Model K29M / ML

Water Triple Point Cell Maintenance System

Operators Manual

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Water Triple Point Cell Maintenance System

1. Background

This report documents the installation, operating and maintenance procedures for the Water Triple Point Maintenance system, Pond Engineering Model Number K29M and K29ML. Information contained in this manual is considered by Pond Engineering Laboratories to be proprietary and is provided for use exclusively by the purchaser for instructional and maintenance purposes relative to the hardware delivered, any other use is prohibited.

2. General Information and Operating Procedures

Figure 1, below, shows the general configuration of the Water Triple Point system and provides the reader a better visualization of its appearance. Figure 1 provides a point of reference for the location and use of the control switches and service points discussed later in this manual.

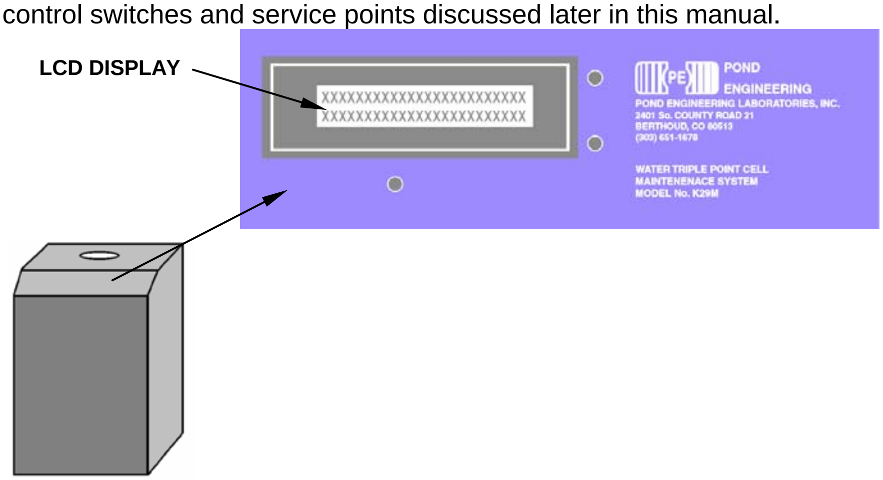

Figure 1 - System General Layout

As shown in Figure 1, the controller front panel is located on a sloping surface at the front of the outer chassis of the Water Triple Point Maintenance System. The Water Triple Point Cell Maintenance System is designed to provide a stable and uniform temperature environment for the preparation and maintenance of an ice mantle inside a Water Triple Point Cell. The System will accept Water Triple Point Cells up to 64 mm outside diameter. The Model K29ML system designates a system with an additional 100 mm well length for use with Japanese TPW cells.

Interior access to the system cabinet is provided by removing the back panel by unscrewing the button head screws around its periphery.

Operator interface is provided by three panel switches adjacent to a 2 line by 24 character Liquid Crystal Display (LCD) located in the front panel of the Water Triple Point Maintenance System as shown in Figure 2 on the next page.

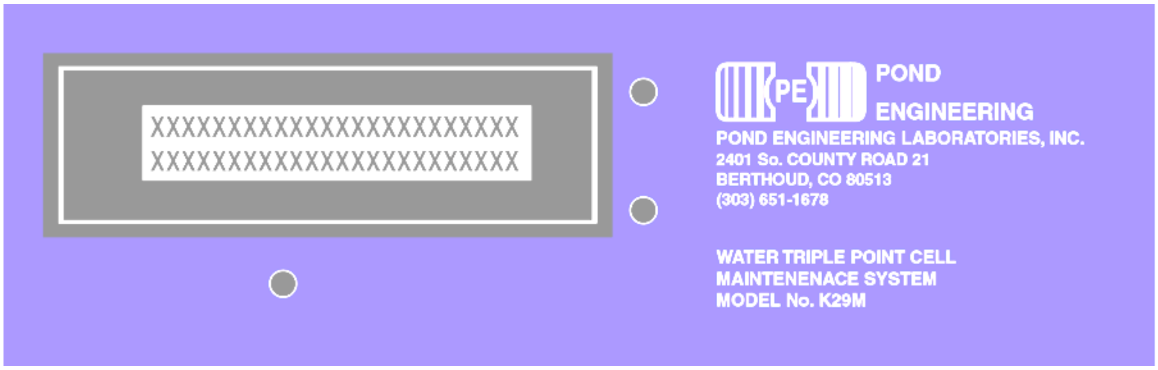

Figure 2 - Front Panel Layout

In the normal operating mode, this display presents the current temperature setpoint for the controller and the measured core temperature on the first and second lines of the display, respectively. Measurements are taken at approximately 3 second intervals and the lower line of the display is updated following measurement. Additional controller functions (for the purpose of providing diagnostic information, sensor calibration etc.) are accessed through the use of the front panel switches and messages presented by the LCD display as outlined in the following sections.

3. Initial Setup and Operation

This section is intended to provide the user with the information necessary to get the system up and running quickly in a minimum amount of time. It is not intended to take the place of gaining an understanding of the operating principles of the system or a thorough review of the entire manual.

