Model 438A
pH Monitor/Controller
Manual

A digital version of this manual is available online at www.krugerandeckels.com

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Description

Model 438A pH controller is designed for controlling the pH of a solution. Model 438A provides a continuous digital dislpay (0 to 14) of the pH.

A complete system consists of several additional parts. An electrode is required to sense the pH of the solution being monitored. An extension cable may be necessary to connect the electrode and the controller. Electrodes may be installed remotely without pre-amplification. A neutralization system will include a tank to hold acid or alkaline neutralizer. Neutralizer flow will be controlled by a valve, pump or feeder. This neutralizer will be mixed with the solution which is to have the pH level controlled. Mixing is usually done in a tank or pit with thorough stirring. The major factor for success of the installation is how quickly the pH electrode sees the changing pH. Active mixing will allow the electrode to respond quickly and reduce over or underfeed.

The controller is intended to control power to a pump or valve whenever the pH of the solution being controlled varies from a set limit. On a terminal strip at the bottom of the instrument, power outputs are available that turn on with either increasing or decreasing pH. The set point controls may be either high or low, and are switch selectable from behind the front panel. See diagram on page 8.

The instrument is housed in a NEMA-4X enclosure. Mounting lugs are on the rear. Access to the interior is by loosening the two thumb screws on the side. All of the controls are on front panel. The meter is on the left side of the panel. Controls for electrode temperature compensation and pH calibration are to the right. The master power switch is immediately below these controls. The adjacent fuse is for the amplifier only. The set point controls are at the bottom. The set point controls have a knob for setting the pH, a 5 amp fuse, a power switch and a indicator light. The set point knob sets the pH value at which power will be switched on. The light indicates when the set point has turned on. The fuse protects the pump or valve from damage. The switch will turn the output power off, which is useful during calibration, or to manually stop feeding chemicals.

The 4-20 Ma output option provides current output from the pH value to drive a proportional valve, pump, or PLC. Zero and span are internally adjustable. See Diagram on page 9.

Installation

The enclosure has been predrilled for conduit mounting. Regular conduit is recommended for the incoming power, as well as the set point output power.

3/4” PVC flex conduit is recommended for the electrode cable routing. 90 degree sweeps should be used rather than elbows when routing the conduit. It must be understood when installing the conduit that later it may be necessary to pull extension cable or electrode cable through the conduit run. Care at this time will assure a trouble free installation.

The controller is housed in a NEMA 4X enclosure and is resistant to most chemicals. When controlling anhydrous ammonia it is recommended that the conduit coming into the cabinet from the electrode and the solenoid valve be sealed. This will keep ammonia fumes from entering the cabinet and discoloring the window and electronics. Locate the controller away from chemical supply tanks or treatment tanks that may overflow or spill. Any damage due to spilled chemicals or fumes is not covered by the warranty. It is possible to locate the instrument up to 100’ away from the chemical source without a delay in response.

The terminal block for power is located on the back panel.

Instrument Power Input

Instrument power wiring of 115 VAC is fed through the middle left bottom hole of the cabinet and connected to the three far right terminals of the block labeled “LINE, COMMON, GROUND”.

Set Point Power Output

Set point power output wiring of 110 VAC is used for connecting an external pump or solenoid valve for chemical feed, a motor for mixer, a chemical feeder, or an audible alarm. This wiring is fed through the cabinet’s bottom hole, just left of the instrument power input hole and terminals to those labeled “LINE COMMON”.

Electrode Input

The male BNC connector plug from an electrode or 80201 extension cable is fed through the far right bottom hole of the cabinet. It is then connected with its mating panel mount BNC jack on the back panel of the instrument.

Operation

Make certain all connections are complete for power, pump (or valve) and electrode(s). Start the mixer for the solution to be controlled and, after a few minutes, turn on the instrument. Set the temperature knob to the solution temperature. Set the pH control knob to the pH at which the pump or valve should turn on.

The following procedure may be used for calibrating the electrode. The voltage produced by different electrodes at a fixed pH such as 7.00 is slightly different. Consequently, the instrument must be calibrated to the individual electrode, using buffer solutions. The procedure is to dip the electrode tip into the buffer and adjust the calibration knob until the meter reads the pH of the buffer. The electrode should be removed, rinsed and immersed into a second buffer of known value. A new electrode should read 90% of the second buffer value in approximately 5 to 10 seconds.

