live reading from the measurement cell and allows the user to change the following values and parameters:

Units: Select 'PPM' or 'mg/l'

Dec Posn: Choose one of the following decimal position settings: ('0.000', '00.00', '000.0', '00000')

Full Scale: This setting must match the range of the disinfectant probe installed. This will be set by Hydro Instruments and should only be adjusted if the disinfectant probe is changed to one with a different range. An output of 4mA represents a residual of zero.

Low Alarm: Adjust the low residual alarm trip-point.

High Alarm: Adjust the high residual alarm trip-point.

Edit Zero Cal?: The analyzer is shipped with the default zero calibration. A zero calibration may need to be performed in the field for best accuracy. This line becomes visible after pressing-and-holding the ⬇ button with the "Flow Stop" line selected. Enter residual value of "zero" sample water. When the residual value on the screen matches the known residual of the "zero" sample water, press the ⬇ button. A confirmation screen should appear indicating that the calibration was performed.

NOTE: The residual zero calibration does not necessarily have to be performed with sample water at a 0.00 PPM residual. However, it is advisable to perform zero and span calibrations with two samples of significantly differing residual values.

Begin/Edit Span Cal?: Press the ⊕ button to begin span calibration. Enter residual value of "span" sample water. When the residual value on the screen matches the known residual of the "span" sample water, press the button. A confirmation screen should appear indicating that the calibration was performed.

pH Electrode Setup: This screen will show the live readings (in pH and mV) from the pH electrode and allows the user to change the following values and parameters:

Low Alarm: Adjust the low pH alarm trip-point (in pH).

High Alarm: Adjust the high pH alarm trip-point (in pH).

Comp Mode (pH Compensation Mode**):** Choose your pH compensation method by pressing the ⊕ key until the desired pH compensation method is displayed.
Your choices of pH compensation are:

AUTO: In this mode, the pH value of the sample water is monitored using a pH electrode (available through Hydro Instruments) and compensation is performed automatically in the controller's software.

MANUAL: In this mode, the pH value of the sample water can be entered and will remain fixed unless changed.

MONITOR: In this mode, the sample water pH will be continuously monitored by the pH electrode but it will have no effect on the residual reading.

NONE: In this mode, the analyzer will assume the pH of the sample water is either stable or has been buffered low enough such that dissociation is not a concern. Note that in this mode, the pH value is not displayed on the main operations mode screen. If this mode is chosen, no pH electrode is needed.

Fixed pH: This will show 'OFF' unless the mode is 'Manual', in which case the value is adjustable to pH values between 4 and 14.

Cal Mode (pH Calibration Mode)**:** The residual analyzer allows the user to select from four different calibration methods including: ('Sample', '4.0 and 7.0', '4.0 and 10.0', '7.0 and 10.0'). The calibration type to use is completely up to the user. However Hydro Instruments recommends using the following selection criteria:

A. If pH buffers are not available, then use the "Sample" calibration. This is only a one point calibration (your sample) and will automatically calculate an ideal calibration slope. This provides reasonable accuracy if the sample pH is close to seven and pH of the process is relatively stable.
B. If sample pH is less than seven, use the '4.0 and 7.0' calibration method.
C. If sample pH is greater than seven, use the '7.0 and 10.0' calibration method.
D. If sample stream is subject to wide swings in pH, use the '4.0 and 10.0' calibration method.

Quick notes to increase calibration accuracy:

- Before placing the pH electrode into a buffer for calibration, blot the bottom of the probe with a clean microfiber cloth.

  CAUTION: Take care not to scratch the probe surface as this will damage the probe and affect your readings.
- Allow the pH meter to sit in the buffer solution for a few seconds prior to calibration. The longer it sits in the buffer solution, the closer it will be to the ideal value. Generally 15-30 seconds for a new probe. When calibrating the pH electrode the controller software will count down from 25 seconds to ensure good calibration.
- Keep the pH sensor and buffer solution still when calibrating your instrument. Vigorous movement of the sensor can disrupt readings and lead to inaccurate calibrations, should the pH electrodes reading be disrupted during calibration the countdown will reset.
- Select a pH range for calibration that will be similar to your operating conditions. For example, if the operating range is 7.80 to 8.10 then perform a 7.00 and 10.00 calibration.
- When calibrating your sensor, always use a fresh buffer solution and discard the buffer after use.
- Be aware of the temperature of the buffers being used. Generally buffer manufactures write on their label at what temperature the pH is its true value (generally 77°F, 25°C). Temperature can influence dissociation and thus if your calibration is done with a buffer not at its prescribed temperature, your calibration will be inaccurate. It is best to calibrate with buffers that have an accurate pH close to your operating conditions.
- Air bubbles and other liquids can form around the outside of the sensor and affect the accuracy of the reading. Be sure to remove any air bubbles upon installation.

'4.0 and 7.0', '7.0 and 10.0', and '4.0 and 10.0' pH calibration methods:

Cal 7.0? (or Cal 4.0?): Calibrate the lower pH for the selected method and span, following notes below.

Cal 10.0? (or Cal 7.0?): Calibrate the upper pH for the selected method and span, following notes below.

These are two point calibrations carried out with two known pH buffer solutions.

1. In the Temperature calibration screen, set the Temperature mode to manual and enter the actual buffer solution temperature.

   NOTE: pH buffer calibrations are somewhat temperature dependent. pH buffers are usually accurate at 25ºC. Error in pH readings can occur if buffer temperatures are drastically different from their prescribed temperature (+/- 5ºC). If the temperature difference is greater than this margin, consider adjusting buffer temperature or performing a sample calibration.
2. Once the calibration method is selected, the first buffer solution required will be displayed on the screen. Place the pH electrode into the appropriate buffer and select 'Begin'.

3. The software waits for the reading to stabilize for 25 seconds before accepting or rejecting it as a valid calibration point. The countdown timer will appear on the screen in real-time. Note: The pH value will not be displayed.
4. If the calibration point is accepted, an “accepted” screen will appear. Press down to clear the screen and the next buffer solution required will appear.
5. Place the pH electrode in the appropriate buffer solution and select ‘Begin’.
6. The software will wait for a stable reading over 25 seconds. If the second calibration point is accepted, an “accepted” screen will appear. Press down to clear and the pH calibration is complete.
7. Place the pH electrode back into the sample solution and change the Temperature back to the original operating conditions.

Sample Calibration: This calibration is carried out with the pH electrode left installed in its holding cell with the sample water flowing through it. However, be sure that the Temperature displayed on your unit is accurate before calibrating the pH.

1. If this calibration option has been selected, the following screen will require the operator to enter the pH of the sample water in which the calibration will be done.
2. Use a hand held pH meter to measure the pH of the sample water and then enter the pH of the sample on the screen.
3. Before proceeding check that no air bubbles have formed on the tip of the pH electrode. Select ‘Begin’; the software will wait for a stable reading over 25 seconds before accepting or rejecting the calibration point. If the calibration point is accepted, press the down key and the pH calibration is complete.

   NOTE: If at any point your pH calibration is rejected, the entire calibration procedure will need to be repeated. If the problem persists, see the troubleshooting section below.

ORP Electrode Setup: This screen shows the live ORP readings (in mV) from its respective ORP electrode and allows the user to change the following values and parameters:

Low Alarm: Adjust the low ORP alarm trip-point (in mV).

High Alarm: Adjust the high ORP alarm trip-point (in mV).

Single Pt Cal (Single Point Calibration)**:** Press the ⊕ key to begin ORP calibration.

Conductivity Electrode Setup: This screen shows the live Conductivity readings (in mS/cm) from its respective conductivity electrode and allows the user to change the following values and parameters:

Low Alarm: Adjust the low conductivity alarm trip-point (in mS/cm).

High Alarm: Adjust the high conductivity alarm trip-point (in mS/cm).

Single Pt Cal (Single Point Calibration)**:** Press the ⊕ key to begin conductivity calibration.

Temp Sensor Setup: This screen shows the live reading from its respective temperature sensor (thermistor) and allows the user to change the following values and parameters:

Units: Select ‘F’ (Fahrenheit) or ‘C’ (Celsius)

Mode: Select ‘AUTO’ (Automatic) or ‘MANL’ (Manual)
Automatic enables the temperature to be automatically detected via the thermistor.