Connecting the system to a power source in the range of 90 to 240 VAC, 48 to 62 Hz. and switching on the power will power up the system with the default setpoint temperature of -0.25 °C. The system will display the system setpoint temperature and the current measured core temperature on the first and second lines of the display. The measured core temperature should be observed to be moving toward the setpoint fairly rapidly at first and then more slowly as the core approaches the operating temperature range. The cell may be placed in the system's main well at any time. The cell will cool in approximately 12 to 36 hours to the point where a mantle will form and maintain in the cell.

Forming an ice mantle on the cell's center well is accomplished by using a number of techniques: finely crushed dry ice, liquid nitrogen cooled rods, or other suitable techniques. The user may refer to NIST Technical Note 1265 for further reference on formation of the mantle. It is important to ensure that the cell doesn't bridge over the liquid surface while the mantle is forming. The liquid water must be allowed to expand into the vapor space at the top of the cell as the ice is formed. If the liquid water does not fill the vapor space, destructive hydrostatic pressures can build up in the cell.

Following formation of a mantle, one may place the cell in the maintenance system to maintain the mantle. It is of importance that an inverse temperature stratification occurs in water around 4°C. One must sufficiently cool the water inside the cell prior to inserting the cell into the maintenance system or significant erosion of the ice mantle at the bottom of the cell will occur. Avoid erosion by inverting the cell a few times immediately after forming a mantle. This will mechanically stir the water and upset the stratification. Placing a small amount of dry ice or liquid nitrogen in the bottom of the system's main well before inserting the cell into the maintenance system will prevent erosion as well. Inversion of the cell is much more safe with a Type "B" cell than with a Type "A" cell. The handle is not present in a Type "B" cell and the risk of causing a violent water hammer (when the cool water reaches the warm glass at the end of the handle) is not nearly as great.

4. Theory of Operation

This maintenance system is constructed with a core assembly consisting of a specially designed superinsulated vacuum dewar with an integral thermoelectrically cooled heat pipe sandwiched between two layers of superinsulation to maintain an isothermal, adiabatic environment for maintenance of the mantle in a Water Triple Point Cell. By controlling the temperature of the heat pipe, the temperature gradient across the superinsulation between the main well, containing the cell and the heat pipe, is minimized. This will minimize the heat transfer to the TPW cell with only moderate accuracy and stability requirements on the control of the heat pipe temperature. Any heat transferred through the outer layer of superinsulation is intercepted by the heat pipe and removed at the system condenser by the thermoelectric cooling module and heat sink. The tremendous thermal impedance provided by the evacuated superinsulation essentially allows the Water Triple Point Cell placed within the core to establish the thermal environment within the main well of the maintenance system.

A custom microprocessor based controller and associated drive electronics provides temperature control for the system. Setpoint of the controller is limited in this system to a range ± 5.0 °C. Due to the minimal heat transfer through the superinsulation, the system can be maintained at operating temperatures by a relatively small thermoelectric module. The small thermoelectric module results in a relatively long initial cool down time, 8 to 24 hours in most cases. The system will cool a cell to about 4.0 °C in 6 to 12 hours but stratification occurs around 4.0 °C due to the temperature and density properties of water. The system takes 6 to 24 more hours to cool the cell the last 4 °C. It is suggested that the user form a mantle in the cell using the usual procedure when the temperature at the bottom of the TPW cell well is less than 1.0 °C.

5. System Controller

In an effort to provide simplicity while maintaining the ability to provide the many functions necessary to operate and maintain the system, the user interface design is based on user interactive software control. The software will provide the user prompts through a set of "COMMAND FUNCTIONS," including "ADJUST SETPOINT," and "ADJUST SYSTEM VARIABLES." In a user-interactive manner, the software displays messages on a 24 character by 2 line Liquid Crystal Display (LCD). This display prompts the user, as necessary, to perform all functions through the use of the three front panel switches surrounding the LCD. The following text and figures provide an outline of the user interface that describes the prompts and user actions necessary to set up, edit configurations, and operate the system.

Because of the multitude of functions that each switch will be called upon to perform, all "labeling" of the switches is provided by the software program and presented to the user via the LCD display. (The labels attached to the switches in Figure 3 on the next page are for the benefit of the reader in understanding the documentation herein, only. Such labels do not appear on the device’s front panel.)

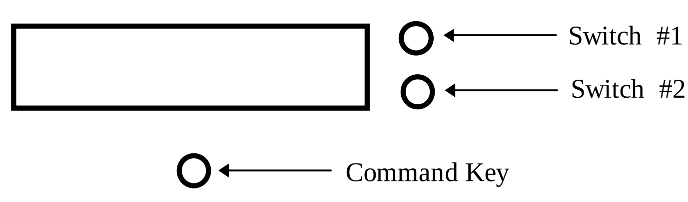

Figure 3 - Front Panel Switch Layout

5.1 Normal Operating Mode

In normal operation, the Water Triple Point System controller will continuously display the current temperature setpoint of the controller and the measured core temperature on the first and second lines of the display, as shown in Figure 4. Measurements are taken at approximately 3 second intervals and the lower line of the display is updated following each measurement. This information is removed from the display when the user presses and holds the "Command Key" for a period of 2 to 3 seconds which allows entry to the "COMMAND FUNCTIONS" portion of the program.