As electrodes contaminate and age, this response time increases. Electrode response time is an excellent indication of electrode condition. Long response times indicate the need for electrode cleaning, recharging or replacement.

When a new system is first started, it will be necessary to watch the pH meter of the controller for several cycles of the control relay. The indicator light will show when the relay is on. The purpose of this monitoring is to determine the correct flow rate for the neutralization solution. The flow rate should be adjusted so the system can handle maximum neutralizer demand. In installations with high and low set points, they should be set far enough apart to eliminate oscillation between the high and low feeders. This will minimize consumption of neutralization material and produce the most consistent pH for the effluent. In some applications, it is only necessary to prevent the pH from going to high or low. For this the flow rate of neutralization material may be far more than necessary and overshoot in one direction is acceptable.

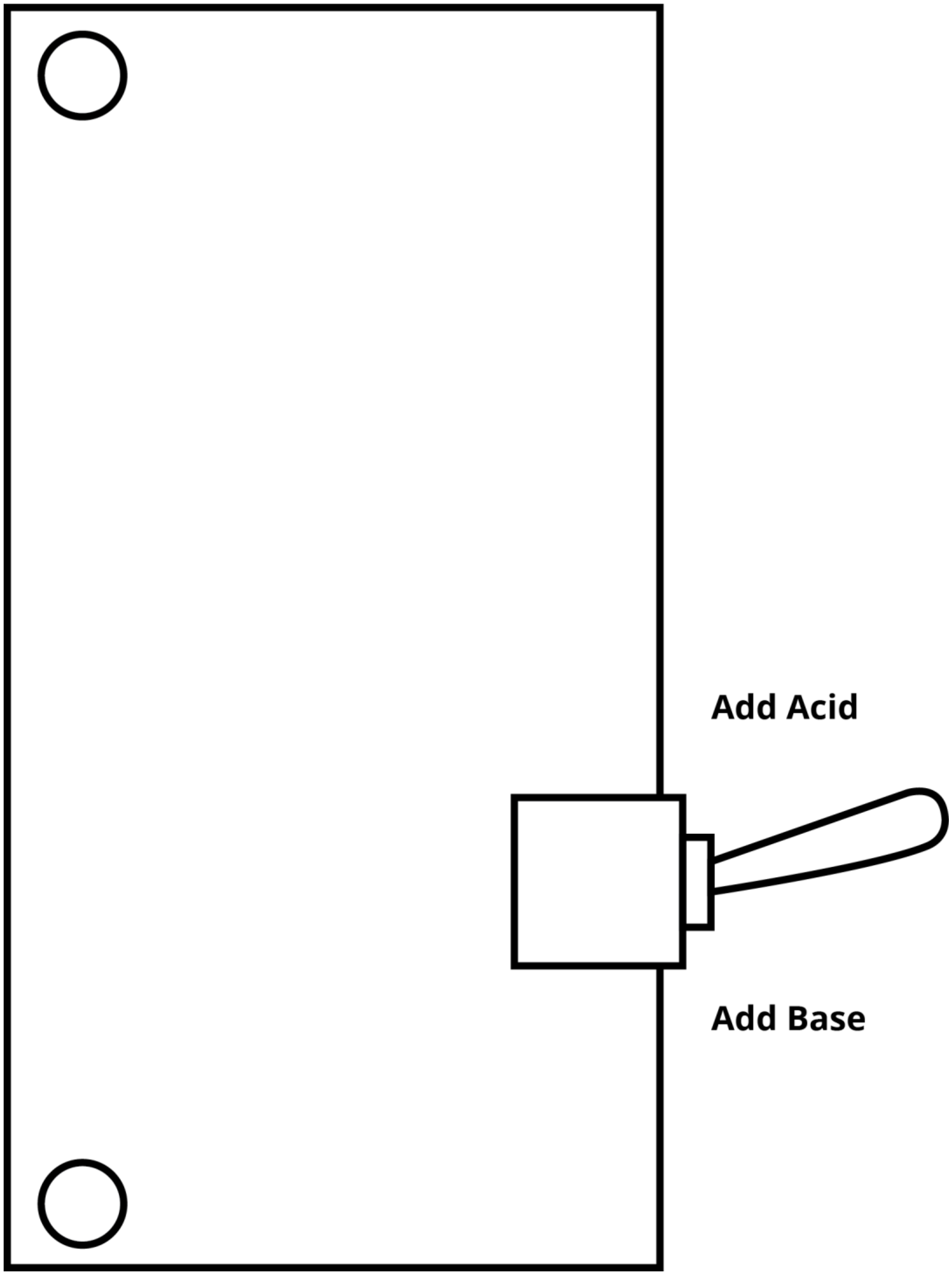
Neutralization solution may be supplied from a pump or gravity fed from a tank through a solenoid valve. In either case, it should be possible to regulate the flow if precise control of the pH is desired. Many different types of metering pumps are available which have adjustable stroke length, period between strokes or motor speed. If gravity feed is used, a needle valve should be near the solenoid valve to control the flow rate. Adjustable rate solids feeders are available from several manufacturers.

