

# Series 250 Amperometric Residual Chlorine Analyzer

**Instruction Manual** 



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RPH-250 Rev. 8/1/17

## Hydro Instruments Series 250 Amperometric Residual Chlorine Analyzer

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## I. FUNCTIONS AND CAPABILITIES

**1. Basic Concept Description:** The Series RPH-250 Residual Analyzer uses a measurement sensor consisting of a cathode and an anode immersed in electrolyte behind a semipermeable membrane. This measurement method is referred to as Amperometric and has been in use for over 50 years.

As described below, the measurement sensor can be used to measure the concentration of Free Chlorine, Total Chlorine, or Chlorine Dioxide (must be ordered for desired measurement type and range). Certain chemical species producean electrical current in the sensor that is proportional to their concentration in the sample water. This electrical current is read and manipulated by the Series RPH-250 monitor as the sample water continuously flows across the probe membrane at a controlled rate. A Temperature sensor is employed to compensate for signal fluctuations caused by Temperature changes. When measuring for Free Chlorine, either the pH of the sample water is manually entered for pH compensation in the software, a pH buffer feed system is used to control the pH in the sample water, or a pH probe is used for automatic compensation in the software.

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.** 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)<sub>2</sub>

 $Ca(OCl)_{2} + 2H_{2}O \iff 2HOCl + Ca^{++} + 2OH^{-1}$ 

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:

 $NH_3 + HOCl \rightarrow H_2O + NH_2Cl (Monochloramine)$   $NH_3 + 2HOCl \rightarrow 2H_2O + NHCl_2 (Dichloramine)$  $NH_3 + 3HOCl \rightarrow 3H_2O + NCl_3 (Nitrogen Trichloride)$ 

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".

#### 3. Measurement Chemistry:

*Free Chlorine Measurements:* As discussed in Section I.2, Free Chlorine is the sum of Hypochlorous Acid and Hypochlorite Ion. Hypochlorous Acid is a reducible species in the Series RPH-250 Residual Chlorine Analyzer. Therefore the measurement probe 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:

 $HOCl + 2e^{-} \rightarrow Cl^{-} + OH^{-}$ 

In summary, accurate pH and temperature readings are vital to obtaining an accurate residual reading. This can either be done by installing a buffer line or using a pH electrode and thermistor.

**Total Chlorine Measurement:** Because Total Chlorine is comprised of a combination of several different molecules, the effects of pH varies for each of these molecules and because the percentage of each molecule as a part of Total Chlorine will not be known, it is not possible to realistically or accurately compensate mathematically for varying pH levels in sample water. If sample water pH varies significantly, it is recommended that the sample line be injected with a pH buffer (Acetic Acid) prior to entering the analyzer cell. Reducing the sample water pH to roughly 5.0 or lower will essentially eliminate any concern of changing pH levels negatively affecting the accuracy of the Total Chlorine analyzer.

#### 4. Basic Specifications

Temperature Range: 5° to 45° C (41° to 113° F). Sample Water Flow Rate: 500 ml/minute / .13 GPM / 8 GPH. 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. Full-scale residual change 90 to 120 seconds. Sample Water: Metal ions or certain corrosion inhibitors may effect analyzer operation. Water must not contain surfactant. Free Chlorine Residual Ranges: 0-2, 0-5, 0-10, 0-20, 0-100, 0-200 PPM. Total Chlorine Residual Ranges: 0-2, 0-5, 0-10, 0-20 PPM Power Consumption: 10 W max. Power Requirements: Any voltage from 100 to 255 V (50-60 Hz), single phase. Accuracy: 0.01 mg/l or +/-1% of range, whichever is larger. Sensitivity: 0.005 mg/l (5 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.



## **II. SYSTEM COMPONENT DESCRIPTION**

#### Refer to Figure 2 for this section.

**1. Temperature Probe:** A Thermistor is used to continuously measure the sample water Temperature. The Temperature can be displayed and retransmitted by the RPH-250 Residual Chlorine Analyzer. It is also used in software for signal manipulation for the two following reasons:

*Temperature compensation for the effects of Thermal Diffusion:* 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.

2. Optional pH Probe: If the unit is not fitted with the reagent feed system then it is recommend that the unit be equipped with an external pH probe. This probe is mounted and 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.

## **III. INSTALLATION**

Refer to Figure 2 for this section.