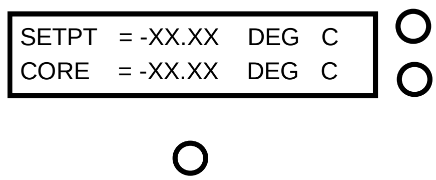

Figure 4 - Normal Operating Mode Display

5.2 The "Command Functions"

In order to perform the many functions necessary, the user must leave the normal operating mode and enter COMMAND FUNCTIONS. To do this, the user should depress and hold the Command Key. As the key is pressed, the words COMMAND FUNCTIONS are immediately displayed on the lower line of the display. If one releases the key, the normal operation screen will be displayed and normal operation will continue. In order to proceed to the Command Functions the operator must press and hold the Command Key for approximately 2-3 seconds or until the message, shown in Figure 5 representing the first command function, is showing on the display.

5.2.1 Change Setpoint

The first command function accessed is CHANGE SETPOINT TEMPERATURE. This function provides a way for the user to change the setpoint to one of three user adjustable memory setpoint temperatures or manually adjust the setpoint temperature. The memory setpoints allow the user to quickly change the setpoint temperature to one of these preset values (Adjusting memory setpoints is discussed in paragraph 3.2.2.1). When changing the setpoint to a value not preprogrammed in one of the memory setpoints the user may adjust the setpoint manually. The setpoint value may be set within the range of ± 5.00 °C. As shown in Figure 5, the "YES" is located adjacent to the top switch, which was identified earlier in Figure 3 as "Switch #1". The "NO" is adjacent to the switch identified as "Switch #2". If the "NO" selection is made, the program will continue on to the next function.

On the other hand, if the user selects "YES" by pressing the corresponding switch, the display shown in Figure 6 will be presented on the LCD.

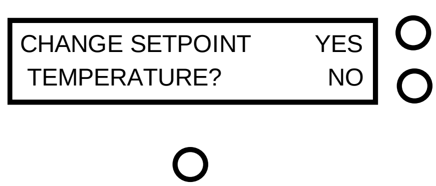

Figure 5 - Setpoint Access Prompt

The user may choose to select the memory setpoint temperatures by pressing the corresponding "YES" switch. A "NO" selection will advance the system to the next memory setpoint. A "NO"

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response to all of the memory setpoint temperatures will allow the user to change the setpoint manually.

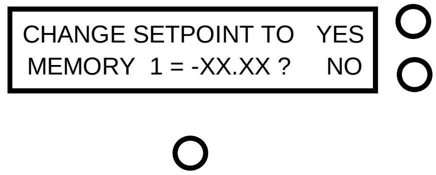

Figure 6 - Memory Setpoint Change

Manual adjustment of the "SETPOINT", within the setpoint range of ± 5.0 °C, may be accomplished by using the two switches on the side adjacent to the labels "UP" and "DN" displayed on the LCD. The "COMMAND" switch, located directly below the LCD, is used to advance the cursor to each of the digits. The current number presented on the display is used by the system controller as the current setpoint even while in the command functions mode.

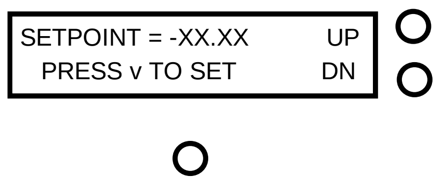

Figure 7 - Manual Setpoint Adjust Prompt

As the cursor is scrolled past the last digit, setpoint adjustment is completed and the system continues to the next Command Function as described in the following section.

5.2.2 Adjust System Variables

This command function is provided to allow user examination and adjustment of the system variables used by the controller as well as a calibration offset for the system core temperature measurements.

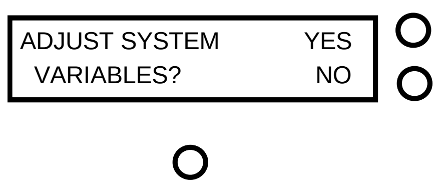

Figure 8 - System Variable Access Prompt

Pressing the switch by the display "YES" will move to the first system variable by presenting the messages shown in Figure 9. Responding with a "NO" command will terminate the function and continues to the next Command Function “Diagnostics Display Mode Select” (see 5.2.3).

5.2.2.1 Adjust Memory Setpoint Temperatures

The first variable accessed by the "Adjust System Variables" function is the "Memory 0" as shown in Figure 9 on the next page. The "Memory 0" variable is the system startup setpoint temperature. Responding "YES" to the prompt will allow the user to adjust the setpoint, while a "NO" response will access the next memory setpoint.

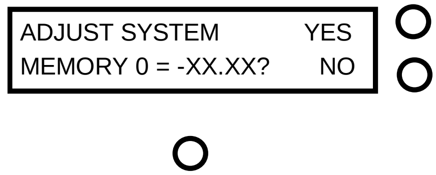

Figure 9 - Adjust Setpoint Memory Prompt

The adjustment of "MEMORY 0" and all subsequent memory setpoints may be accomplished by using the two switches on the side corresponding to the labels "UP" and "DN" displayed on the LCD. The "COMMAND" switch, located directly below the LCD, is used to advance the cursor to each of the digits in a manner similar to that for the manual setpoint adjustment described earlier.

As the cursor is scrolled past the last digit, memory setpoint adjustment is completed and the system moves to the next memory setpoint. When all memory setpoint adjustments have been presented, the system advances to the next Command Function as described in the following section.

5.2.2.2 Calibration of Core Sensor

The next variables presented are "CALIBRATION" variables, or the offset between the actual temperature of the core and the measured value by the core sensor.

