PALM TECHNOLOGY, INC.

ENControl™

Electroless Nickel Controller

Model 3300

Operating Manual

Version 1.51

INSTALLATION AND OPERATING MANUAL
ENControl™ MODEL 3300 ELECTROLESS NICKEL CONTROLLER
TABLE OF CONTENTS

Section I
Introduction

The ENControl™ Model 3300 is a state-of-the-art, automatic controller for electroless nickel plating baths. It is the latest advaced electroless nickel controller based on Palm's proven EN-Control systems. It will maintain the bath's strength within very close limits with a minimum of operator assistance. The controller is very easy to use and may be adapted for most electroless nickel solutions.

The ENControl™ Model 3300 monitors the bath's concentration, pH and temperature. When needed, it makes additions of nickel and hypophosphite replenishers and neutralizers to keep the solution within the proper operating range. It also keeps a record of the bath and its age, and the volume of chemicals used and remaining. These records can be used to track costs and profitability.

The ENControl™ Model 3300 has several advanced features such as Palm's Colorshift™ technology that allows the controller to automatically change its calibration points based on bath age to compensate for the color change that happens in normal electroless nickel baths. It also has a completly customizable pH ramping technology which allows the user to change the pH setpoints based on bath age. The ENControl™ system also allows for a third replenisher to be added to the bath that is fully user customizable.

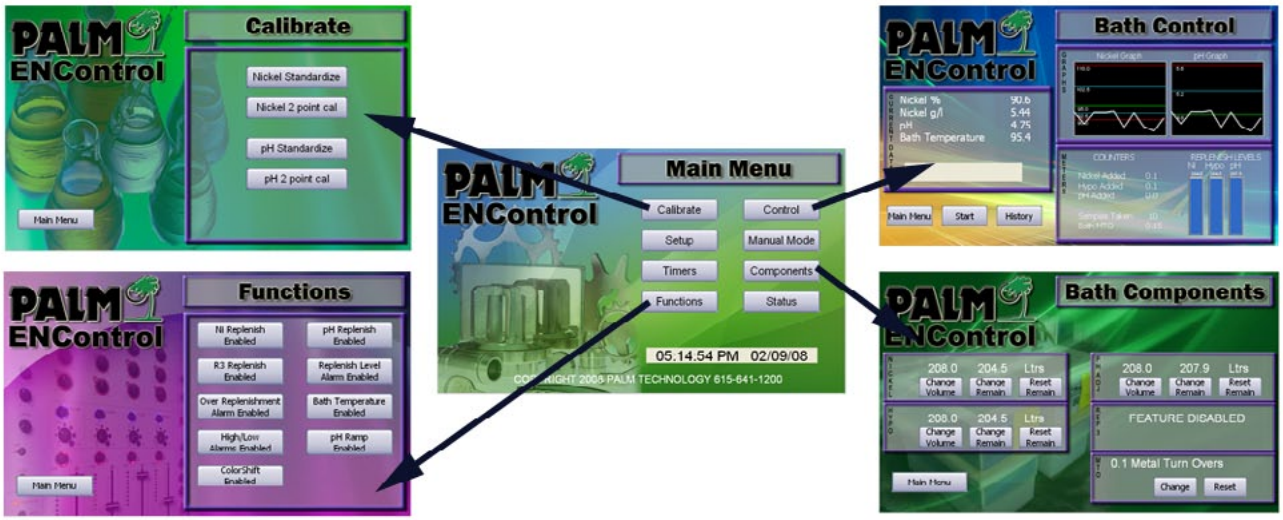
In addition, it analyses can be transmitted to a personal computer by industrial ethernet. With the ENCollect™ software, the data can be analyzed, graphed, or printed. It will provide basic statistical process control and product certification. If more advanced SPC is required the data can be exported to an SPC program. The controller also has audible, high and low level alarms to alert the operator to out-of -limit conditions.

The ENControl™ Model 3300 contains a custom designed, microprocessor to allow close control, maximum flexibility, advanced record keeping, and statistical data handling. It is very user friendly. It prompts the operator to enter any required information through a menu selection process. Set points, alarm levels, bath volume, concentration and age, and sampling and addition times are all adjustable. The user can easily change them to account for changes in bath chemistry or volume.

Section II
The ENControl™ User Interface

The ENControl™ Model 3300 controller has a unique and easy to use interface. Its 7 inch wide touchscreen LCD makes setting up and using the system as easy as possible All setup variables and alarms have user friendly informational screens to guide the user. Any setpoints that are out of range will alarm the user and prompt them with the acceptable ranges.

The ENControl™ Model 3300 starts up in the main menu, all user setup and bath control will begin from the main menu. The following shows the main menu and a small sampling of the subscreens.



Main Menu and sub screens

The operating manual will use the following format for guiding you on how to setup and enter data in the ENControl™ system.

1. Informational notes will have the information symbol.

2. Warning information will have the warning symbol.

3. Each **Step** for setting up unit will be numbered and in bold type

4. Menu navigation will be Centered, Bolded, Italisized and have **>** between button presses.

MAIN MENU > SETUP > BATH SETUP > BATH VOLUME

When the user needs to enter a setpoint suchs as Bath Volume, they will click the setup screen, by pressing SETUP, then in setup screen they will click BATH SETUP and finally in the bath setup screen they would click the BATH VOLUME button. The ENControl system will display the keypad for entering the bath volume, the prompts will guide the user as to what they need to enter such as Enter Bath Volume in Ltrs.

MAIN MENU > SETUP > BATH SETUP > BATH VOLUME

Section III
Installing the Controller

The installation of the ENControl™ Model 3300 controller and its components is illustrated by Section XV (Installation of the Model 3300 COntroller) in the Technical Section of the manual and is described by the following paragraphs.

STEP 1: Unpack all of the shipping containers and inspect the contents to ensure that no damage has occurred during shipment and that all of the components are present. The system will include at least the following components:

- Controller enclosure,
- Pump relay enclosure,
- Bath temperature sensor and pH probe,
- Connecting cables, and
- Operating manual.

It may also include sampling, replenishment and neutralizer pumps, pick up tubes, hoses, a heat exchanger, and the ENCollect™ software. The list of materials, enclosed with the shipment, shows its contents.

STEP 2: Mount the ENControl™ within about twenty five feet (25) of the plating bath, the sample cell can be more than twenty five (25) from the plating tank, but this will increase the sampling time and slow the instrument's response. Mount the ENControl™ enclosure away from traffic, steam, harmful vapors and potential damage. The enclosure has mounting lugs that can be used to attach it to a wall or other structure.

STEP 3: Install the pH electrode into its opening in the sensor block. The opening for the pH electrode is at the top of the block and is labeled pH PROBE on the front of the block. The electrode is held in place with compression type, tubing connector. Tighten the connector just enough to ensure leak free operation. Be careful not to damage the electrode.

NOTE: *The pH electrode should not be allowed to dry out, if you are not going to be running liquid through the controller but only setting the unit up please skip this step untill you plan on running liquid (water or electroless nickel) into the unit.*

STEP 4: Connect the pH and cell temperature sensor signal cables from the sensor block to their respective BNC receptacles on the bottom of the controller enclosure.

NOTE: *The cell temperature sensor is installed in the sensor block before shipment, and its cable is should be connected to the controller.*

STEP 5: Install the bath temperature sensor in the plating tank at a location where it will be protected from damage and will not interfere with the work being processed. Route its cable back to the controller enclosure. Locate the cable where it will be protected from mechanical abuse and chemicals. Connect the cable to its BNC receptacle on the bottom of the

controller enclosure.

NOTE: *The standard, bath temperature sensor is 36 inches (90 cm) in length. Other length sensors are available on special order. The bath temperature sensor is normally supplied with a 25 foot (7½ meter) long connection cable. Other length cables are available on special order.*

STEP 6: Connect the power cable from the controller enclosure to a fused, 15 ampere power supply (120 volt or 240 volt). A separate dedicated circuit for the controller is desirable to limit noise.

NOTE*: In high noise environments, special filtering of the power supply may be required.*

STEP 7: Mount the pump relay module next to the location where the pumps will be installed. The relay module controls the sampling, replenisher and neutralizer pumps. The best location for the pumps is near the plating tank to reduce hose lengths and the chance of their damage. The best location for the relay module is on a nearby wall away from potential damage. The module has mounting lugs that can be used to attach it to a wall or other structure.

STEP 8: Connect the power cable from the relay module to a fused, 15 ampere power supply (120 volt or 240 volt depending on the voltage of the replenishemtn pumps to be used). Connect the sampling, replenisher and neutralizer pump cables to their respective receptacles on the bottom of the relay module. The location of these connections is shown in Figure 3.

NOTE: *The power cables from the controller enclosure and the relay module are best connected to separate circuits. However, if they must operate from the same circuit, a minimum of a 20 ampere supply will be needed.*

The sample pump is a bellows pump with 1/4 inch (6 mm) connections. The replenisher pumps are a single bellows pump with 1/2 inch (12 mm) connections. One pump adds the nickel containing replenisher and the other one adds the hypophosphite containing replenisher. The pH neutralizer pump is the single bellows pump with 3/8 inch (9½ mm) connections.

STEP 9: Connect the relay control cable a circular plastic connector to the bottom of the relay module. Route this cable back to the controller enclosure so it will be protected from mechanical abuse and chemicals. Figures 2 and 3 also show the location of both receptacles.

NOTE: *The standard length for the cable is 40 feet (12 meters). Other length cables are available on special order.*

STEP 10: Install the plating solution pickup tube in the plating tank at a location where it will be protected from damage and will not interfere with the work being processed. It should also be located away from direct impingement by air from the aeration sparger, and where a minimum of bubbles will be drawn in with the sample. A corner of the tank is usually the best

NOTE: *Where the amount of air entering with the sample cannot be controlled, a separate debubbling chamber may have to be installed in the sampling circuit. Contact Technical Support at Palm Technology for more information on debubbling chambers,*

STEP 11: Connect the 1/4 inch (6 mm) diameter sampling tubing to the pickup tube, and route it to the heat exchanger or cooling coil and on to the colorimeter and pH sensor block. High temperature, polyurethane tubing must be used. Locate the tubing so that it is protected from mechanical abuse and does not become kinked. For best results, the sensor block and controller should be within about twenty five feet of the plating tank. For longer distances, the sample pumping and cooling times must be adjusted.

The cooling coil may be four to six loops of sample tubing coiled into a circle. It or an immersion heat exchanger should be placed into a convenient rinse tank with sufficient agitation and water flow to cool the sample. Alternately, an in line heat exchanger may be used. Both immersion and in line exchangers are available from Palm.

STEP 12: Connect the 1/4 inch (6 mm) diameter sample return tubing from the sensor block to the sampling pump and back to the plating tank. The sampling pump is the single bellows pump with 1/4 inch (6 mm) connections.

NOTE: *Ensure that the return tubing is well attached to the tank so that it cannot come loose and spill plating solution outside the tank. Also insure that the sample pump is located after the controller so that it pulls a sample into the controller instead of pushing a sample. Excessive pressure buildup in this line can cause leakage from the colorimeter module into the controller enclosure. By installing the pump after the sample block, the chance of leakage and damage to the controller is reduced and debubbling is improved. The sample return tubing must be routed so that restrictions or kinking cannot occur, and so that it is protected from mechanical abuse.*

STEP 13: Install the replenisher and neutralizer pickup tubes into their respective drums or containers. The tubes must be inserted to the bottom of the container. Connect the 1/2 inch (12 mm) and 3/8 inch (9½ mm) diameter, braid reinforced PVC, addition hoses to the pickup tubes and to the inlets of their respective pumps. Then connect the addition hoses to the pumps' outlets and route them to the plating tank. Locate the hoses so that they are protected from mechanical abuse and do not become kinked.

NOTE: *Ensure that the addition hoses are well attached to the tank so that they cannot come loose and spill addition solutions outside the tank.*

NOTE: *It is often convenient and effective to add replenishers and neutralizers either into the filter bag or into the circulation pump overflow hole. This location helps to provide rapid mixing and to capture any particles that may be produced.*

STEP 15: Ensure that all connections to the controller enclosure, sensor block and relay case are secure.

STEP 16: After all of the components have been installed and connected, and the operator is ready to turn the controller on, the power switch on the bottom of the controller enclosure. After the controller finished booting the MAIN MENU will appear. Select the STATUS button then press the restore factory defaults button, three (3) times. This action will clear the controller's operating program of any faulty data that may have been introduced during shipping and forces a reboot.

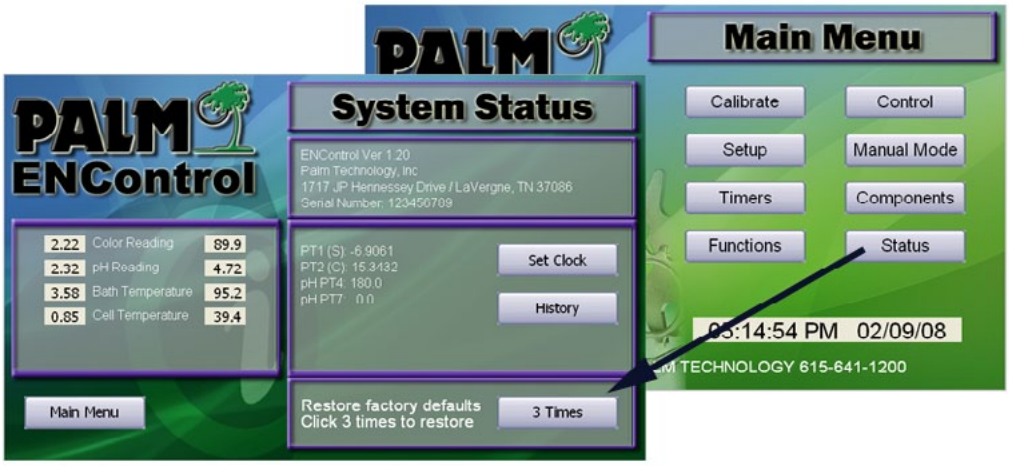


Figure 1 - System Default Restore

NOTE: *A factory restore restart resets the controller to its original default values and erases any user programmed preferences from the controller's memory. A warm restart with the RESET button located inside the controller on the CPU board, however, only restarts the controller program any user variable will be maintained with the units supercapacitor.*

STEP 17: Proceed to Section IV on Initializing the controller.

Section IV
Initializing the Controller
Process Worksheet

After the ENControl™ Model 3300 controller has been installed, the controller must be initialized or set up for the new application. Several steps are required to complete this process. The sample pumping and cooling times must be measured, the sensor cell flow adjusted, the replenishment pumps calibrated, the new bath's operating parameters added to the operating program, the calendar and clock set, and the pH probe and colorimeter calibrated. These steps are described in several subsections of Section IV. The following is a process worksheet that you can use to write down the parameters that you will need to know to setup the controller. Items listed with a * are items that you will calculate during setup the other items you will need to have available.

BATH SETUP

ITEM	VALUE	UOM	DESCRIPTION
Bath Volume	_____	Ltrs	The value of the EN bath volume in liters.
Bath Concentration	_____	g/L	The 100% operating concentration of your EN bath, this value can be provided by your EN solution manufacturer.
Rep. Concentration	_____	g/L	This is the nickel concentration of the EN nickel replenishment solution. This value can be provided by your EN solution manufacturer.
Low Temperature	_____	C	This is low temperature alarm point.
High Temperature	_____	C	This is the high temperature alarm point.

NICKEL ADD/ALARMS

ITEM	VALUE	UOM	DESCRIPTION
Nickel add point	_____	%	The point at which add will be made, any thing below this point will trigger an addition.
Nickel add amount	_____	%	The amount of addition to make.
Nickel high alarm	_____	%	The point at which the high alarm is sounded.
Nickel low alarm	_____	%	The point at which the low alarm is sounded.
Nickel stop add	_____	%	The point at which the stop alarm is sounded and no additions will be made below this value.
Nickel Save %	_____	%	If Nickel Save is enabled this is the amount to reduce the setpoint by over the following two MTO Points
Nickel Save MTO Start	_____	MTO	The MTO start point to start the nickel reduction
Nickel Save MTO Stop	_____	MTO	The MTO stop point to stop the reduction

pH ADD/ALARMS - No Ramp

ITEM	VALUE	UOM	DESCRIPTION
pH add point	_____	pH	The point at which add will be made, any thing below this point will trigger an addition.
pH high alarm	_____	pH	The point at which the high alarm is sounded.
pH low alarm	_____	pH	The point at which the low alarm is sounded.
pH adjust amount	_____	mL/L	The amount of pH neutralizer solution in mL that will adjust one bath liter by 0.1 pH units.

pH ADD/ALARMS - Ramping Function Enables

ITEM	VALUE	UOM	DESCRIPTION
pH add point 1	_____	pH	The first point at which add will be made, any thing below this point will trigger an addition.
MTO point 1	_____	MTO	The MTO amount at which addition point one is enabled to, for example if MTO 1 is entered here then addition point 1 is valid from MTO 0 to MTO 1.
pH add point 2	_____	pH	The second point at which add will be made, any thing below this point will trigger an addition.
MTO point 2	_____	MTO	The MTO amount at which addition point two is enabled.
pH add point 3	_____	pH	The third point at which add will be made, any thing below this point will trigger an addition.
MTO point 3	_____	MTO	The MTO amount at which addition point three is enabled.
pH add point 4	_____	pH	The forth point at which add will be made, any thing below this point will trigger an addition.
MTO point 4	_____	MTO	The MTO amount at which addition point four is enabled.
pH add point 5	_____	pH	The fifth and final point at which add will be made, any thing below this point will trigger an addition.
MTO point 5	_____	MTO	The MTO amount at which addition point five is enabled, the fifth point will continue until the MTO is reset.
pH high alarm	_____	pH	The point at which the high alarm is sounded.
pH low alarm	_____	pH	The point at which the low alarm is sounded.
pH adjust amount	_____	mL/L	The amount of pH neutralizer solution in mL that will adjust one bath liter by 0.1 pH units.

Pump Rates

ITEM	VALUE	UOM	DESCRIPTION
*Nickel pump	_____	mL/min	The nickel pump solution rate.
*Hypo pump	_____	mL/min	The hypo pump solution rate.
*pH pump	_____	mL/min	The pH pump solution rate.
*R3 pump	_____	mL/min	The replenisher 3 pump solution rate. This menu item will show up if you have replenisher 3 enabled.

Timers

ITEM	VALUE	UOM	DESCRIPTION
*Sample time	_____	secs	The amount of time to pull the sample half way to the controller.
*Cool time	_____	secs	The amount of time for the solution to wait to cool before a second sample time is run.
*Settle time	_____	secs	The time for the sample to wait in the colorimeter to settle before a the sensor is read.
*Mix delay	_____	secs	If an addition is made after the sample is read this time will be enabled before another sample is pulled.
*Loop delay	_____	secs	If no addition is made after the sample is read this time will be enabled before another sample is pulled.

Functions

ITEM	VALUE	UOM	DESCRIPTION
Nickel Replenish	_____	Enabled/ Disabled	If this is enabled then nickel and hypo will be replenished as set.
pH Replenish	_____	Enabled/ Disabled	If this is enabled the pH additions will be made.
R3 Replenish	_____	Enabled/ Disabled	If this is enabled the user can customize a third replenisher to be made based on nickel adds.
Replenish level alarm	_____	Enabled/ Disabled	If this is enabled the user will be notified when the replenisher levels fall below 15 liters.
Over replenish alarm	_____	Enabled/ Disabled	If this is enabled and during control mode 5 additions are made in a row, the user will be notified.
Bath Temperature	_____	Enabled/ Disabled	If this is enabled the bath temperature will be read and high/low alarms for temperature will be sounded.
High/Low Alarm	_____	Enabled/ Disabled	If this is enabled all high/low alarms for nickel and pH will be sounded.

ITEM	VALUE	UOM	DESCRIPTION
pH Ramp	_____	Enabled/ Disabled	If this is enabled the user can setup a custom pH addition ramp based on bath age (MTO).
ColorShift™	_____	Enabled/ Disabled	If this is enabled the controller will auto audjust the colorimeter calibration to conpensate for bath age.
Variable Nickel Adds	_____	Enabled/ Disabled	By enabling this function the system will do variable nickel add's up to a programmable maximum percentage.
Nickel Save	_____	Enabled/ Disabled	This is the Nickel Save technology that allows you to reduce your nickel add point by a programmable % over a programmable bath age time frame.

Bath Components

ITEM	VALUE	UOM	DESCRIPTION
Nickel replenish volume	_____	Ltrs.	This is the total volume of the nickel replenishment container.
Hypo replenish volume	_____	Ltrs.	This is the total volume of the hypo replenishment container.
pH replenish volume	_____	Ltrs.	This is the total volume of the pH replenishment container.
R3 replenish volume	_____	Ltrs.	If R3 is enabled in FUNCTIONS then this is the total volume of the R3 replenishment container.

Section IV
Initializing the Controller
Setting the controllers password

The ENControl™ Model 3300 password protects three critical setup functions the Setup, Timers, and Functions. In order to access those functions and administrator user must log into the unit. You can either keep the default password or change it. Once the admin logs on the system will keep them logged on for 30 mins, after the 30 mins has expired they will be automatically logged off. The user could also manually log themselves off by repressing the lock button.

STEP 1: To enter the admin password, press the unlock button from the lower left hand section of the screen.

MAIN MENU

STEP 2: Enter the default password of 2244.

STEP 3: Click the Status screen to get to the change password section.

STEP 4: Once your in the Status screen you can click the Change Password button to change the administrator password. If you change the password make sure to write it down and not loose it.

Section IV
Initializing the Controller
Admin Logon

The ENControl™ Model 3300 allows you to configure the controller to suit your particular setup, the following describes each individual function and how it affects your setup.

STEP 1: To enter the admin password, press the unlock button from the lower left hand section of the screen.

MAIN MENU

STEP 2: Enter the password (Default password is 2244), if you have changed the password enter it here.