Manual Temp: This will show ‘OFF’ unless the mode is ‘MANL’, in which case the value is adjustable.

Sample Calibration: This line is visible when the temperature mode is set to ‘AUTO’. The temperature displayed represents what the program interprets the current temperature reading to be. If necessary, adjust the displayed temperature using the ⊕ and ⊖ buttons.

Alarm and Relay Setup: This screen allows the user to change the following values and parameters for the four alarm relays (Relay 1, Relay 2, Relay 3, Relay 4):

Alm Mode (Alarm Mode): Select 'Latching' or 'Non-latching'
A latching relay will require manual acknowledgement of any alarm condition (by pressing the [MINUS] button with the Main Screen active). When Non-Latching is selected, alarms will clear themselves whenever the alarm condition no longer exists.

Alm Delay (Alarm Delay): Adjust the delay time. Any alarm condition must then exist for this period of time before tripping the relay. This delay can help avoid false alarms and is recommended to be set at 5 seconds or longer.

Relay 1, 2, 3 or 4: The analyzer is equipped with four alarm relays. Each of these relays can be individually set to represent any of the following alarm conditions:

Res High/Low Alm	*(Residual Low Alarm)*
pH High/Low Alm	*(pH High or Low Alarm)*
ORP High/Low Alm	*(ORP High or Low Alarm)*
Cond High/Low Alm	*(Conductivity High or Low Alarm)*
Flow Stop Alm	*(Sample Flow Stop Alarm)*
PV1 Low	*(PID control water flow low alarm.)*
Any Alm	*(Any of the listed alarm conditions.)*

4/20mA Outputs Setup: This screen accesses the settings for the four 4-20mA output channels.

AO1, AO2, AO3 or AO4: Each analog output channel can be individually set to represent one of the following live readings (with corresponding values shown for 4mA and 20mA outputs):

		4mA	**20mA**
Res	*(Residual)*	zero residual	full scale residual
pH	*(pH)*	zero pH	14 pH
Temp	*(Temperature)*	0º C (32º F)	50º C (122º F)
ORP	*(ORP)*	ORP Chart Min	ORP Chart Max
Cond	*(Conductivity)*	Cond Chart Min	Cond Chart Max
PO1	*(PID Process Output)*	zero process feed	full scale process feed

[HIDDEN] 4/20mA Calibration: This hidden screen can be accessed by holding the ⬇ button when the AO3 line is selected (on the 4/20mA Outputs Setup screen). While using an ammeter to measure the output current, the following calibration values can be adjusted using the ⊕ and ⊖ buttons:

NOTE: Adjustable values on this screen are Digital-to-Analog Converter (DAC) values.

AO1 4mA Cal: Adjust the DAC value that corresponds to 4mA for Analog Output 1 (AO1)
20mA Cal: Adjust the DAC value that corresponds to 20mA for Analog Output 1 (AO1)
AO2 4mA Cal: Adjust the DAC value that corresponds to 4mA for Analog Output 2 (AO2)
20mA Cal: Adjust the DAC value that corresponds to 20mA for Analog Output 2 (AO2)
AO3 4mA Cal: Adjust the DAC value that corresponds to 4mA for Analog Output 3 (AO3)
20mA Cal: Adjust the DAC value that corresponds to 20mA for Analog Output 3 (AO3)
AO4 4mA Cal: Adjust the DAC value that corresponds to 4mA for Analog Output 4 (AO4)
20mA Cal: Adjust the DAC value that corresponds to 20mA for Analog Output 4 (AO4)

Data Log Setup: This screen allows user to change the following values and parameters for setting the optional data logger:

Data Log: Select 'ON' or 'OFF' to enable/disable data logging.
Interval: Adjust the frequency at which data will be recorded.
Set Date: Set the current date (Day, Month, Year). Hidden if Data Log is 'OFF'.
Set Time: Set the current time (Hour:Minute). Hidden if Data Log is 'OFF'.

Live Chart Setup: This screen allows the user to change the following values:

Chart Time: Adjust the duration of time shown graphically on the three charts after the Main Screen.
Res Chart Max: Adjust the maximum residual shown on the Residual Chart.
Temp Chart Max: Adjust the maximum temperature shown on the Temperature Chart.
Temp Chart Min: Adjust the minimum temperature shown on the Temperature Chart.
pH Chart Max: Adjust the maximum pH value shown on the pH Chart.
pH Chart Min: Adjust the minimum pH value shown on the pH Chart.
ORP Chart Max: Adjust the maximum ORP value shown on the pH Chart.
For any analog outputs (i.e. AO1 through AO4) set to represent ORP, a 20mA signal will represent this ORP Chart Max value.
ORP Chart Min: Adjust the minimum ORP value shown on the pH Chart.
For any analog outputs (i.e. AO1 through AO4) set to represent ORP, a 4mA signal will represent this ORP Chart Min value.
Cond Chart Max: Adjust the maximum conductivity value shown on the Conductivity Chart.
For any analog outputs (i.e. AO1 through AO4) set to represent conductivity, a 20mA signal will represent the Conductivty Chart Max value.
Cond Chart Min: Adjust the minimum conductivity value shown on the Conductivity Chart.
For any analog outputs (i.e. AO1 through AO4) set to represent conductivity, a 4mA signal will represent the Conductivity Chart Min value.

VIII. EXPLANATION OF PID CONTROL SCREENS

PID1 and PID2 Control: The PID Control program can be accessed via Configuration screen 1. It uses the first five menu options: “PID1 Contorl”, “PID2 Control”, “Flow Input”, “PO1 Output” and “PO2 Output”. There are two PID control loops that can be set up; PID1 and PID2. “PID1 Control” settings corresponds to and use the “PO1 Output” settings and “PID2 Control” settings corresponds to and use the “PO2 Output” settings. Each PID loop can be used to control off of a different process variable. For example PID1 can control an automatic valve using the RAH-280’s residual chlorine reading and PID2 can simultaniously control a different automatic valve using the RAH-280’s pH reading. These Configuration sceens can be accessed from the operation mode, scroll down and enter “280” as the password when prompted.

Control Mode: Select desired control type.

OFF: When “OFF” is selected, the PID Control program will be deactivated.

Flow Pacing: This control type will provide a process output (PO#) proportional to the AI1 proportional input signal (and multiplied by the Dosage setting). This control method does not factor the residual in any way.

Residual/ORP: This control type will provide a process output (PO#) that is adjusted as needed to maintain the “Set Point” value.

Compound Loop: This control type will provide a process output (PO#) that is adjusted as needed to maintain the “Set Point” value and also factors in changes registered through the proportional input signal (and multiplied by the Dosage setting).

Channel: Select the channel (i.e. measurement) that the PID# control will use in its calculations (e.g. Residual, pH, ORP or Conductivity).

Set Point: Set the target measurement value that the PID# control will use to adjust chemical feed.

Dead Band: This is a dead band around the Set Point. As long as the residual is within (+ or -) this amount from Set Point, the program will consider the Set Point met. This is used to avoid excessive, continual adjustments.

Integral: A factor used in the calculation of needed adjustments to the process output. This value ranges from 0 – 100%. Essentially, the program makes a calculation of how much the output needs to be adjusted in order to reach Set Point and this factor. Increasing the Integral will increase the rate of each individual adjustment (and vice versa).

Lag Time: This is the time that elapses between a change in chemical feed rate and the change in residual observed by the analyzer. The PID# Control program will wait-out this amount of time between each adjustment to PO#. Instruments should be installed to minimize lag time in order to optimize control (ideally limit this time to less than 5 minutes).

Max Lag Time: A maximum Lag Time, which can be used in Compound Loop Control only. When in use, this sets limits the maximum lag time that can be calculated by the variable lag time formula.

Lag Time Mode: Select “Fixed” or “Variable”. If “Fixed” is selected, only the “Residual Lag Time” will be used. If “Variable” is selected, the lag time used will vary as the flow varies, but will be limited to the Max Lag Time.

Flow Variable K: Enter desired flow level. If “Variable” is selected, the lag time will be calculated as follows: Flow at Variable Lag divided by the current flow rate and then multiplied by the Residual Lag Time.

NOTE: In applications where flows vary greatly, lag times may also change significantly. In these instances, the use of variable lag times will improve control timing.