This variable may be examined or adjusted by the user by responding "YES" to the prompt shown in Figure 10. A " NO" response will conclude the function and allow the user to move to the next routine as described in the following section.

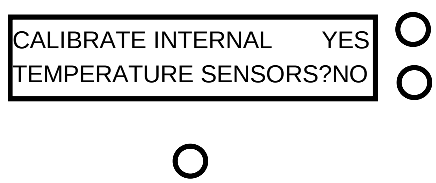

Figure 10 - Calibration Access Prompt

At this point the system checks to verify that the internally measured core temperature is within the range of ± 5 °C and that the core is being controlled within 0.1 °C of the setpoint. In the event that these conditions are not met, the system will only allow manual offset values to insure that the system is stable and that the calibration offset values are being calculated correctly as shown in Figure 11 on the following page.

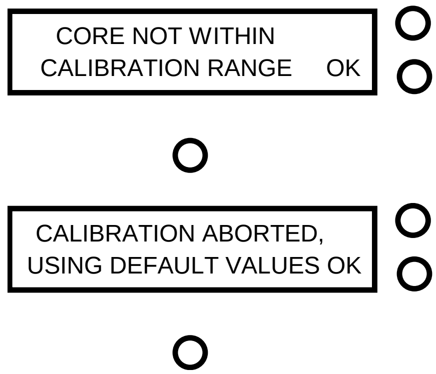

Figure 11 - Core Out of Range Prompts

The user must then press the switch labeled "OK" and the prompt will appear as shown in Figure 13 (calculation and display of the calibrated core temperature as shown in Figure 12 will be skipped).

In the event the calibration conditions are met, the system will allow user entry of a calibrated core temperature as measured by a thermometer placed at the bottom of the system precool well next to the main well.

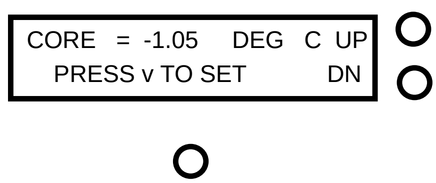

Figure 12 - Core Temperature Adjust Prompt

The user then has the option of modifying the main core offset variable being applied to the measured value simply by entering the calibrated temperature measured in the precool well. Modification of the variable is accomplished by pressing the two switches on the right of the LCD. Pressing the switch adjacent to the "UP" prompt, as shown in Figure 12, will cause the value of the variable to increase by one hundredth. Pressing the switch adjacent to the "DN" will cause the variable to decrease by one hundredth. The system will continually update the measured value, apply the current offset, and display the corrected value so all changes reflect in the display as they occur. It is recommended that the user monitor the displayed core temperature and the externally measured core temperature for a period of time after entering the calibrated temperature to insure system stability. After the desired offset has been established by incrementing or decrementing the value as described above, pressing the Command Key causes the value to be stored as a temporary system variable and the user is given the opportunity to examine or modify the calculated offset by the following prompt shown in Figure 13.

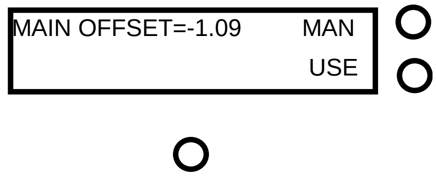

Figure 13 - Manual Core Offset Adjustment Prompt

It is recommended that the user record any new offset resulting from a calibration in a log similar to the log provided at the end of this manual. The information in Figure 13 allows the user to examine the offset value being applied to the main sensor. It must be noted that a new value is calculated for the offset variable each time the calibration routine is executed and the system is within the calibration range. In the event the user wishes only to examine the current default value, simply execute the calibrate function with the setpoint more than 0.1 degrees different from the front panel indicated core temperature. The prompts shown allow the user to either manually adjust this offset value, "MAN", or "USE" this value as the calibration offset. In the event that the user chooses to "USE" this value, the system will set the offset variable to the value displayed. This choice skips the manual adjustment function discussed in the following section, while a choice to MANually adjust the system will display the prompt shown below in Figure 14.

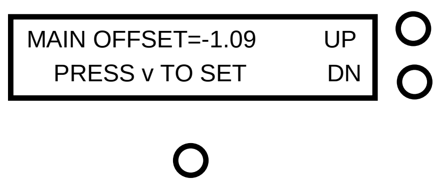

Figure 14 - Manual Core Offset Adjustment Prompt

Manual adjustment of "MAIN OFFSET" may be accomplished by using the two switches on the side corresponding the labels "UP" and "DN" displayed on the LCD. The "COMMAND" switch, located directly below the LCD, is used to advance the cursor to each of the digits.

As the cursor scrolls past the last digit, the main core offset adjustment is completed and the system sets the offset variable to the manually established value. The screen then advances to the next Command Function as described in the following section.

5.2.2.3 Activate Getters Function

In order to insure a long service life for the system, provisions have been made in the design to maintain the vacuum level in the core dewar by the use of "getters". These are materials that scavenge any residual gasses which may degas from the interior surfaces of the core dewar over time. Depending on the condition of the particular dewar and the amount of time since manufactured, these getter materials must be activated periodically. The system controller is set up to automatically initiate a getter activation cycle when the system detects an increase in the cooling power necessary to maintain the setpoint temperature. This function is provided to allow a user to manually initiate an activation cycle, if necessary, and to determine the total number of times the getters have been activated during the lifetime of the system. Manual initiation of a getter activation cycle is intended for use by trained service personnel only. Interrogation of the activation cycle counter should be done periodically to verify that the cycle is not being initiated more frequently than about once per week.