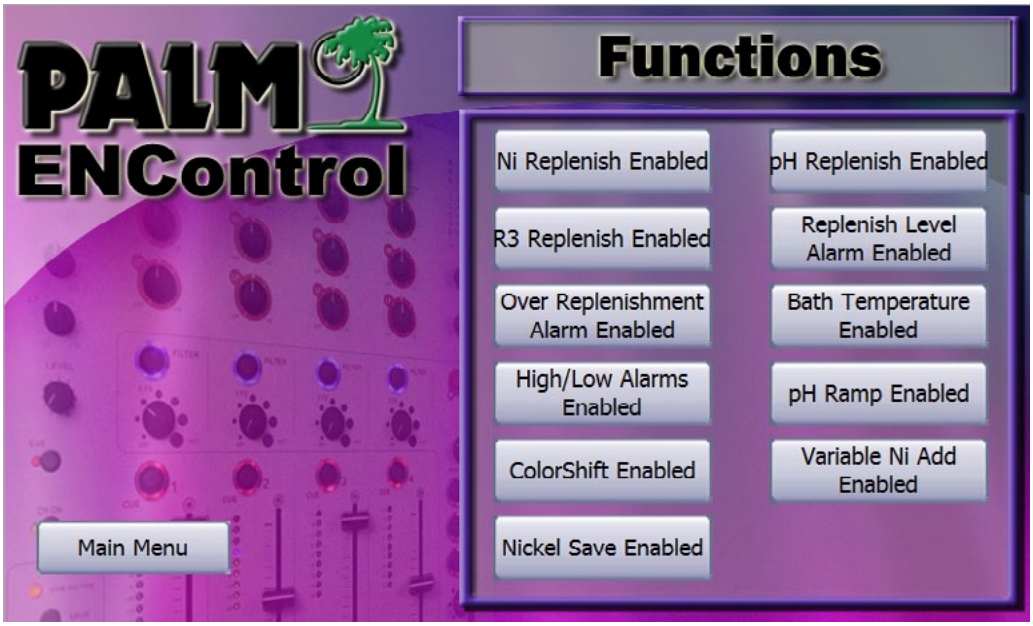
STEP 3: Once logged on the system will keep the Admin logged on for 30 mins, after that time period it will automatically log the Admin off the system.

STEP 4: To manually log of the system click the lock button on the home screen.

Section IV
Initializing the Controller
Functions Setup

The ENControl™ Model 3300 allows you to configure the controller to suit your particular setup, the following describes each individual function and how it affects your setup.

STEP 1: Enter the function menu as follows:



MAIN MENU > FUNCTIONS

Nickel Replenishment: Allows for the enablement of Nickel/Hypo replenishments, if this is disabled no additions of nickel or hypophosphite will be made to the bath, the controller will still monitor the nickel metal concentration.

pH Replenishment: Allows for the pH additions to be enabled or disabled to the electroless nickel bath, if this is disabled the controller will still monitor the pH level in the bath.

R3 Replenishment: If enabled this allows for a third component to replenish the bath based on nickel adds, the addition percentage can be configured under bath setup menu and is based on a user configured percentage addition to the nickel add that starts at a user configured metal turn over point.

Replenish Level Alarm: This function enables the controller to alarm when the replenisher container level falls below 15 liters.

Over Replenishment Alarm: If enabled this allows for the controller to alarm when it has made more then 5 consecutive additions to the bath, additions will still be made however it alerts the user that something might be wrong because several consecutive additions have been made.

Bath Temperature: Enables or Disables the reading of the bath temperature during the control cycle.

High/Low Alarms: If disabled all high and low alarms for nickel, pH, and temperature will be disabled, it is recommended that this function be enabled to alert the user of out of control conditions.

pH Ramp: Allows for the pH additions to be a configurable ramp. If this is enabled there will be a pH ramp setup screen instead of a pH setpoint under that bath pH add alarms screen. The pH ramp can have five seperate pH addition points at five different MTO (Metal Turn Over) points. Several bath chemistries benefit from allowing the bath pH to get higher as the bath ages. If this is disabled then only one setpoint will be active for pH additions.

Colorshift: Allows for the enablement of the colorimeter shifting functions. As a typical electroless nickel ages its color changes, this is why colorimeter standardizations are necessary this funtion keeps up with that colorshift and can reduce the number of standardizations necessary to the bath.

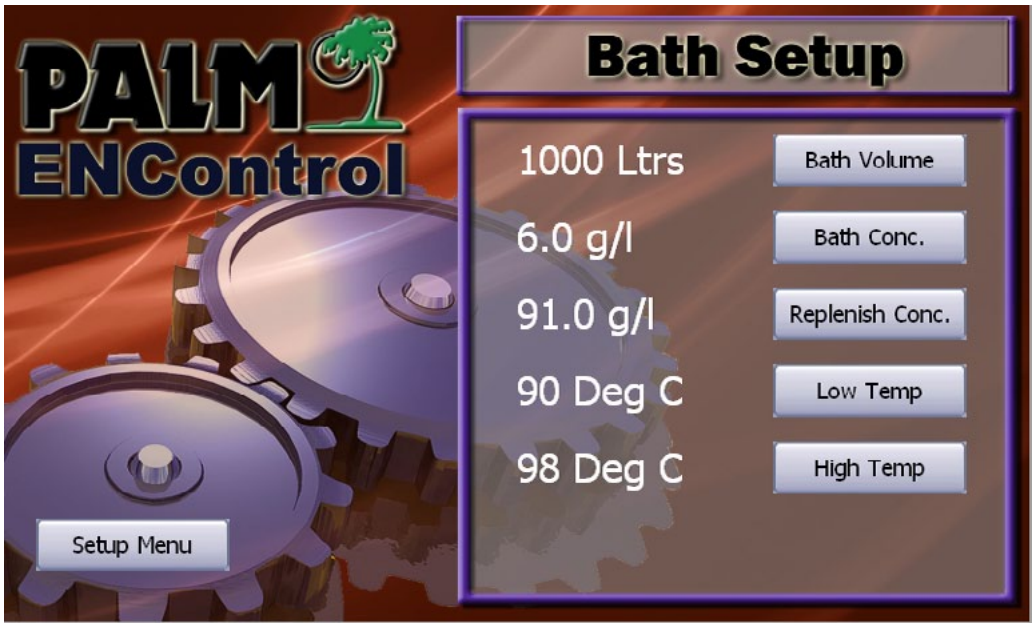
Variable Nickel Adds: If enabled the controller will add a variable replenishment amount to return the bath to 100% concentration. Instead of a fixed addition amount under the bath nickel add setup there will be a maximum amount addition. Once an add is necessary the controller will add an amount up to the maximum to the bath to bring it back to 100% concentration.

Nickel Save: If enabled the controller can be setup to reduce the nickel add point by a programmable percentage at a programmable Metal Turn Over (MTO). This parameter is setup via the Nickel addpoints and alarms screen. If this is disabled then only one setpoint will be active for nickel additions. The use of this function along with the pH ramp functions can allow you to maintain bath activity toward the end of the life of the bath and when disposing the bath not have to dump a 100% nickel solution. Please contact your chemical provider if you need some guidence and reducing the Nickel percentage along with ramp the pH toward the end of the bath life.

Section IV
Initializing the Controller
Programming bath parameters

The ENControl™ Model 3300 calculates the volume and time of replenisher or neutralizer additions based upon information about the bath that must be entered into the operating program. This information entered through the setup menu. Use the following procedure to enter this information.

STEP 1: Enter the bath's parameters as follows:



MAIN MENU > SETUP > BATH PARAMETERS

STEP 2: Enter the plating bath's volume in liters by pressing the BATH VOLUME button and entering it in the keypad. Any value between 10 and 19999 is allowed.

STEP 3: Enter the nickel concentration of the electroless nickel plating bath at 100% by pressing the BATH CONC. button and entering it in the keypad. Any value between 2.0 and 9.0 is allowed.

STEP 4: Enter the nickel concentration of the electroless nickel plating replenisher concentration by pressing the REPLENISH CONC. button and entering it in the keypad. Any value between 50.0 and 150.0 is allowed.

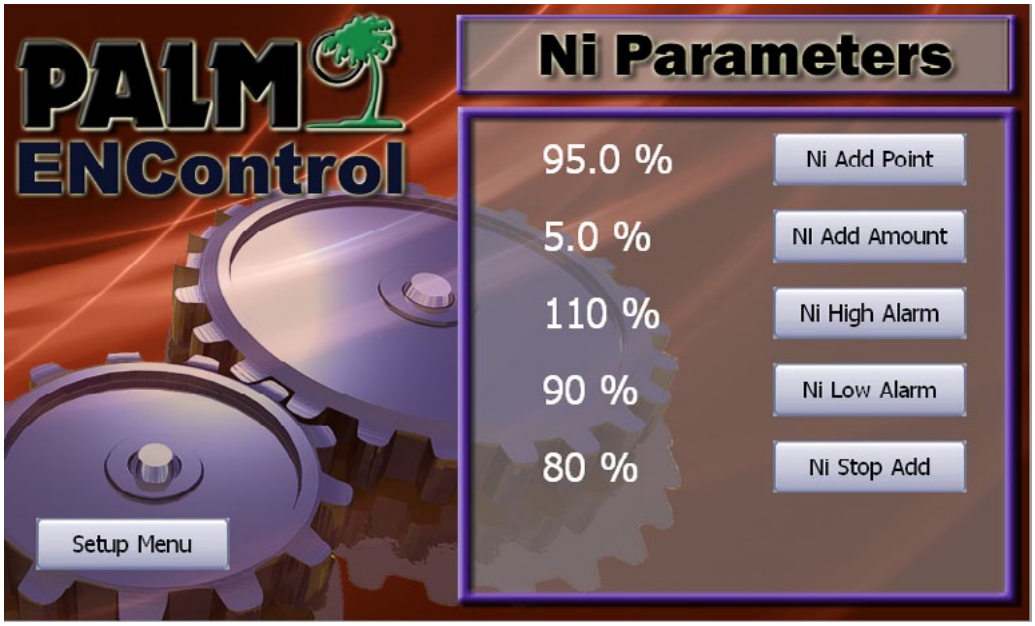
STEP 5: Enter the low alarm point for bath temperature in degrees Celsius by pressing the LOW TEMP button and entering it in the keypad. Any value between 0.0 and 110.0 is allowed.

STEP 6: Enter the high alarm point for bath temperature in degrees Celsius by pressing the HIGH TEMP button and entering it in the keypad. Any value between 0.0 and 110.0 is allowed. Press the Setup Menu button to return to the Setup menu

Section IV
Initializing the Controller
Nickel Add Point and Alarms

The ENControl™ Model 3300 will add solution to the plating bath based on the nickel add points and add amounts programmed into the add/alarms screen. Use the following procedure to enter this information.

STEP 1: Enter the bath's Nickel Parameters as follows:



MAIN MENU > SETUP > NICKEL ADD/ALARMS

STEP 2: Enter the Nickel Add Point in Percentage concentration by pressing the NI ADD POINT button and entering it in the keypad. Any value between 80 and 110% is allowed. If the Nickel Save feature is enabled in the Functions menu then this will only show a Nickel Add Point button that will take you to the Nickel Save screen. Please see Nickel Save in the next section.

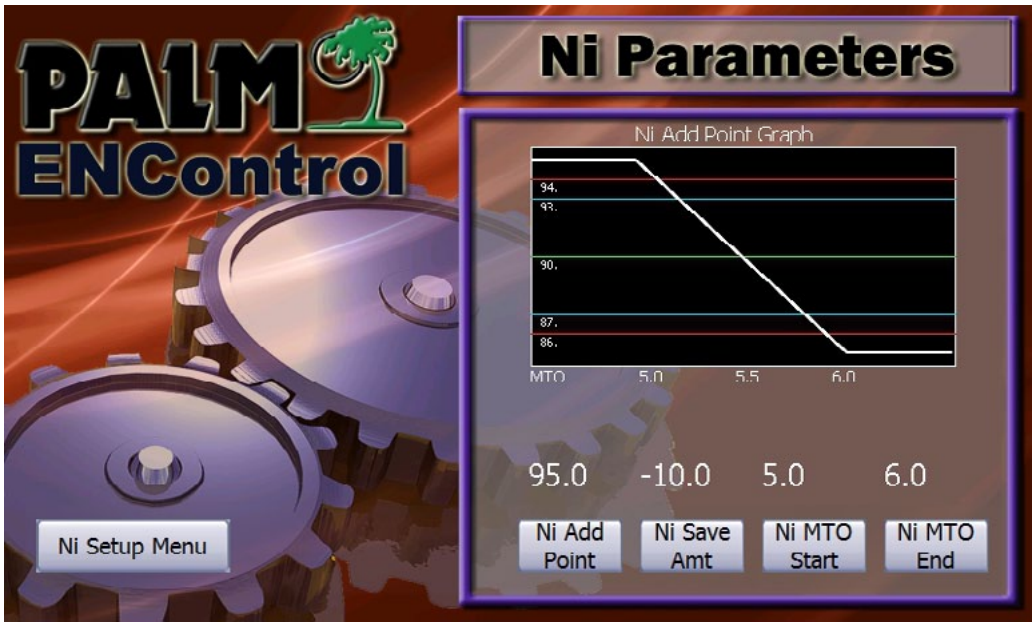
STEP 3: The nickel add amount or nickel max amount will show depending on if you have the variable addition amount enabled under the functions menu. For a 6 g/L bath, a 5 percent addition is the amount needed to replace 0.3 g/L of nickel. If you have variable additions enabled the controller will add the amount of nickel replenishment to get the bath back to 100% concentration when the controller drops below the add point. If you have the variable addition amount disabled then a fixed addition amount will be made. Enter the Nickel Add Amount or Nickel Add Maximum by pressing the NI ADD AMOUNT or NI ADD MAX button and entering it in the keypad. Any value between 1 and 10% or 1 and 15% (for max) is allowed.

STEP 4: Enter the Nickel High Alarm in Percentage concentration by pressing the NI HIGH ALARM button and entering it in the keypad. Any value between 90 and 120% is allowed.

STEP 5: Enter the Nickel Low Alarm in Percentage concentration by pressing the NI LOW ALARM button and entering it in the keypad. Any value between 70 and 100% is allowed.

STEP 6: Enter the Nickel Stop Addition in Percentage concentration by pressing the NI STOP ADD button and entering it in the keypad. Any value between 50 and 90% is allowed.

Section IV
Initializing the Controller
Nickel Add Point and Alarms
Nickel Save Technology



***MAIN MENU > SETUP > NICKEL ADD/ALARMS* > NICKEL ADDPOINTS**

If you have the Nickel Save technology enabled under the functions menu (See section IV Initializing Function), then instead of a nickel set point under the Nickel add/alarms screen you will have a Nickel Add Point button, once you click that it will take you to the next screen to set up the Nickel Save feature.

With the Nickel save feature pick your normal nickel addpoint. Next pick a nickel save amt in percentage. You then need to pick the MTO start and end points.

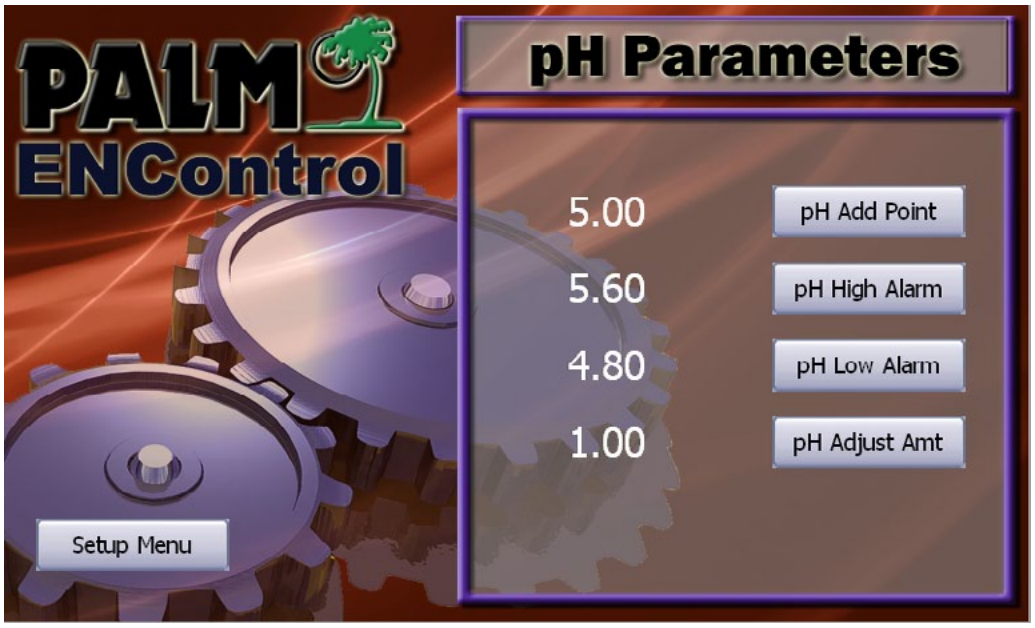
In the above example, from MTO 0-5.0 the nickel add point will be 95%. Then from MTO 5.0 to MTO 6.0 the nickel add point is slowing dropped by 10% so at MTO 6.0 the nickel add point will be 85%.

The use of this function along with the pH ramp cability can allow you not to sacrifice plating rate while at the same time saving the amount of nickel you must dispose of at the end of your bath life.

Section IV
Initializing the Controller
pH Add Point and Alarms

The ENControl™ Model 3300 calculates the volume and time of neutralizer additions based upon information you program into the pH add point menus Use the following procedure to enter this information.

STEP 1: Enter the bath's pH parameters as follows:



MAIN MENU > SETUP > PH ADD/ALARMS

STEP 2: If you have enabled pH ramp technology the description for setting this is later in this section, if you have it disabled the pH ramp technology the pH add point will show and you can adjust it by pressing the PH ADD POINT button and entering it in the keypad. Any value between 3.0 and 6.0 is allowed.

STEP 3: Enter the pH High Alarm point by pressing the PH HIGH ALARM button and entering it in the keypad. Any value between 3.0 and 7.0 is allowed.

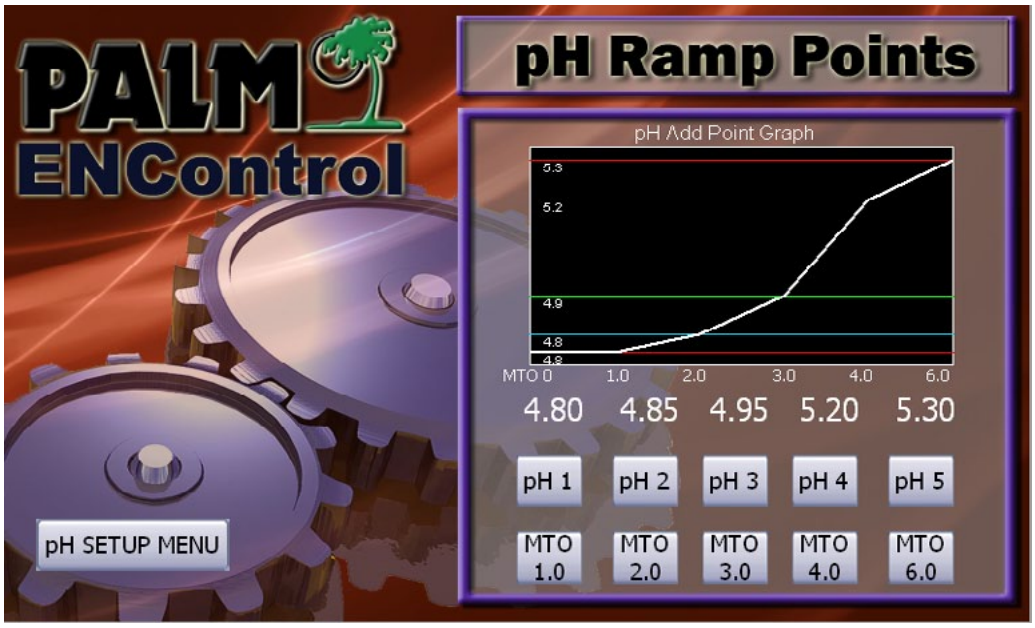
STEP 4: Enter the pH Low Alarm point by pressing the PH LOW ALARM button and entering it in the keypad. Any value between 2.0 and 6.0 is allowed.

STEP 5: Enter the pH adjustment amount this is the addition rate that the controller uses to calculate the size of a neutralizer addition. When the controller finds that a neutralizer addition is needed, it will add a volume equal to the bath volume (in liters) times the pH addition rate (in mL/L). For example, for a tank with a capacity of 1000 liters (260 gallons), each neutralizer addition will equal:

1000 L * 1 mL/L = 1000 mL.

One mL/L is normally enough 50 percent ammonium hydroxide or potassium carbonate to raise the pH of a bath by 0.1 pH unit. For more diluted neutralizer solutions, the rate may need to be increased.

Section IV
Initializing the Controller
Programming bath pH parameters
pH Ramp Technology



MAIN MENU > SETUP > pH ADD/ALARMS > pH RAMP POINTS

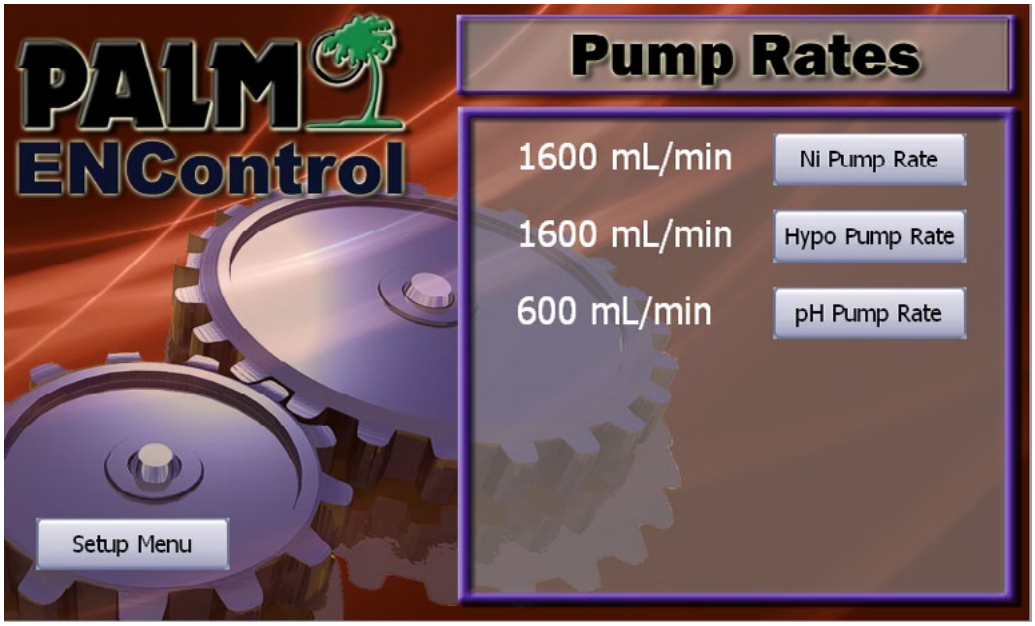
If you have the pH Ramp technology enabled under the functions menu (See section IV Initializing Function), then instead of a pH set point under the pH parameters screen you will have a pH Ramp Points button, once you click that it will take you to the next screen to set up the pH ramp.