1. Sample Water Connection and Control: The following are some considerations relating to the sample water supply. The Series 250 Residual Chlorine 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 residual analyzer 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 3 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 of the residual analyzer.

**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 residual analyzer. 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 residual analyzer.

**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 residual analyzer 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 residual analyzer. Refer to the MSDS of the chemical in question for instructions on proper disposal.

#### 3. Sample Point Selection: Consider Figure 4 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 residual analyzer.

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 (Sample Sources)



#### FIGURE 4 (Installation Example)



## IV. CHLORINE 4-20 mA SENSORS

### 1. Introduction

a. **Chlorine Sensor Assembly:** The chlorine sensor is shipped with the membrane cap installed. The membrane cap must be removed and filled with electrolyte before use.

**WARNING:** When removing the membrane cap do not touch silver chloride electrode surface. This may damage the chlorine sensor. (See Figure 5)

NOTES:

- 1. Membrane caps are specific to the type of chlorine sensor used. The correct membrane cap must be used for proper operation. For membrane cap part numbers see Dwg. No. RPH-250 BOM in this document.
- 2. Electrolyte solutions are specific to the type of chlorine sensor used. The correct electrolyte must be used for proper operation. For electrolyte part numbers see Dwg. No. RPH-250 BOM in this document.
- 3. The electrolyte has an expiration date printed on the bottle. Do not use electrolyte that has expired.

#### b. Membrane Cap Assembly:

- 1. Remove or lift rubber band from the membrane cap to expose the vent hole before removing from the sensor.
- 2. Remove the membrane cap from the chlorine sensor's body as shown in Figure 6.
- 3. Fill the membrane cap to the top with electrolyte as shown in Figure 7. Do not shake the electrolyte before filling the cap. Air bubbles must not be present in the electrolyte because they can create pressure that can damage the membrane. Be sure to re-cap the electrolyte and store until next use.
- 4. Hold the Sensor's body vertically and screw the membrane cap onto the Sensor's body. Some electrolyte will be displaced out of the cap and through the vent hole as shown in Figure 8. Screw the membrane cap until it is hand tight on the body.



5. Replace rubber band into cap groove and rinse the Sensor with running water and wash your hands. NOTE: IF ELECTRODE IS STORED DRY OUT OF FLOW CELL AND WATER OR SALT CRYSTALS ARE SEEN ON MEMBRANE OR WHERE CAP THREADS ONTO BODY A LEAK IS PRESENT. REPLACE CAP AND ELECTROLYTE BEFORE INSTALLING INTO FLOW CELL.

### 2. Sensor Installation Into Flow Cell

To obtain accurate Chlorine reading, the Sensor must be installed into the Flow Cell to prevent air bubble formation on the membrane.

- a. First install threaded fitting into the AFC-TH threaded holder.
- b. Slide o-ring onto body of sensor until it reaches the bottom of threaded fitting
- c. Place sensor assembly into top of flow cell (See parts diagram on page 30).
- d. Install tubing connectors into their respective inlet and outlet lines (See parts diagram on page 30).

### 3. Electrical Installation

The chlorine sensor output is 4-20mA. This signal is proportional to the chlorine probes range. See Figure 13 for more details.

- a. Some analyzers are supplied with a sample water ground pin to prevent electrical interferences that may be present in the sample water. This sample water ground pin is tied into the incoming AC ground.
- b. The chlorine probe is powered from the MB126 circuit board with an isolated 24 VDC output, terminal (VO+). This isolated output must be used to power the chlorine sensor to prevent electrical interferences and may not be connected to anything else.
- c. The chlorine probes 4-20mA signal is received by the MB126 circuit board, terminal (AI1).
- d. If a pH probe is not being used a jumper wire must be connected between the AI3 & AIC terminals on the MB126 circuit board. Failure to install the jumper will cause the A/D converter to be inaccurate.

*NOTE:* If a pH probe is installed it is normal for the chlorine residual reading to be effected when the pH probe is removed from the flow cell.

### 4. Sensor Conditioning

The sensor requires conditioning prior to generating stable values.

- a. For new Sensors, allow the Sensor to run overnight before calibration.
- b. If the Sensor will be unpowered for 2 hours or more, run for 3 hours prior to use.
- c. After membrane/electrolyte replacement, allow the Sensor to run for one hour.

