OPERATION AND
SERVICE GUIDE
O-685A
JAN. 1997

# MODEL 436 & 437 pH CONTROLLER


***Refers to Bulletin A-302***

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pH CONTROLLER MODEL 436/437 SERIAL NUMBER________________________

# DESCRIPTION

Models 436 and 437 are pH controllers or pH recorders, respectively. The instrument is designed for controlling the pH of a solution. Model 436 provides a continuous indication of the pH on the O to 14 scale of the meter. Model 437 provides a continuous record of the pH on a chart from pH 2 to pH 12. This manual is written for the indicator controller Model 436 and the word recorder should be substituted for the words indicator or meter if Model 437 has been purchased. The control functions are the same for either instrument since the control signal is furnished by a separate amplifier .

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 preamplification. 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 instrument is housed in a NEMA-4X enclosure. Mounting lugs are on the rear. Access to the interior is by loosening the two hasps on the side. All of the controls are on a panel on the inside. The meter or recorder 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. If purchased, a timer will be installed at the bottom. The terminal block for power is under a cover at the bottom of the cabinet.

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.

INSTRUMENT POWER INPUT
Instrument power wiring is fed through the far right 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 a pump or solenoid valve for chemical feed, a motor for mixer or chemical feeder or an audible alarm. This wiring is fed through the cabinet 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 left bottom hole of the cabinet. It is then connected with its mating panel mount BNC jack on the internal left side of the instrument. If a separate reference electrode is used in the system, it plugs into the pin jack. Extension cable, Part No. 80182 Pin Jack to Pin Plug Cable is available.

# 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. If the pump or feed mechanism requires more power than this instrument is capable of handling, a heavy duty electrical contactor will be required.

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 minutes supply, at maximum 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.

# 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.

REFERENCE ELECTRODE

To complete the electrical circuit to the pH controller, a second electrode is required. The reference electrode contains a neutral salt solution which isolates the wire from solution chemistry. Electrical contact from the reference electrode to the solution is through a junction which will pass a small amount of solution. The junction is either an asbestos fiber, ceramic rod or other porous material. For combination electrodes, this junction appears just above the pH bulb and on the side. For separate reference electrodes, the junction is on the bottom. It is important that this junction be kept clean, otherwise the pH reading will drift. To clean, use a wet paper towel and wipe the junction several times. It may be necessary to acid wash and brush to clean a seriously contaminated reference junction. For accurate readings, the flow must always be out of the electrode and sample should not enter the electrode. Sample entering a reference cell may cause a calibration drift or offset of the pH. If the electrode is calibrated with contaminated filling solution inside, the calibration may cancel out much of the error but it will return if conditions change.

SILVER CHLORIDE REFERENCE ELECTRODE

A silver/silver chloride electrode must be kept filled with 4M potassium chloride saturated with silver chloride. Do NOT use filling solution without silver chloride or the electrode will be slowly damaged, as the silver dissolves.

There are several reasons for selecting a silver chloride reference. Most types will operate at a high temperature range. If the filling solution is allowed to run out, and the reference cell goes dry, there is generally less problem in re-establishing satisfactory operation when than with others.

ELECTRODE TEMPERATURE

The pH calibration of all glass electrodes is dependent on temperature. At pH 7.00 temperature has no effect of pH measurement. It is necessary to compensate for temperature as the pH deviates from 7.00. A temperature control knob is on the front panel for this compensation. For measurements within one pH of the buffer and between 100C and 4OC, the temperature correction is below 0.1 pH. Consequently, for this type of measurement, the temperature control may be left a 25C. For measurements at greater than one pH from the buffer and requiring accurate results, the temperature compensation 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 should be the same. The method of accomplishing this for field work is to immerse the bottle of buffer in the sample for a few minutes.

Glass electrodes have a temperature coefficient 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 25C, each pH change will produce an output change of 59 millivolts. At 5OC, each pH change produces an electrode output change of 65 millivolts. The meter temperature knob adjusts the sensitivity required to make one pH change on meter. The instrument temperature compensation knob is essentially a slope control, or an amplifier gain control.