NOTE: If “Fixed” is selected as “Lag Time Method”, the settings of “Residual Max Lag Time” and “Flow at Variable Lag” are ignored.

Flow Input: This branch accesses the settings for the proportional (flow) input.

Dosage (Gain): This value will adjust the ratio of chemical feed to the PV1 water flow. It is effectively a multiplication factor that is applied to the calculated chemical feed rate.

Units: Select desired units (MGD, GPM, GPD, LPM, MLD, %, M^3/H).

Dec Posn: Select desired decimal position.

Full Scale: Enter the proportional input full scale. This setting should be what a 20 mA proportional input (AI1) signal represents.

Low Alarm: Enter low flow alarm trip point (if desired).

Threshold: This setting allows the user to set a value (above zero) to be treated as zero for the proportional input (AI1) signal. In proportional (Flow Pacing) control, this would mean the output signal (PO#) would remain at zero (4mA) until the proportional input reached this value.

Flow Stop: This setting is only used in Compound Loop Control (CDC) to prevent PO# adjustment based on the Set Point when PV1 water flow has stopped. The user can enter a PV1 water flow value below which the PO# output will go to and remain at 4mA until the PV1 water flow returns to a value greater than the entered Flow Stop value.

Filter Time: This is an adjustable span of time over which the PV1 input signal will be continually averaged. It is recommended that it be set to 5-10 seconds.

PO1 and PO2 Output: These branches access the settings for the PID# Control output signals.

Units: Select desired units (PPD, GR/H, KG/H, GPH, GPM, GPD, %).

Dec Posn: Select desired decimal place.

Full Scale: Enter the desired output full scale. This is what a 20 mA output signal (selected as PO#) will represent.

NOTE: A minimum of three integers must be used. Therefore, if the PO# Full Scale is set below 100, one decimal position must be used (ex: 99.9)

Control Mode: Select either “Normal” or “Inverted”. These two selections are basic classifications of what chemical type the PID Control program is controlling. “Normal” represents any chemical that will increase the residual reading and “Inverted” represents and chemical that will decrease the residual reading.

Run Mode: The PID# control can be set to run automatically “Auto” or the user can input a desired PO# output value “Manual”.

IX. MAINTENANCE AND CLEANING

The quality of the water greatly effects the frequency of cleaning that is required. Cleaning requirements will be different at each installation. Visually checking the condition of the analyzer regularly is the best way to determine the required frequency of cleaning.

1. **Inlet Filter Screen and Weir**: Regularly check the inlet filter screen and weir condition. If it is found to be dirty, then lift out the weir and filter screen and clean them with clean water before reinstalling them.

2. **Flushing the Measurement Cell:** If water will not flow through the measurement cell then follow this procedure to flush it:
   a. Turn off the power to the analyzer.
   b. Remove the flush plug in the flow tube and allow to drain.
   c. Reinstall the flush plug.
   d. Repeat as necessary before turning the power back on.

3. **Reagent Pump:** If reagent is not feeding then first be sure that all air bubbles are removed from the reagent feed tubing. To check if reagent is feeding, mark the level on the reagent bottle and wait for 8 hours before rechecking. If the level does not change in 8 hours, then the reagent pump tube needs to be replaced as follows:
   a. Turn off the power to the reagent pump.
   b. Remove the center screw from the pump head cover and lift the pump head cover off.
   c. Carefully remove the pump tube and pump rotor assembly.
   d. Dispose of old pump tube.
   e. Wrap new pump tube around rotor assembly and insert back into the pump head housing.
   f. Reinstall the pump head cover.
   g. Turn on the power to the reagent pump and allow some time for the pump start pulling reagent through the tubing.

4. **Cell Assembly:** The analyzers cell assembly should be maintained on an as needed basis, but no less than once a year.

   NOTE: When removing the probe assembly, approximately 130 PTFE cleaning balls will fall out. Place a container underneath the cell assembly to catch the cleaning balls.

   CAUTION: Never reuse dirty and/or damaged cleaning balls.

- Follow section VI.3 a. through e. to remove all reagent chemical and drain the measurement cell.
- Disconnect the two wires from the cell assembly (side and bottom).
- Unscrew the probe assembly taking care to catch the PTFE cleaning balls held within the cell assembly.
- Clean the probe with a clean non-abrasive cloth. If the electrode is damaged it must be replaced.
- Inspect the inside surface of the copper cell. If there is significant indications of wear or pitting, replace the cell. If the surface appears to have little or no wear, clean the internal surface of the copper cell with a scouring pad or similar mild abrasive.
- To remove the copper cell, unthread the four ¼-20 x 2 ¾" bolts holding the bottom body, copper cell and top body together. Take care not to let the copper cell fall once the bolts are loose.
- Replace the gasket above and below the copper cell before reassembly.
- Replace the O-ring at the base of the probe body and reinstall the probe assembly.
- Remove the Front Plug from the top body and deposit the cleaning balls through the hole in which the Front Plug was removed. A funnel helps in this process. Once all cleaning balls have been deposited

into the cell assembly, reinstall the Front Plug.

- Rotate the motor/striker manually by hand to check for binding. If the striker will not turn freely it may be necessary to repeat this process, or refer to section VI.6.
- Reconnect the wires to the cell assembly (side and bottom).
- Start the sample water flow and once water can be seen flowing out of the drain, turn on the power to the analyzer.

5. **Motor/Striker Assembly:** In order to replace the motor or striker assembly, the measurement cell assembly should be removed from the panel and controller and taken to a table to perform the operation.
   a. Turn off power to the analyzer and drain reagent and the measurement cell as described in section VI.3.
   b. Disconnect all wires from the measurement cell to the controller.
   c. Remove screws that hold the measurement cell assembly to the panel. Remove assembly and take to a table for this work.
   d. With the motor assembly upright, remove the three screws holding the motor plate to the top body. Lift the motor straight up and out of the body.
   e. Invert the measurement cell assembly to empty the cleaning balls into a container. Remove the valve adapter.
   f. If the motor is to be replaced, remove the striker and rubber boot from the motor shaft. Install the boot on the new motor and striker after loosening the center set screws approximately 2 turns.
   g. The striker should slide onto the motor shaft when force is applied. Tighten the side set screw in the striker until it contacts the motor shaft.
   h. Fit the striker on to the motor so that a ¼" space is left between the top of the striker and the motor plate. Insert the motor/striker assembly into the measurement cell assembly by pushing on the
   motor until the motor plate is sealed on the top body.
   i. Carefully remove the motor/striker from the main assembly. Lightly tighten the side set screw in the striker. Turn the center set screw until contact is made with the motor shaft, then back out the center set screw ⅛ to ¼ turn. Loosen the side striker set screw and motor/striker assembly with the three motor plate screws.
   j. Rotate the motor/striker assembly by hand to check for binding and rubbing.
   k. Insert the cleaning balls and rotate the striker again by hand. If any rough spots or drag is noticed, then repeat steps VI.6.g through VI.6.j to readjust the striker.
   l. Once no drag is noticed, reassemble by repeating steps VI.6.a to VI.6.c in reverse order.

6. **Thermistor:** If the thermistor fails, then it will give a very high or very low signal. To test the thermistor, follow this procedure:
   a. Turn off power to the analyzer.
   b. Open the analyzer NEMA 4x enclosure and remove the two thermistor wires from the MB128 board (RS1 and AIC).
   c. Use an ohm meter to check the resistance of the thermistor. If the ohm meter shows a stable resistance reading around 10 kohms, then the thermistor is not defective. If the reading is zero or infinite, the thermistor is defective and must be replaced.
   d. After replacement, thermistor recalibration may be required.
   e. If the thermistor fails, the analyzer temperature mode can be set to “Manual” to allow for proper operation until a replacement thermistor is installed.

7. **pH Electrode:** The pH electrode will periodically require replacement. The frequency of replacement is dependent on the quality of the water. Also, all handling instructions must be followed carefully to

avoid damaging the pH probe. Failure of the pH probe can be indicated by an excessively high or low reading. If the probe cannot be recalibrated, then it must be replaced. Instructions for replacement will be included with the replacement pH probes available from Hydro Instruments.
Refer to sections I.1, II.4, VI, and Troubleshooting of this manual.