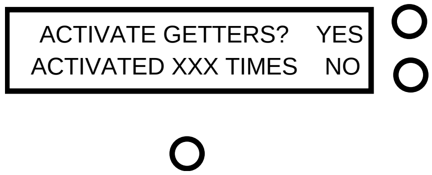

Figure 15 - Activate Getters Prompt

Responding YES to this prompt will manually initiate an activation cycle and will have no immediately measurable effect on the system performance. Over a period of several tens of minutes, a gradual decrease in the cooling power necessary to maintain the system setpoint (as determined by the thermoelectric drive voltage displayed in the diagnostic display) should be observed. An activation cycle lasts for approximately 15 minutes and is enunciated by a flashing (approximately 3 seconds on and 3 seconds off) asterisk (*) in the left most position of the lower line of the normal front panel display.

5.2.2.4 Access Vars Array

This function allows access to variables stored in the system's memory. It is strongly recommended that before responding YES one carefully reviews what each variable represents (see chart below). It is strongly recommended that only experienced users familiar with this system and its limitations exercise this option.

****DO NOT ADJUST VARS ARRAY WITHOUT FIRST CONSULTING FACTORY!!!** Doing so can cause severe damage to the Furnace and could be very dangerous! If the message UNABLE TO LOAD VARIABLES should appear on the front panel display call Pond Engineering immediately for service.

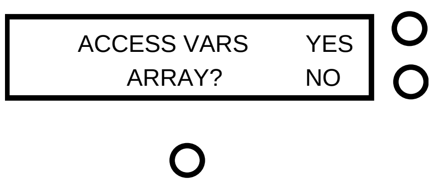

Figure 16 - Access Variables Array Prompt

Responding YES will cause Figure 17 to appear. This is to warn the user of the danger if this function is not used properly. Press Switch #1 to continue or Switch #2 to exit to the next function.

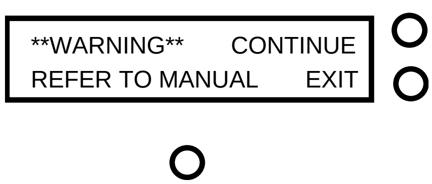

Figure 17 - Warning Prompt

Variables can be viewed and changed as shown below. The variables are not labeled. Please refer to the following chart for information about each variable.

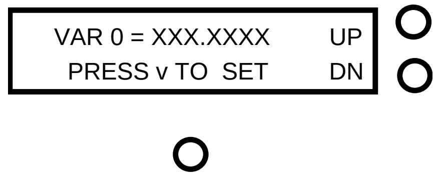

Figure 18 - Variable 0 Adjustment Prompt

Scrolling through the variables is accomplished by pressing either of the two switches to the right of the LCD, the switch adjacent to UP increments the variable number and the switch adjacent to DN decrements it. The command key located directly below the LCD is used to start the adjustment of the selected variable by advancing the cursor through the digits. Pressing the switch adjacent to the UP prompt shown in Figure 18 will cause the value of the selected digit to increment one, while pressing the switch adjacent to the DN will cause it to decrement by one. As the cursor passes the last digit the value is stored as a temporary system variable.
****WARNING** Software checking is not done for these entries and inputting values outside the recommended ranges can result in permanent damage to the system if utilized for operating the system.**

The following is a list of the variables and their locations.

#	Variable \Description	Default Values	Recommend Range
0	Setpoint Temperature	-0.2500 degrees C	-5 to 5 degrees C
1	Memory 0 Setpoint Temperature	-0.2500 degrees C	-5 to 5 degrees C
2	Memory 1 Setpoint Temperature	-0.2500 degrees C	-5 to 5 degrees C
3	Memory 2 Setpoint Temperature	0.0000 degrees C	-5 to 5 degrees C
4	Memory 3 Setpoint Temperature	-5.0000 degrees C	-5 to 5 degrees C
5	Core Offset	0.0000 degrees C	
6	Number of Times Getters have been Fired		
7	Measured Core Temperature		
8	Thermoelectric Drive Voltage	0.0000	
9	Initialization Variable	0.0000	
10	GPIB primary Address	6.0000	
20	ACCESS CODE for protected variables	0.0000	Call Factory

****Protected Variables****

#	Variable \Description	Default Values	Recommend Range
21	Control loop proportional gain	-2.5000	
22	Control loop integral gain	-0.1000	
23	Proportional drive signal	0.0000	
24	Integrator drive signal	0.0000	
25	Max TE drive voltage	9.5000	
26	Integrator Max limit	9.5000	
27	Sensor TPW Res. (Ohms) factory calibrated	101.5000	
28	TE drive voltage to fire getters	5.5000	
29	Delay time to fire getters (control cycles)	9600	
30	Getter fire time (control cycles)	300	
42	System Configuration variable	0.0000	

5.2.2.5 Save Changes to Variables

Here the user is given the opportunity to save the newly established system variables to nonvolatile memory. The newly established system variables are stored as temporary system variables at this point, responding YES to this prompt causes the variables to be stored in nonvolatile memory within the system controller. System variables stored in nonvolatile memory are utilized to establish the values for the system variables the next time the system is turned on.