# BUFFER SOLUTION

Buffer solutions for calibrating the electrode are available from your pH meter dealer. 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 C | pH 4.01 phthalate | pH 7.00 phosphate | pH 9.18 borate |
|---|---|---|---|
| 0 | 4.01 | 7.12 | 9.46 |
| 5 | 4.01 | 7.09 | 9.39 |
| 10 | 4.00 | 7.06 | 9.33 |
| 15 | 4.00 | 7.04 | 9.27 |
| 20 | 4.00 | 7.02 | 9.22 |
| 25 | 4.01 | 7.00 | 9.18 |
| 30 | 4.01 | 6.99 | 9.14 |
| 35 | 4.02 | 6.98 | 9.10 |
| 40 | 4.03 | 6.98 | 9.07 |
| 45 | 4.04 | 6.97 | 9.04 |
| 50 | 4.06 | 6.97 | 9.01 |
| 55 | 4.08 | 6.98 | 8.99 |
| 60 | 4.10 | 6.98 | 8.96 |
| 70 | 4.12 | 6.99 | 8.92 |
| 80 | 4.16 | 7.00 | 8.88 |
| 90 | 4.20 | 7.00 | 8.85 |

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.

# MAINTENANCE

At weekly intervals, the filling solution level in the reference electrode should be checked. If a flow or immersion assembly is being used, the filling solution level need be checked only once a month. If the sample is oily or has a large amount of suspended solids, the glass pH bulb and the junction should be thoroughly wiped with a wet paper towel. Some applications require that the electrode be cleaned with strong acids or caustic solutions. The electrode is designed to resist damage from these materials, but care must be used in using these solutions for cleaning.

Periodically, the temperature of the solution being neutralized should be tested to determine if the temperature compensation knob is set correctly.

If the relay contacts become worn, it should be replaced. The relay is a standard type available from several manufacturers. A replacement unit should have a 12 volt coil with at least 75 ohms resistance. This is available from your dealer Part No. 38209.

If the temperature knob is removed, returning it to the shaft requires an electrical calibration procedure. The temperature control knob determines the change in meter reading produced by a change in the input voltage. To set this knob, it will be necessary to have a precise 0.414 volt source. With the instrument input shorted, set the meter to 7.00 with the calibration knob. With +0.414 volts DC injected into the BNC connector, turn the temperature control shaft until the meter reads 0.00 pH. Attach the knob so the pointer indicates 25C.

# ELECTRODE CALIBRATION

It is essential that the electrodes be periodically calibrated. The frequency will depend on the amount of oil and suspended solids in 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. 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

If an electrode becomes severely fouled, it is possible that the response to pH changes will be reduced. It may be possible to calibrate the electrode at one pH (for example 7.00 but not have a correct reading at a pH different from the buffer. To determine whether the electrode pH response is accurate, it is necessary to calibrate the electrode at least at two different pH values. This may be done with two different buffer solutions. Adjust the pointer to the correct value with the electrode in the first buffer, remove the buffer, rinse the electrode with pure water and then dip the electrode in the second buffer of different pH. The pointer should read correctly. If not, clean the electrode. It is important that both the glass pH sensitive bulb and the reference junction be clean. Wipe thoroughly with a wet paper towel. Clean or replace electrode parts until the correct response is obtained. A secondary reason for incorrect response is that the temperature correction knob is out of adjustment. If the knob is set too high a temperature, the change in instrument reading for a change in pH will be less than should occur.

# TIMER OPTIONS

80382 - ADJUSTABLE TIMER

This timer is intended for tuming off a pump after a set period of time. The purpose is to prevent addition of excessive neutralizer to a system as a result of electrode failure. A pH electrode may become damaged or fouled and send an incorrect pH signal to the controller.

With the timer switch in the off position, the controller will operate in the normal cycle. When the timer switch is turned on, the timer will not operate if the set point is off. As soon as the pH exceeds the set point, the injection will start and the timer will start. If the injection does not stop within the time period set by the timer knob, the timer will shut off the power to the feeder.

The timer is reset to time zero each time the pH crosses the set point. If the time limit has been exceeded, it will be necessary to lower the pH below the set point or momentarily raise the set point above the pH to reset the timer.