8. **ORP Electrode:** The ORP electrode will periodically require replacement. The frequency of replacement is dependent on the quality of the water. Also, all handling instructions must be followed carefully to avoid damaging the ORP electrode. Failure of the ORP electrode can be indicated by an excessively high or low reading. If the probe cannot be recalibrated, then it must be replaced. Instructions for replacement will be included with the replacement ORP electrode available from Hydro Instruments.
   Refer to sections I.1, II.4, VI, and Troubleshooting of this manual.

9. **Conductivity Electrode:** The conductivity electrode will periodically require replacement. The frequency of replacement is dependent on the quality of the water. Also, all handling instructions must be followed carefully to avoid damaging the conductivity electrode. Failure of the conductivity electrode will be indicated by an excessively high or low reading. If the probe cannot be recalibrated, then it must be replaced. Instructions for replacement will be included with the replacement conductivity electrode available from Hydro Instruments.
   Refer to sections I.1, II.4, VI, and Troubleshooting of this manual.

X. TROUBLESHOOTING

Accurate calibration is critical to proper operation. With regards to the recommended troubleshooting points that follow, consider that;

1. 100% response time of the measurement cell may be as long as 10 minutes. Therefore, in order for the analyzer to be accurately calibrated, zero and span calibrations must only be performed after flowing a stable zero sample or stable span sample through the measurement cell for at least 10 minutes prior to performing the calibration point.
2. Zero point calibration with actual sample water having zero chlorine residual may be required. Sample water with zero residual may cause the measurement cell to read above 0mV due to its composition.

Problems with Displayed Residual

Excessive high residual readings

Independently test sample water residual and verify the residual. If the displayed residual is not correct, this may be the result of an improperly performed residual calibration, inadequate A/C ground, a sudden reduction in sample water pH, overfeeding of reagent chemical (if in use), a failed pH probe (if in use) or a failure in the electronic circuit board.

Residual reading does not match test kit residual

This may be the result of an improperly performed residual calibration, a sudden reduction in sample water pH, overfeeding of reagent chemical (if in use), a failed pH probe (if in use), accumulation of foreign matter in the cell or normal wear to the cell electrodes. Carefully perform a new residual span calibration to match the independent test kit measurement.

Unable to perform residual span calibration

1. If span calibrations do not reflect on the operating screen, this means one of two things; (a) the cell signal to the electronic circuit board is at or very close to zero millivolts or (b) the analyzer was previously calibrated with a signal at or very close to zero millivolts.
2. Once this occurs, the analyzer software must be reset by performing a factory default. This is accomplished by turning the power off and then pressing and holding the up and down arrow keys while the unit is turned on.

   NOTE: It is important to note that the residual span calibration should never be performed with a very low residual, as compared to the measurement range for which the analyzer was provided. The span calibration should be performed with a residual value of at least 25% of the ordered range. Ideally, the span calibration should be performed with a residual value of 50% or more of the ordered range. If the normal measurement range is less than 25% of the ordered range, contact Hydro Instruments or an authorized distributor for guidance on resetting the range of the analyzer.

Residual displayed drops to/remains at zero

1. Independently test sample water residual and verify the residual.
2. If the displayed residual is not correct, this may be the result of an improperly performed residual span calibration, coated cell electrodes, inadequate A/C ground, a loss of cell signal connection to the electronic controller, a sudden increase in sample water pH, stoppage of reagent chemical feed (if in use), a failed pH probe (if in use) or a failure in the electronic circuit board.
3. Sample flow has stopped. Check the sample water line for closed valves, blockages, etc.

Residual reading oscillates up and down

1. If oscillations are dramatic, the cause may be an improper grounded A/C or an improperly performed residual calibration.

2. If oscillations are modest and over a period of less than one minute, this can be dampened out by lengthening the residual filter period time (consult factory or your authorized Hydro Instruments dealer to change the filter time).
3. If oscillations are modest and over a longer period of time, performed coinciding test kit samples to determine if the readings are correct or not.

Slow reaction to residual changes

This may be caused by coating of the cell electrodes, dirt or debris in the cell or by excessively long filter times.

Residual reading is unreliable at low residual levels

1. This may be the result of attempting to monitor a residual level at the very low end of the ordered range. For example, if a particular analyzer is ordered and set-up for a measurement range of 0 – 5.0 mg/l and the actual application involves measuring for residuals of 0.1 or 0.2 mg/l, the accuracy of the measurement will suffer. If the normal measurement range is less than 25% of the ordered range, contact Hydro Instruments or an authorized distributor for guidance on resetting the range of the analyzer.
2. This may also be caused by coating of the cell electrodes, dirt or debris in the cell or by improper residual calibration.

   NOTE: It is important to note that the residual span calibration should never be performed with a very low residual, as compared to the measurement range for which the analyzer was provided. The span calibration should be performed with a residual value of at least 25% of the ordered range. Ideally, the span calibration should be performed with a residual value of 50% or more of the ordered range. If the normal measurement range is less than 25% of the ordered range, contact Hydro Instruments or an authorized distributor for guidance on resetting the range of the analyzer.

Temperature

Temperature reading is not correct

1. Independently test sample water temperature and verify the temperature.
2. If the displayed temperature is not correct, recalibrate the temperature.
3. If the displayed temperature is extremely high or extremely low, the thermistor has either lost connection to the circuit board or has failed, requiring replacement. This is a 10K Ohm resistor and replacements are available from Hydro Instruments.

Thermistor is damaged or missing

1. Replace thermistor.
2. The temperature compensation mode can be set to “Manual” to allow for continued analyzer operation until the thermistor is replaced.

pH

pH reading does not match independent pH meter measurement

1. Recalibrate pH.
2. Clean the pH electrode.
3. Recalibration can be performed at a single point (“grab cal”) or at two points using known pH buffers.
4. If the pH being displayed is dramatically incorrect or fluctuating drastically and cannot be corrected, check all pH electrode cable connections as well as the cable connector at the electrode. If all connections are verified and the problem cannot be corrected through through cleaning and/or a two-point calibration, replace the pH electrode.

5. If the raw pH sensor mV values are outside the acceptable ranges listed in the table on Figure 9 of this manual, then replace the pH probe.

ORP

ORP reading does not match independent ORP measurement

1. Recalibrate ORP electrode.
2. Clean the ORP electode.
3. If the ORP being displayed is dramatically incorrect or fluctuating drastically and cannot be corrected, check all ORP cable connections as well as the cable connector at the electrode. If all connections are verified and the problem cannot be corrected through cleaning and/or recalibration, replace the ORP electrode.

Conductivity

Conductivity reading does not match independent conductivity meter measurement

1. Recalibrate conductivity electrode.
2. Clean the conductivity electrode.
3. If the conductivity being displayed is dramatically incorrect or fluctuating drastically and cannot be corrected, check all conductivity cable connections as well as the cable connector to the electrode. If all connections are verified and the problem cannot be corrected through cleaning and/or recalibration, replace the conductivity electrode.

Motor

Motor Jammed

1. This can be caused by debris inside the cell, a jammed cleaning ball or an internal failure of the motor.
2. Turn the power off to the analyzer, shut off the sample water flow and drain the cell. Being sure to catch the cleaning balls, unscrew and remove the probe assembly. Remove all cleaning balls from the cell.
3. Attempt to turn the motor / striker assembly by hand. If a ball or other solid material is jammed in the cell, it may be necessary to move the assembly back and forth to dislodge the jam.
4. If nothing is physically jammed in the cell, turn on the power to test the operation of the motor while the cell is empty of water and cleaning balls to determine if the motor is damaged internally. Check to be sure the striker is not rubbing against the cell wall or gasket(s).

Noisy Motor

1. The specific amount of noise that comes from the motor will vary somewhat from one motor to another. But if the motor becomes noticeably louder, this most likely indicates a problem developing in the cell or inside the motor.
2. Follow steps 2 and 4 from the previous section on “Motor Jammed” to identify the source of the noise.
3. If necessary, replace the motor.

   **IMPORTANT NOTE: Do not attempt to disassemble the motor. It is encapsulated and is not intended to be repaired in the field.*

Motor is hot to the touch

The motor will always operate hot to the touch. The specific temperature of the motor will vary depending on the air temperature. The motor casing temperature is expected to be 35 – 50 degrees Celsius (60 – 90 degrees F Fahrenheit) greater than the air temperature.