With pH ramp technology you can pick five different pH set points and five different metal turn over set points to associate with each other. Click each button to enter the set points and MTO points.

Section IV
Initializing the Controller
Replenishment Pump Rates

The ENControl™ Model 3300 will use the pump rates to calculate how long to turn on the pumps during a replenishment cycle. Use the following procedure to enter this information.

STEP 1: Enter the bath's pump rates as follows:



MAIN MENU > SETUP > PUMP RATES

STEP 2: Once you have determined the output of each pump you enter the nickel pump rate by pressing the NI PUMP RATE button. To aid in determining the output of each pump you can use the manual operation to run each pump, see the section IV on manual operation of each pump.

STEP 3: Enter the hypophosphite pump rate by pressing the HYPO PUMP RATE button and entering the output of that pump.

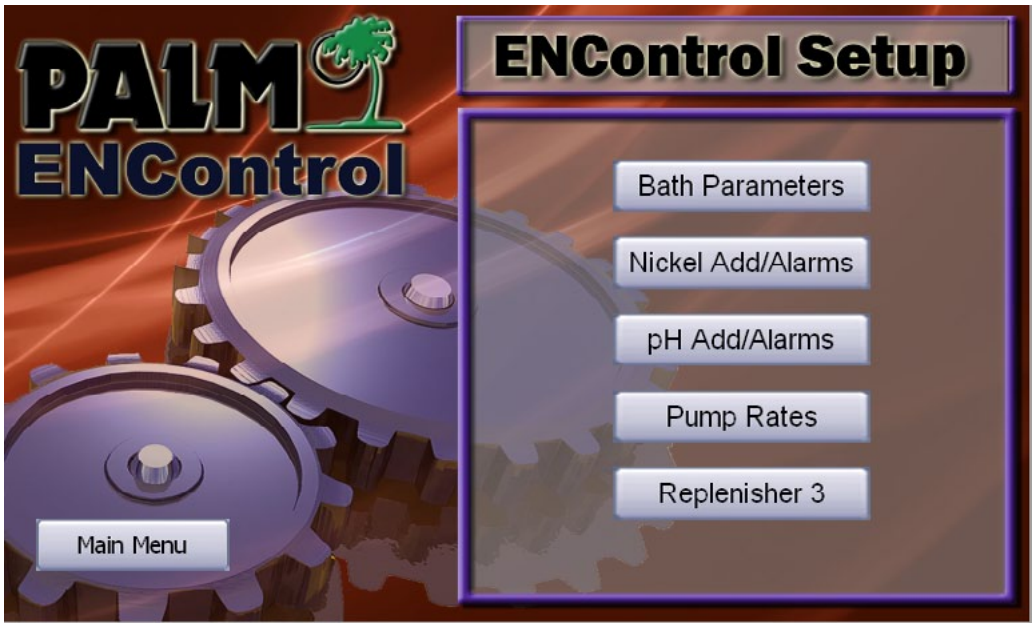
STEP 4: Enter the pH neutralizer pump rate by pressing the PH PUMP RATE button and entering the output of that pump.

STEP 5: If you have the third replenisher R3 enabled under the functions menu (See section IV Initializing Functions) then the third replenisher pump rate will show under the pH pump rate and you can enter it here.

Section IV
Initializing the Controller
Replenisher 3 Setup

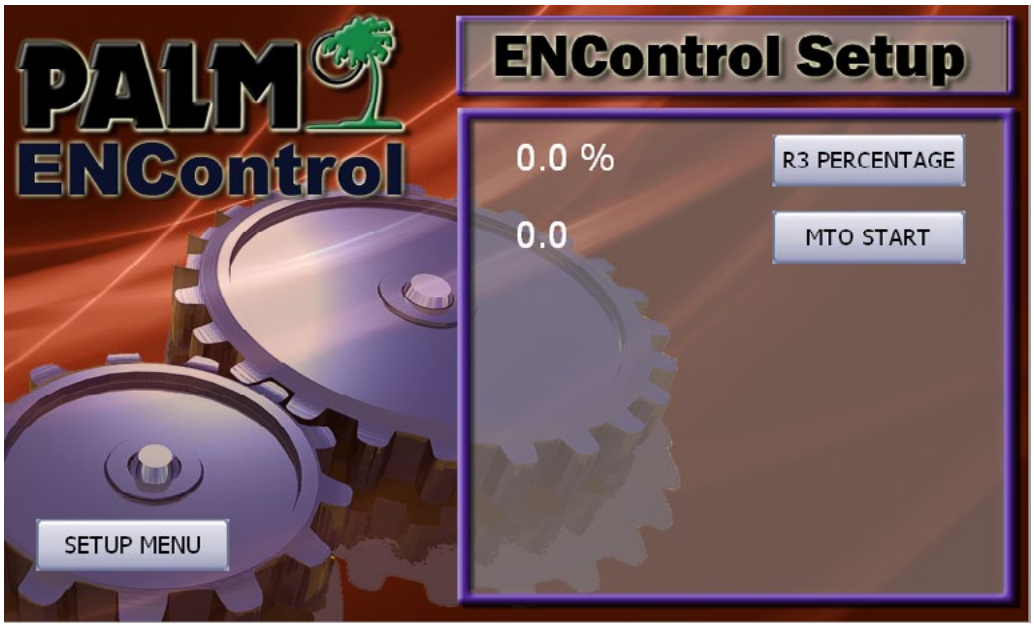
The ENControl™ Model 3300 normally operates two component pumps a Nickel Pump and Hypo Pump. However the user can setup the unit to operate a third replenishment pump that operates as a percentage to the nickel add. To setup this function use the following steps.

STEP 1: Enable the third replenisher from the Functions menu:



MAIN MENU > SETUP

STEP 2: Once the R3 has been enabled the Replenisher 3 button will appear in the setup menu list. Press this button to enter the R3 setup screen.



MAIN MENU > SETUP > REPLENISHER 3

STEP 3: From the replenisher 3 screen there are two parameters you can setup. The first one is the amount (%) to add based on the Nickel add required. The second one is the bath age in MTO's to start making this add.

If the user had 10% in the R3 percentage and 1.0 in the MTO start point, then the 3300 would not make any R3 additions until the MTO was 1.0. After that it would calculate the Nickel add required in mL for example 3200 mL required and then add 10% of R3 320 mL as well to the bath.

Section IV
Initializing the Controller
Determining Control Cycle Timers

The ENControl™ Model 3300 controls the flow of solution through the cooling coil, sensor block and colorimeter by starting and stopping the sample pump. This action helps cool and debubble the sample. It first pumps the solution from the tank to the sample box while cooling the sample with the cooling plate. Next, the controller allow the sample to settle. Finally, it measures the nickel concentration and pH of the solution, and decides whether an addition is needed. After each analysis, the controller delays for several minutes before the next sampling cycle.

The controller is shipped with default time values suitable for a distance of about fifteen feet (5 meters) from the tank.

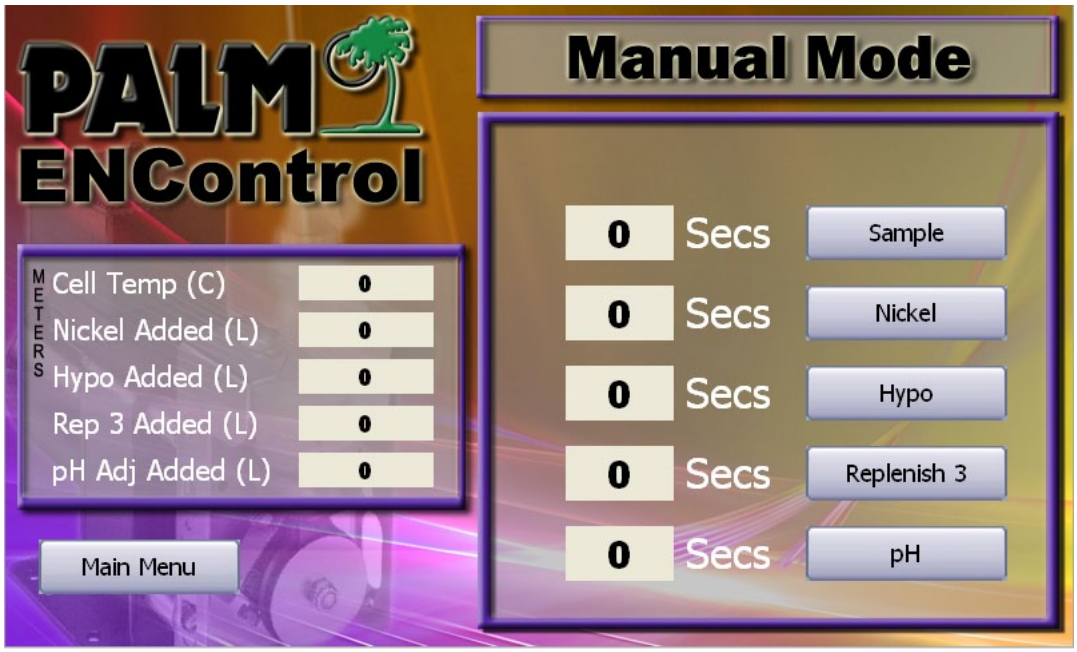
These values are:

Sample period	60 seconds
Cool time	90 seconds
Settling stop period	20 seconds
Delay between sampling cycles after addition (Mix Delay)	10 minutes
Delay between sampling cycles (Loop Delay)	5 minutes

Use the following procedure to establish times for installation, or to fine tune the operation of the controller for special applications. These measurements must be conducted using the bath at its operating temperature.

STEP 1: Measure the time needed to pump a fresh sample from the tank to the sample cell. First remove the pH probe from the sensor block, to protect it from contact with hot plating solution, and plug its mounting hole with a 3/8 inch (9½ mm) diameter rubber stopper.

Fill the sensor block and the sample and return tubing with deionized water. Take the sample pickup tube from the plating tank and place it into a bucket filled with deionized water. Turn on the sample pump and pump water through the sample loop until it returns to the plating tank. The sample pump may be operated manually by pressing the following keys:



MAIN MENU > MANUAL MODE > SAMPLE PUMP

The pump will continue to operate until the user presses the SAMPLE PUMP button.

Reinstall the sample pickup tube into the plating tank. Turn on the sample pump a second time and pump plating solution from the tank until it reaches a few feet (one meter) beyond the sensor block and then stop the pump. The controller's LCD display will show the amount of time that has passed during pumping.

NOTE: The sample pump time will change only when the sample tubing length or the sample pump flow rate is changed, but the cooling time can be affected by seasonal changes in water and room temperature. Thus, it is best to set the cooling time to provide a solution temperature as low as possible.

STEP 3: Enter the sample pump time and the cooling time into the controller's operating program by pressing the following keys:

MAIN MENU > TIMERS

STEP 4: Press the SAMPLE TIME button and enter the new value for sample pump time. The controller will automatically prompt the user if they enter an incorrect time. On the keypad screen once you have entered the time you want press the enter button to accept the changes, or the cancel to cancel out of the screen.

STEP 5: Press the COOL TIME button and enter the value for the cooling time. The cool time is the amount of time that the sample will sit in the sample line and cooling coil between samples. This value should to be adjusted based on the amount of cooling you have. If you have the cooling coil mounted in the cold water rinse tank a small amount of time

STEP 6: Once the cool time has been entered you can change the SETTLE TIME. This is the time that the controller allows the solution in the colorimeter cell to settle and stop moving. It may be increased to improve the stability of the colorimeter's readings, or reduced to help reduce the period of the sample cycle. Practically, the settling time should not be less than 10 seconds or greater than 90 seconds.

STEP 7: Enter the LOOP DELAY. This is the time after the controller analyzes the bath that it waits before it starts another sampling cycle. Reduce the loop delay to increase the frequency of testing and to reduce the period of the sampling cycle. The controller will prompt the operator to enter the number in seconds. For instance, 4½ minutes should be entered as 270 seconds.

STEP 7: Enter the MIX DELAY. This is the time after the controller analyzes the bath, decides that a replenisher or neutralizer addition is needed, and makes that addition, which it waits before it starts another sampling cycle. It is intended to allow the replenisher or neutralizer to completely mix in the bath, so that a uniform sample is delivered to the sensor block. With a well agitated bath, such as one with vigorous air agitation, mixing may be complete in two minutes or less. Accordingly, it may often be possible to reduce the mix time to increase the frequency of testing and to reduce the period of the sampling cycle.

NOTE: The time between sampling cycles consists of the *sample time* plus the *cool time*, plus the *sample time*, plus the settle time, plus **EITHER** the *loop delay* (if no addition is made) or the replenisher/neutralizer pumping time plus the *mix delay* (if an addition is made). For example, for the default pumping times, the sampling cycle is:

45 sec (Sample Time) + 40 sec (Cooltime) + 45 sec (Sample Time) + 10 sec (Settle Time)
If no addition is needed
+ 10 min (Loop Delay)
If an addition is needed
+ addition pump time + 10 min (Mix Delay)

Practically, this means that the controller will make a complete cycle in about 15 or 16 minutes, even if it makes an addition each time. Since most electroless nickel baths need only two or three 5 percent additions every hour, this frequency is normally adequate. For those applications where larger or more frequent additions are needed (such as baths with very high loadings) the sample and addition cycle time can be reduced by reducing the loop and mix delay times, by shortening the sample tubing length, or by improving the cooling cycle. It is possible to get the system to do a cycle of 3 - 4 minutes without additions and 8-10 mins with additions.

STEP 8: Reinstall the pH probe into the sample cell and ensure that all of the tubing connections are tight and leak free.

Section IV
Initializing the Controller
Adjusting Sensor Block Flow

An excessive quantity of air bubbles entering the sensor block in the ENControl™ Model 3300 can cause inaccurate measurements of nickel concentration. The presence of bubbles can be observed visually in the sensor block and the tubing inside the colorimeter module. Also, bubbles passing through the colorimeter cell (the black block containing the colorimeter lamp and sensor) will often cause a visual flash of light at the top or bottom of the cell.

Normally, excessive bubbling is not a problem with a properly installed controller. A few bubbles may occasionally enter the colorimeter cell during the sample pump time, but they will float free from it during the settling time. If many bubbles are present, however, and if they are entering and remaining in the colorimeter cell at the end of the settle time, the sampling loop will have to be adjusted using the following procedure.

It is best to allow the controller to go through its complete sampling cycle, so that the effects of the sample pump time, the cool time and the settle time can be observed. This cycle can be accomplished by pressing the F key to return to main menu and then the C key to start a sample cycle. This function will automatically
turn the sample pump on and off for the selected sample pump, cool and settle times and allow the operator to observe the colorimeter module.

NOTE: Operating the sample pump manually to observe bubble movement can allow hot solution to enter the sensor block, which can damage the pH electrode.

STEP 1: First, with the sample pump in operation, try repositioning the sample pickup tube in the plating tank to a less agitated location away from the air sparger.

STEP 2: If bubbles persist in the colorimeter module, reduce the pumping rate of the sample pump by 25 percent.

NOTE: If the pumping rate is reduced, the sample pump time, as determined above, will have to be measured again.

The flow rate of the GRI sample pump is changed with the adjustment screw on the pump's crank assembly. First loosen the lock screw and then rotate the adjusting screw counterclockwise to reduce the flow. The position of both the lock and adjusting screws are marked on the face of the crank. The approximate output of the pump is shown on the scale on the right side of the crank. Retighten the lock screw when the flow rate has been reduced by 25 percent.

NOTE: Do not loosen or turn the lock nut on the bottom of the adjusting screw. Also, do not reduce the pump's flow rate by restricting the suction or discharge tubing; this will cause excessive pressure within the pump and shorten its life.

NOTE: The GRI sampling pump is normally supplied with its flow set to 100 percent of its maximum output. Typically, this flow is about 410
mL/min (at 60 Hz or 340 mL/min at 50 Hz).

STEP 3: If bubbles are still passing through the colorimeter cell, loosen the flow adjustment plug in the sensor block to divert solution and bubbles through the bypass loop. The adjustment plug (marked FLOW ADJ on the sensor block) is adjusted by rotating it counterclockwise to increase flow through the bypass loop (and reduce flow to the colorimeter) or by rotating it clockwise to reduce flow through the bypass loop (and increase flow to the colorimeter).

Loosen the plug one quarter to one half turn at a time and observe the flow of solution passing through the sensor block and colorimeter module.

NOTE: Be careful not to loosen the adjustment plug that little or no flow is passing through the colorimeter.

With a properly operating sampling loop and sensor block there will typically be a small air space in the block just below the adjustment plug. This space will move down and up as the sampling pump moves solution through the cell. The passage beneath the air space should be flooded with solution.

If bubbles continue to block the colorimeter cell, it will probably be necessary to install a debubbling chamber in the sample line ahead of the sensor block. Contact Technical Support at Palm Technology for more information on debubbling chambers.

Section IV
Initializing the Controller
Setting The Clock

For the Model 3300 to keep and print proper records of bath parameters and additions, it must know the correct date and time. Use the following procedure to set the calendar and clock.

Enter the date and time into the controller's operating program by pressing the following keys:

MAIN MENU > STATUS > SET CLOCK

STEP 1: To set the clock press the Hour button and then enter the hour. Enter the current time in 24 hour (military) format. For instance, 10:30 PM equals 22:30 hours.

STEP 2: Next hit the Minute button and enter the current minute.

STEP 3: Enter the current date by pressing the Month enter the number from 1 to 12 which equals the current month.

STEP 4: Enter the current date by pressing the Day enter the number from 1 to 31 which equals the current day.

STEP 5: Enter the current date by pressing the Year enter the number from 0 to 99 which equals the current year. Enter the last two digits of the current year.

Section IV
Initializing the Controller
Configuration of the Serial Port

The ENControl™ Model 3300 has a single multipurpose RS232 serial port that the user can configure its operation either as a printer port or an SPC port for hookup to a personal computer.

STEP 1: To enter the serial port configuration screen.

MAIN MENU > SETUP > COMMUNICATIONS

STEP 2: From the communications screen the user can toggle between the two types of serial port by pressing the Serial Port button. THe current type of serial port is displayed to the left.

STEP 3: If the printer port is selected please setup your serial printer for the following communication parameters. 19200 Baud, 8 Databits, 1 Stop Bit, No parity.

If the SPC port is selected you can then set a unique unit number for the 3300. This unit number will be transmitted with the rest of the control readings to the PC. If you are using the Palm ENCollect software see the ENCollect manual for the PC communication setup.

Section IV
Initializing the Controller
Backup/Restore

The ENControl™ Model 3300 keeps all the program variables and setup configuration files in a super capacitor backed RAM. If the power to the unit if shut off these values will be retained for a period of time based on the capacitor. This amount of time is 5-6 days. If the unit is powered off for a longer period of time like an extended holiday shutdown once its powered back on it will default back to its factory settings.

Once you have the unit programed for your setup you can back these values up to a flashable EEPROM inside the unit. If you ever loose those values you can then restore them from EEPROM. To back them up follow these simple steps.

STEP 1: To enter the admin password, press the unlock button from the lower left hand section of the screen.

MAIN MENU

STEP 2: Enter the password (Default password is 2244)

STEP 3: Click the Status screen to get to the backup section.

STEP 4: Once your in the Status screen you can click the backup button to backup all the system setup configuration files. To restore those values click the restore button.

NOTE: If you every have to restore those values you will need to redo all the calibration setup routines.

Section V
Calibrating the Controller
Two Point Nickel

For the Model 3300 to accurately measure the nickel content of the electroless nickel bath, its colorimeter ust be calibrated so that it can recognize the properties of the plating solution. The colorimeter is calibrated using the following procedure:

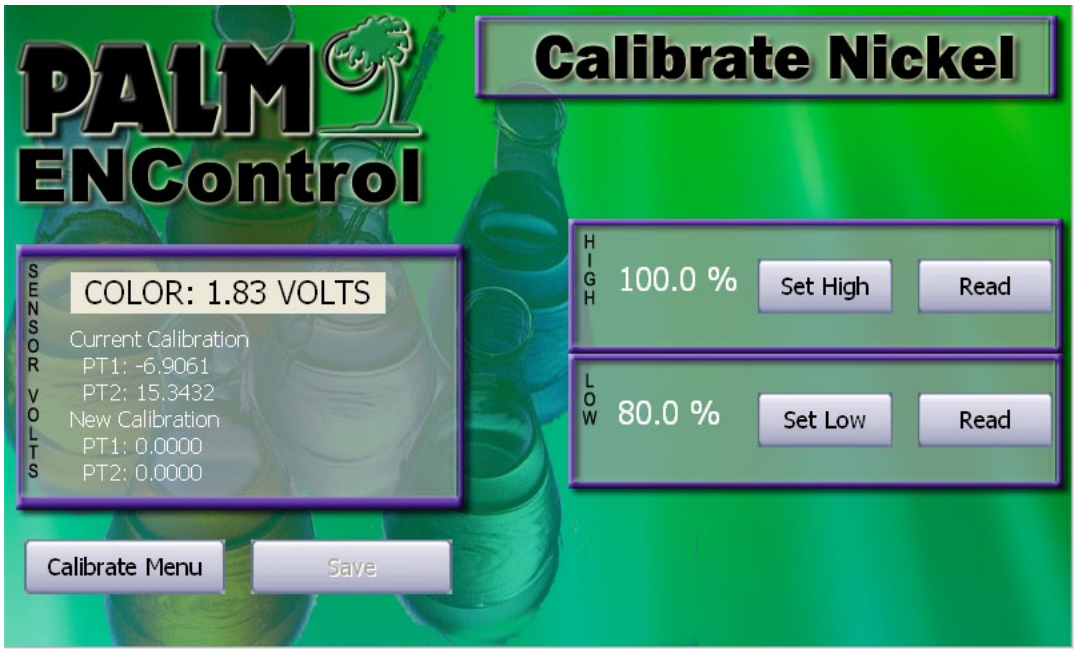
NOTE: The controller must be completely warmed up before it is calibrated. It should be turned on at least 5 minutes before the calibration is begun.