A simple means of neutralizing acid waste is with anhydrous ammonia. This may be controlled by a special needle valve and a solenoid valve. Another advantage of ammonia is that it may be possible to use a smaller tank mixer because ammonia entering water causes turbulence. A waste treatment system generally consists of a pit or series of pits with dividers to promote mixing. The first pit or section of a pit has a motor driven stirrer and an overflow weir to the next pit or compartments. This first pit or section must be large enough to hold a several minute’s supply, at maxi- mum rate of flow, of the material to be neutralized. The larger the pit the better the pH control. The series of pits or baffles may be designed to promote mixing or to provide a place for solids to settle out of solution. The drain leaves through the wall of the final compartment or pit. The pH controller monitors the first pit or pit section and neutralization material is added at this point. Regulations may require a record of the waste being discharged to the sewer. The recorder provides this record. The electrode for the recorder should be located close to the point of discharge to the sewer. For some application a single, very large, well-stirred pit is adequate for the waste treatment system.

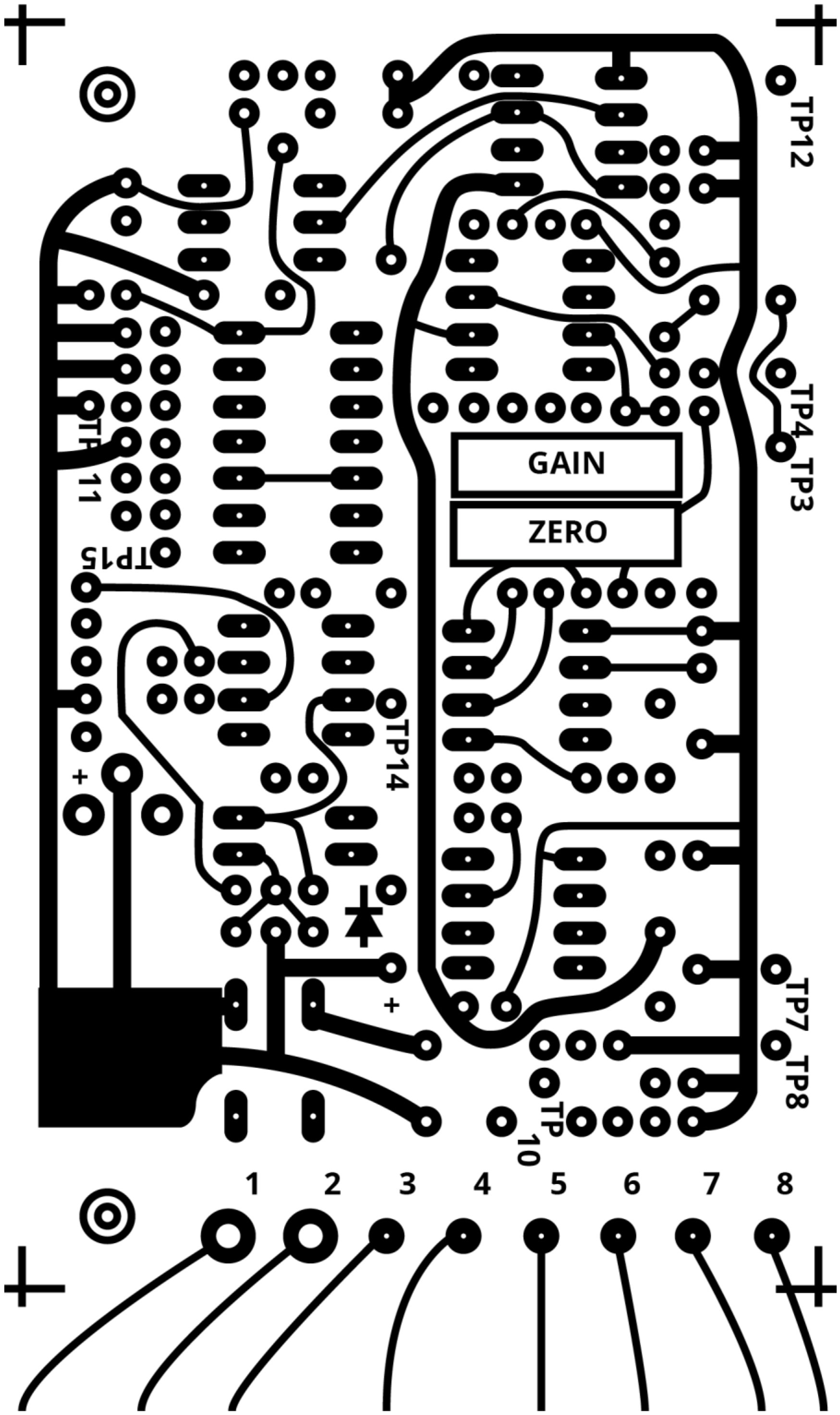
The set point logic has been preset at the factory to provide power output for either acid or alkaline addition. If the need ever arises to change the power output from acid to alkaline or vice versa, it can be done by the following procedure