### 5. Sensor Storage

Store sensor at 5° C- 50° C ONLY.

- a. Short Term Storage (1 week or less): Store in Flow cell with water to prevent the probe from drying out.
- b. Intermediate Term (1 week to 1 month): Store in cap, bottle, or beaker with water to keep membrane wet.
- c. Long Term (1 month or longer): Remove Membrane Cap, rinse cap and electrodes with distilled or deionized water. Allow to dry. Loosely screw cap onto Sensor (do not screw on cap so that it stretches the membrane).

### 6. Sensor Maintenance/Reconditioning

**Membrane Replacement:** If membrane replacement is required, a new cap with preinstalled membrane must be used. Order appropriate cap/membrane replacement. Follow directions in Section IV.1 for reassembly of the sensor.

### 7. Sensor Troubleshooting (Calibration Problems)

- a. Sensor output HIGHER than DPD test:
  - 1. Run in time too short
  - 2. Membrane cap damaged
  - 3. Interference from water contaminants (see Specifications, "Cross Sensitivity")
  - 4. Cable short circuit or damage
  - 5. pH value less than pH 5.5
- b. Sensor output LOWER than DPD test:
  - 1. Run in time too short
  - 2. Deposits on Membrane cap
  - 3. Flow rate too low
  - 4. Air bubbles on membrane
  - 5. Surfactants in water
  - 6. pH value more than pH 8.0
  - 7. No electrolyte in membrane cap
- c. Sensor ouput is 4mA (zero ppm):
  - 1. Run in time too short
  - 2. Only bound chlorine present
  - 3. Chlorine content below detection limit
  - 4. Sensor not wired correctly (See Part 3 of this section)
  - 5. Defective sensor
- d. Sensor output UNSTABLE:
  - 1. Air bubbles on membrane
  - 2. Membrane damage
  - 3. Non-sensor problem

### 8. Conditioning the Analyzer

Before calibration is carried out, the analyzer should be operated for at least 4 hours to allow the readings to stabilize.

- 1. Start the sample water flow to the measurement cell. Water must be flowing at a steady rate.
- 2. Sample flow rate should be set between 8 and 26 GPH (30 and 100 LPH). Under all circumstances, the electrodes must be kept wet, even if the sample water flow must stop periodically. See Figure 2.
- 3. If necessary a flushable y-strainer should be installed to prevent clogging in the sample line. Other filters are not recommended.
- 4. Turn on the power to the analyzer.
- 5. Check for air bubbles in the sample line. Remove any air bubbles.
- 6. Allow the analyzer to operate with the sample water flowing for at least 4 hours. After this, the analyzer can be calibrated.

## **V. CALIBRATION AND PROGRAMMING**

#### 1. Modes of the RPH-250 Residual Analyzer

- a. *Operation Mode (See Section VII):* This is the mode used during normal operation of the RPH-250 Analyzer. It provides a display of the current residual reading, water temperature reading, pH and any alarm conditions that may exist.
- b. *Configuration and Calibration Mode (Programming) (See Section VIII):* This mode is used to set up the display options, operational parameters and other features.
- c. *PID Control Mode (See Section IX):* This mode enables and configures the PID Control program in the software. The program can perform proportional, set-point (residual) or compound loop control. One or more of the analog outputs (AO1 to AO4) can be programmed to transmit a 4-20 mA control signal.

#### 2. Switching Between Modes

- a. *Operation Mode:* This is the standard mode, which appears during initial powering of the device. To return to this mode from any other screen simply press the ( ) button repeatedly.
- b. *Configuration and Calibration Mode:* This mode is accessed from the Operation Mode by pressing the button until the password screen is reached. Then enter the password "250" and then press the button.
- c. *PID Control Mode:* When enabled, this program will display several general status and control screens in the Operation Mode. To access the screens, which allow this program to be set-up, press the () button (in the Operation Mode) until the password screen is reached. Then enter the password "220" 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 ① or ① 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 9 (Operation Menu Flow Chart)



## **VI. EXPLANATION OF OPERATION MODE SCREENS**

*Main:* This screen will display the residual value as well as the sample water temperature. If "Manual", "Auto" or "Monitor" is selected as the "pH Compensation Mode", the main screen will also display the pH value.

Alarm Status: Displays any existing alarm conditions.

*Turbidity:* This screen is present when one or more of the two Turbidity channels is enabled. It displays Turbidity reading(s).