STEP 1: Prepare two standard samples of the bath. One should have a nickel content of approximately 100 percent and the other's concentration should be about 80 percent. The concentrations of the two solutions are not critical as long as they are about 20 percentage points apart and their correct nickel concentration is known. Measuring these two solutions will allow the controller to measure the slope and gain for the individual plating solution and will allow it to accurately measure the concentration of new samples.

STEP 2: Enter the Calibrate Sensors menu by pressing the following keys:

MAIN MENU > CALIBRATE

STEP 3: Enter the Two Calibrate Sensors menu by pressing the following keys:



MAIN MENU > CALIBRATE > NICKEL 2 POINT CAL

STEP 4: In the left hand window you will find the following information.

- COLOR: X.XX VOLTS - This is the voltage coming from the colorimeter circuit. Normally with 100% solution you should see a voltage from 0.8 Volts to as high as 1.50 volts with the ideal voltage of 1.25 volts.
- Current Calibration - This is the current two points that equal your current calibration, they are provided as a reference or informational purposes only.
- New Calibration - Once you have done the two point calibration these two points will equal the new calibration if you save the calibration, they are provided as a reference or informational purposes only.

STEP 5: First, remove the clear plastic cover from the colorimeter module. Then open the two white, quick disconnect tubing couplings above and below the cell. Insert the calbration hose (Clear plastic hose with two quick disconnects and a pinch clamp) that shipped with your unit into the lower hose and pinch the clamp shut. Pour the first sample into the upper tube until the cell is completely flooded and wait for one minutes to allow the cell to stabilize.

NOTE: The first sample can be either the 100 percent or the 80 percent standard.

STEP 6: If you inserted the high nickel sample into the cell and its different then the 100% currently displayed on the LCD, press the SET HIGH button and enter the actual value of the solution in the cell. Once you have entered that valve press the READ button to read the colorimeter. After the controller reads the valve the READ button for the high sample will be grayed out.

STEP 7: Drain out the first sample and pour the second sample into the upper tube until the cell is completely flooded and wait for two minutes to allow the cell to stabilize.

STEP 8: If you inserted the low nickel sample into the cell and its different then the 80% currently displayed on the LCD, press the SET LOW button and enter the actual value of the solution in the cell. Once you have entered that valve press the READ button to read the colorimeter. After the controller reads the valve the READ button for the low sample will be grayed out.

STEP 9: If the controller gets acceptable readings from both samples the new calibration points should display and the SAVE button will become enabled. If you are satified with your calibration press the SAVE button to save them to the controllers memory.

Reconnect the two quick disconnect couplings and replace the module's cover.

Calibration is now complete. Press the Calibrate Menu and then Main Menu buttons to get back to the main menu.

Section V
Calibrating the Controller
Two Point pH

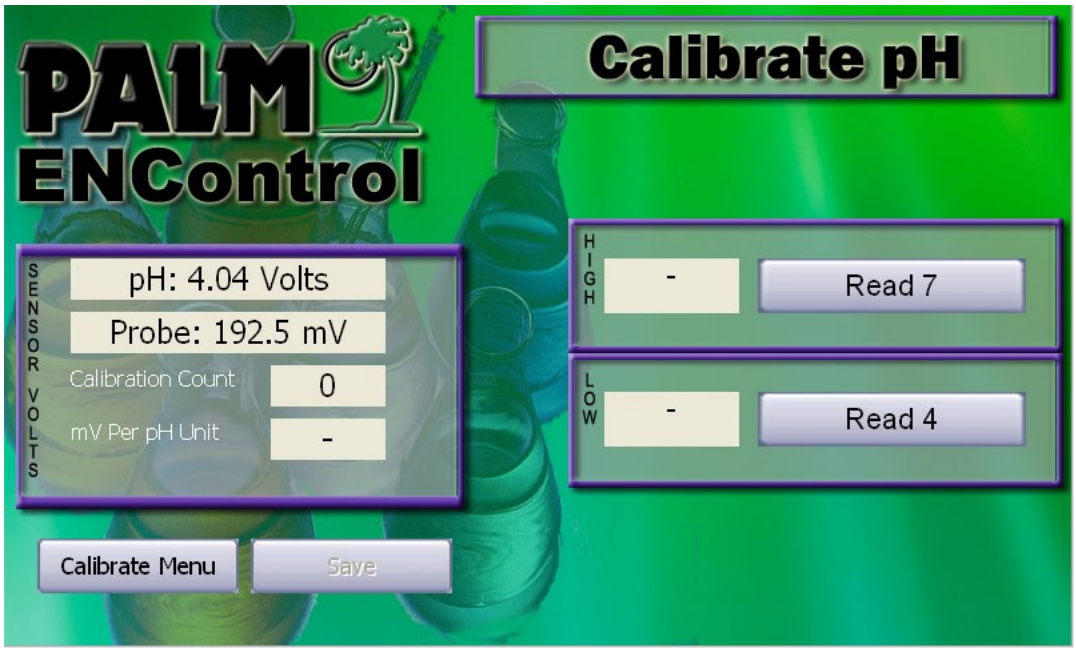
For the ENControl™ Model 3300 to accurately measure the pH of the electroless nickel bath, its pH sensor must first be calibrated so that it can recognize the properties of the plating solution. The pH sensor is calibrated using the following procedure:

STEP 1: Obtain standard pH buffer solutions for 4 and 7 pH. Measuring these two solutions will allow the controller to find the slope or gain of the pH electrode and will allow it to accurately measure the pH of the plating bath.

STEP 2: Enter the Calibrate Sensors menu by pressing the following:

MAIN MENU > CALIBRATE

Press the pH 2 Point Cal button
The LCD display will show:



MAIN MENU > CALIBRATE > pH 2 POINT CAL

Remove the pH electrode from the sensor block, rinse it with deionized water, and place it into a beaker containing the 4 pH buffer. Wait for about 60 seconds to allow the electrode to stabilize. Then press the READ 4 key to select the 4 pH buffer. The controller will count to 20 while it is measuring.

Remove the pH electrode from the beaker, rinse it with deionized water, and place it into a beaker containing the 7 pH buffer. Wait for about 60 seconds to allow the electrode to stabilize. Then press the READ 7 key to select the 7 pH buffer. The controller will count to 20 while it is measuring.

Press the SAVE key to save the calibration data in the controller's operating program. Calibration is now complete. Remove the pH electrode from the beaker, rinse it with deionized water, and return it to the sensor block.

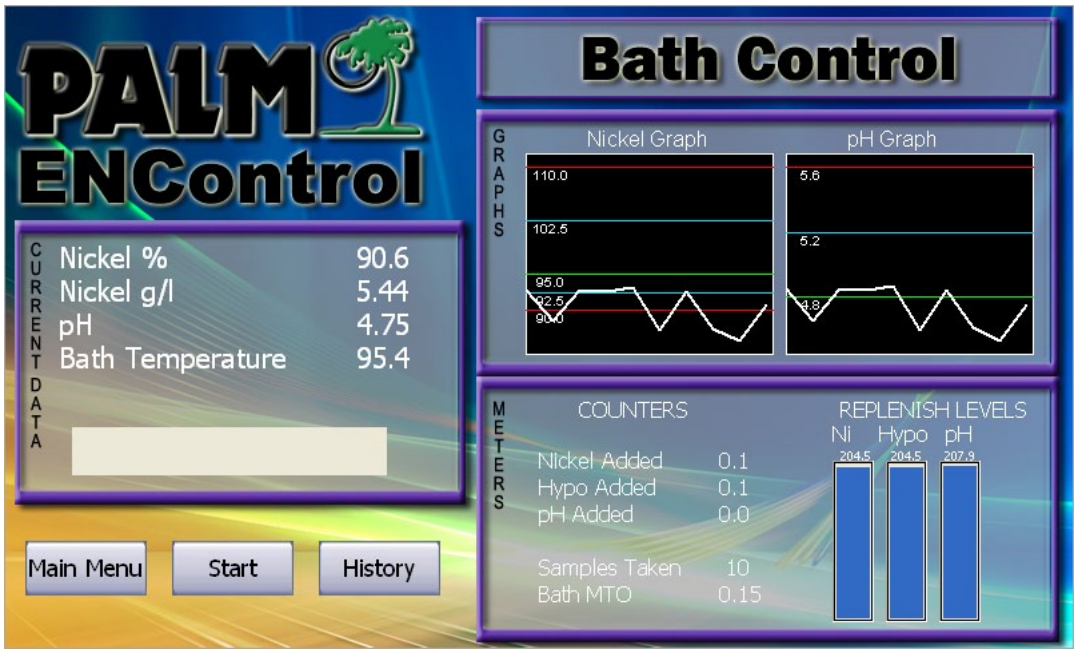
NOTE: If after pressing both buffer measurements, the controller will run the calibrated values and check that the 7 buffer is within 20mV of 0 and that there is at least a 120 mV difference between the 4 and 7 buffer. If it fails the two checks it will display a CALIBRATION ERROR and not allow you to save the invalid calibration.

The ENControl™ Model 3300 is now ready to operate. Proceed to Section VI on Operating the Controller.

Section VI
Operating The Controller
ENControl™ Control

After the ENControl™ Model 3300 has been installed and setup, the controller is ready to begin
controlling the electroless nickel plating bath.

When the controller is first turned on (when the power switch beneath the controller is flipped to the on position), system will boot into the MAIN MENU screen. After the MAIN MENU is displayed, the operator can either press the Control key to operate the controller.



MAIN MENU > CONTROL

The controller will then flash WAITING FOR START in the status dialog box. The CONTROL screen is divided into three sections.

- CURRENT DATA - This section provides the last reading from the control cycle it also contains the STATUS dialog box. The STATUS dialog box will prompt the operator with the current status in the control loop.
- GRAPHS - This section shows a graph for both the nickel and pH readings, the high and low alarm points the green line is the setpoint and the blue lines represent the half way point between the setpoint and the high alarm point. The graph will show the last 10 samples with the newest sample always on the right.
- METERS - The meters section displays the inventory levels of the replenishment containers (in liters). There are also counters to display the amount of replenishers added during this control cycle as well as the number of cycles and current bath MTO (Metal Turn Overs)

To go into automatic control mode press the START key. After the START key is pressed, the controller first pumps plating solution about half way from the tank to the colorimeter. During this period the STATUS box will show the message:

PULL SAMPLE XXX YY.YC
XXX represents the sample pump time counter
YY.Y represents the cell temperature in degs C.

Then the controller will stop the sample pump to allow the solution in the cooling coil or heat exchanger to cool to the proper temperature. During this period the STATUS box will show the message:

COOL TIME XXX
XXX represents the cool time counter

Next, the controller pumps the cooled solution to the sensor block and colorimeter. During this period the STATUS box will show the message:

PULL SAMPLE XXX YY.YC
XXX represents the sample pump time counter
YY.Y represents the cell temperature in degs C.

Then the controller will stop the sample pump again to allow the solution to settle and debubble. During this period the STATUS box will show the message:

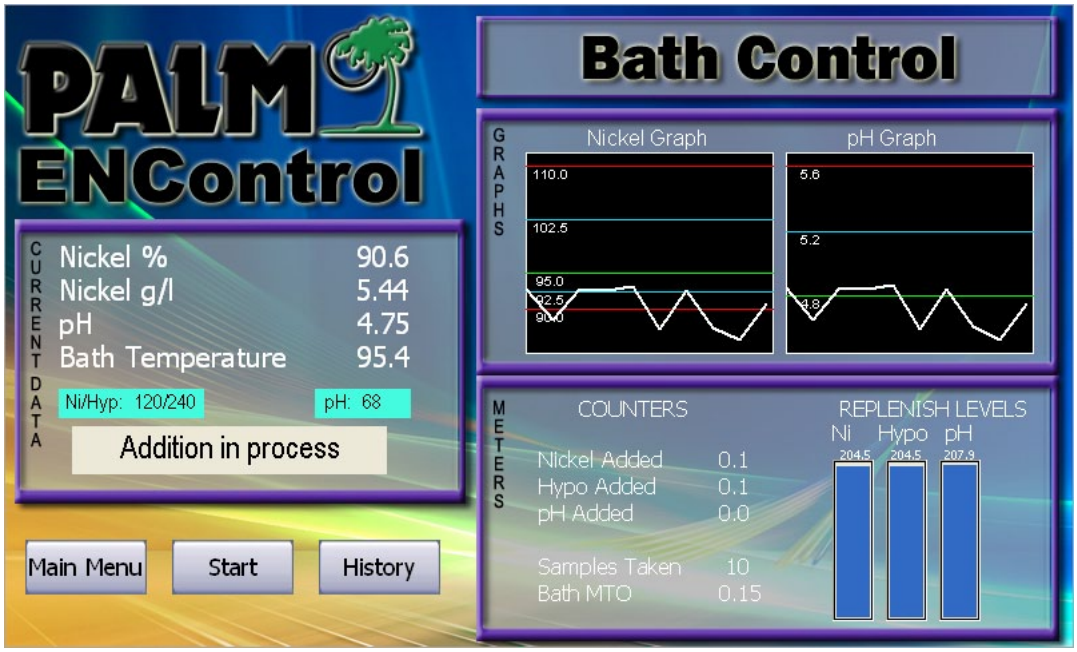
SETTLE XXX
XXX represents the settle time counter

During each of these steps the STATUS box will count down the time remaining before the next step begins.

The controller then measures the nickel concentration and pH of the solution in the sensor block and colorimeter cell and displays the results. The CURRENT DATA window will show a message similar to:

Nickel %	98.0%
Nickel g/l	5.88
pH	5.01
Bath Temperature C	90C

If an addition of replenisher or neutralizer is needed, the controller will turn on the appropriate pump for the time needed to add the required amount of solution. During this period, directly above the STATUS dialog any addition pump that is on will display the time remaining in the addition (colored in teal).



ADDITION IN PROCESS

When the controller begins making an addition, it also updates its internal record of the bath and its history. It increases the amount of replenisher and neutralizer used so far during the life of the bath, and the bath's age, and it reduces the volume of chemicals remaining in the addition storage vessels.

After the addition is complete, the controller waits for the replenisher or neutralizer to be mixed into the bath. During this period the STATUS box will show the message:

MIX DELAY XXX
Where XXX is the mix time counter

If an addition is not needed, the controller will wait for several minutes before it begins the next sampling cycle. STATUS box will show the message:

LOOP DELAY.
Where XXX is the loop time counter

After the mixing or loop delay times are complete, the controller turns on the sampling pump again and the next sampling cycle begins.

As described in the Section IV, the operator can adjust each period in the sampling cycle to suit different baths and applications.

Section VI
Operating The Controller
One Point Nickel Standardization

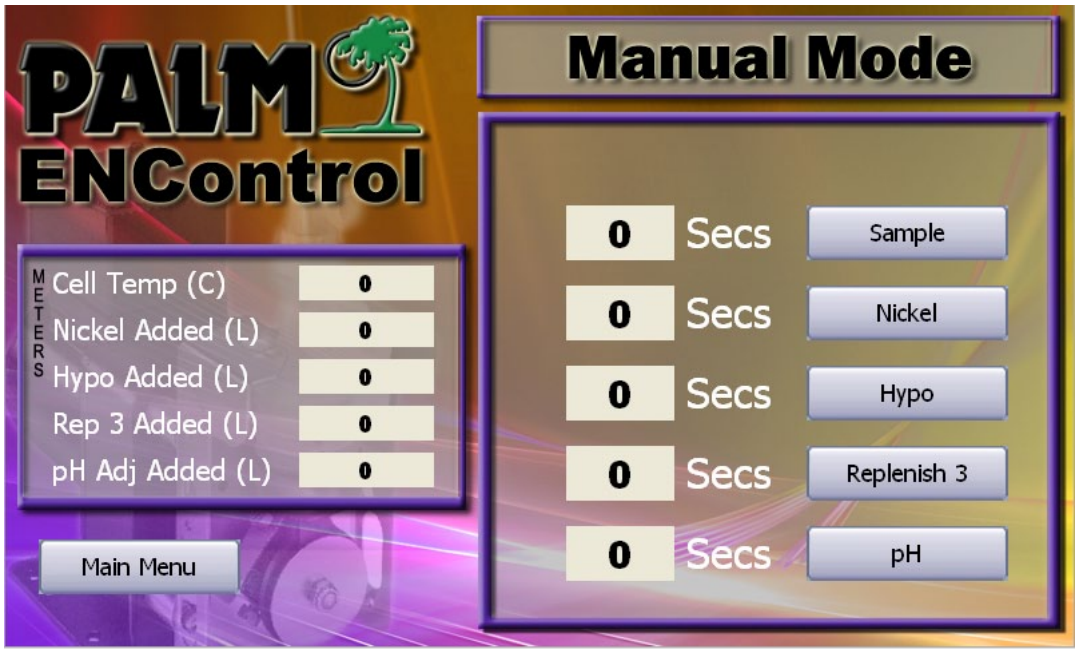
To ensure the continued accurate measurement of the bath's nickel content and pH, the colorimeter and pH electrode must be standardized periodically. For most applications, these sensors should be standardized at least once per shift. Usually, it is most convenient to standardize the sensors in the morning while the bath is still heating, and before the controller is set to automatic control mode. Use the following procedure to standardize the sensors.

STEP 1: First visually check all of the tubing, sample and pickup tubes, pumps, connections, etc. to ensure that they are tight and leak free.

STEP 2: Turn on the controller and let it warm up for at least 20 minutes before it is to be standardized.

STEP 3: Have the nickel content and pH of the bath measured by the laboratory. The nickel content should be analyzed by EDTA titration and the pH by electrometric measurement of a cooled sample.

STEP 4: While the bath temperature is still below 100 F (40 C), turn on the sample pump to displace all of the old solution or water in the tubing and cell and to ensure that the solution in the colorimeter is a fresh sample. The pump should remain on for a period equal to at least four times the sample pump time established in Section IV. This period is usually at least 3 minutes. The sample pump may be operated by pressing the following:



MAIN MENU > MANUAL MODE

NOTE: If the temperature of the plating solution is greater than 100 F (40 C), it may be necessary to start and stop the sample pump several times to allow the solution to cool before it enters the sensor block. The display will show the cell temperature while the sample pump is running.

STEP 5: Enter the Standardize Nickel Sensor menu by pressing the following keys:

MAIN MENU > CALIBRATE > NICKEL STANDARDIZE

The controller will then measure the solution's nickel content and will display its results on the LCD.

If the controller's measurement of nickel concentration is different from that analyzed by the laboratory, change it to agree. Pressing the UP key will increase the displayed bath concentration by 0.5 percent each time it is pressed. Pressing the DOWN key will decrease the displayed bath concentration by 0.5 percent each time it is pressed.

After the displayed value of nickel concentration has been changed to equal that of the laboratory analysis, press the CALIBRATE MENU key to save the new standardization value and to exit standardize nickel sensor.

NOTE: For the colorimeter to be accurately standardized the solution analyzed by the laboratory must be identical to the solution pumped through the sensor block. Alternatively, a standardized sample of known concentration can be placed into the cell as described in Calibrating the Colorimeter in Section V.

Section VI
Operating The Controller
ColorShift™

Electroless Nickels color changes as a function of bath age. The ENControl™ Model 3300 includes a technology called ColorShift™. The helps compensate for that colorshift by keeping track of the calibration shift of the standardization of the unit correlated to bath age. To use this feature, the ColorShift™ function should be enabled. See Section IV Functions Setup.

MAIN MENU > CALIBRATE > NICKEL STANDARDIZE

Once ColorShift™ is enabled the current calibration section of the Nickel Standardize screen will show six (6) ColorShift™ points each one representing MTO 0-6. If you are standardizing a sample the controller will display the current MTO point for the bath it has been monitoring, if you need to change the MTO to match the sample you are feeding the controller use the SET MTO button to set the MTO of the sample in the controller you are standardizing.

NOTE: If you want to setup ColorShift™ all at once you should obtain six bath samples at MTO 0-6, feed each one in, use the SET MTO to set the MTO point, then use the UP/DOWN to stadardize that MTO point.

WARNING: ColorShift™ is a very useful technology that will minimize the amount of Standardizations the operator has to do, however it relies on the operator paying attention to the MTO of the sample while doing the standardization, misuse of this feature can cause errors in the unit reading the correct concentration.

Section VI
Operating The Controller
One Point pH Standardization

To ensure the continued accurate measurement of the bath's nickel content and pH, the colorimeter and pH electrode must be standardized periodically. For most applications, these sensors should be standardized at least once per shift. Usually, it is most convenient to standardize the sensors in the morning while the bath is still heating, and before the controller is set to automatic control mode. Use the following procedure to standardize the sensors.

STEP 1: Enter the Standardize pH Sensor menu by pressing the following keys:

MAIN MENU > CALIBRATE > pH STANDARDIZE

If the controller's measurement of pH is different from that measured by the laboratory, change it to agree. You can adjust it with the UP/DOWN key for both fine and course adjustments.

After the displayed value of pH has been changed to equal that of the laboratory measurement, press the CALIBRATE MENU key to save the new standardization value and to exit standardize pH sensor.

NOTE: For the pH electrode to be accurately standardized, the solution analyzed by the laboratory must be identical to the solution pumped through the sensor block and at the same temperature. Alternatively, the pH electrode can be standardized using a standard 4 pH buffer solution and the above procedure. Removing the probe from the sensor block is described in Calibrating the pH Sensor in Section V.

Section VI
Operating The Controller
Component inventory levels

The ENControl™ Model 3300 monitors the volume of replenishers and neutralizer remaining in their storage vessels so that it can alert the operator when it is nearing the time to check and change them. It accomplishes this task by progressively subtracting the volumes used for each addition from the volume originally present in the vessel. For the controller to keep an accurate record of the solutions remaining, it must be told whenever the replenisher or neutralizer vessel is changed or refilled. Use the following procedure to change the addition chemicals' volume:

STEP 1: Enter the new replenisher or neutralizer volume into the controller's operating program by pressing the following keys:

MAIN MENU > COMPONENTS

Once the operator is in the Bath Components screen there are five windows. Four of the windows are related to the volumes for the Nickel, Hypo, pH Adjust and Rep 3 replenishers (If that funtion is enabled it will show its volume, otherwise it will be disabled).