Reagent Feed Pump

Reagent feeds too slowly or too fast

1. Adjust the reagent pump speed.
2. If adjusting the pump speed does not correct; replace the pump tube.

Display and Circuit Board

Display is blank

1. Verify the power is turned on to the unit.
2. If it is, check the DC voltage to the analyzer circuit board on terminal connections V- and V+. Refer to Figure 9.
3. A blank display may indicate a failure of the display, the power supply board or the primary circuit board. Consult Hydro Instruments or an authorized representative for assistance.

4-20 mA Output channel values are not accurate

1. Verify the output selection is correct. For example, if the output signal on a 5 mg/l analyzer measuring 2.5 mg/l is something other than 12mA, verify that the output you are measuring is configured to “Resl”.
2. Check the output calibrations at 4mA and 20mA by accessing the appropriate output channel calibration as detailed in the note on Figure 7.

   NOTE: The output calibration numbers from the factory calibration are recorded on the inside of the electronics enclosure for future reference.
3. Check to see if the Sample Flow Stop alarm is active. If the Sample Flow Stop Alarm is active the 4-20mA outputs will be frozen. Correct the sample water flow issue. Once the Sample Flow Stop alarm has been cleared the 4-20mA outputs will indicate live readings. If the optional sample flow switch is not installed than the setting for the Sample Flow Stop alarm may be wrongfully enabled.

Communication Errors

The MB410 Display board is communicating with the other boards by Modbus over the ribbon cable. If the ribbon cable is not properly connected to each board, then the MB410 Display board may lose communication with one or more circuit boards. If so, you would see a “COMM ERROR” message such as “Node 1 Error”. Node numbers are identified on Figures 10 and 11. As can be seen there, the MB127 board is Node 1. If such an error occurs, check to ensure that the ribbon cable is properly connected to all relevant circuit boards per Figure 11.

TABLE 2: Circuit Board Descriptions and Node Numbers

Node Number (Comm Error)	Circuit Board	Board Description	Application
1	MB127	Cl2 Cell Board	Measurement Cell
2	MB128	Temp2, pH & Flow mA Board	pH, Temp and PV1 mA input
3	MB128	Temp3, ORP	ORP
4	MB130	Temp4, Conductivity	Conductivity
5	MB114	Four Analog Outputs Board	4-20mA outputs
6	MB104	Four Relay Board	Relay outputs
7	MB181	Eight Contact Inputs Board	Flow Stop Switch
-	MJ500	Real-time Clock	Data Logger

XI. OPTIONAL DATA LOGGER

1. **Description:** When enabled in the analyzer software, the data logger records the measured residual, sample water temperature, turbidity, and pH value (if being measured) at a selectable frequency. This data is recorded on the Micro SDHC memory card and can be retrieved using any text-reading program. The Micro SDHC memory card is installed in the slot on the MB410 board as indicated on Figure 11 of this manual. To use the data logger the controller must be provided with the MJ500 Real Time Clock board (which mounts directly on the MB410 board as shown on Figure 11).

2. **Operation:** To enable, enter the configuration menu on the residual analyzer control software and select the option "DL". The first menu option that appears will be the On/Off menu. The menus which follow allow for adjustment of the data logger frequency and for changes to the clock (date and time). See figure 7.

   a. ***Frequency***: The frequency is the time interval between data recordings. The frequency is adjustable in seconds, with a minimum setting of 5 seconds.

   b. ***Data Logger Clock***: The clock is factory-set before shipment. However, because the clock is set on Eastern Standard time it may be necessary to change the date and time upon start-up.

3. **Stored Data Files:** The data will be written to text files on the Micro SDHC memory card. The formatting and handling of these files is as described below:

   a. ***File Format:*** The following is an example data file to illustrate the format used. As you can see, there is a three line header for each file. The fourth and fifth lines are headers for the data. You will see that each header and data entry is delimited by a comma.

   b. ***File Name:*** Each data file will be named according to the date on which it was created. For example if created on May 24, 2016, the file name would be May24_16.txt

      i. If the Micro SDHC memory card already has a file started earlier on the same day, then data will be written onto the existing file.

      ii. The text files are limited to 5 MB. Once this limit has been reached, a new file will automatically be created to allow data to continue to be written.

   c. ***Importing data into Excel:*** The data files can be imported into Excel as follows:

      NOTE: This assumes use of Excel 2007 version.

      i. Select the "Data" tab.

      ii. Among the "Get External Data" tabs on the toolbar, select "From Text"

      iii. A pop up window will appear allowing you to search for and select the data file that you wish to import. After you have selected the file, click on "IMPORT".

      iv. Another pop up window "Text Import Wizard – Step 1 of 3" will then appear.

         1. Here under "Original Data Type" you must select "Delimited".

         2. Lower down you are asked to select "Start import at row:___". In order to eliminate the 3 line file header, you can select "4" here to start the data import on row 4 of the file.

         3. Then click "Next".

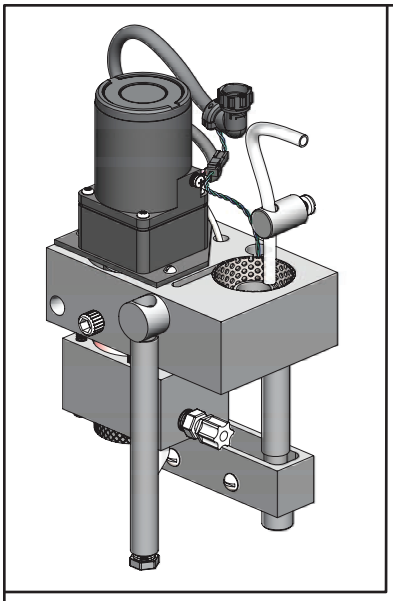
      v. On the next pop up window "Text Import Wizard – Step 2 of 3" you need to select the type of delimiter being used in the data file. The data entries in these files are delimited by commas and so you must select "Comma". After selecting Comma and only Comma, then click "Next".

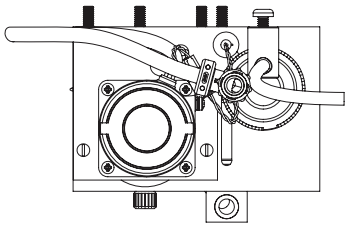
      vi. On the next pop up window "Text Import Wizard – Step 3 of 3" you can accept the "Column data format" setting of "General" and then click "Finish".

vii. On the next (and final) pop up window “Import Data”, it is asking you whether you will import to the worksheet that is open or if you want to import it to a new worksheet. Make your selection and then click “OK”. Now the data should have been imported into the Excel spreadsheet.

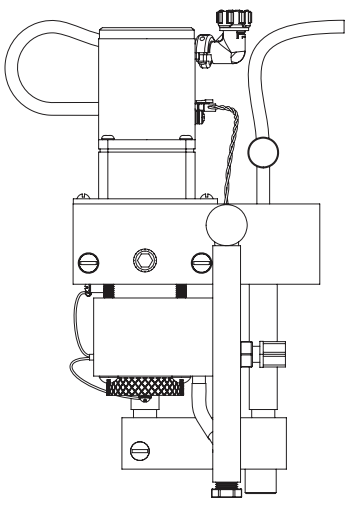
TABLE 3: Hydro Instruments RAH-210 Residual Data Log File V5.1

Date	Time	Resl	Temp	pH	Turb1	Turb2	Flow	MF	Raw Resl
MM/DD/YEAR	**HH:MM:SS**	**PPM**	**C**		**NTU**	**NTU**			**mV**
05/24/2016	11:25:06	0.80	23	7.80	0.50	1.00	0	1.80	22
05/24/2016	11:26:06	0.81	23	7.80	0.55	1.02	0	1.80	22
05/24/2016	11:27:06	0.80	23	7.81	0.53	1.03	0	1.81	22
05/24/2016	11:28:06	0.81	23	7.81	0.54	1.03	0	1.81	22
05/24/2016	11:29:06	0.80	23	7.81	0.53	1.02	0	1.81	22