*Control Operational:* This menu appears when the PID Control program is enabled. It displays the PID Control Status (Manual or Auto), the Process Variable(s) and the Process Output. To change between "Auto" and "Manual" control status, press the  $\bigcirc$  button. When Compound Loop Control is in use, there will be two Control Operation screens.

*Set Dosage:* This menu appears when the PID Control program is enabled and the Control Mode is selected as either Proportional or Compound Loop Control. This is an adjustable factor that is multiplied to the incoming flow signal.

*Set Point RES/ORP:* This menu appears when the PID Control program is enabled and the Control Mode is selected as either Residual or Compound Loop Control. This is an adjustable factor that represents the desired value for residual (or ORP).

*Set PO1:* This menu appears when the PID Control program is enabled and the control status is set to "Manual". On this screen, the control output can be changed by pressing the (+) and (-) buttons.

*Skip to RES Span Cal?:* This screen allows a direct jump to the residual span cal screen (bypassing the password). To pass this screen, press the button twice or press the button when the word "No" is blinking.

*Enter Password:* This screen allows access to the configuration or PID Control menus. Enter the desired password and then press the button.

## FIGURE 10 (Configuration Menu Flow Chart)

#### **Configuration Menus (Configuration Menu Flow Chart)**



## **VII. EXPLANATION OF CONFIGURATION MODE SCREENS**

*Main:* The Configuration Mode is structured as a "tree branch" program. The main screen is the trunk from which each branch can be accessed (Figure 10 pg. 15). Seven options appear on this screen, with one option blinking. To change which option is blinking, press the  $\textcircled{\bullet}$  button. To select the blinking option, press the  $\textcircled{\bullet}$  button. To access the configuration mode from the operation mode scroll down and enter "250" as the password when prompted.

*Res:* This branch accesses the settings for the residual (as related only to the analyzer). To calibrate the instrument residual, follow the steps below.

Residual Units: Select PPM or MG/L.

Residual Decimal Position: Select desired decimal place for residual.

*Residual Full Scale:* Enter desired full scale (range). This setting is what a 20 mA residual output signal represents. An output of 4mA always represents a residual of zero.

Residual Low Alarm: Enter low residual alarm trip-point (if desired).

Residual High Alarm: Enter high residual alarm trip-point (if desired).

**Begin Residual Zero Cal?:** The residual zero calibration has been performed at the factory prior to shipment and generally should not be required in the field. To access this calibration menu, follow the steps noted on Figure 10. To pass by this screen, press the button twice or press the button when the word "Skip" is blinking. To perform a residual zero cal, press the button to make the word "Begin" blink. Then press the button.

<u>NOTE</u>: Although it is recommended, the residual zero calibration does not necessarily have to be performed with "zero-residual" water. However, it is advisable to perform zero and span calibrations with two samples of significantly differing residual values.

*Residual Zero Cal:* 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.

**Begin Residual Span Cal**?: To pass by this screen, press the I button twice or press the I button when the word "Skip" is blinking. To perform a residual span cal, press the I button to make the word "Begin" blink. Then press the I button.

*Residual Span Cal:* 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.

*Temp:* This branch accesses the settings for the temperature. To calibrate the temperature, follow the steps below.

Temperature Units: Select "F" (Fahrenheit) or "C" (Celsius).

*Temperature Mode:* Select "Manual" or "Auto". Automatic enables the temperature to be automatically detected via the thermistor.

*Manual Temperature:* This screen appears when Temperature Mode "Manual" has been selected. Enter the sample water temperature using the  $\oplus$  and  $\bigcirc$  buttons.

*Temp Sample Cal:* This screen appears when Temperature Mode "Auto" has been selected. The temperature displayed represents what the program interprets the current temperature reading to be. If necessary, adjust the displayed temperature using the (-) and (-) buttons.

<u>NOTE</u>: Displaying the temperature on the main operating screen is optional and can be changed by accessing a hidden menu as detailed in the note on Figure 10.

*pH*: This branch accesses the pH compensation settings and pH electrode calibration.

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

- 1. *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.
- 2. *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.
- 3. *Manual:* In this mode, the pH value of the sample water can be entered and will remain fixed unless changed. See Figure 9 for explanation of this option.
- 4. *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.

If Auto or Monitor modes have been chosen; on the following screen you can select your calibration type. Select the calibration method based on recommendations A-D below.