Each of the volume windows contain the following features

- Change Volume - This will change the container volume, once the volume on the container is set the operator can just hit the Reset Remain button to reset the remaining counter to this amount.
- Change Remain - This allows the operator to manually adjust the amount remaining in the container if its not equal to the full amount.
- Reset Ramain - This will reset the volume remaining amount to the full amount, use this when changing out containers.

Section VI
Operating The Controller
Replacing the Bath

The ENControl™ Model 3300 records the age of the plating solution both for record keeping and to help alert the operator when it is nearing the time to replace the bath. It accomplishes this task by progressively adding the amount of each replenisher addition to the age of the bath. For the controller to keep an accurate record of bath age, it must be told whenever the bath is spent and replaced. Use the following procedure to zero the bath age counter when a new bath is made up.

STEP 1: Enter the new bath age into the controller's operating program by pressing the following keys:

MAIN MENU > COMPONENTS

In the MTO windows of the components screen the user can either change the MTO value to the known amount or press the RESET button to change the MTO point to 0.0, which will replace the bath.

Section VI
Operating The Controller
Bath History

The ENControl™ Model 3300 has an internal history database that stores the last 50 control samples. The operator can view them from either the CONTROL screen or the MAIN MENU.

WARNING: If the controller is in automatic control mode, accessing the HISTORY screen will stop the control cycle and will need to be restarted once returning to the CONTROL screen.

To access the history from the MAIN MENU, press the following keys:

MAIN MENU > STATUS > HISTORY

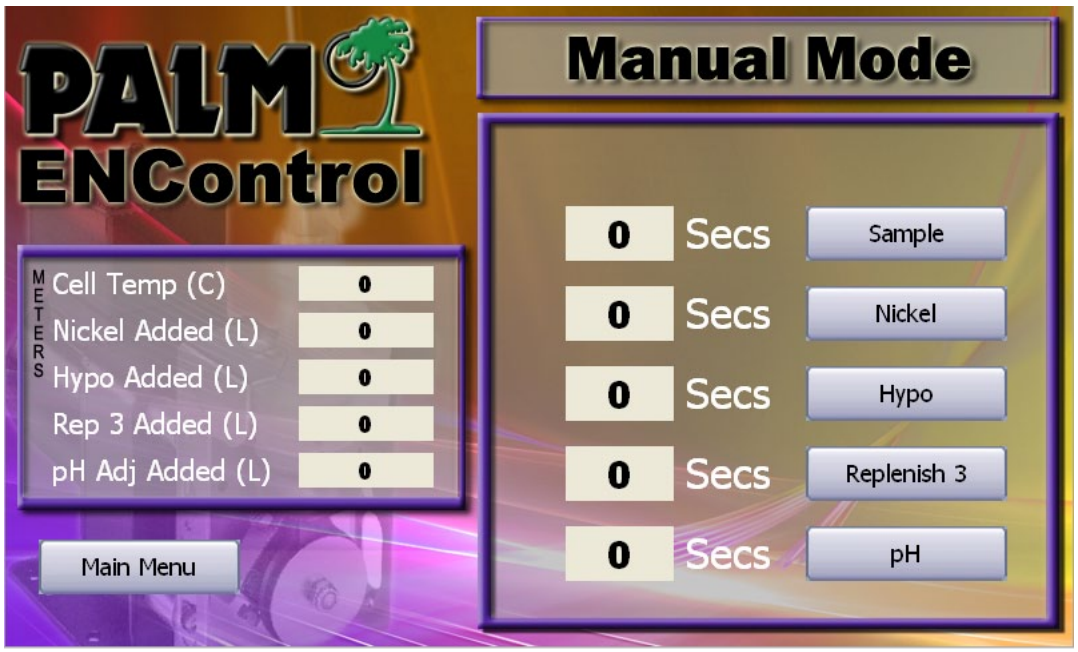
Once in this screen, the samples are sorted by date and time in descending order, press the forward button to move forward and back button to move back. If the operator would like to print a record of these results, press the PRINT HISTORY button to send them to an optional attached serial printer.

NOTE: If the operator enters this screen from the CONTROL screen they will see a CONTROL button to return to the CONTROL screen, if they enter from the STATUS screen they will see a STATUS button.

Section VI
Operating The Controller
Manual operation of the pumps

The ENControl™ Model 3300 takes care of running all the sample and addition pumps during a normal control cycle, however the user may need to operate them manually to do a manual addition or to check the calibration of the pumps.

To access the main pump mode press the following keys:



MAIN MENU > MANUAL MODE

To run any of the pumps press their corresponding button, the system will count the time the pump is on as well as display to total volume added for that component in the meters window. The inventory levels for each component will also be adjusted once the operator stops the pumps operation.

During manual operation of the sample pump the Cell Temperature will be displayed in the meters window.

WARNING: During a sample feed the automatic shutdown of the sample pump based on a cell temperature of 45 degrees C is disabled. Do not attempt to run the sample pump above that temperature unless the pH probe has been removed.

NOTE: If the operator exits this screen with any of the pumps operating, the system will automatically stop the pumps as a safety precaution.

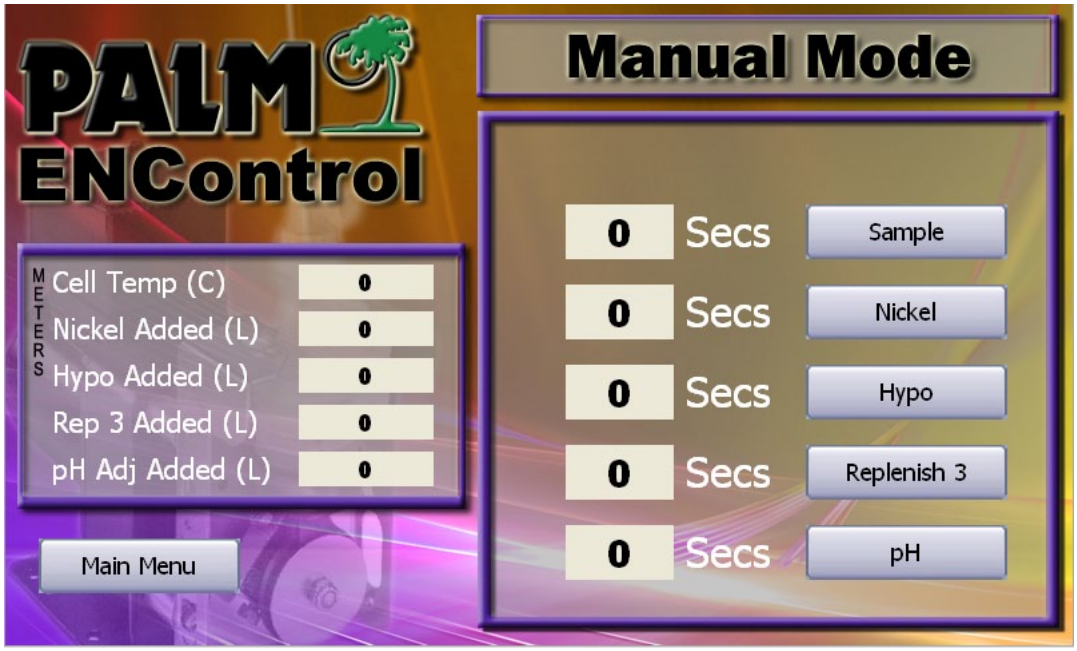
Section VI
Operating The Controller
Shut Down Procedures

At the end of each week or period of extended non-use of the controller, the plating solution should be cleaned from the tubing and sensor block. This action will protect them from plugging and to prevent damage to the colorimeter and pH electrode. Use the following procedure to shut down the controller and clean the sampling circuit:

STEP 1: Exit the automatic control mode to stop the controller.

STEP 2: Remove the sample pickup tube from the bath (or the tubing connected to it, if it is permanently mounted) and place it into a bucket of deionized water. Turn on the sample pump and pump water through the sample loop until it returns to the plating tank.

The sample pump may be operated manually by pressing the following keys:



MAIN MENU > MANUAL MODE

STEP 3: Turn the power to the controller off with the power switch beneath the controller.

Section VI
Operating The Controller
Using the Controller with a Twin Tank System

Often, electroless nickel plating baths are operated alternatively in two plating tanks. The bath is operated first in one tank, and then transferred to a second tank to allow the first tank to be passivated. This is called the twin tank system. The Model 3300 can be used to control both tanks by moving the sample pickup and return tubes, the temperature sensor, and the replenisher and neutralizer addition tubes from the first to the second tank. Frequently, this transfer can be made easier by attaching all of the tubes and tubing to one bracket which is clamped to the side of the tank.

Section VI
Operating The Controller
Optimizing Calibration and Accuracy

While the steps outlined so far in this manual will provide a very accurate electroless nickel control some applications need to optimize the accuracy of there instruments. The following are steps that serve as a guide line to achieve the most accurate control.

DAILY

1. Perform daily standardizations of the nickel content and pH
2. Double check the volumes in the replenisher containers making sure they match the component levels in the instrument.
3. Check all

WEEKLY

1. Perform a two point calibration of the pH probe with 4 and 7 buffers
2. Perform a two point calibration of the nickel content.
3. Check the output of all the replenishment pumps and adjust the pump rates in the controller.

Section VI
Operating The Controller
Replenishment Totalizers

The Model 3300 keeps track of the inventory levels of your replenishment containers under the menu item Containers (See Section VI Component inventory levels) but it also keeps a running total of the complete amount of replenishment chemical added. These Totalizer will continue to accumulate until they are reset by the user. To view the totalizer press the following keys:

MENU > STATUS > TOTALIZERS

Once in the totalizers screen you can view each component (provided they are enabled under the functions features see Section IV Functions). Each components totalizer will be listed in total liters added. To reset the totalizer to zero press the Reset button for each component.

Section VII
Maintaining The Controller

The Model 3300 is a precision electronic instrument, which requires little maintenance, other than periodic cleaning and calibration. The controller is supplied in a water tight, NEMA 4, plastic enclosure, which protects its components from normal plating environments. Similarly, the GRI bellows pumps used for sampling and additions are of a rugged design and can give of years of continuous service.

The controller's electronic components are unlikely to fail, but can be broken by rough handling. Under normal conditions, the operator should not have to open the controller enclosure, colorimeter module or relay module. If this should be necessary, however, always disconnect the power supply to the controller and its relays and be very careful when handling the circuit boards, LCD display, colorimeter, and other components.

A few of the controller's components do have a limited life and will require periodic replacement. These components are the colorimeter lamp, colorimeter filter, pH probe, and valves for the bellows pumps. Standard nickel solutions and pH buffers are also needed to calibrate the colorimeter and pH sensor.

The colorimeter lamp, like any other electric light, becomes dimmer over time and will eventually burn out. The rated life of the colorimeter's lamp is one to two years depending on how often the controller is used. The colorimeter filter should also be replaced every 3-5 years. However, to ensure constant light output for the colorimeter, the lamp should be changed yearly. Replacing the lamp is described in Section IX.

A pH electrode also loses sensitivity with time as the glass and reference junction become coated with salts and organic compounds. These coatings reduce the speed of response of the electrode and can reduce its slope leading to reading errors. To minimize these errors and to ensure accurate control, the pH electrode should be reconditioned, or the electrode replaced, every six months. Reconditioning the electrode is described in Section IX. Replacing the electrode is described in Section IX.

The check valves in both the sampling and addition pumps are made of EPDM rubber, which will lose some of its elastic properties over time. They also can become gummed with organic compounds. These changes can lead to bypassing and loss of pumping capacity. To guard against changes in flow rate, the valves in all of the pumps should be replaced yearly. Replacing the valves is shown in Section XV.

The following is a spare parts list for the Model 3300 controller.

Part Number	Description
Circuit Boards	
3300-LCD	7” Touch Screen LCD replacement
3300-PWS	Power supply
3300-CPUMOD	CPU module
3300-pHMOD	pH/temperature module
3300-CLRMOD	Colorimeter module
3300-RELAYMOD	Relay module
Renewable Parts	
60150B	pH electrode
L1023	Colorimeter lamp
56411 100	High temperature, 1/4” sample tubing, 100’
60702 100	pH replenisher 3/8” hose, 100’
60703 100	Ni/hypo replenisher 1/2” hose, 100’
32764 002	Sample pickup tube
32764 003	Replenisher Pickup Tube (1/2” or 3/8”)
Pump Parts	
DUCKBILL	Duckbill valves for sample bellows pump
POPPET	Poppet valves for pH & Ni and Hypo bellows pump
BELL 1	Bellows kit for pH & sample bellows pump
BELL 2	Bellows kit for Ni/hypo bellows pump
1/4 CONN	1/4” connectors for sample bellows pump
3/8 CONN	3/8” connectors for pH bellows pump
1/2 CONN	1/2” connectors for Ni/hypo pump
BARBS	Hose barbs, clamps, etc. for colorimeter module
CRANK 1	Crank assembly for sample and pH bellows pump
CRANK 2	Crank assembly for Ni/hypo bellows pump
Other Components	
20251	Cell temperature sensor
20250	Bath temperature sensor
CELL-1	Colorimeter cell (w/o filter, lamp and photocell)
CELL-2	Colorimeter cell (with filter, lamp and photocell)
FLOW	Acrylic plastic sensor block
FLOWPLUG	Flow adjustment plug
3300-RELAYCBL	Relay module cable
3300-PRINTERCBL	Printer cable
S-CABLE	Personal computer cable
32764-001	Heat exchanger, in rinse tank type
32764-004	Heat exchanger, in line type

Section VIII
Troubleshooting The Controller

The Model 3300 is designed to provide nearly trouble free operation for years of service if operated properly. However, all equipment will require service at some point in time. The following information may help to identify the source of problems and to correct them quickly.

Faulty Circuits and Connections

Faulty measurements can result if fumes are allowed to enter the controller or colorimeter enclosures. Chemical fumes can attack the circuit boards, breaking traces or creating short circuits, which can result in improper operation. The controller should be located in an area away from traffic, steam, harmful vapors and potential damage.

To ease assembly and repair, the different components in the controller are connected with cables and plug in connectors. Plating shop fumes can corrode these contacts leading to poor connections and to faulty readings. Check the connections inside the controller enclosure between the CPU circuit board and the four smaller boards. They should be clean and tightly connected. Also, check the BNC and circular connectors on the bottom of the enclosure. Clean the contacts only when absolutely necessary. Mechanical cleaning can damage the connector or its cable. It is better to spray the contacts with contact cleaner spray.

Checking the Sensor Voltages

The output voltage from the controller's sensors can often be used to diagnose problems. The operator should know these voltages before calling Palm's Technical Support. Use the following procedure to read the output voltage of the controller's sensors.

STEP 1: To read the sensor voltages, press the following keys:

MENU > STATUS

The LCD display will show all sensor readings for the following devices

- Color Reading
- pH Reading
- Bath Temperature
- Cell Temperature

STEP 2: Checking the Colorimeter Calibration Data

The calibration values for the colorimeter can often be used to diagnose problems. The operator should know these values before calling Palm's Technical Support. Use the following procedure to display the colorimeter's calibration data.

PT1 = -7.6433
PT2 = 15.3089
Typically PT1 will have a value of less than -3 and PT2 will have a value of greater than 12.

STEP 3: Checking the pH Calibration Data
pH PT4 = 180.0
pH PT7 = 0.0
Typically PT4 should be 150 or higher and PT7 should be 0.0 - 20.0

Incorrect Nickel Measurements

If the controller's nickel concentration measurements are consistently different from those obtained by the laboratory, use the following guide to check for possible causes.

White Out. The present of particles in the sample in the colorimeter cell will block the light passing through it and produce high measurements. The most common source of particles is white out. When the salt content of an electroless nickel solution becomes too high, nickel phosphite, sulfate or hydroxide can precipitate leading to the formation of flock like particles throughout the solution and a characteristic milky color. Consult the plating bath's operating instructions for methods to correct and prevent white out.

High or Constant Readings. If the colorimeter's nickel concentration readings are very high or do not vary with solution concentration, use the following procedures to test the colorimeter.

STEP 1: Use the read sensor voltages as described above to check the colorimeter's output voltage with a standard 100 percent plating solution sample in the colorimeter cell.

STEP 2: If the reading is between 0.00 and 0.09 volts:

A. Check to see that the colorimeter lamp is operating (that it is lit). A glow should be visual above and below the colorimeter cell.
B. Check the colorimeter lamp voltage on the colorimeter board as described in Section IX. It should be about +0.625 volt. If it is incorrect, adjust it to +0.625 volt as described in Section IX.
C. Check that the lamp and photocell sensor connections to the colorimeter module (as shown in the colorimeter module layout drawing in Section X) are clean and tightly connected.
D. Check that the connections on the ribbon cable from the colorimeter module to the CPU board are clean and tightly connected.
E. Check the photocell output voltage on the colorimeter board. Connect a digital voltmeter between test points GND and Vo (as shown on the colorimeter module layout drawing in Section X) and measure its voltage. It should be equal or nearly equal to that display when the A key is pressed. If it is not, the cable is probably faulty.

STEP 3: If the reading is greater the 0.10:

A. Check the colorimeter lamp voltage on the colorimeter board as described in Section IX. It should be about +0.625 volt. If it is incorrect, adjust it to +0.625 volt as described in Section IX.
B. Use the read sensor voltages as described above to check the colorimeter's ou put voltage with the standard 100 percent plating solution sample in the colorimeter cell.
C. Adjust gain control pot VR3 (marked gain on the board inside the colorimeter module) until a reading of 1.00 to 1.20 volts is obtained on the sensor voltage display.
D. Do a two-point calibration as described in Section V.

Low Readings. If the colorimeter's nickel concentration readings are very low, use the following procedures to test the colorimeter.

STEP 1: Use the read sensors voltages key as described above to check the colorimeter's output voltage with the standard 100 percent plating solution sample in the colorimeter cell.

STEP 2: Adjust gain control pot VR3 (marked gain on the board inside the colorimeter module) until a reading of 1.00 to 1.20 volts is obtained on the sensor voltage display.

STEP 3: Do a two-point calibration as described in Section V.

Bubbles. If the colorimeter's nickel concentration readings jump and vary rapidly, the cause is probably the presence of bubbles in the colorimeter cell. Bubbles refract the light across the cell and will cause fluctuating and typically low readings. These bubbles may be due to air entrained with the sample from the bath, or may be due to hydrogen produced by electroless nickel plating in the sampling loop or from an unstable bath.

STEP 1: If the bubbles are due to entrained air, refer to Adjusting Sensor Block Flow in Section III for methods to correct it. If the bubbles are due to plate out in the sample tubing, replace the tubing with new 1/4 inch (6 mm) diameter, polyurethane tubing. Stripping the tubing with diluted nitric acid is not recommended. Nitric acid will oxidize and embrittle the sample tubing, and the sensor block and the tubing inside the colorimeter module.

STEP 2: If the bubbles are due to plating inside the colorimeter cell, strip the glass tube in the cell with nitric acid. First, remove the clear plastic cover from the colorimeter module. Open the two white, quick disconnect tubing couplings located above and below the cell. Plug the lower tube with a rubber plug or close the tubing with a pinch clamp. Then pour 30 percent (by volume) nitric acid into the upper tube until the cell is completely flooded. Leave the cell filled until all the plating is dissolved. Then open the lower tube and drain the nitric acid from the cell into a suitable container. Rinse the cell and the tubing completely with deionized water. Reconnect the two quick disconnect couplings and replace the module's cover.

Incorrect pH Measurements

If the controller's pH measurements are consistently different from those obtained by the laboratory, use the following guide to check for possible causes.

STEP 1: Use the read sensor voltages as described above to check the pH electrode's output voltage with a plating solution sample in the sensor block. If the sensor voltage is either 0.00 or 2.55 volts, the pH electrode contains an open or short circuit and must be replaced.

STEP 2: If the sensor voltage is more than 0.00 and less than 2.55 volts:

A. Check that the electrode signal cable connection to the BNC receptacle on the bottom of the controller enclosure is clean and tightly connected.

B. Check that the connections on the ribbon cable from the pH/temperature module to the CPU board (as shown in the pH/temperature module layout drawing in Section X) are clean and tightly connected.

C. Do a two-point calibration of the electrode, using 4 and 7 pH buffer, as described in Section V.

D. Recondition the pH electrode as described in Section XIV, or try a new electrode.

E. Check the pH offset voltage on the pH/temperature board. Connect a digital voltmeter between test points GND and Pos (as shown on the pH/temperature module layout drawing in Section X) and measure its voltage. It should be 0.20 volts with the pH probe connected.

STEP 3: If the pH readings float up and down, the pH electrode is probably dirty or faulty. Recondition the pH electrode as described in Section XIV, or install a new electrode. Also check the pH voltage using the sensor voltages as described above. If the voltage is not stable in a known buffer such as 4 or 7 you might have a ground loop problem. Ground loops are caused by the controllers main power supply ground connection not having a good physical connection to earth. Verifiy with a digital voltmeter the ground connection to a known earth source.

Incorrect Temperature Measurements

If the controller's temperature measurements are incorrect, use the following guide to check for possible causes.

STEP 1: If the temperature reading is either high or low, but is moving up and down as the temperature changes in the bath or sensor block, calibrate the sensor as described in Section IX.

STEP 2: Use the check sensor voltages as described above to check the temperature sensor's output voltage. If the sensor voltage is either 0.00 or 2.55 volts the temperature sensor contains an open or short circuit and must be replaced.

STEP 3: Check the temperature offset voltage on the pH/temperature board. Connect a digital voltmeter between test points GND and Tos (as shown on the pH/temperature module layout drawing in Section X) and measure its voltage. It should be 1.706 volts. If it is incorrect, adjust it to 1.706 volts using pot VR4 as described in Section IX.

Faulty LCD Display

If the controller's LCD display is faulty, use the following guide to check for possible causes.

STEP 1: Measure the output voltage of the controller's power supply is check that it is normal. Connect a digital voltmeter the LCD connector on the LCD, GND and +24. If they are not correct, the power supply or the connection is probably faulty.