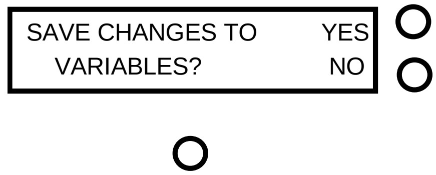

Figure 19 - Save Variables Prompt

Responding "NO" to this prompt causes the system to exit the function without saving the variables to non-volatile EEPROM. This allows the user to temporarily establish new values for the system variables without permanently altering the default values. If the power is turned off or interrupted before the new information was stored into the non-volatile EEPROM, the newly established values would be lost and the system would utilize the previous default values. Following verification of performance of the newly established variable values, they may be stored by entering the ADJUST SYSTEM VARIABLES routine and responding YES to the SAVE CHANGES prompt when prompted.

****NOTE****
The user must manually enter the previously recorded offset values or go through the entire calibration procedure if changed variables are not saved prior to turning off the system.

5.2.3 Diagnostics Display Mode Select

Here the user is given the opportunity to choose which set of information is presented by the display during operation. Two choices are presented, NORMAL DISPLAY and DIAGNOSTIC INFORMATION. The NORMAL DISPLAY mode is always presented upon system power up and is changed through this control function to allow display of DIAGNOSTIC INFORMATION by answering YES to the command function prompt shown in Figure 20.

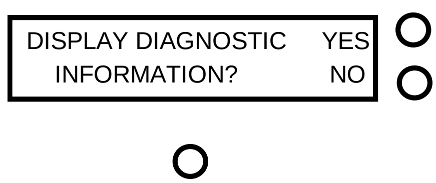

Figure 20 - Diagnostics Mode Display Prompt

If the system is currently displaying DIAGNOSTIC INFORMATION, the prompt will be modified, as shown below, to allow the user to toggle back to the NORMAL DISPLAY mode by answering YES to the command function prompt.

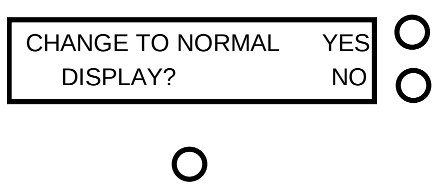

Figure 21 - Normal Mode Display Prompt

The DIAGNOSTIC INFORMATION display presents an array of numeric information for system diagnostics of the system control loops. An example of the diagnostic information is shown in the figure below.

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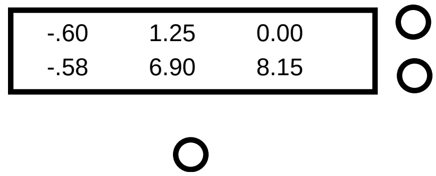


Figure 22 - Diagnostics Display

The information presented by this display is as follows. Top row left to right: current system setpoint, thermoelectric cooler proportional drive signal, thermoelectric cooler derivative drive signal. Bottom row left to right: measured core temperature, thermoelectric cooler integrator drive signal, and thermoelectric cooler drive voltage.

**** NOTE ****
Once the DIAGNOSTIC INFORMATION mode has been entered the display will only present the diagnostic information. Normal display mode can be obtained through the "COMMAND FUNCTIONS" options as described above.

After completing all of the command functions as described above, the Water Triple Point Maintenance system will again return to the normal operating mode as described earlier.

5.3 Unable to Cool Properly Warning Message

The system has a built in diagnostic routine that monitors its performance and activates the getters as described above. If the system is unable to cool properly, the getters will be activated repeatedly for approximately 32 hours If the system still can't cool properly the following warning message will appear on the LCD.

Figure 23 - Warning Display

This message will remain on the front panel display until the system is reset by cycling the system power. All other system functions continue normally and the system will continue to attempt to cool the core to the current system setpoint. It should be noted that there are several potential causes for this condition as discussed in the following paragraphs.

5.3.1 Potential Causes of Inability to Cool

The following three paragraphs describe some of the possible causes why the system would not be cooling correctly.

5.3.1.1 Insulating Plug Not In Place

Since the system is designed to require a minimal amount of cooling in order to minimize the possibility of completely freezing and breaking a cell, it cannot properly cool the core without the insulating plug at the top of the main well in place. If the plug is not in place the warning message will likely be presented after a period of time.

5.3.1.2 Unusually High Ambient Air Temperatures

Operation of the system in unusually high ambient air temperatures will cause an increase in the thermoelectric drive voltage primarily due to the increased temperature differential between the system core and the heat sink. The system should operate satisfactorily up to an ambient air temperature of 30 °C.

5.3.1.3 Obstruction of Cooling Air Flow

To prevent blockage of the cooling air inlet, the system should not be placed closer than 3" to a wall or other solid surface in the vicinity of the cooling fan inlet (adjacent to the fan on the left side of the system cabinet).