*pH Calibration Type:* The residual analyzer allows the user to select from four different calibration methods including: 4-7 pH calibration, 7-10 pH calibration, 4-10 pH calibration, and the sample pH calibration. The calibration type to use is completely up to the user. However Hydro Instruments recommends using the following setting:

- 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 "4-7" calibration.
- C. If sample pH is greater than seven, use the "7-10 calibration.
- D. If sample stream is subject to wide swings in pH, use the "4-10" calibration.

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 – 7 pH, 7 – 10 pH & 4 – 10 pH: 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 25°C. Error in *pH* readings can occur if buffer temperatures are drastically different from their prescribed temperature (+/- 5°C). 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.

AOut: This branch accesses the settings for the four 4-20mA output channels. (AO1, AO2, AO3, AO4)

*Select AOX:* Each of the four analog output channels can be independently set to represent one of the following parameters.

*Residual:* When "resl" is selected, the analog output will send a 4-20 analog signal representative of the residual value (4 mA being zero residual and 20 mA being full scale residual).

*PO1:* When "PO1" is selected, the analog output will send a 4-20 analog signal representative of the PID Control Program Process Output (4 mA being zero and 20 mA being PO1 full scale).

*pH:* When "pH" is selected, the analog output will send a 4-20 analog signal representative of the pH value (4 mA being zero pH and 20 mA being 14 pH).

*Temp:* When "Temp" is selected, the analog output will send a 4-20 mA analog signal representative of the sample water temperature (4 mA being 0° C / 32° F and 20 mA being 50° C / 122° F).

*Turb1/Turb2:* When Turb1 or Turb2 is selected the analog output will send a 4-20mA analog signal representative of the corresponding Turbidity reading.

<u>NOTE</u>: The AOX output calibration menus are accessed as detailed in the note on Figure 10.

*AOX 4mA Cal:* This screen allows for calibration of the AOX 4mA output. Using a meter to read the output, fine adjustments can be made using the + and - buttons.

*AOX 20mA Cal:* This screen allows for calibration of the AOX 20mA output. Using a meter to read the output, fine adjustments can be made using the  $\oplus$  and  $\bigcirc$  buttons.

*Alarm:* This branch accesses the settings for the four alarm relays. (Relay 1, Relay 2, Relay 3, Relay 4)

*Alarm Mode:* Select "Latching" or "Non-Latching". A latching relay will require manual acknowledgement of any alarm condition (by pressing the  $\bigcirc$  button on the Main Operation Mode screen). When Non-Latching is selected, alarms will clear themselves whenever the alarm condition no longer exists.

*Alarm Delay:* Enter desired 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.

<u>NOTE</u>: The analyzer is equipped with four alarm relays. Each of these relays can be individually set to represent any of the following alarm conditions:

- 1. Low Residual
- 2. High Residual
- 3. Turbidity 1 high alarm
- 4. Turbidity 2 high alarm
- 5. *pH high/low alarm*
- 6. Any alarm

*DL*: This branch accesses the settings for the optional data logger.

*On/Off:* Depending on whether the data logger feature is enabled or disabled, this menu will present the option to change the status.

*Data Log Frequency:* Whenever the data logger feature is enabled, the frequency with which data is recorded is adjustable on this menu.

*Set New Date/Time:* If it is necessary to set or change the date and time in the data logger software, select "YES" on this menu.

*Set Data Log Clock:* This menu allows the date and time to be set. Whenever this menu is accessed, the current date and time must be entered. A confirmation screen will appear afterward.

#### FIGURE 11 (PID Control Menu Flow Chart)





#### FIGURE 12 (pH Calibration Menu Flow Chart)

## **VIII. EXPLANATION OF PID CONTROL MODE SCREENS**

*Main:* The PID Control Mode is structured as a "tree branch" program. The main screen is the trunk from which each branch can be accessed. Four options appear on this screen, with one option blinking. To change which option is blinking, press the  $\textcircled{\bullet}$  button. To select the blinking option, press the  $\textcircled{\bullet}$  button. To access the control mode from the operation mode scroll down and enter "220" as the password when prompted.

*Control:* This branch accesses the settings for the control method.

Control Type: Select desired control type.