STEP 2: If the backlight on the LCD display does not light up and the display does not show any characters:

A. Check that the connections on the ribbon cable from the LCD module to the CPU board (as shown in the CPU module layout drawing in Section X) are clean and tightly connected.

Pumps Inoperative

If the sampling or addition pumps will not operate, use the following guide to check for possible causes.

STEP 1: Check the on/off switches on the pumps to ensure that they have not been turned off. Also, check that the power cables from the pumps are properly connected to the relay module.

STEP 2: Plug the pump's power cable directly into a power outlet receptacle to check that it will operate.

STEP 3: Check the fuses inside the relay module to see if they have blown.

STEP 4: Try operating the pump manually. See Section VI Manual Operation of the pumps.

Observe the LED indicator lights on the inside of the relay module to see if the controller is operating properly. The LED lights should light when the controller signals the pump to turn on. If the LED indicator on the relay mode does not light up the relay cable is probably faulty.

Technical Support

If the problem still has not been resolved, record the sensor voltages and the colorimeter calibration values and contact Technical Support at:

Palm Technology, Inc.
1717 JP Hennessy Drive
LaVergne, TN 37086

Voice 615 641 1200
Fax 615 641 1205
email support@palminc.com

Section IX
Operating System Description and Specifications

The Model 3300 controller is a custom designed microprocessor, with inputs for nickel, pH and temperature, and outputs to control one sampling pump and up to 4 addition pumps. Its individual components and their features are described in the following:

Central Processing Unit

The central processing unit (CPU) is a custom designed multitasking embedded microprocessor a super capacitor backed RAM (random access memory) and onboard program EEPROM (electronic erasable programmable ROM).

I/O

The I/O (input/output) function uses an 10 bit analog to digital converter which is multiplexed to provide 16 analog inputs. Outputs are decoded to an 16 line relay driver.

Console

The controller enclosure includes a 7” high resolution touchscreen LCD for communication between the operator and the controller.

Program

The operating program (software) was especially written for controlling electroless nickel baths. The program is stored in EEPROM. A logic flow chart for the controller’s control functions is shown in Figure 6.

Audible Signals

The operating program uses sound extensively to notify the operator of events. Alarms, records, key entries, and errors are announced by the CPU sound generator. A variety of tones are employed as condition indicators.

Sensors

The pH meter uses a combination, sealed reference, pH electrode with an operating range of 4 to 7. The colorimeter is a visible light, interference type instrument equipped with a custom, filter. Bath and cell temperature is measured with a diode temperature sensor in a stainless steel probe.

Pump Control

The sampling, replenishment and neutralizer pumps are switched on and off with solid state relays, which provide up to 5 amps at 240 volts AC. Control voltage to the relays is 24 volts DC.

Optional Printer

The operating program produces a printed record of all of its activities during the sampling cycle. The printer is connected to the controller through a RS232 interface operating at 19200 baud.

Specifications

POWER INPUT:	
Main Unit:	100 - 240 VAC, 50 - 60 Hz @ 1.2 or 0.6 amperes
Relay Box:	24 - 280 VAC, 50 - 60 Hz @ 10 amperes
Supply Wiring:	Green = Ground Black = Hot/Line White = Neutral
OPERATION:	
Ambient Temperature:	0 - 50 C
Humidity Range:	5% to 95%
Flow Rate:	100 - 400 mL/min @ 15 psi maximum
WEIGHT:	
Main Enclosure:	17 lbs or 7.7 kg
Relay Box:	5 lbs or 2.3 kg

Section X
Adjusting the Colorimeter, pH and temperature circuits

Occasionally, to account for aging or replacement components, it may be necessary to adjust some circuits inside the controller enclosure. Use the following procedures to adjust the colorimeter, pH and temperature circuits in the controller. The layout drawings for the different modules and circuit boards are shown in Section XI.

Colorimeter Module: Lamp Voltage, Offset, and Gain

Lamp Voltage. Connect a digital voltmeter between test points VL+ and VL and, using a small screw driver, adjust the variable resistance pot VR1 (marked lamp voltage on the board inside of the colorimeter module) until a voltage of +0.625 volts is measured. The colorimeter module layout drawing shows the position of the test points and pot. This voltage should only have to be adjusted when the lamp is replaced. This voltage establishes the lamp current. Higher lamp voltages can lead to early lamp failure. For instance, if the lamp voltage is set to above +0.650 volt, the lamp may burn out in only a few weeks.

Offset Voltage. Connect the voltmeter between test points GND and Vos and adjust the pot VR2 until a voltage of 0.55 volts is measured. The colorimeter layout drawing also shows the position of these points. ***This voltage is preset before shipment and should not require adjustment.***

Gain. Gain is the primary adjustment for the colorimeter. To adjust the gain, fill the colorimeter with 100% electroless nickel solution. Then go into the Status screen from the main menu by pressing the following keys:

MAIN MENU > STATUS

Then with a 100 percent nickel standard solution in the colorimeter cell, adjust gain control pot VR3 (marked gain on the board inside of the colorimeter module) until the Color Reading voltage is within the range of 0.8 - 1.5 volts. The ideal voltage for 100% is 1.25 volts, however because of an aging lamp or an aging colorimeter filter you may bot beable to get it to the idea voltage. If however you can't get it into the ideal range replace the colorimeter lamp or filter.

pH Module Alignment

The pH module voltages are preset before shipment and should not be adjusted. Because an isolation amplifier is used to protect the pH electrode, a special instrument is needed to adjust this circuit. The isolation amplifier provides common mode isolation of 1500 volts between the electrode and the A/D converter.

Bath and Cell Temperature Probes

Probe Calibration. Both temperature probes provide a nominal output of 25 mV per degree Celsius. This is preset before shipment. Adjustment of the circuit should only be needed if a probe is replaced. To adjust the circuit and calibrate the probes, first press the B key to read sensors. The LCD display shows the current bath and cell temperature (along with nickel concentration and pH).

Next, immerse the probes into a solution of known temperature and allow the temperature readings to stabilize. Adjust bath temperature adjustment pot VR6 until the correct temperature of the test solution is displayed on the LCD display. Repeat this procedure for the cell temperature probe by adjusting pot VR5 until the correct temperature of the test solution is displayed on the LCD display. The pH and temperature module layout drawing shows the position of the adjustment pots.

Offset Voltage. The circuit's zero offset voltage is preset before shipment and should not normally have to be adjusted. This voltage offsets the probe's output by 273 degrees Kelvin and compensates for its reading from absolute zero. To test the offset voltage, connect a digital voltmeter between test points GND and Tos. This voltage must be 1.706 volts. If not, adjust the pot VR4 until the correct value is obtained at Tos. The pH and temperature layout drawing

Section XI
Module and Circuit Layout Drawings
Power Supply Module

INPUT J1:

AMP P/N 640445-3, 0.156 CTR 0.045 SQUARE PIN HEADER

PIN 3) AC NEUTRAL
PIN 2) NO PIN
PIN 1) AC LINE

OUTPUT J2:

AMP P/N 640445-6, 0.156 CTR 0.045 SQUARE PIN HEADER

MULTIPLE OUTPUT	SINGLE OUTPUT
PIN 1) OUTPUT #2	PIN 1-3) OUTPUT
PIN 2) OUTPUT #1	PIN 4-6) RETURN
PIN 3) OUTPUT #1	
PIN 4) COMMON	
PIN 5) COMMON	
PIN 6) OUTPUT #3	

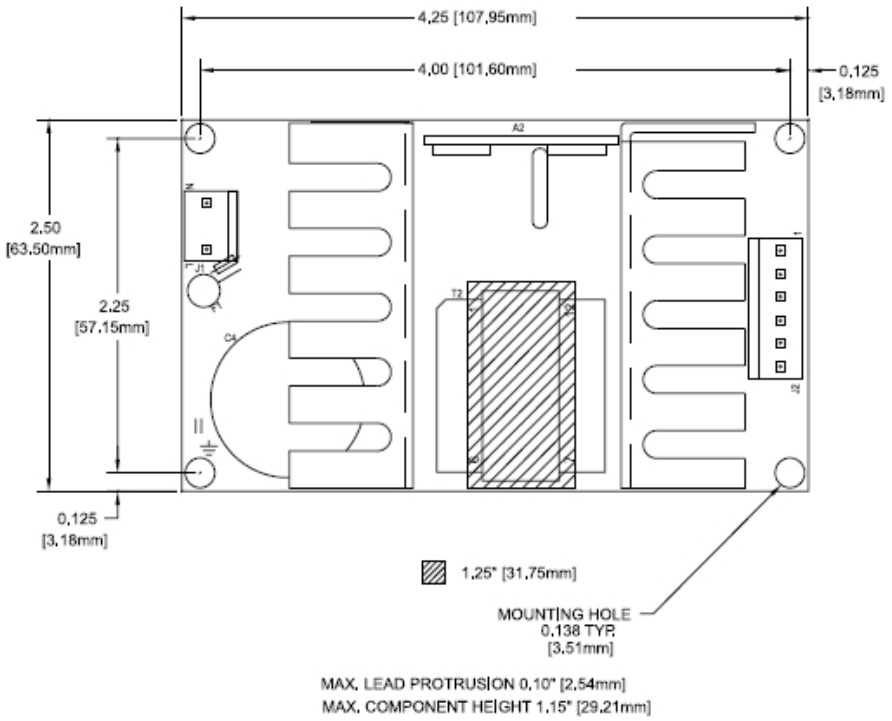
MATING CONNECTORS: AMP P/N

	HOUSING	CONTACTS
INPUT	640250-3	770476-1
OUTPUT	640250-6	770476-1

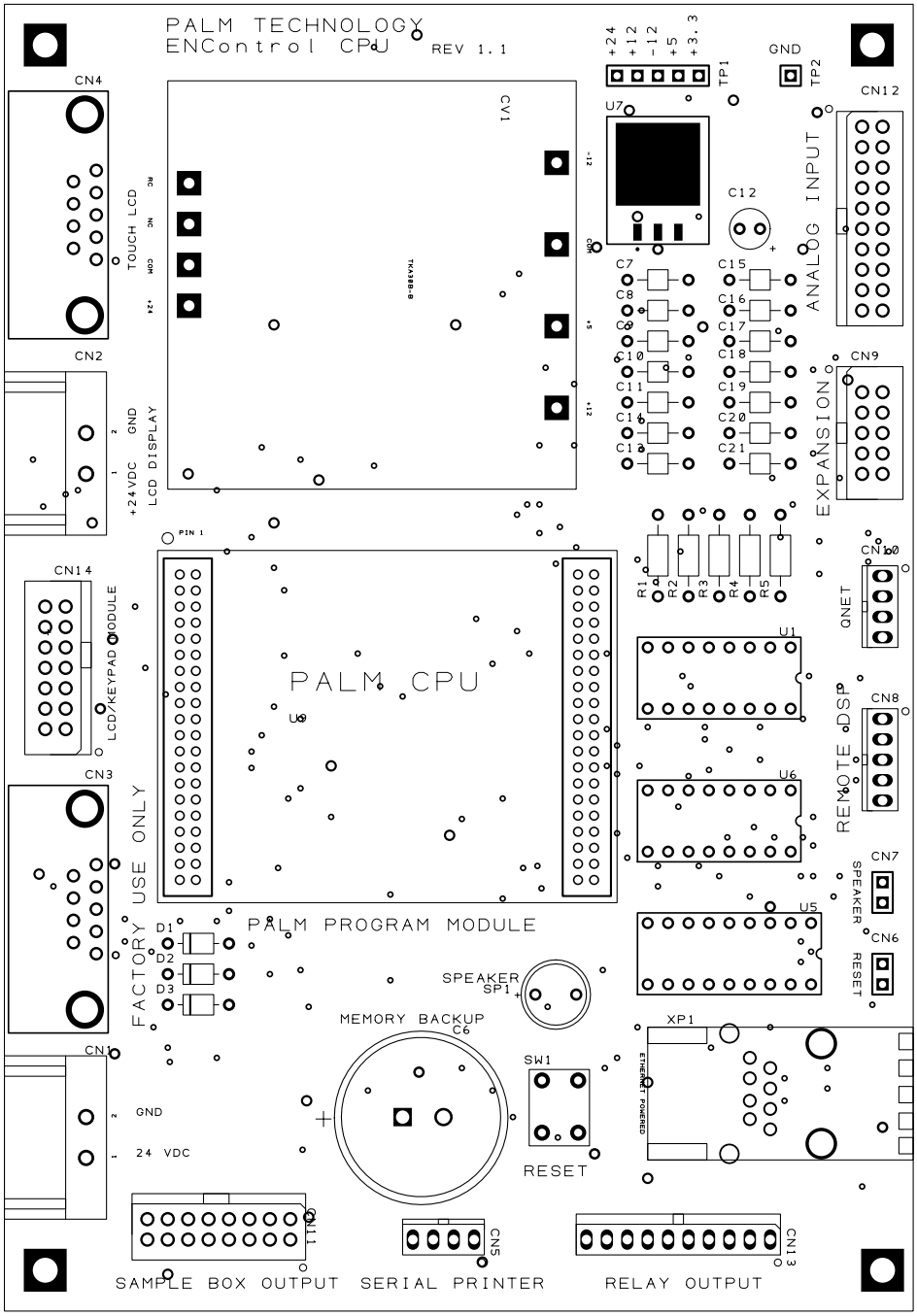
NOTE: 5A MAXIMUM RECOMMENDED CURRENT PER CONNECTOR PIN

WEIGHT 5 OZ. [0.142 KG]

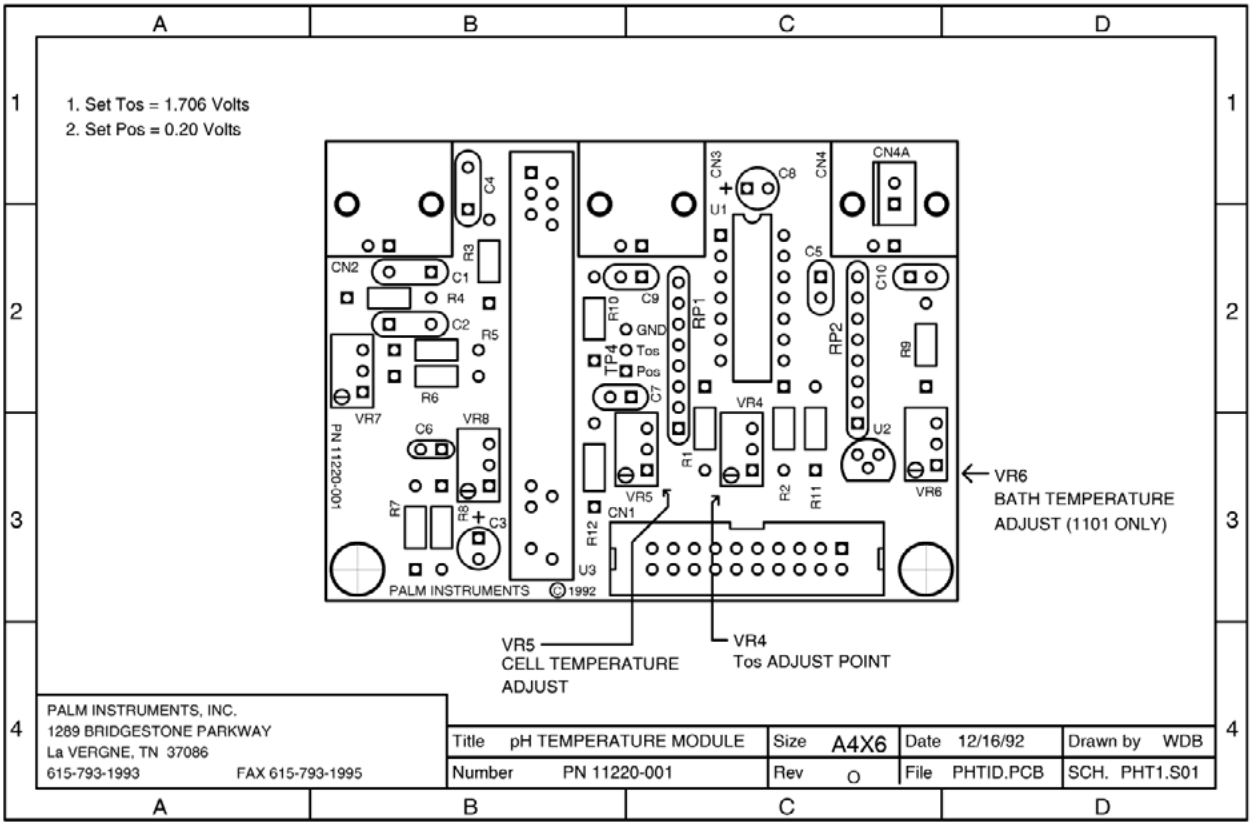
TOLERANCES: X.XX=0.030 [0.76mm]
X.XXX=0.010 [0.25mm]



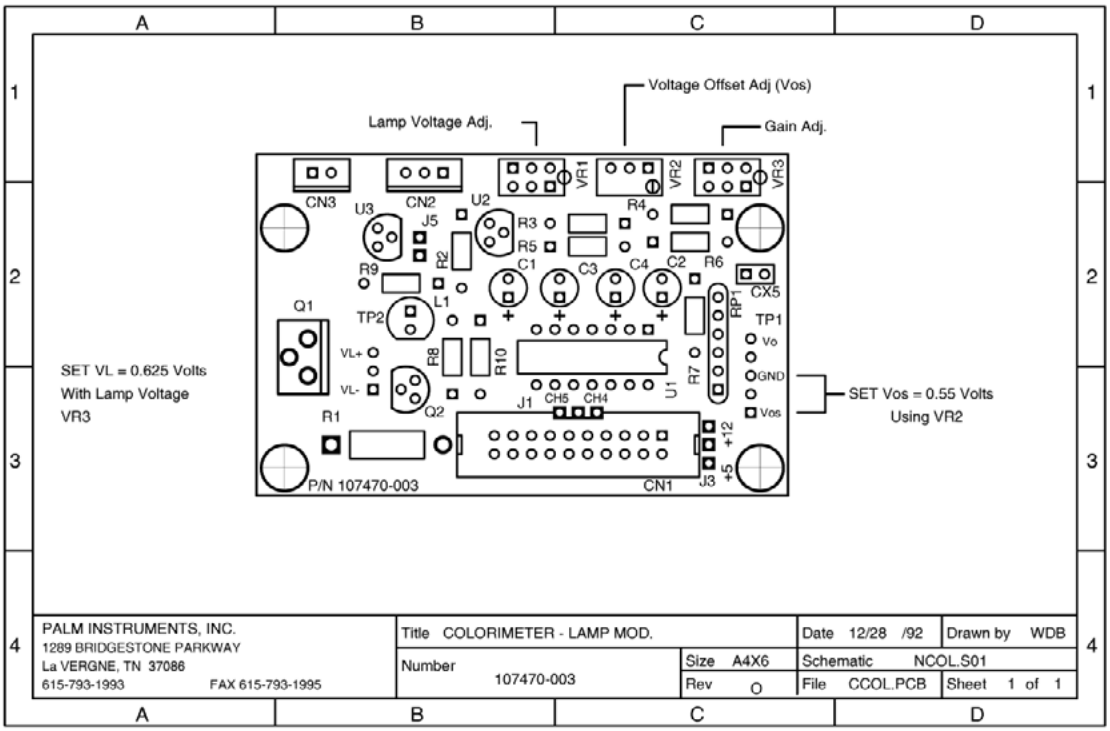
Section XI
Module and Circuit Layout Drawings
CPU Module