6. Periodic Maintenance

Besides normal cosmetic cleaning of the system, the following periodic maintenance is recommended for the system:

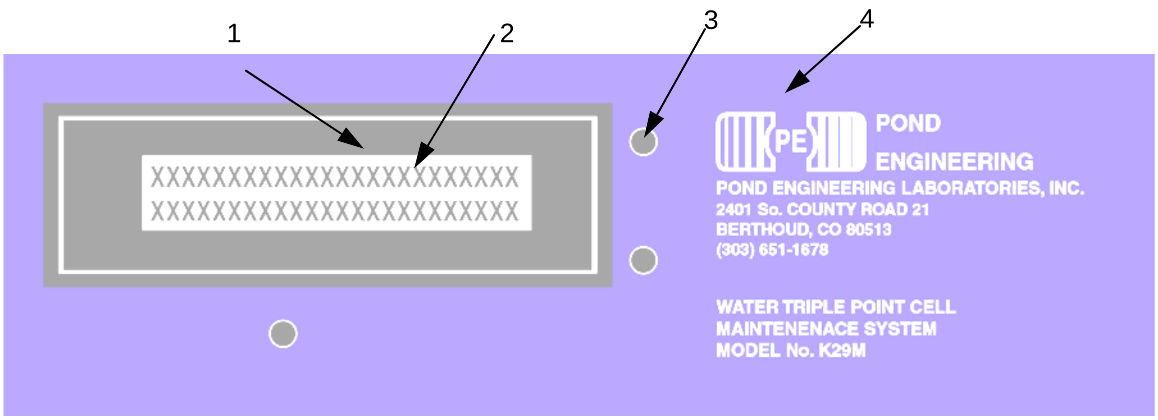
Remove any significant accumulation of condensed atmospheric moisture in the main well and precool well as necessary. Depending on the conditions in the lab, this may need to be done on a weekly or monthly basis, preferably at the same time the condition of the cell mantle is checked.

It is recommended that the desiccant pack, contained in a threaded plug adjacent to the thermoelectric heat sink, be checked every one to four months and replaced as necessary. This may be accomplished by removing the 8 screws attaching the system back panel and removing the back panel with the system power switched off. Remove the threaded plug by unscrewing the plug in a counter clockwise direction. The desiccant indicating beads will turn from blue to pink when the desiccant pack is saturated. The desiccant pack should be replaced or reactivated when saturated. They may be reactivated by placing the desiccant pack in a desiccator for the period of time recommended by the desiccator manufacturer or until the beads turn blue.

7. System Hardware Description

A brief description of system hardware is provided is this section as a reference to aid the user in providing periodic maintenance of the system. In the event significant maintenance or repair is required, it recommended that Pond Engineering be contacted prior to replacing or modifying major system components.

7.1 Front Panel



REF. #	NAME	MAKE	MODEL
1	Die Cast Metal Bezel	JMJ Technical Products, Inc.	1-458
2	24X2 Dot Matrix LCD Module DMC Series	Optrex	DMC20261
3	Miniature Push-button panel Mount SPDT Switches - 3 each - with	Eaton Cutler-Hammer	PS1-100Q
	Caps for Miniature Switches	Eaton Cutler-Hammer	W-KN-17
4	Engraved Laminate Front Panel	Pond Engineering	K29-FP