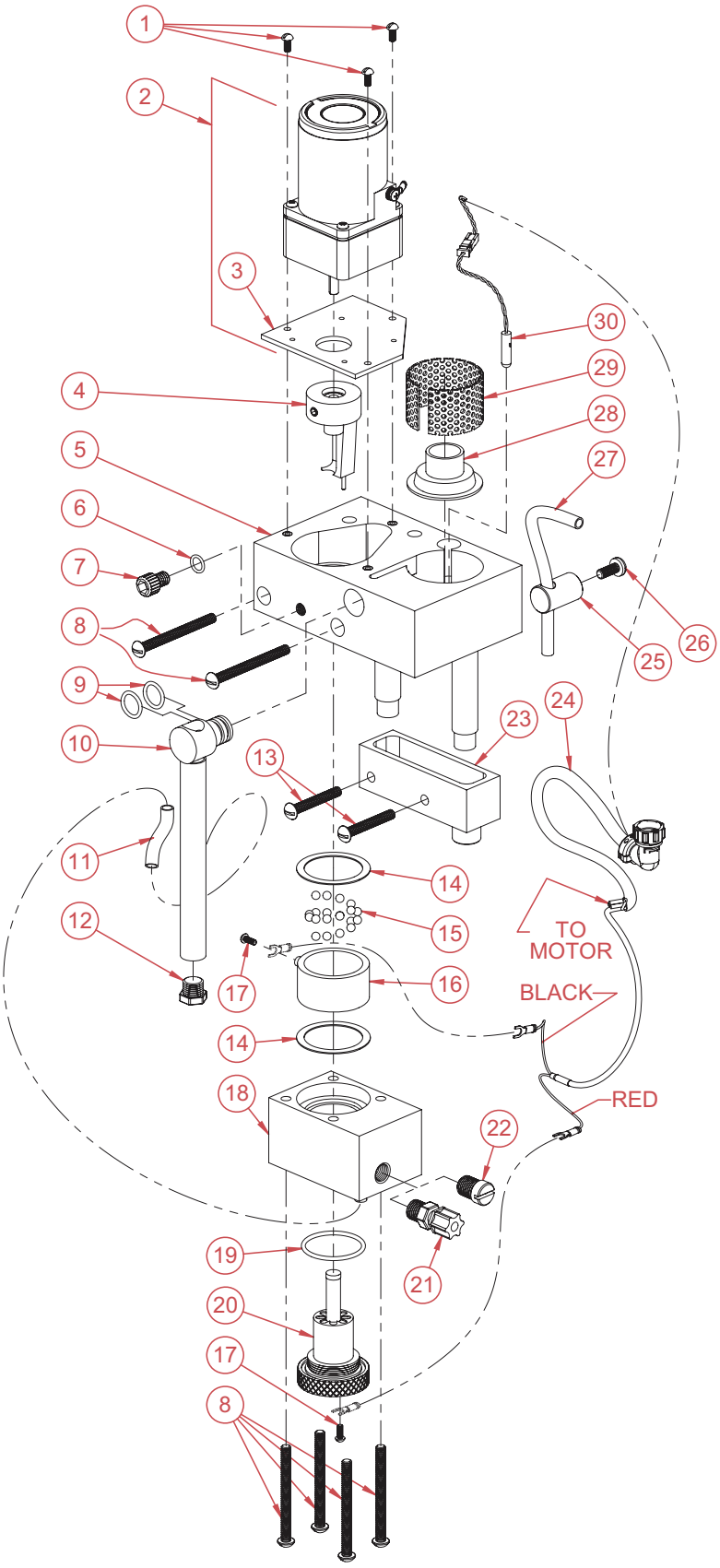




TOP



FRONT



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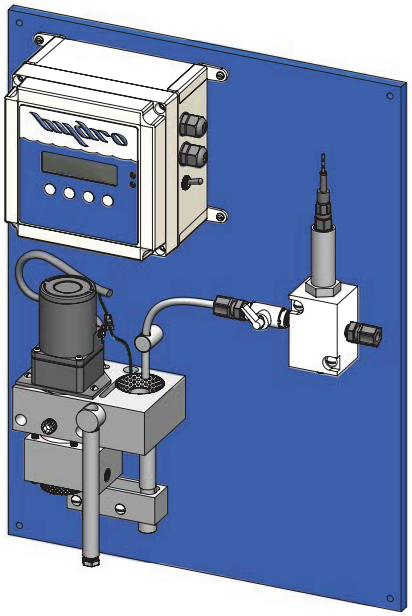
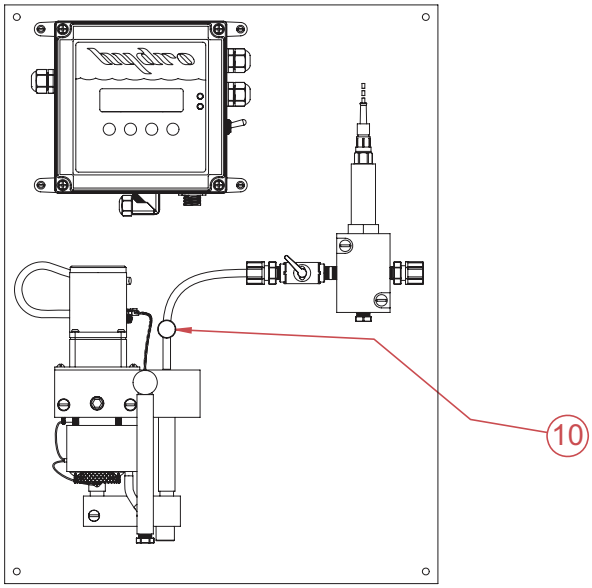
RESIDUAL CHLORINE ANALYZER
MEASUREMENT CELL

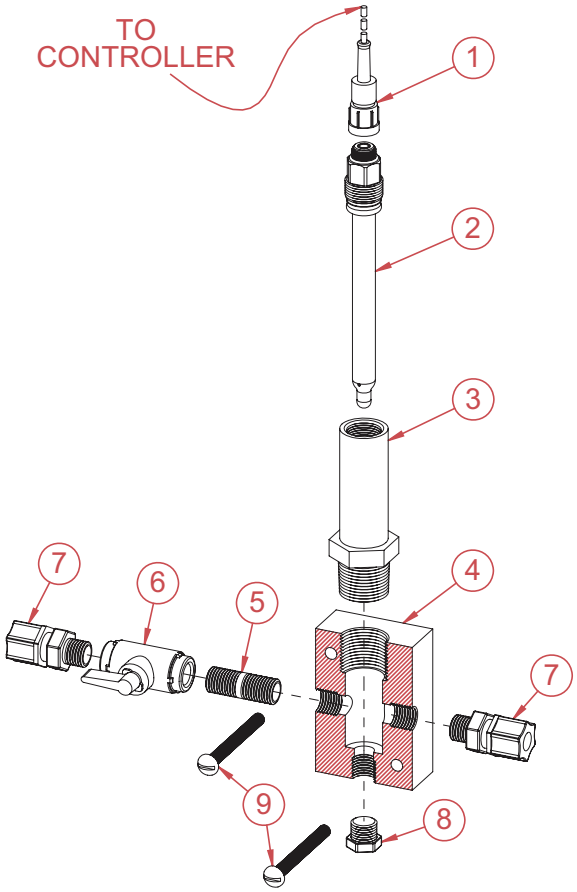
Date: 2023-01-19-v1
EXPLODED VIEW
Dwg. No. RAH-210-CELL, EXP