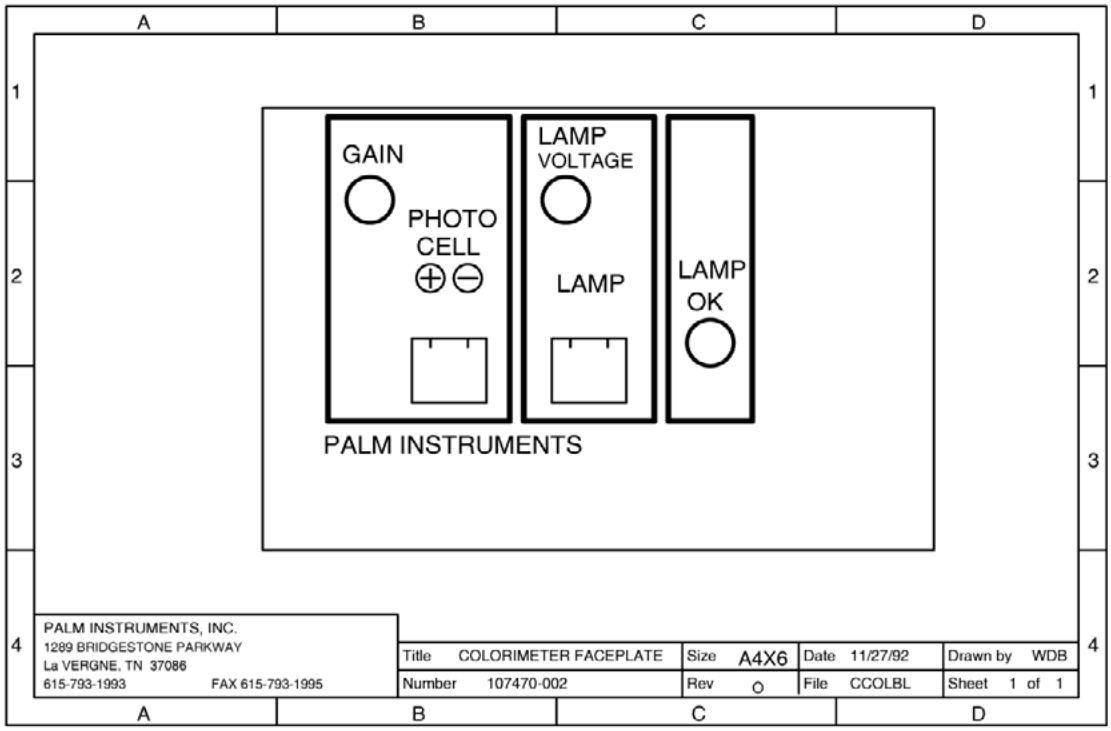


Section XI
Module and Circuit Layout Drawings
pH Module

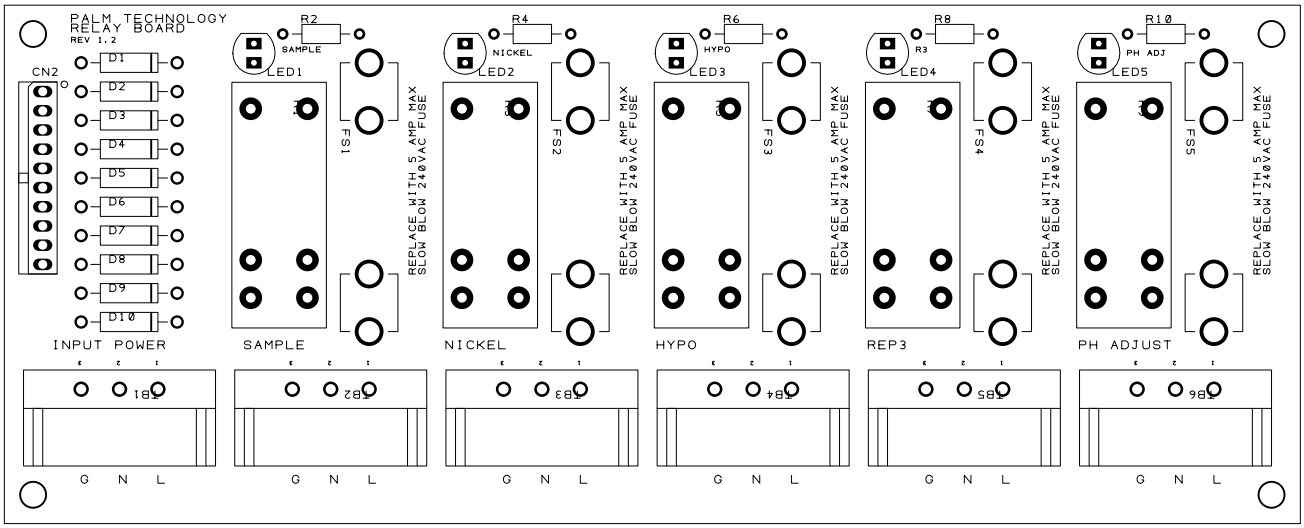


Section XI
Module and Circuit Layout Drawings
Colorimeter Module

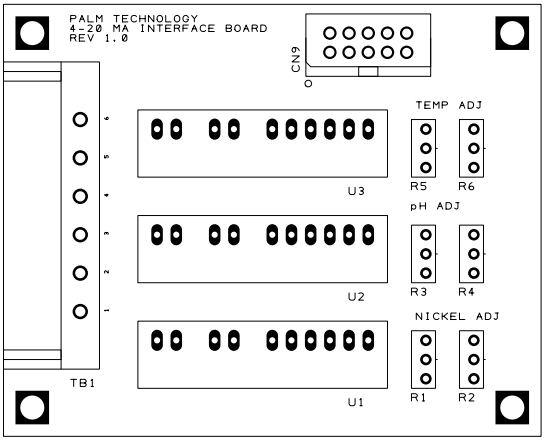




Section XI
Module and Circuit Layout Drawings
Relay Module



Section XI
Module and Circuit Layout Drawings
4-20mA Output Module (Optional)



Pin 1&2 = Nickel 4-20mA output
Pin 3&4 = pH 4-20mA output
Pin 5&6 = Bath Temperature 4-20mA output

Section XII
Replacing Components

Over the life of the controller some of its components may need to be replaced. Use the following procedures to replace the colorimeter lamp, pH electrode, Program Module, and relay module fuses.

Replacing the Colorimeter Lamp

The colorimeter's lamp only has a life of one to two years and will require periodic replacement. Use the following procedure to replace the colorimeter lamp. The lamp is located on the left side of the colorimeter cell as shown in Figure 7.

STEP 1: Carefully unscrew the old lamp's power cables from the screw connector block on the colorimeter interface board inside the colorimeter module. This is the block marked lamp on the board.

STEP 2: Loosen the lamp set screw with an allen wrench and remove the old lamp.

STEP 3: Connect the new lamp plug to the interface board and turn on the power to the controller. The lamp emits a focused beam which produces an oval shaped spot. Rotate the lamp so that the spot's widest dimension is horizontal to the colorimeter cell. Insert the lamp into the hole in the cell, leaving about 0.25 inch (6 mm) of the base protruding from the cell.

STEP 4: Then holding the lamp in this position, carefully tighten the set screw just enough to hold the lamp in place.

CAUTION: DO NOT OVER TIGHTENED THE SET SCREW OR THE GLASS LAMP WILL BREAK.

During the first few days of operation, as the lamp ages, its output may vary, which will reduce the accuracy of the colorimeter. To avoid these errors, the controller should be left turned on, with plating solution in the colorimeter cell, to allow the lamp to burn in.

Replacing the pH Electrode

The pH electrode loses sensitivity over time and should be replaced at least yearly. Use the following procedure to replace the pH electrode.

STEP 1: Loosen the compression type tubing connector at the top of the sensor block and remove the old electrode. Disconnect the BNC connector on the electrode's signal cable from the receptacle on the bottom of the controller enclosure.

STEP 2: Install the new pH electrode into its opening in the sensor block. Tighten the tubing connector enough to ensure leak free operation, but no so much as to damage the electrode.

STEP 3: Connect the signal cable from the pH electrode to its BNC receptacle on the bottom of the controller enclosure.

STEP 4: Calibrate the new pH electrode as described in Calibrating the pH Sensor in Section III.

Replacing the Cell Temperature Sensor

The cell temperature sensor may occasionally need to be replaced, especially if it is exposed to higher temperatures. Use the following procedure to replace the temperature sensor.

STEP 1: Loosen the compression type tubing connector at the bottom of the sensor block and remove the old sensor. Disconnect the BNC connector on the sensor's signal cable from the receptacle on the bottom of the controller enclosure.

STEP 2: Install the new sensor into its opening in the sensor block. Tighten the tubing connector enough to ensure leak free operation, but no so much as to damage the sensor.

STEP 3: Connect the signal cable from the temperature sensor to its BNC receptacle on the bottom of the controller enclosure.

STEP 4: Calibrate the new temperature sensor as described in Probe Calibration in Section IX.

Replacing the Program Module

Occasionally, it may be necessary to replace the controller's operating program to upgrade the unit or to install custom programming. Use the following procedure to replace the Program EPROM integrated circuit (IC) device. The IC is located on the center of the CPU circuit board as shown in the CPU Module Layout drawing.

NOTE: Changing the Program Module will erase all of the user programmed preferences from the operating program. The pump and bath characteristics, set points and limits, and other preferences will have to be reinstalled as described in Section IV and V. You may want to go through the parameters list write down all of your setup parameters before doing this procedure.

STEP 1: Turn off the power to the controller and open the controller enclosure.

STEP 2: Using a small screwdriver, carefully remove the old Program Module from the CPU circuit board. Gently pry the Module up at one end and then at the other until the Module pops out.

STEP 3: Using only fingers, carefully insert the new Program Module into the CPU circuit board. Be sure that the Pin 1 on the end of the IC is on the same end as the Pin 1 printed on the CPU board. This will correctly match the IC's pins with those in its holder.

STEP 4: Perform a Restore Factory Reset listed in Section III.

STEP 5: Changing the Program Module will erase all of the user programmed preferences from the operating program. The pump and bath characteristics, set points and limits, and other preferences will have to be reinstalled as described in Section IV and V.

Replacing the Relay Module Fuses

The fuses inside the pump relay module protects the relay from excessive currents and overload in the event of a pump failure. They rarely fail. However, the following procedure should be used to replace a fuse, if it does fail. The fuses are located on the Relay circuit board as shown in the Relay Module Layout drawing.

STEP 1: Turn off the power to the relay module by disconnecting the power cable from its power supply.

STEP 2: Using a screwdriver, carefully unscrew the four attachment screws in the enclosure cover.

STEP 3: Unplug the LED cable on the back of the enclosure cover and set it aside.

STEP 4: Using a small screwdriver, remove the failed fuse by gently prying up one of its ends from the fuse holder and discard.

STEP 5: Carefully insert a new 250VAC, 2.5 Ampere, FF - Very Fast Acting, metric 5x20 mm size fuse in the fuse holder.

STEP 6: Plug the LED cable back into the back of the enclosure cover and attach the cover to the enclosure using the four attachment screws.

STEP 7: Reconnect the power cable from the relay box to its power supply.

Section XIII
Sensorex pH Probe

PRODUCT INSTRUCTION SHEET

POLYMER BODY, SEALED
COMBINATION pH/REFERENCE ELECTRODES

Epoxy body combination electrodes afford a unique ease of use. Because the pH bulb is recessed inside the polymer body, the electrode can be allowed to rest against the bottom of a beaker without damaging the glass bulb. In many measurements this recessed bulb design eliminates the need for electrode holders and the electrode can actually be used as a stirring rod. The sealed reference design eliminates the need to add filling solutions, minimizes reference dryout and allows the electrode to be used in up to 100 psig systems without the need for external pressurization.

FIG. 1

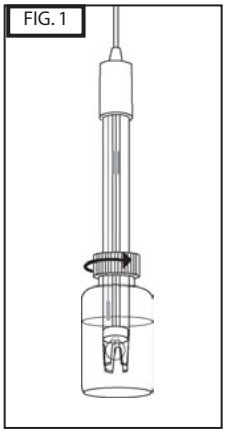
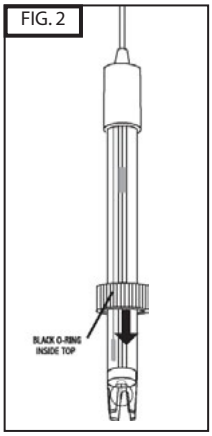


FIG. 2

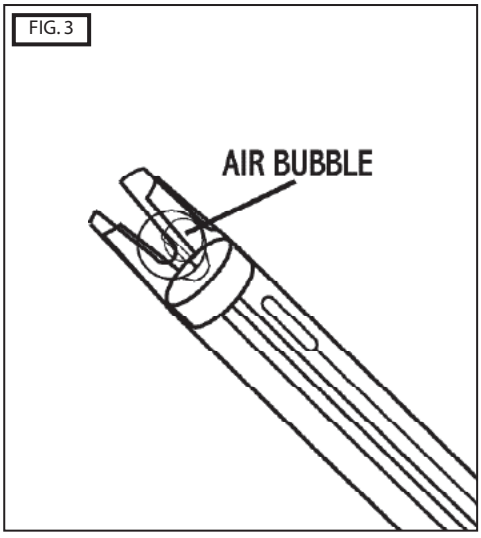


SECTION 1.0
HELPFUL OPERATING TIPS

1. The electrode is shipped in a plastic bottle containing a solution of pH 4 buffer and potassium chloride. The electrode should remain in the bottle until it is used. If the electrode is used infrequently, the bottle and its solution should be saved and the electrode stored in it. (see Electrode Storage Section). Take out electrode by loosening plastic top on bottle counterclockwise and pull electrode out. Slide cap and o-ring off electrode and save (SEE FIGS 1&2).

2. During shipment the air bubble in the electrode's stem may move into the bulb area. If bubbles are seen in the bulb area, hold the electrode by its top cap and shake downward as is done with a clinical thermometer (SEE FIG 3)

FIG. 3



3. Vigorously stir the electrode in the sample, buffer or rinse solution. This action will bring solution to the electrode's surface more quickly and improve speed of response.

4. After exposure to sample, buffer or rinse solution, shake the electrode with a snap motion to remove residual drops of solution. (SEE FIG 4, NEXT PAGE) This action will minimize contamination from carryover.

5. As a rinse solution, use a part of the next sample or buffer which is to be measured. This action will also minimize contamination from carryover.

6. When calibrating, use a buffer close in value to that expected from the sample. This action will minimize span errors.

7. Keep buffers and samples at the same temperature. This action will eliminate the need to correct values for temperature effects.

Parts covered by this product instruction sheet include:
S200C, S200CD, S900C, S900CD, S700C, S700CD, S350CD, S450C, S450CD, S100C, S120C, S175CD

FORM: COMBELECTRODEINSTRUCT [REV:0707]

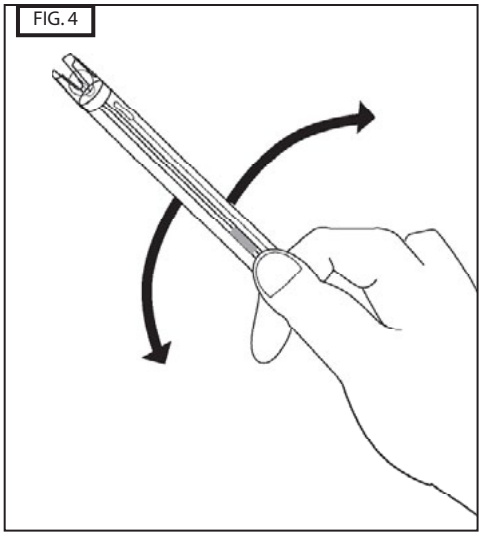
PRODUCT INSTRUCTION SHEET

SECTION 1.0
HELPFUL OPERATING TIPS (CONT)

8. pH readings stabilize faster in some solutions than in others; allow time for reading to stabilize. In general, buffers provide stable readings in several seconds (tris buffers take somewhat longer) while samples usually take longer times.

9. Keep in mind that all pH electrodes age with time. Aging is characterized by shortened span (slope) and slower speed of response. If the meter has a manual or microprocessor slope control, the control can be adjusted to compensate for electrode span errors (but will not affect the speed of response). Aging is best detected by calibrating the electrode in, for example, pH 7 buffer, then rinsing and placing the electrode in pH 4 buffer. As a rule, if the span is 10% or more in error (a reading of 4.3 or higher for this example) the electrode should be cleaned and retested (see the Electrode Cleaning Section) or reconditioned (see Reconditioning Section). If performance is not restored the electrode should be replaced.

FIG. 4

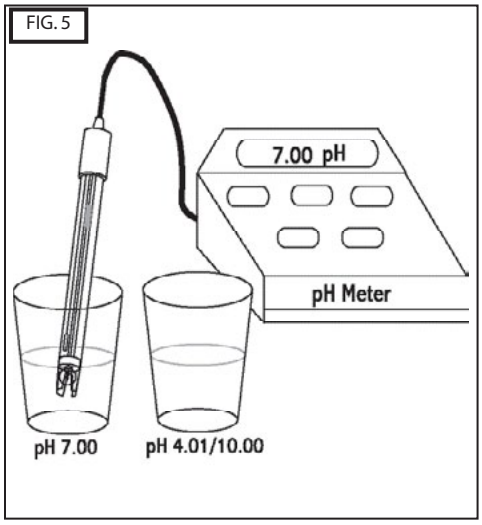


SECTION 2.0
CALIBRATION PROCEDURE

As a rule, follow the procedures recommended by the pH meter manufacturer keeping in mind the Helpful Operating Techniques given on page 1. The frequency of calibration is a function of the electrode, the pH meter and the solutions the electrode is exposed to. The electrode and meter should always be calibrated together with the calibration frequency determined by experience. Use two buffers, for example 7 & 4 or 7 & 10. (SEE FIG 5)Use the following step-wise procedure for both calibration in buffers and for sample measurements:

1. Remove the electrode from its soaker bottle and the save the bottle.
2. Vigorously stir the electrode in a rinse solution.
3. Shake the electrode with a snap action to remove residual drops of solution.
4. Vigorously stir the electrode in the buffer or sample and allow the electrode to rest against the beaker's wall.
5. Allow the reading to stabilize and then take the reading.
6. Repeat these steps for each sample or buffer determination.

FIG. 5



Parts covered by this product instruction sheet include:
S200C, S200CD, S900C, S900CD, S700C, S700CD, S350CD, S450C, S450CD, S100C, S120C, S175CD

FORM: COMBELECTRODEINSTRUCT [REV:0707]

PRODUCT INSTRUCTION SHEET

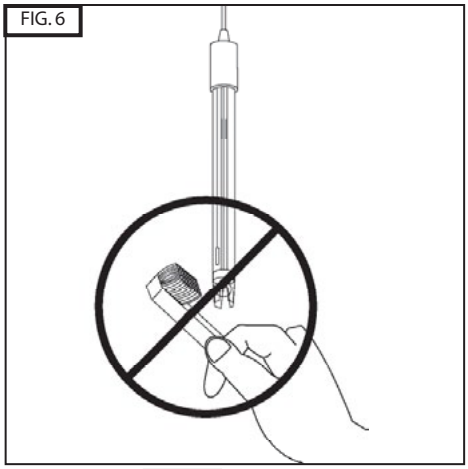
SECTION 3.0
ELECTRODE STORAGE

When pH readings are made infrequently, for example, several days or weeks apart, the electrode can be stored simply by replacing it in its soaker bottle. First, slide the cap onto the electrode, then the o-ring, then insert the electrode into the bottle and firmly tighten the cap. If the solution in the soaker bottle is missing, fill the bottle with pH 4 buffer.

SECTION 4.0
ELECTRODE CLEANING

Coating of the pH bulb can lead to erroneous readings including shortened span (slope). The type of coating will determine the cleaning technique. Soft coatings can be removed by vigorous stirring or by the use of a squirt bottle. Organic chemical or hard coatings should be chemically removed. 5-10% hydrochloric acid (HCl) soak for a few minutes often removes many coatings . Dilute detergents are also effective electrode cleaners. For Protein-based coatings an enzyme cleaner is recommended (Terg-a-zyme www.alconox.com). If cleaning does not restore performance, reconditioning may be tried. DO NOT USE BRUSH OR ABRASIVES ON ELECTRODE (SEE FIG 6.)

FIG. 6



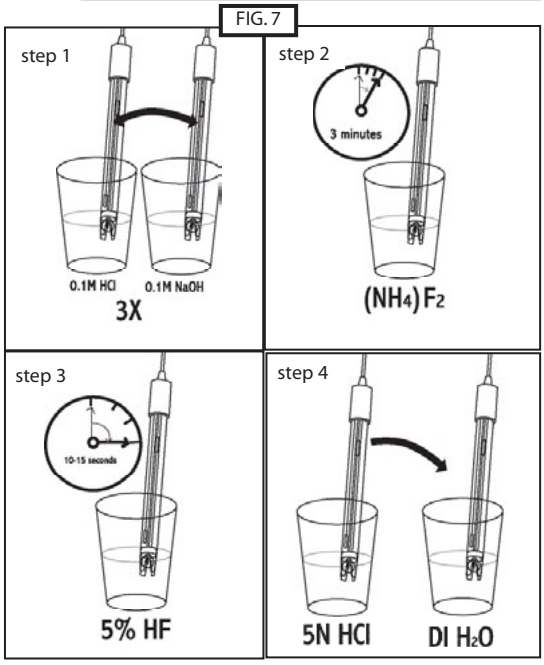
SECTION 5.0
ELECTRODE RECONDITIONING

When reconditioning is required due to electrode aging (see Helpful Operating Techniques, Part 9), the following chemical treatments can be tried. They are presented in the order of the severity of attack on the pH glass and may not improve (and in some cases actually further deteriorate) electrode performance.

NOTE: Use proper precautions when handling these hazardous chemicals. Ammonium bifluoride and HF (hydrofluoric acid) are extremely hazardous and should only be used by qualified personnel.

1. Immerse the electrode tip in 0.1 N HCl for 15 seconds, rinse in tap water and then immerse tip in 0.1 M NaOH for 15 seconds and rinse in tap water. Repeat this sequence three times and then recheck the electrode's performance. If performance has not been restored, try Step 2.
2. Immerse the tip in a 20% solution of NH4F- HF (ammonium bifluoride) for 2 to 3 minutes, rinse in tap water and recheck performance. If performance has not been restored try Step 3.
3. Immerse electrode tip in 5% HF for 10-15 seconds, rinse well in tap water, quickly rinse in 5N HCl, rinse well in tap water and recheck performance. If performance has not been restored, it is time to get another Sensorex epoxy body combination pH electrode. (SEE FIG. 7)

FIG. 7



Parts covered by this product instruction sheet include:
S200C, S200CD, S900C, S900CD, S700C, S700CD, S350CD, S450C, S450CD, S100C, S120C, S175CD

Section XIV
GRI Pumps

GORMAN-RUPP INDUSTRIES
DIVISION OF THE GORMAN-RUPP COMPANY

Standard Bellows Metering Pump
Service Data Sheet

Phone 419.886.3001
FAX 419.886.2338
grisales@gripumps.com
www.gripumps.com

STANDARD BELLOWS METERING PUMP

DESCRIPTION
The bellows pump size is the actual outside diameter of the bellows. The pump operates on an adjustable stroke, positive displacement principle. Output is adjusted by changing the stroke. The pump is driven by a thermally protected gearmotor which is attached to an adjustable eccentric hub. The bellows, pump body, tubing connectors and valve seats are made of polypropylene (PPR).

Exposure of the motor to extremely dusty or corrosive environment may reduce life.

PRIMING
The pump is self-priming under most conditions: however, the priming ability lessens with greater suction lift, higher discharge head, or with reduced stroke. For dry start up on pumps with anti-siphon spring adjusted at low stroke, pump may not prime. Remove anti-siphon spring, prime pump and replace spring.

After the pump has been primed and is full of liquid, subsequent repriming ability will be improved.

FLOW ADJUSTMENT
Flow rate is modified with the adjustable screw on crank assembly. Loosen lock screw on crank assembly and rotate adjusting screw clockwise to increase flow and counterclockwise to decrease flow. Retighten lock screw when desired flow rate is achieved (10 in.- lbs. max.). Do not turn or loosen lock nut on adjusting screw.

Do not reduce output flow by restricting suction or discharge as this will cause excessive pressure within the pump.

PRESSURE
The bellows pump has the ability to discharge into a pressurized system; however, if system or discharge pressure exceeds maximum psi rating of bellows, it may cause damage to the bellows or gearbox.

Maximum PSI Rating:
½" modules pump – 50 psi
¾" modules pump – 5 psi
1" modules pump – 40 psi
1½" modules pump – 20 psi
2" modules pump – 5 psi
2½" modules pump – 5 psi

NOTE: Pumps are designed for use with liquid up to 120°F (49°C) at catalog rated pressure. Reduce the maximum psi rating by 50% for temperatures over 120°F. Not applicable in liquids over 140°F.