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

<u>*Flow Pacing:*</u> This control type will provide a process output (PO1) proportional to the AI1 proportional input signal (and multiplied by the Dosage setting). This control method does not factor the residual in any way.

<u>*Residual/ORP*</u>: This control type will provide a process output (PO1) that is adjusted as needed to maintain the "Set Point" residual value.

<u>*Compound Loop:*</u> This control type will provide a process output (PO1) that is adjusted as needed to maintain the "Set Point" residual value and also factors in changes registered through the proportional input signal (and multiplied by the Dosage setting). This control method type will not appear as an option unless the needed input signals are detected.

*Resl:* This branch accesses the settings for the residual (as related to Set-Point or PID Control).

*Residual 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.

**Residual Integral Value:** 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).

**Residual 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 PO1. Instruments should be installed to minimize lag time in order to optimize control (ideally limit this time to less than 5 minutes).

*Residual 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 Method:* 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 at Variable Lag:* 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.

*Residual Reset Value:* If the water flow rate value falls below this level, then the control will ignore residual readings and consider only proportional control based on water flow rate.

<u>NOTE</u>: 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.

<u>NOTE</u>: If "Fixed" is selected as "Lag Time Method", the settings of "Residual Max Lag Time" and "Flow at Variable Lag" are ignored.

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

Flow Units: Select desired units (MGD, GPM, GPD, LPM, MLD, %, M<sup>3</sup>/H).

Flow Decimal Position: Select desired decimal position.

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

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

*Flow 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 (PO1) would remain at zero (4mA) until the proportional input reached this value.

*Flow Filter Time:* This is an adjustable span of time over which the input signal will be continually averaged. It is recommended to be set to at least 5 seconds.

*Flow Filter K:* Used in a digital filter for input signals. A value of zero provides no dampening. Optimum range is between 0.5 and 0.9.

**Begin Flow Zero Cal?:** To pass by this screen, press the  $\textcircled{\bullet}$  button twice or press the  $\textcircled{\bullet}$  button when the word "Skip" is blinking. To perform a flow zero cal, press  $\textcircled{\bullet}$  button to make the word "Begin" blink. Then press the  $\textcircled{\bullet}$  button.

*Flow Zero Cal:* Input a steady 4.000 mA signal to AI1. Adjust the displayed "Flow" value until it reads zero. Then press the () button. A confirmation screen should appear indicating that the calibration was performed.

**Begin Flow Span Cal?:** To pass by this screen, press the  $\textcircled{\bullet}$  button twice or press the  $\textcircled{\bullet}$  button when the word "Skip" is blinking. To perform a flow span cal, press the  $\textcircled{\bullet}$  button to make the word "Begin" blink. Then press the  $\textcircled{\bullet}$  button.

*Flow Span Cal:* Input a steady 20.000 mA signal to AI1. Adjust the displayed "Flow" value until it reads flow full scale value. Then press the button. A confirmation screen should appear indicating that the calibration was performed.

<u>NOTE</u>: Although it is recommended (for maximum accuracy and precision) that the flow zero and span calibrations be performed at 4 and 20 mA, they can be performed at values between 4 and 20 mA.

**PO1:** This branch accesses the settings for the PID Control output signal.

PO1 Units: Select desired units (PPD, GR/H, KG/H, GPH, GPM, GPD, %).

PO1 Decimal Position: Select desired decimal place.

*PO1 Full Scale:* Enter the desired output full scale. This is what a 20 mA output signal (selected as PO1) will represent.

<u>NOTE</u>: A minimum of three integers must be used. Therefore, if the PO1 Full Scale is set below 100, one decimal position must be used (ex: 99.9)

*Gas Feed Type:* Select either "CL2" or "SO2". These two selections are basic classifications of what chemical type the PID Control program is controlling. "CL2" represents any chemical that will increase the residual reading and "SO2" represents and chemical that will decrease the residual reading.

## **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 weir condition. If it is found to be dirty, then clean them with clean water.
- **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.** 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 MB-126 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.
- **4. pH Probe:** The pH probe 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 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 pH probes available from Hydro Instruments. Refer to sections I.1, II.4, VI, and Troubleshooting of this manual.

## X. TROUBLESHOOTING

### **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), or accumulation of foreign matter. 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 chlorine probe 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.

<u>NOTE</u>: 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.

#### 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 membrane cap, inadequate A/C ground, 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.