1. Remove the two thumb screws on the right of the control panel.
2. Located directly behind the meter display is a circuit board. On the lower side of the circuit board is a toggle switch. Flip this switch to the other side to change the power output. Figure I on page 8 shows where the switch should be for acid addition and alkaline addition.

Set Point Circuit Board



4-20 mA Output Signal



Electrodes

There are several types of electrodes available for controllers and recorders. A combination electrode is generally ordered with the instrument. A combination electrode has both a glass pH sensitive electrode and a reference electrode in one unit. Separate glass and reference electrodes are for special applications such as high pressure, temperature or unusual chemistries.

The glass pH electrode produces an output voltage potential dependent on the pH of the solution on the outside of the glass bulb. The pH sensitive portion is a thin glass membrane with a spherical surface on the end of the electrode. Inside this bulb is a silver wire coated with silver chloride and a buffer solution. The amount of voltage potential produced depends on the pH and is influenced by temperature. The pH potential is measured across the glass membrane which constitutes a high resistance in the order of 20 to 200 megohms.

Electrode Temperature

The pH calibration of all glass electrodes is dependent on temperature. Therefore, it is necessary to compensate for temperature of the electrode. A Temperature control knob is on the front panel for this compensation. For measurements within one pH of the buffer and between 10C and 40C, the temperature correction error is below 0.1 pH. Consequently, for this type of measurement, the temperature control may be left at 25 C. For measurements at greater than one pH from the buffer and requiring accurate results, the temperature knob must be adjusted. Set this knob to the temperature of the buffer when standardizing the electrode.

For best accuracy, the buffer temperature and the sample temperature must be the same. One method of accomplishing for field work is to immerse the bottle of buffer in the sample solution for a few minutes.

All glass electrodes have a temperature co-efficient proportional to the absolute temperature. The voltage produced by the electrode is greater at higher temperatures. For example, if an electrode is calibrated with buffer at pH 7.00 and a temperature of 25 C, each one pH change will produce an output change of 59 millivolts. At 50 C, each one pH change will produce an electrode output change of 64 millivolts. The meter Temperature knob adjusts the number of millivolts change at the input connector required to make a one pH change on meter. The instrument temperature compensation knob is essentially a slope control or in electronic terms, an amplifier gain control.

It is essential that the electrodes be periodically calibrated. The frequency will depend on the amount of oil and suspended solids and the chemistry of the water being controlled. Satisfactory electrode performance is dependent on good electrical contact between the electrode and the water. Accumulated deposits on the electrode surface can interfere with response to pH. One of the electrode calibration procedures described in this manual under OPERATION should be used. For a new system at first this should be daily. If it is found the calibration drift is insignificant, the period between calibration tests may be extended.

Electrode Cleaning

Soap and water will remove oil and grease but will not remove scale or calcification. Hydrochloric acid will remove scale and calcium deposits but it will not remove oil and grease. In order to properly clean an electrode the nature of the contaminant should be identified, and a proper cleaner found. Soap and water and a small tooth brush will remove many common contaminants.