81575 - TIMER OPTION

Dual control on/off timer permits the operator to adjust the on cycle and the off cycle independently. Timing cycle is 60 seconds. The timer is designed to permit the operator to vary the addition rate o material through solenoid or fixed orifices, where other adjustment is not available.

# MODEL 436/437 REPLACEMENT PARTS

| | |
|---|---|
| 35501 | REPLACEMENT METER |
| 35700 | REPLACEMENT RECORDER |
| 37510 | PILOT LIGHT SCREW BASE |
| 38213 | REPLACEMENT RELAY |
| 38315 | SHORTING STRAP |
| 38501 | FUSES 5 AMP BOX OF 5 |
| 38504 | FUSES 1/4 AMP BOX OF 5 |
| 47500 | CHART PAPER - 30 DAY |
| 80283 | MANUAL MODEL 436/437 |

# TROUBLESHOOTING pH INSTRUMENTATION AND CONTROLS

ISOLATE THE PROBLEM TO:
1. The instrument
2. The electrode
3. The extension cable or electrode installation

I. INSTRUMENT CHECKOUT

A. Short the input with a shorting strap, shunt or a paper clip. Connect the center conductor to the shell of the BNC.

1. The instrument should span from pH 5 to 9 when the calibration knob is turned from full left to full right.
2. Some instruments will have a 10 turn calibration knob and will span from 0 to 14 pH.
3. If the instrument is offset for antimony electrodes, the span will be below 0 to 4 or 5 pH.
4. Adjust the calibration knob to read pH 9 and turn the temperature knob from 0C to 100C. The reading should change almost a full pH unit
5. If the pointer doesn't move:
   a. Check the wires to the meter for a short or a loose connection.
   b. 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 obtruction. The meter zero adjust may have been broken and jammed the movement; the mechanical zero adjust is not necessary in most pH measurements.
6. 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.

B. Set the indicator to pH 7 with the calibration knob.

1. 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.
2. 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.
3. Newer instruments have a switch on the set point circuit board to select for above or below set point operation. These controller have outputs labeled line and common.
4. Some instruments are wired for a contact closure only. These will show an open or closed measurement with an ohmeter.
5. Series wired set points (Interwired set points)
   a. In this case a second set point will also have an affect on set point output. The most common case is that the first set point has to be on and the overrange safety set point has to be on.
   b. 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.

II. ELECTRODE CHECKOUT

A. Plug the electrode directly into the instrument.
B. Rinse the electrode with distilled water; some meter movement is normal during washing.
C. 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.
D. 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 9.18 buffer.
   1. If the electrode will not produce a reading:
      a. The electrode is shorted and needs to be replaced.
      b. The reference solution is contaminated or gone and needs to be replaced.
   2. If the electrode will not read the buffer values and/or is slow in response:
      a. The pH bulb is contaminated and needs to be cleaned. A fingerprint is enough to cause incorrect readings.
      b. 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.
      c. 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.

III. EXTENSION CABLES AND ELECTRODE INSTALLATION

A. Extension cable failure
   1. The BNC shell has become grounded. The should be more than 100 megohms between the BNC shell and instrument and solution ground.
   2. The cable is shorted
      a. There should be more than 100 megohms between the center conductor and the shell of the BNC connector. If a high resisance short is found, it may be caused by moisture in the BNC. Clean with alcohol and retest.
      b. 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.
   3. The cable is open and should be replaced.
      a. There should be continuity between the shell at one end and the shell at the other.
      b. There should be continuity between the center contacts at both ends of the cable.
B. Electrode Installation
   1. The electrode should be deep enough into the solution so that both the reference and the glass bulb are submerged.
   2. The electrode should be close to vertical with the pH bulb down.
   3. The BNC connector should be insulated from any electrical ground potential.
   4. In some installations the sample solution will have to be grounded in order to have accurate readings, and normal electrode life.