Item No.	Description	Quantity	Part No.
1	8-32 x ⅜" Stainless Steel Bolt (RHMS)	3	BTH-RA-169
2	Motor Assembly (120 VAC)	1	RAH-1087-115
2	Motor Assembly (240 VAC)	1	RAH-1087-230
3	Motor Plate	1	RAH-108-1
4	Striker Assembly	1	RAH-242
5	Top Body	1	RAH-232
6	PM O-Ring	1	OH-BUN-012
7	Front Plug	1	RAH-833
8	¼-20 x 2¾" Stainless Steel Bolt (RHMS)	6	BTH-RA-125
9	PM O-Ring	2	OH-BUN-113
10	Flow Tube Assembly	1	RAH-228
11	PM Flow Tube Piece	1	RAH-488
12	Flush Plug	1	RAH-472
13	¼-20 x 1¾" Stainless Steel Bolt (RHMS)	2	BTH-RA-124
14	PM Gasket	2	GAH-BUN-130
15	PM Cleaning Balls	1	RAH-471
16	PM Copper Cell	1	RAH-263
17	6-32 x ¼" Stainless Steel Bolt (RHMS)	2	BTH-RA-127
18	Bottom Body	1	RAH-442
19	PM O-Ring	1	OH-BUN-128
20	Gold Probe Assembly	1	RAH-226-AU-1
21	¼" NPT ¼" Tube Tubing Connector (PVDF Kynar)	1	10-4-4-KO
22	¼" NPT Plug	1	PLH-108-250
23	Drain Assembly	1	RAH-1128
24	Cell Assembly Wiring Harness (included with motor assembly)	1	
25	Tubing Guide	1	RAH-460
26	¼-20 x ⅝" Stainless Steel Bolt (PHMS)	1	BTH-RA-270
27	⅜" OD x ¼" ID Black Tubing	1	P-138
28	Overflow Tube	1	RAH-445
29	Straining Screen	1	RAH-267
30	Thermistor	1	RAH-THERMISTOR
PM	Part and Maintenance Kit	1	KT1-RAH-210
-	Complete Measurement Cell Assembly (120 VAC)	1	RAMC-120-AU
-	Complete Measurement Cell Assembly (240 VAC)	1	RAMC-240-AU

Note: Complete assemblies include all items except No.8, 13 and 23.







Item No.	Description	Quantity	Part No.
1	pH Probe Cable	1	PHE-14-S7
2	pH Electrode	1	PHE-14-135
3	pH Probe Gland	1	PHV-GLAND
4	pH Fixure	1	AFC-CHP-025
5	¼" x 1½" PVC Nipple	1	880-015
6	¼" Ball Valve	1	22321
7	Tubing Connector	2	BKF-64
8	¼" PVC Plug	1	850-002
9	¼-20 x 2¼" SS (PHMS)	2	BTH-RA-129
10	Tubing Guide	1	RAH-460

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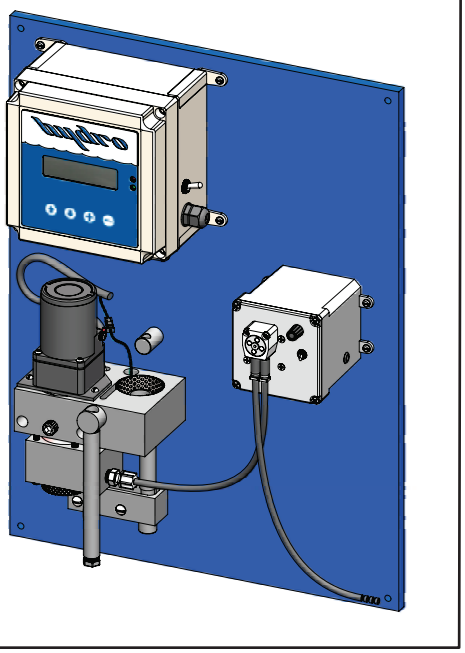
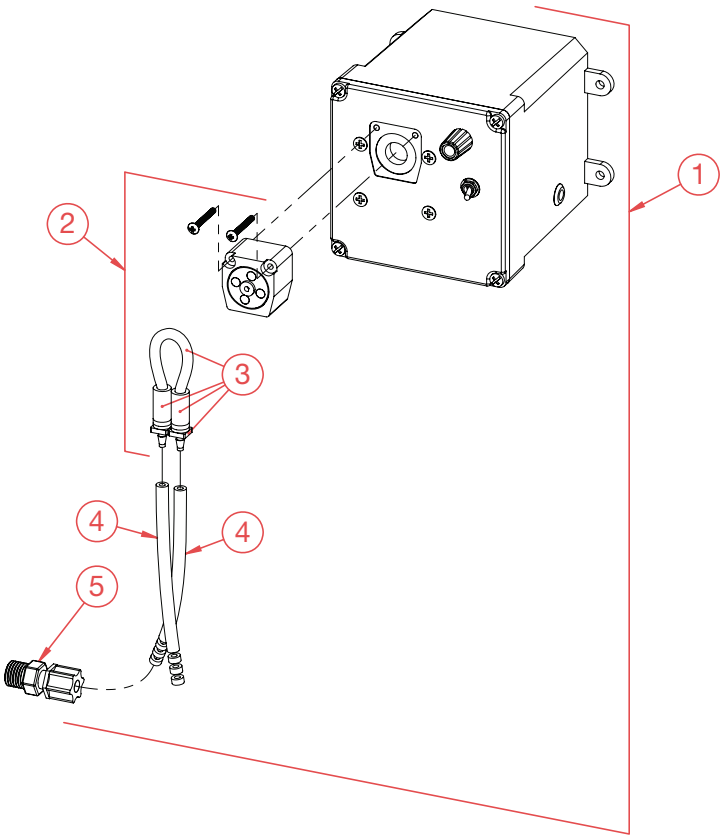
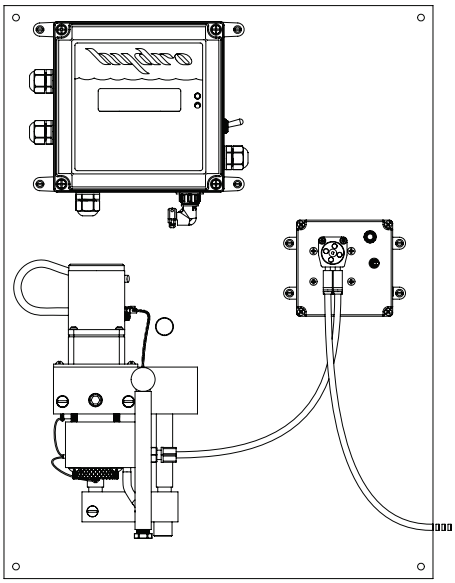
RESIDUAL CHLORINE ANALYZER
OPTION: pH PROBE

Date: 2020-07-02-v1
EXPLODED VIEW & BOM
Dwg. No. RAH-210-PROBE







Item No.	Description	Quantity	Part No.
1	Buffer Feed Peristaltic Pump Assembly	1	RAH-RFP
2	Pumphead Assembly with Pump Tube, Hose Barbs, and Screws	1	RAH-101-951
3	Neoprene Pump Tube with Hose Barbs	1	RAH-TS-NOR
4	¼" LDPE Tubing	1	P-114
5	¼" NPT ¼" Tube Tubing Connector (PVDF Kynar)	1	10-4-4-KO

NOTES:

1. Item 4, P-114 ¼" LDPE Tubing is ordered per foot. The tubing can be cut to the required length.
2. At least 18" (46 cm) of the P-114 ¼" LDPE Tubing is needed from the pump head to the measurement cell.