It should be noted that many soaps, commercial cleaners, glass cleaners, contain chemicals that will leave a electrically conductive film on the pH sensor, and interfere with the measurement. When inspecting the electrode for contamination, check the electrode when it is dry. Liquid on the electrode will make the glass or platinum surface glossy and hide scale. Hard water can cause scale on the electrode. Dry patches on a wet electrode may indicate oil or grease contamination.

Electrode Storage

When pH and ORP electrodes are not in use they should be stored in 3.8 M KCl or saturated KCl. Sometimes the electrodes come with a protective plastic cap on the pH bulb, and this can be filled and used for storage. If the electrodes are stored dry the filling solution will slowly wick out of the electrode. This is not a problem with refillable electrodes, but will reduce the effective lifetime of non-refillable electrodes. Storing the electrode dry will also affect the pH sensitive glass bulb which will dehydrate, and need to be soaked in KCl before being used for measurement.

Do not store pH electrodes in distilled or deionized water, as it will leach out the filling solution. Distilled and deionized water can cause crystals to form inside the reference junction. A good storage solution is 3.8M potassium chloride or saturated potassium chloride. Reorder #81966

Buffer Solution

Buffer solutions for calibrating the electrode are available from your pH meter dealer, or may be prepared from the instructions provided in many chemical handbooks. For best test accuracy, the buffer pH should be as close as possible to the sample pH. Buffer solution pH may change with time due to absorption of carbon dioxide. Solution stored in plastic bottles for more than a year should be suspect and checked against fresh buffer. Deterioration is greatest for high pH buffer, such as borate.

All buffer solutions change pH with a change in temperature.

The pH of buffer solutions available from your dealer is shown below:

Temperature	4.00 pH Buffer	7.00 pH Buffer	10.00 pH Buffer
0	4.00	7.12	10.31
10	4.00	7.06	10.17
15	4.00	7.04	10.11
20	4.00	7.02	10.05
25	4.00	7.00	10.00
30	4.01	6.99	9.95
35	4.02	6.98	9.91
40	4.03	6.97	9.87
50	4.06	6.97	9.81

Sample pH will also change with temperature depending on the composition. For accurate results, it is important that buffer and sample be at the same temperature. Conversely, if an accuracy of only 0.2 pH is required, buffer pH drift with temperature generally may be ignored.

Troubleshooting Instrumentation

Isolate the problem to:

1. The instrument
2. The electrode
3. The extension cable

Instrument Checkout

1. Short the input with a shorting strap, shunt or a paper clip. Connect the center conductor to the shell of the BNC.
    a. The instrument should span from pH 0 to 14 when the calibration knob is turned from full left to full right.
    b. Some instruments will have a 10 turn calibration knob and will span from 0 to 14 pH.
    c. If the instrument is offset for antimony electrodes, the span will be below 0 to 4 or 5 pH.
    d. Adjust the calibration knob to read pH 9 and turn the temperature knob from OC to 100C. The reading should change almost a full pH unit
    e. If the pointer doesn't move:
        i. Check the wires to the meter for a short or a loose connection.
        ii. If possible, move the instrument to see if the pointer will move. If the pointer is stuck, remove the meter and remove the cover. Carefully check and remove the obstruction. The meter zero adjust may have been broken and jammed the movement; the mechanical zero adjust is not necessary in most pH measurements.
    f. If the meter drifts, is erratic or is full upscale or downscale with the BNC shorted, the electronics may need service. Consult your dealer or the factory.
2. Set the indicator to pH 7 with the calibration knob.
    a. Rotate the set point knob through the indicator value. There should be relay actuation and the lamp should go on or off. Power at the output terminals should also go on or off.
    b. On some instruments the set point lamp will go on only above the set point. In these instruments there are separate output connections for alkaline and acid feeders.
    c. Newer instruments have a switch on the set point circuit board to select for above or below set point operation. These controllers have outputs labeled line and common.
    d. Some instruments are wired for a contact closure only. These will show an open or closed measurement with an ohmmeter.
    e. Series wired set points (Inter-wired set points)
        i. In this case a second set point will also have an effect on set point output. The most common case is that the first set point has to be on and the over-range safety set point has to be on.

        ii. With the first set point on, rotate the second set point to see if it will control the output. Generally, the second set point will interrupt feed if the pH goes above the second set point.