IV. OTHER FAILURE CONDITIONS

A. The instrument reacts when a solinoid or valve turns on or off.
   1. Improper grounding of the instrument or solution.
   2. Low voltage to the instrument, causing the instrument to fall out of regulation.
B. pH measurements are not stable or controller is unable to stabilize the sample.
   1. Insufficient mixing of the sample.
   2. The electrode and the neutralizer feeder are too close together or too far apart.
C. Instrument calling for feed and no indication of pH change.

1. Lack of neutralizer in the supply tank.
2. Failure of the feed solinoid to open; frozen or jammed.
3. Lack of agitation in the neutralization tank,
or loss of sample flow past the electrode.
4. Fuse blown at the instrument, and no voltage to the feeder.
5. Override switch on the instrument in the off position.

D. Instrument not calling for feed and pH changing.
1. Solinoid or valve stuck in the open position.
2. Instrument relay stuck in the on position.

E. Instrument calibrates correctly in buffers but will not read pH correctly in the sample.
1. The BNC has become grounded in the electrode system.

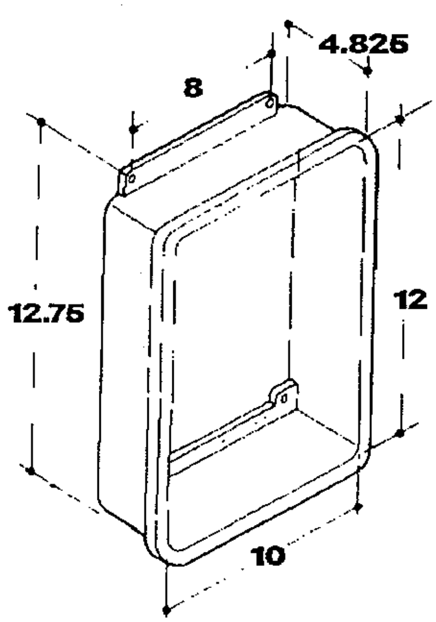
# INSTALLATION

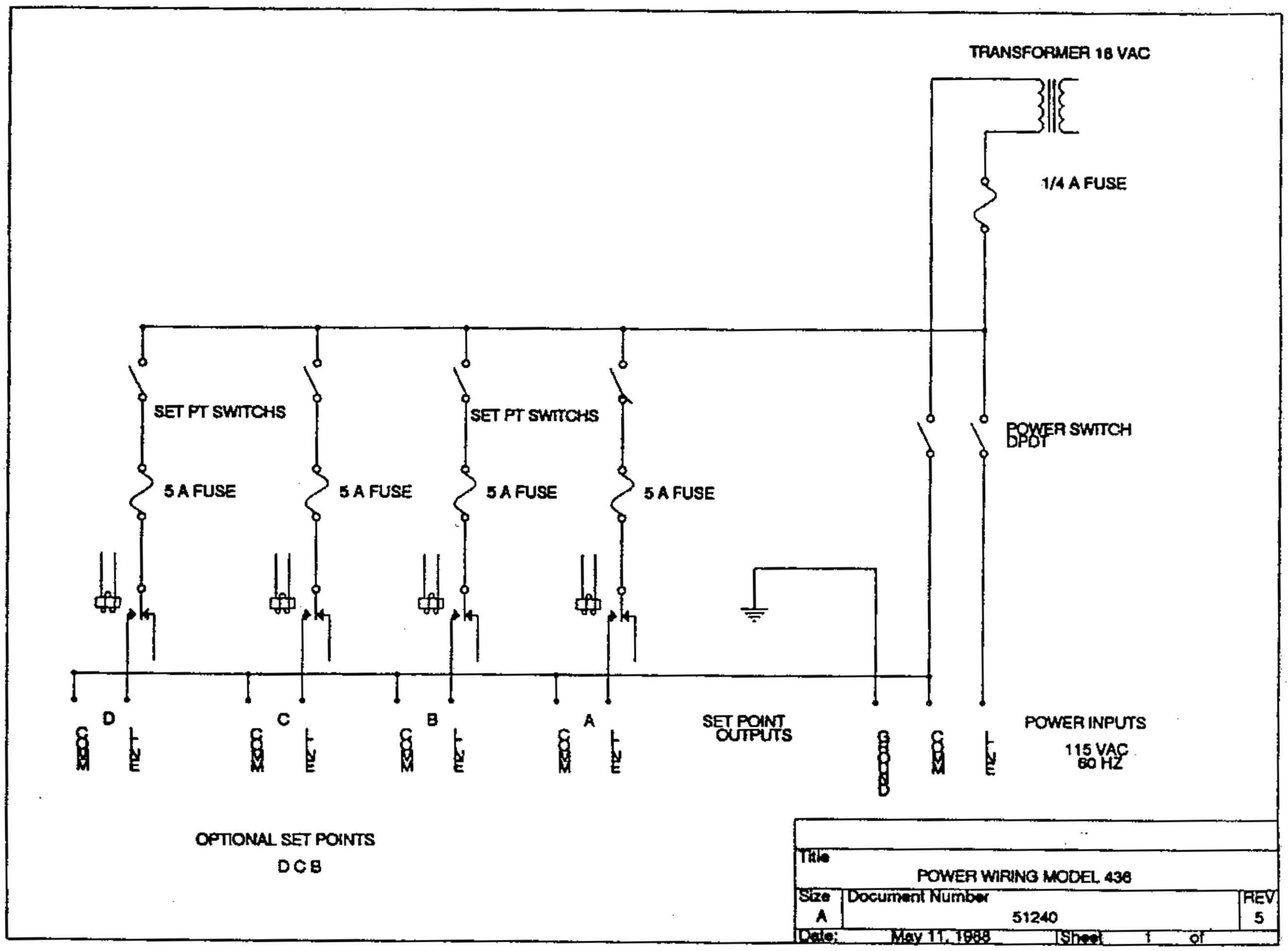
The controllers are designed for wall or panel mounting. The location should be near the tank being treated. The electrode should be located in the tank in an area that will see well mixed sample. The electrode must be installed for easy removal for cleaning and calibration.