RESIDUAL CHLORINE ANALYZER
OPTION: BUFFER FEED PUMP

Date: 2020-09-18-v1
EXPLODED VIEW & BOM
Dwg. No. RAH-210-PUMP

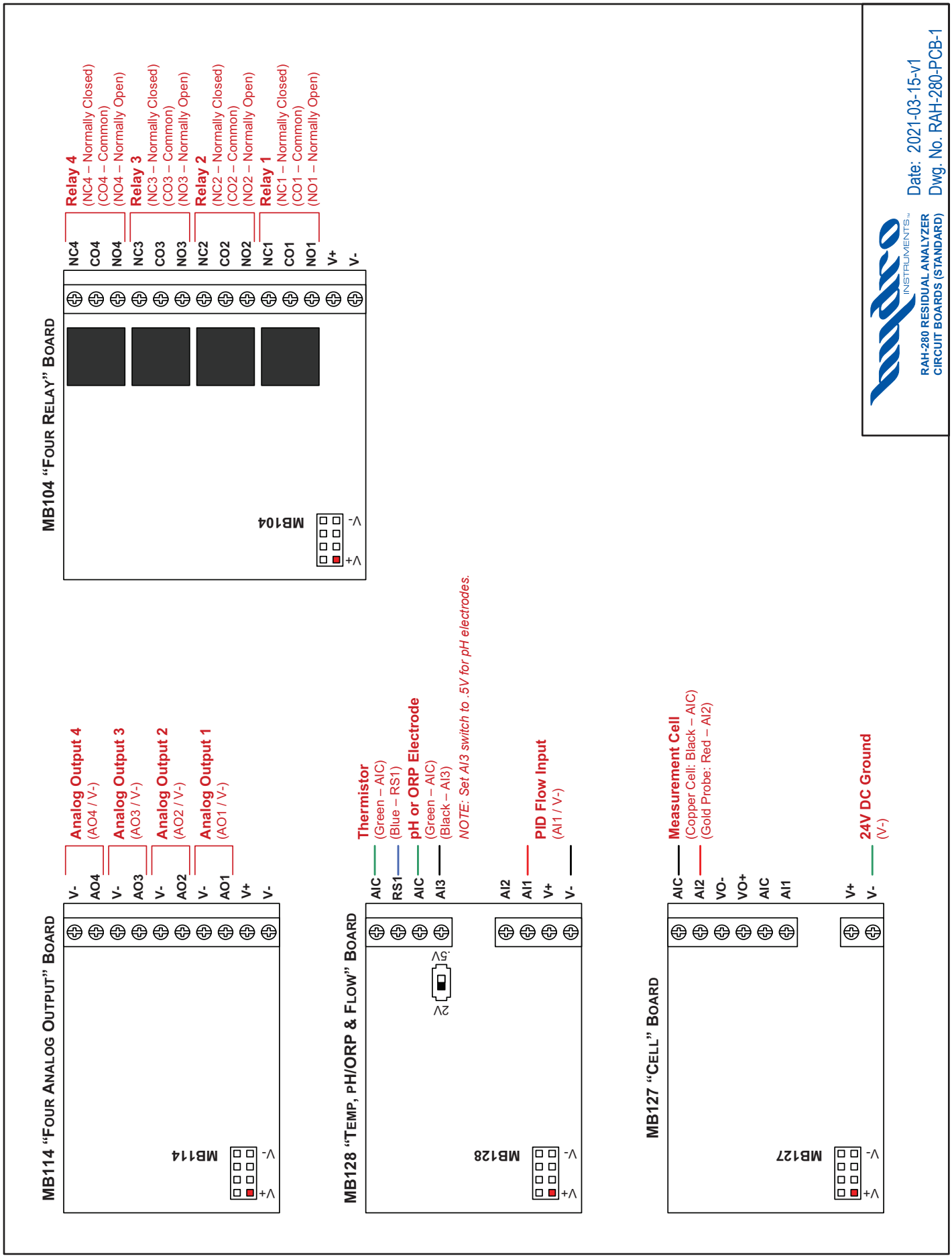

MB104 "FOUR RELAY" BOARD
NC4
CO4
NO4
NC3
CO3
NO3
NC2
CO2
NO2
NC1
CO1
NO1
V+
V-
Relay 4
(NC4 – Normally Closed)
(CO4 – Common)
(NO4 – Normally Open)
Relay 3
(NC3 – Normally Closed)
(CO3 – Common)
(NO3 – Normally Open)
Relay 2
(NC2 – Normally Closed)
(CO2 – Common)
(NO2 – Normally Open)
Relay 1
(NC1 – Normally Closed)
(CO1 – Common)
(NO1 – Normally Open)
MB104
V+
V-
MB114 "FOUR ANALOG OUTPUT" BOARD
V-
AO4
V-
AO3
V-
AO2
V-
AO1
V+
V-
Analog Output 4
(AO4 / V-)
Analog Output 3
(AO3 / V-)
Analog Output 2
(AO2 / V-)
Analog Output 1
(AO1 / V-)
MB114
V+
V-
MB128 "TEMP, PH/ORP & FLOW" BOARD
AIC
RS1
AIC
AI3
2V
.5V
AI2
AI1
V+
V-
Thermistor
(Green – AIC)
(Blue – RS1)
pH or ORP Electrode
(Green – AIC)
(Black – AI3)
NOTE: Set AI3 switch to .5V for pH electrodes.
PID Flow Input
(AI1 / V-)
MB128
V+
V-
MB127 "CELL" BOARD
AIC
AI2
VO-
VO+
AIC
AI1
V+
V-
Measurement Cell
(Copper Cell: Black – AIC)
(Gold Probe: Red – AI2)
24V DC Ground
(V-)
MB127
V+
V-
RAH-280 RESIDUAL ANALYZER
CIRCUIT BOARDS (STANDARD)
Date: 2021-03-15-v1
Dwg. No. RAH-280-PCB-1

FIGURE 10 (RAH-280 Circuit Boards - Optional)

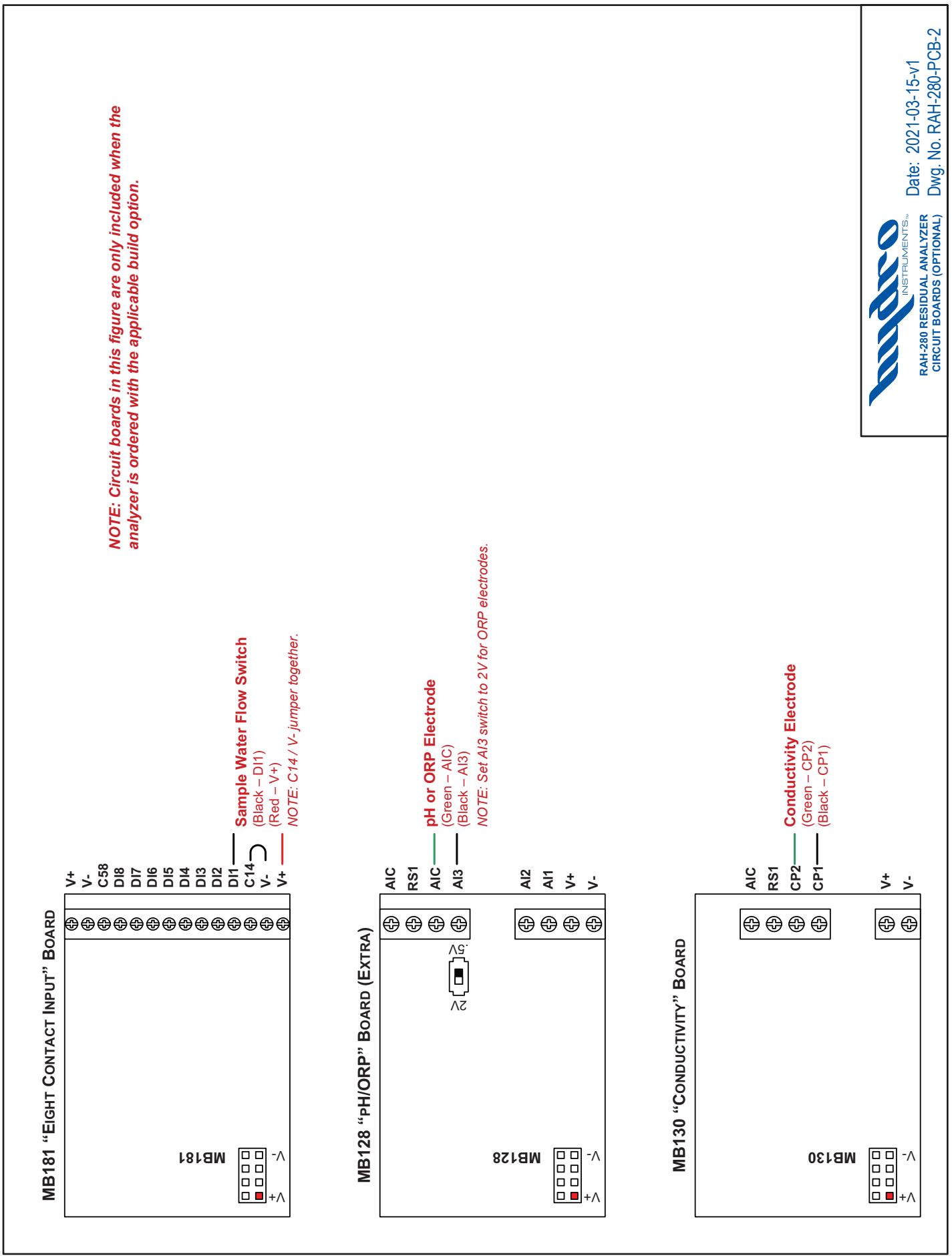


FIGURE 11 (Monitor Internal Wiring and Connections)