Electrode Checkout

1. Plug the electrode directly into the instrument.
2. Rinse the electrode with distilled water; some meter movement is normal during washing.
3. Put the electrode into pH 7 buffer solution, allow the electrode to stabilize and adjust the calibration knob to make the instrument read 7.00.
4. Remove the electrode, rinse, and put the electrode into pH 4.01 buffer. The electrode should read the buffer value in the first few minutes. Repeat the above with pH 10.00 buffer.
    a. If the electrode will not produce a reading:
        i. The electrode is shorted and needs to be replaced.
        ii. The reference solution is contaminated or gone and needs to be replaced.
    b. If the electrode will not read the buffer values and/or is slow in response:
        i. The pH bulb is contaminated and needs to be cleaned. A fingerprint is enough to cause incorrect readings.
        ii. The reference junction is clogged or the reference solution is contaminated.
            1. Sealed electrodes can temperature-cycled in a 2 molar KC1 solution which may clear the obstruction.
            2. Refillable electrodes can be recharged and the reference junction can be replaced. Consult the dealer or manufacturer.
        iii. Compressed response is an indication that the electrode is aging or needs service. As a temporary measure the temperature knob can be used to amplify the electrode output, or the slope control can be used for compensation.

Extension Cables and Electrode Installation

1. Extension cable failure
    a. The BNC shell has become grounded. There should be more than 100 megohms between the BNC shell and instrument and solution ground.
    b. The cable is shorted
        i. There should be more than 100 megohms between the center conductor and the shell of the BNC connector. If a high resistance short is found, it may be caused by moisture in the BNC. Clean with alcohol and retest.
        ii. A low resistance short is caused by the shield coming in contact with the center conductor of the cable. In this case replace the cable.
    c. The cable is open and should be replaced.
        i. There should be continuity between the shell at one end and the shell at the other.
        ii. There should be continuity between the center contacts at both ends of the cable.
2. Electrode Installation

a. The electrode should be deep enough into the solution so that both the reference and the glass bulb are submerged.
b. The electrode should be close to vertical with the pH bulb down.
c. The BNC connector should be insulated from any electrical ground potential.
d. In some installations the sample solution will have to be grounded in order to have accurate readings, and normal electrode life.

Other Failure Conditions

1. The instrument reacts when a solenoid or valve turns on or off.
    a. Improper grounding of the instrument or solution.
    b. Low voltage to the instrument, causing the instrument to fall out of regulation.
2. pH measurements are not stable or controller is unable to stabilize the sample.
    a. Insufficient mixing of the sample.
    b. The electrode and the neutralizer feeder are too close together or too far apart.
3. Instrument calling for feed and no indication of pH Change.
    a. Lack of neutralizer in the supply tank.
    b. Failure of the feed solenoid to open; frozen or jammed.
    c. Lack of agitation in the neutralization tank, or loss of sample flow past the electrode.
    d. Fuse blown at the instrument, and no voltage to the feeder.
    e. Override switch on the instrument in the off position.
4. Instrument not calling for feed and pH changing.
    a. Solenoid or valve stuck in the open position.
    b. Instrument relay stuck in the on position.
5. Instrument calibrates correctly in buffers but will not read pH correctly in the sample.
    a. The BNC has become grounded in the electrode system.

Warranty

Kruger & Eckels, Inc. warrants all of its electronic instrumentation for two years against defects in material or workmanship. This warranty does not apply to mechanical meters, recorders or electrodes, which are covered by separate warranties by their own manufacturers. Should a failure occur, the unit will be repaired at no charge to the customer.

Mechanical meters and recorders are warranted for one year, and electrodes are warranted for six months. This warranty covers normal use and does not cover damage which occurs in shipping or failure which results from accident, abuse, improper installation, improper maintenance, or using the device in a manner which is not recommended by Kruger & Eckels.

Replacement Parts

Part Name	Part Number
Digital display	81590
¼ amp fuses (Box of 5)	38504
5 amp fuses (Box of 5)	38504
Replacement relay	38213
Shorting strap	38315
Pilot light screw base	37510A

Maintenance Accessories

Part Name	Part Number
Sensor storage solution	81966
Buffer solution 4.00 pH	81968
Buffer solution 7.00 pH	81969
Buffer solution 10.00 pH	81970