The enclosure has been predrilled for conduit mounting. The incoming power, power for pumps or solenoids, and electrode cables should have their own conduits.

Electrode conduit should be 3/4' PVC or larger. 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 blocked. 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.

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# ELECTRODE CLEANING

pH and ORP sensors need periodic cleaning. The cleaning frequency and type of the cleaner will vary with the type of contamination. pH and ORP sensors are constructed to be chemically resistant to strong acids or bases, and a wide variety of cleaners can be used.

CLEANING THE pH ELECTRODE

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.

CLEANING THE ORP ELECTRODE

In addition to the above, contamination of an ORP sensor may also be the gradual deposition of ionic metal onto the platinum. This is identified by a slight dulling of the platinum surface, and eventually the appearance of color. This can be removed by polishing with DE or Bon Ami. Use a damp cloth or paper towel and some powder and polish the platinum surface. If there is color on the cloth after cleaning, your treatment system should be checked for ground faults, solution ground and the source of the ionic metal. In selecting a cleaner for the platinum electrode, check the contents to see that there are no oxidizers in the cleaner. If the platinum electrode is cleaned with this type of cleaner the electrode will be polarized during the cleaning and will take some time to discharge. Also check the cleaner to see if it contains highly abrasive materials such as sand, which would scratch the platinum surface.

CLEANING THE REFERENCE JUNCTION

Cleaning also includes cleaning the reference junction. This will vary with the style of the electrode design. Sealed nonrefillable generally have a ceramic, or other porous material for the reference. The most common reference failure is by clogging. If the obstruction is a potassium chloride crystal, temperature cycling the electrode may make the crystal redissolve. If the obstruction is oil, cleaning with alcohol may remove it. If the reference junction is removable, it can be soaked in alcohol to remove the oil contamination or boiled in water to remove a crystal contamination. With some electrode styles the reference material may be lightly sanded to remove any contamination from the outer surface.

# ELECTRODE STORAGE

When pH and ORP electrodes are not in use they should be stored in 3.8 M KCl or saturated KCl in pH 7 buffer. 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. Do not store electrodes in pH 4 or pH 10 buffers, as these can effect the pH of the filling solution inside the electrode. A good storage solution is pH 7 buffer saturated with potassium chloride.