#### 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 membrane cap, dirt or debris in the flow 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.
- 2. This may also be caused by fouling of the membrane cap, dirt or debris in the flow cell or by improper residual calibration.

<u>NOTE</u>: 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.

### 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.

### рΗ

#### pH reading does not match independent pH meter measurement

- 1. Recalibrate pH.
- 2. Recalibration can be performed at a single point ("grab cal") or at two points using known pH buffers.
- 3. If the pH being displayed is dramatically incorrect or fluctuating drastically and cannot be corrected through a two-point calibration, check all pH cable connections as well as the cable connector to the probe. If all connections are verified and the problem cannot be corrected through recalibration, replace the pH electrode (Hydro part number PHE-250).
- 4. If the raw pH sensor mV values are outside the acceptable ranges listed in the table on Figure 8 of this manual, then replace the pH probe.

## **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 8.
- 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 10.

<u>NOTE</u>: The output calibration numbers from the factory calibration are recorded on the inside of the electronics enclosure for future reference.

#### **Communication Errors**

The MB-220 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 MB-220 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 13 and 14. As can be seen there, the MB-126 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 14.

## **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 MB220 board as indicated on Figure 14 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 MB220 board as shown on Figure 14).
- **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 11.
  - 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: <u>NOTE</u>: *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.

Date	Time	Resl	Temp	pН	Turb1	Turb2	Flow	MF	Raw Resl
MM/DD/YEAR	HH:MM:SS	PPM	С		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

### Hydro Instruments RPH-250 Residual Data Log File



Item No.	Description	Quantity	Part No.					
1	Cap Cable Assembly	1	S648-L-EC					
2	pH Electrode	1	PHE-250					
3A	Vented pH Probe Gland	1	PHF-Gland-1					
3B	Port Plug, ¾" NPT	1	850-007					
4	Acrylic Flow Cell	1	AFC-Body					
5	Port Plug, 1/2" NPT	1	850-005					
6	† Ground Rod & ¾" NPT Plug	1	RPH-GND					
7	1/4-20 x 3.25" RHMS (Stainless)	4						
8	* Free Cl <sub>2</sub> Probe (0-2 PPM)	1	FCL-002-1					
8	* Free Cl <sub>2</sub> Probe (0-5 PPM)	1	FCL-005-1					
8	* Free Cl <sub>2</sub> Probe (0-10 PPM)	1	FCL-010-1					
8	* Free Cl <sub>2</sub> Probe (0-20 PPM)	1	FCL-020-1					
8	* Free Cl <sub>2</sub> Probe (0-100 PPM)	1	FCL-100-1					
8	* Free Cl <sub>2</sub> Probe (0-200 PPM)	1	FCL-200-1					
8	* Total Cl <sub>2</sub> Probe (0-2 PPM)	1	TCL-002-1					
8	* Total Cl <sub>2</sub> Probe (0-5 PPM)	1	TCL-005-1					
8	* Total Cl <sub>2</sub> Probe (0-10 PPM)	1	TCL-010-1					
8	* Total Cl <sub>2</sub> Probe (0-20 PPM)	1	TCL-020-1					
9	† Probe Nut	1	PFC-PROBENUT					
10	† <sup>PM</sup> O-Ring	1	3RS-213					
11	Threaded Holder	1	AFC-TH					
12	† Thermistor	1	RAH-THERMISTOR					
13	Port Plug, 1/4" NPT	1	850-002					
14	1/4" NPT Close Nipple	2	880-005					
15	1/4" NPT Threaded Ball Valve	2	22321					
16	PM 1/4" NPT 3/8" Tube Tubing Connector	2	BKF-64					
*	Items marked with † are included when ordering a new Cl <sub>2</sub> Probe (Item 8)							
PM	Part & Maintenance Kit	1	KT2-RPH-250					
	(PM kit also includes Large Brush and	d Small Brush)						
	Replacement Membrane Caps:							
	Free Chlorine: MCH-250							
	Total Chlorine: TMC-250							
	Replacement Electrolyte:							
	Free Chlorine: REH-250							
	Total Chlorine: TRE-250							
		hildro Date	: December 2016					
		INSTRUMENTS BILL SERIES 250 AMPEROMETRIC RESIDUAL CHLORINE ANALYZER DWG	OF MATERIALS . No.: RPH-250, BOM					



#### FIGURE 13 (RPH-250 Circuit Board)