VISCOSITY
The pump has been designed to handle a wide range of liquid viscosities. It should be noted, however, that when pumping thicker liquids it may be necessary to increase the size of connectors and tubing to relieve the pressure buildup within the pump assembly. It is good practice when pumping the heavier liquids to keep the liquid velocity (pump speed) as low as possible.

When pumping heavy suspensions which may tend to settle out, extremely corrosive solutions or any liquid which may tend to become more viscous with time, flush pump after use to increase pump life.

CHEMICAL SERVICE
The bellows pump will handle many different kinds of liquids. For specific chemical service, refer to our Standard Pump Catalog, form no. 86230.

Special bellows materials (sodium hypochlorite resistant and acid resistant) are available. Sodium hypochlorite resistant bellows are available in ½", ¾", 1", 1½", 2" and 2½" sizes. Pumps using sodium hypochlorite resistant bellows should have pressure ratings shown in the paragraph under pressure heading reduced by 50%. Acid resistant bellows are available in 1" and 1½" sizes only, and standard pressures apply.

TEMPERATURE
Pumps are designed to operate in 80°F (27°C) ambient temperature. For higher ambient temperature operations, consult the factory.

TROUBLESHOOTING GUIDE

The troubleshooting guide is a suggestion or aid in helping solve problems that might arise.

NOTE: Never work on pump without making certain power is off.

PUMP LEAKS
1. Bellows loose – Turn adjusting screw to full stroke, then rotate crank assembly to maximum bellows compression. Tighten plastic nut on crank assembly to 14 in.- lbs. maximum. **CAUTION:** Overtightening will distort bellows and cause leaks.
2. Connectors loose – Tighten to 5½ to 6⅔ in.- lbs. torque (finger tight).
3. O-ring defective or missing – See illustration.

MOTOR WILL NOT RUN
1. Cord, plug or switch defective.
2. Wires pulled loose.
3. Motor overtemperature thermostat open, motor overheating or poor ventilation.

UNIT WILL NOT PRIME
1. Pump leaks on suction side (see "Pump Leaks" section).
2. Bellows ruptured.
3. O-ring defective or missing – See illustration.
4. Valves inverted or reversed.
5. Pump air-locked – Temporarily bleed off discharge pressure.
6. Stroke too short – Adjust screw to increase stroke.
7. Viscosity too high.
8. Anti-siphon spring with pump adjusted at low stroke.

PUMP NOISY
1. Fan hitting.
2. Gearmotor worn out.

ERRATIC OR LOW FLOW
1. Valves dirty – Dirt or foreign material in valves.
2. Crank set screw broken.
3. Valves not seating.
4. Connectors loose.

UNIT WILL NOT PUMP
1. Bellows ruptured.
2. Crank broken.
3. Crank set screw broken.
4. Valves dirty – Dirt or foreign material in valves.
5. Valves may have deteriorated.

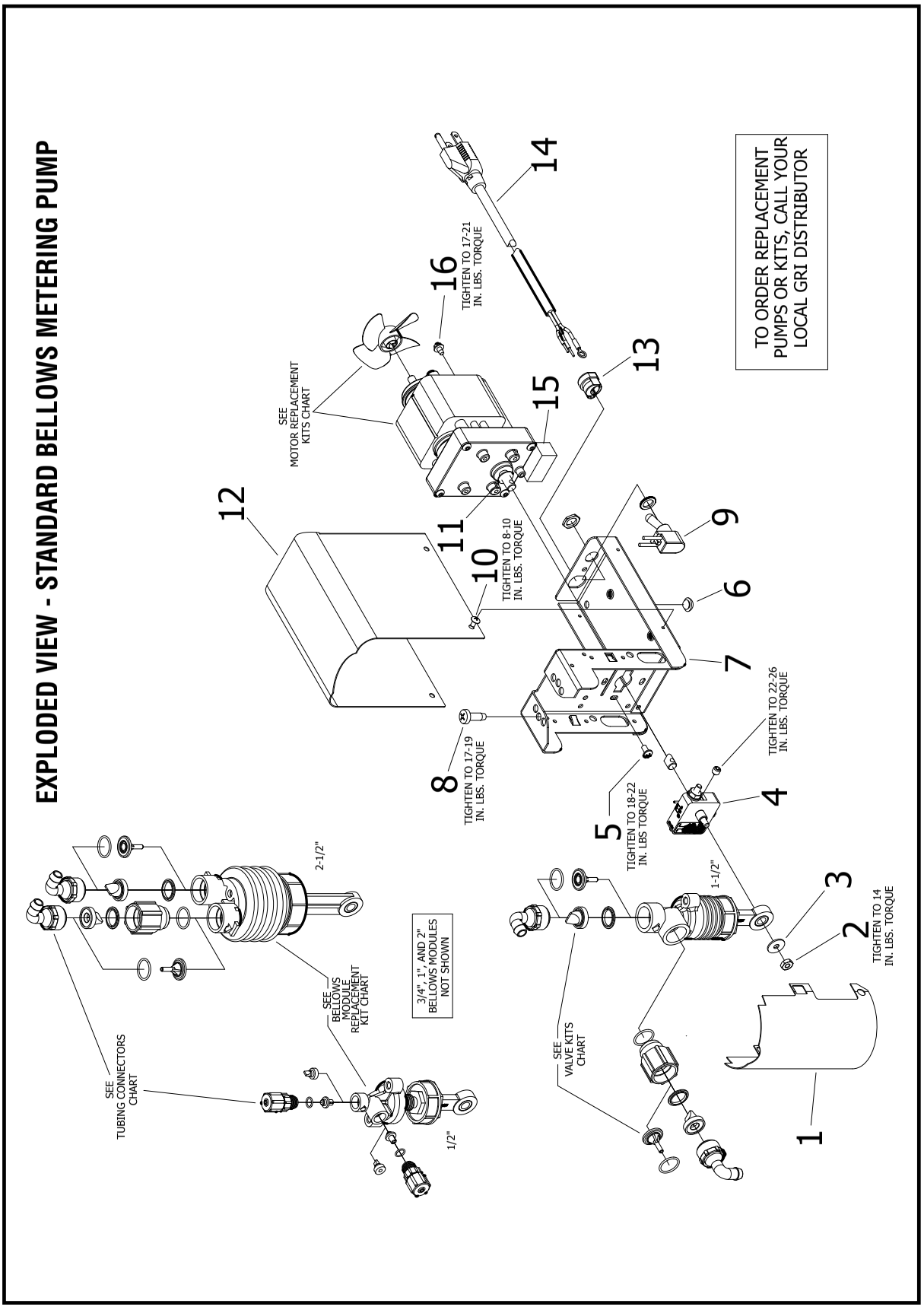
WARRANTY

Gorman-Rupp Industries warrants to Buyer that products sold by it will upon shipment conform to the description on the face hereof and any written specifications expressly approved by Seller and be free from defects in title, material and workmanship. NO OTHER WARRANTY, WHETHER EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, SHALL EXIST IN CONNECTION WITH ANY PRODUCTS SOLD BY SELLER, AND ALL SUCH WARRANTIES ARE HEREBY EXPRESSLY EXCLUDED.

WARNING

DANGER:
Improper application, installation, adjusting, or servicing can result in serious injury or death. Always disconnect power source before working on these products.

Caution:
Products with electric motors must be properly grounded and may start automatically at any time. For product information, consult Gorman-Rupp Industries, Bellville, Ohio 44813, Phone (419) 886-3001.


EXPLODED VIEW - STANDARD BELLOWS METERING PUMP
TO ORDER REPLACEMENT PUMPS OR KITS, CALL YOUR LOCAL GRI DISTRIBUTOR
1
2
TIGHTEN TO 14 IN. LBS. TORQUE
3
1-1/2"
4
TIGHTEN TO 22-26 IN. LBS. TORQUE
5
TIGHTEN TO 18-22 IN. LBS TORQUE
6
7
8
TIGHTEN TO 17-19 IN. LBS. TORQUE
9
10
TIGHTEN TO 8-10 IN. LBS. TORQUE
11
12
13
14
15
16
TIGHTEN TO 17-21 IN. LBS. TORQUE
SEE MOTOR REPLACEMENT KITS CHART
SEE VALVE KITS CHART
SEE TUBING CONNECTORS CHART
SEE BELLOWS MODULE REPLACEMENT KIT CHART
2-1/2"
1/2"
3/4", 1", AND 2" BELLOWS MODULES NOT SHOWN

PARTS LIST

ITEM	REQ.	DESCRIPTION	ORDERING INFORMATION
1	1	Splash Shield	See note below
2	1	10-32 Lock Nut	Included in Crank Assembly Replacement Kit - See Chart
3	1	Flat Washer	Included in Crank Assembly Replacement Kit - See Chart
4	1	Crank Assembly	Included in Crank Assembly Replacement Kit - See Chart
5	4	8-32 Motor Mounting Screw	Included in Motor Replacement Kit - See Chart
6	4	Bumper	See note below
7	1	Mounting Bracket	See note below
8	2	¼-14 Screw	Included in Bellows Module Replacement Kit - See Chart
9	1	Switch	See note below
10	4	6-32 Screw	See note below
11	1	Washer Slinger	See note below
12	1	Cover	See note below
13	1	Strain Relief	See note below
14	1	Cord & Plug 115V (240V w/o Plug)	See note below
15	1	Felt Pad	Included in Motor Replacement Kit - See Chart
16	1	8-32 Ground Screw	Included in Motor Replacement Kit - See Chart

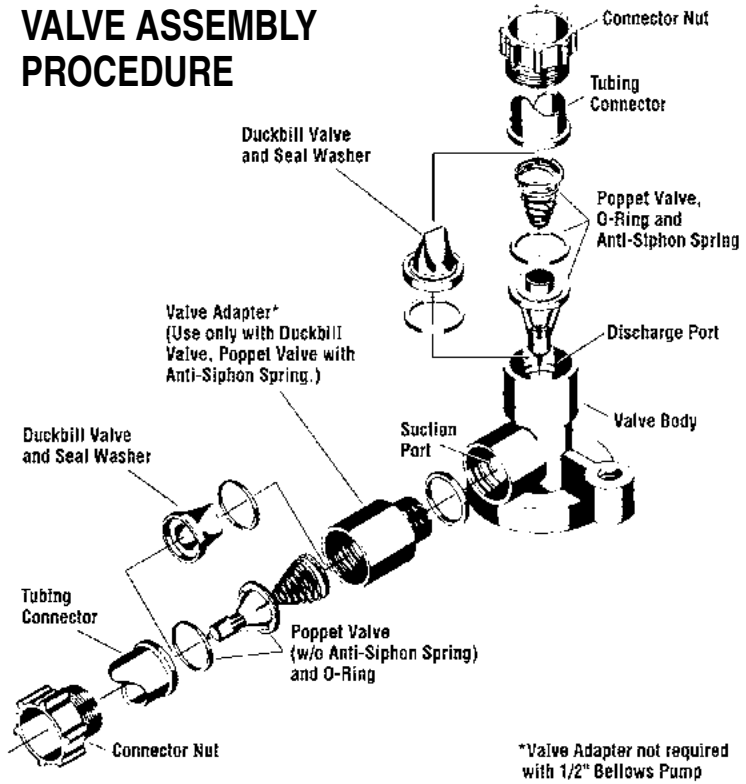
NOTE: Parts not available unless stocked by GRI Distributor or purchased in OEM quantities.

MOTOR REPLACEMENT KITS

115 VOLT		240 VOLT	
MOTOR	KIT NUMBER	MOTOR	KIT NUMBER
39 RPM	02500-996	39 RPM	02501-003
60 RPM	02500-995	60 RPM	02501-004
90 RPM	02500-999	90 RPM	02501-005
165 RPM	02501-000	165 RPM	02501-006

Kit includes Motor, Fan, Felt Pad, Ground Screw and Mounting Screws.

VALVE ASSEMBLY PROCEDURE



BELLOWS MODULE REPLACEMENT KITS

BELLOWS SIZE	HYPALON®	EPT	VITON®/ FLUOROELASTOMER
1/2"	02500-313	02500-315	02500-314
3/4"	02501-429	02501-426	02501-430
1"	02500-262	02500-274	02500-385
1-1/2"	02500-263	02500-279	02500-379
2"	02501-437	02501-434	02501-438
2-1/2"	02500-237	02500-284	02500-373

NOTE: Kit includes Connecting Rod Assembly, Bellows Module, Displacement Cup, Screws and O-Rings.

CRANK ASSEMBLY REPLACEMENT KITS

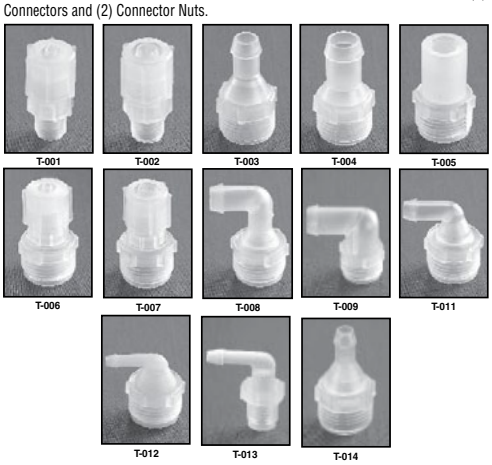
BELLOWS SIZE	KIT NUMBER
1/2"	02500-851
3/4"	02501-586
1", 1-1/2", 2"	02500-852
2-1/2"	02500-853

Kit includes 10-32 Lock Nut, Flat Washer and Crank Assembly.

TUBING CONNECTORS (2 PER KIT) – POLYPROPYLENE

T-CODES			
T-Code	**For Elastomeric Tubing Size**	**Connector Type**	**Bellows Module Size**
T-001 (02500-312)	⅛" I.D. x ¼" O.D.	Barbed Compression	½"
T-002 (02500-635)	¼" I.D. x ⅜" O.D.	Barbed Compression	½"
T-003 (02500-352)	⅜" I.D.	Barbed	¾", 1", 1½", 2", 2½"
T-004 (02500-353)	½" I.D.	Barbed	¾", 1", 1½", 2", 2½"
T-005 (02500-258)	⅛" pipe thread	Female NPT	¾", 1", 1½", 2", 2½"
T-006 (02500-259)	⅛" I.D. x ¼" O.D.	Barbed Compression	¾"
T-007 (02500-260)	¼" I.D. X ⅜" O.D.	Barbed Compression	¾", 1", 1½", 2", 2½"
T-008 (02500-261)	⅜" I.D.	Elbow Swivel, Barbed	¾", 1", 1½", 2", 2½"
T-009 (02500-354)	½" I.D.	Elbow Swivel, Barbed	¾", 1", 1½", 2", 2½"
T-011 (02501-337)	¼" I.D.	Elbow Swivel, Barbed	¾", 1", 1½", 2", 2½"
T-012 (02501-246)	4mm (5⁄32") I.D.	Elbow Swivel, Barbed	¾"
T-013 (02501-541)	4mm (5⁄32") I.D.	Elbow Swivel, Barbed	½"
T-014 (02501-673)	¼" I.D.	Barbed	¾", 1", 1½", 2", 2½"

NOTE: "T" codes are used for identification purposes only, to show tubing connectors used in pump. Use "T" code on label as a guide. Use 8-digit kit number beside corresponding "T" code when ordering replacement tubing connector kit.
Example: If T-008 is on pump label, order kit number 02500-261. Kit includes (2) Connectors and (2) Connector Nuts.



POPPET AND DUCKBILL VALVE KITS

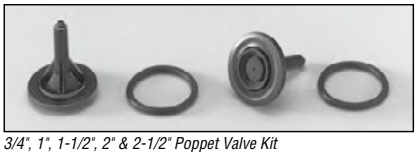
POPPET VALVE KITS			
BELLOWS SIZE	**HYPALON®**	**EPT**	**VITON®/ FLUOROELASTOMER**
1/2"	X-005 (02500-316)	X-002 (02500-318)	X-006 (02500-317)
3/4", 1", 1-1/2"	X-115 (02500-608)	X-112 (02500-605)	X-116 (02500-609)
2"	X-145 (02500-608)	X-142 (02500-605)	X-146 (02500-609)
2-1/2"	X-125 (02500-608)	X-122 (02500-605)	X-126 (02500-609)

DUCKBILL VALVE KITS			
BELLOWS SIZE	**HYPALON®**	**EPT**	**VITON®/ FLUOROELASTOMER**
1/2"	X-095 (02500-600)	X-092 (02500-597)	X-096 (02500-601)
3/4", 1", 1-1/2"	X-035 (02500-325)	X-032 (02500-322)	X-036 (02500-319)
2"	X-155 (02500-325)	X-152 (02500-322)	X-156 (02500-319)
2-1/2"	X-045 (02500-325)	X-042 (02500-322)	X-046 (02500-319)

NOTE: "X" codes are used for identification purposes only, to show elastomer in pump. Use "X" codes on pump label as a guide. Use 8-digit kit number beside corresponding "X" code when ordering replacement valve kit.
Example: If X-005 is on pump label, order kit number 02500-316.


1/2" Poppet Valve Kit


1/2" Duckbill Valve Kit


3/4", 1", 1-1/2", 2" & 2-1/2" Poppet Valve Kit


3/4", 1", 1-1/2", 2" & 2-1/2" Duckbill Valve Kit

Registered Trademark Names
VITON® ..... DuPont Dow Elastomers
HYPALON® ..... DuPont Dow Elastomers

GORMAN-RUPP INDUSTRIES
DIVISION OF THE GORMAN-RUPP COMPANY
Phone 419.886.3001 • FAX 419.886.2338
grisales@gripumps.com • www.gripumps.com

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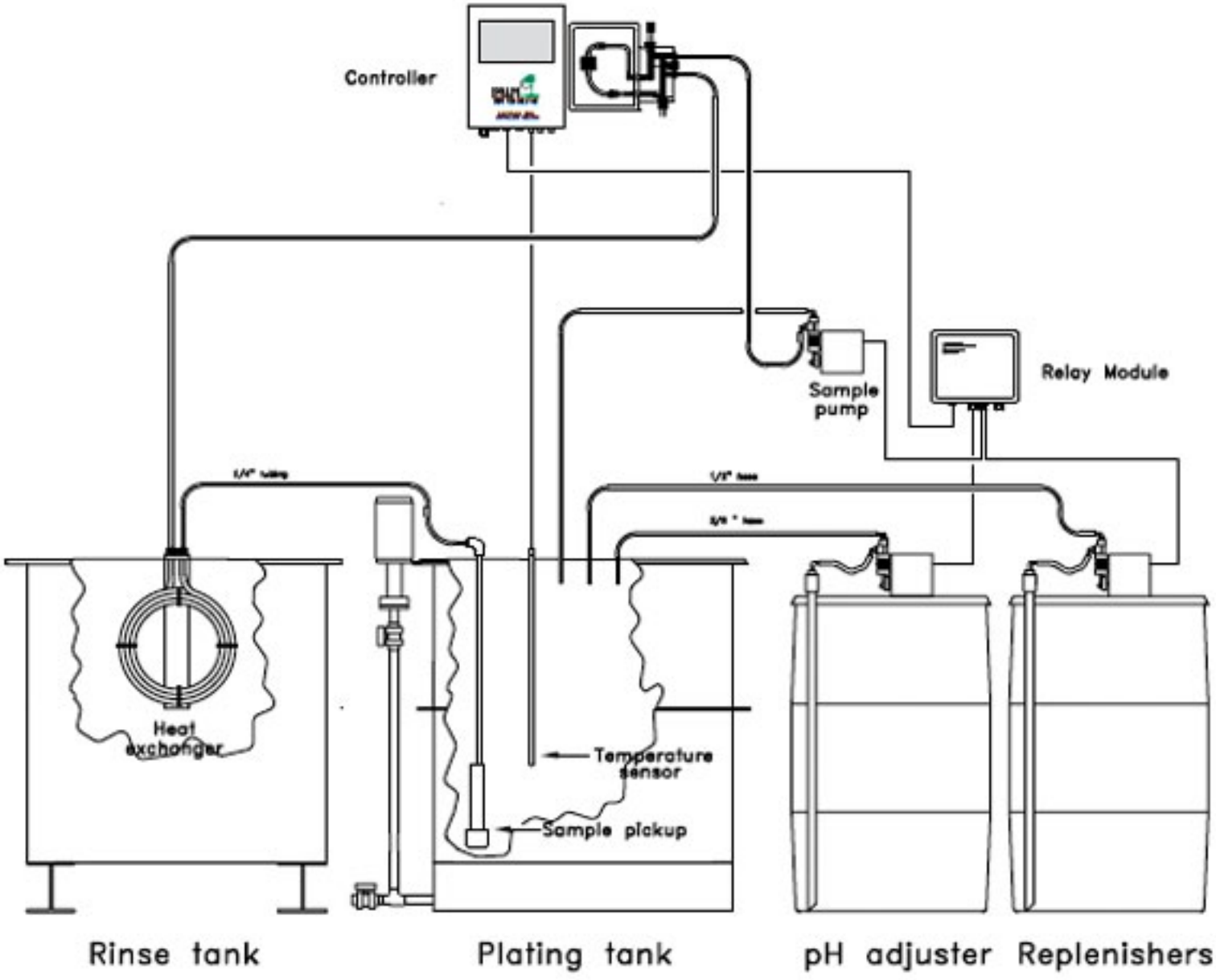
Section XV
Installation Diagram

Figure 1

INSTALLATION OF MODEL 3300 CONTROLLER



ENControl Model 3300
Warranty

Equipment manufactured by Palm Technology, Inc. is warranted to be free from defects in material and workmanship for a period of twelve (12) months when operated under design conditions within the specifications outlined in the Operating Manual. Palm's sole liability and Purchaser's sole remedy for failure of equipment under this warranty and for any and all other claims arising out of the purchase and use of equipment shall be limited to either the repair or replacement, at Palm's option, of the equipment found to be defective. Palm shall have no liability under this warranty unless it receives written notice of the claimed defect within the earlier of thirty (30) days from the date of discovery by Purchaser or the termination of the Warranty Period.

This warranty will not apply equipment failures due to ordinary wear, misuse, neglect, misapplication, improper installation, abuse, shipping damage, equipment modification, improper maintenance, usage contrary to the Operating Manual, or failure to provide a suitable operating environment.

This warranty does not extend to any product of another manufacturer. The warranty, if any, with respect to any product of another manufacturer is limited to the warranty, if any, extended by that manufacturer.

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