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Pond Engineering Laboratories, Inc.
2401 S. County Road 21, Berthoud, CO 80513 USA
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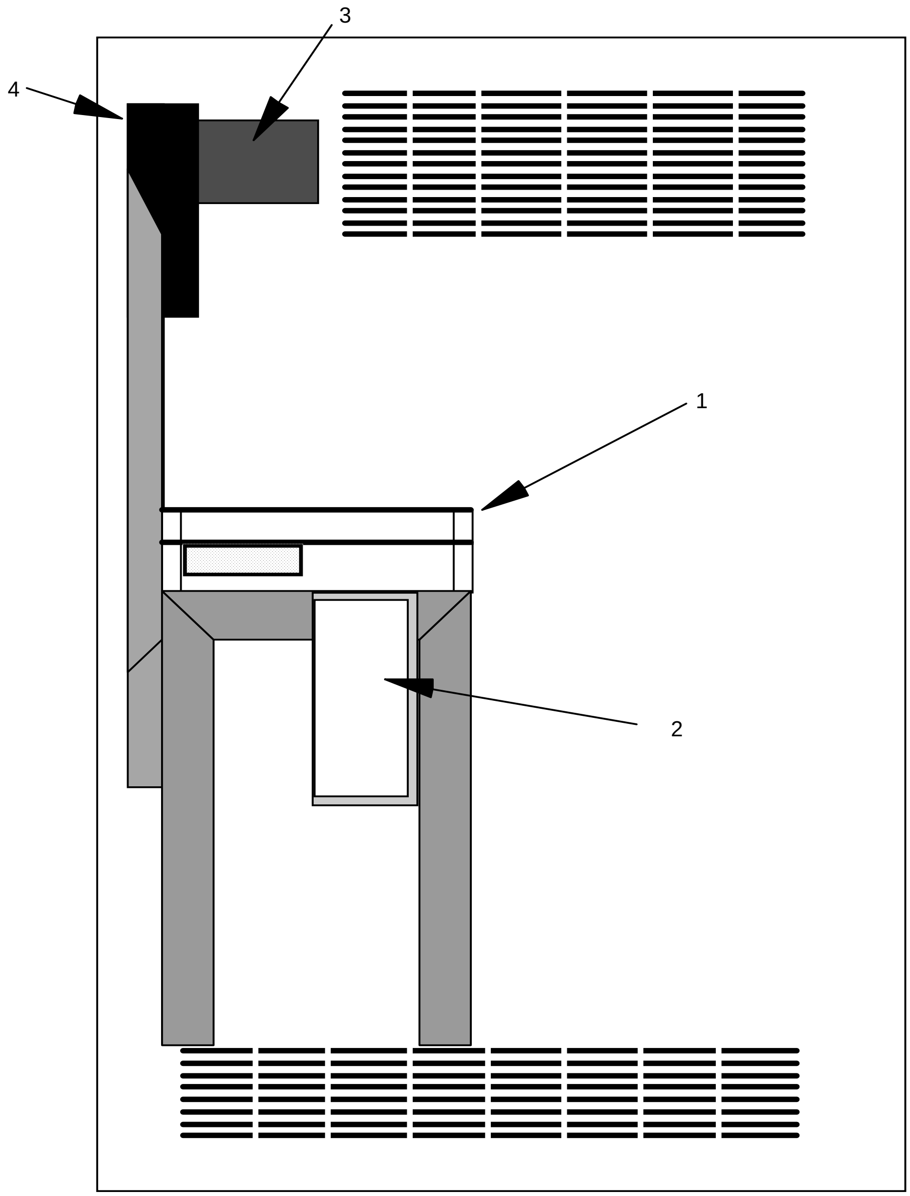
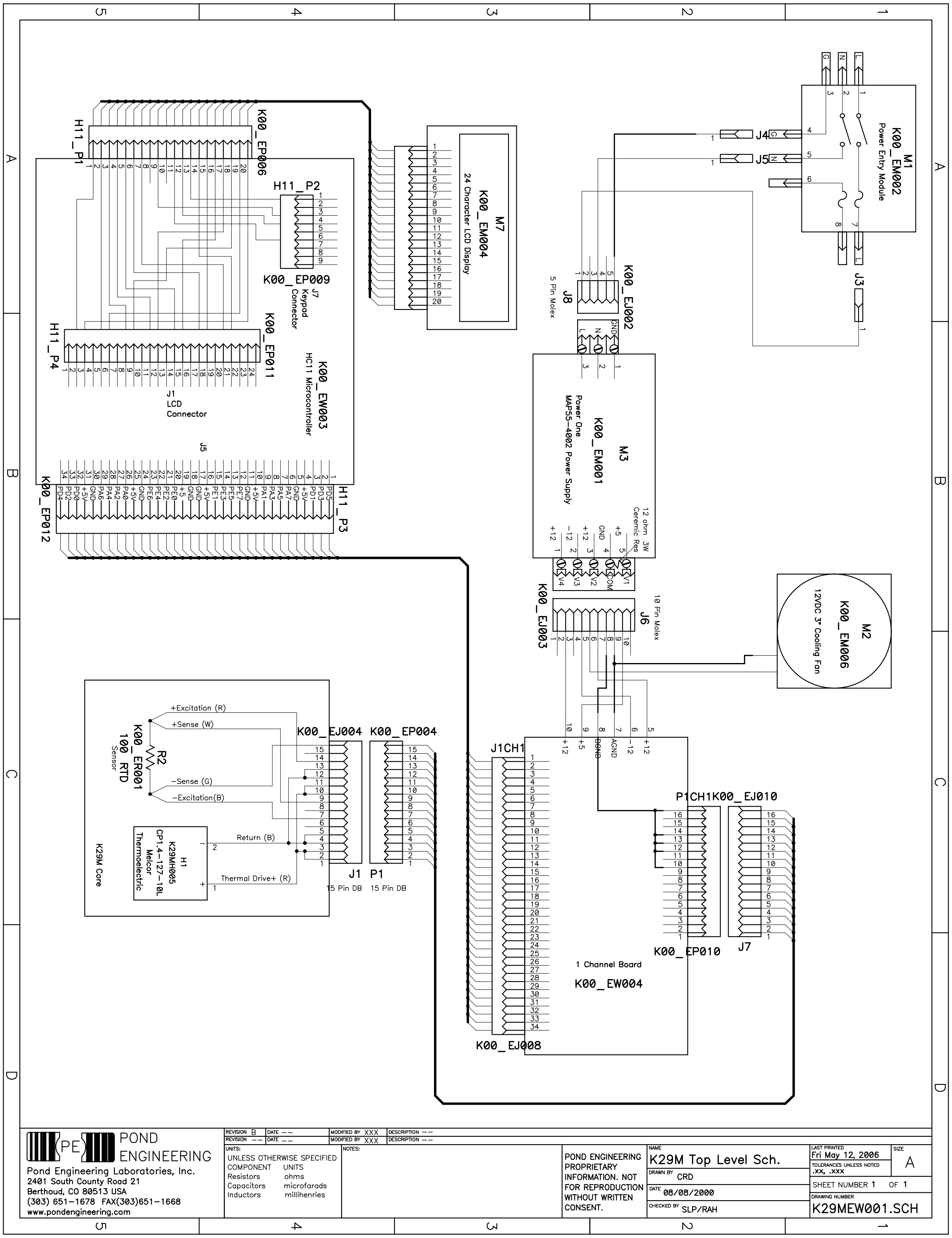
7.2 Electronics Chassis / Back Panel



REF. #	NAME	MAKE	MODEL
1	Microprocessor/Controller	Pond Engineering Labs.	K29M-400
2	Power Supply	Power-One Inc.	MAP55-4002
3	System ON/OFF Switch	Power Dynamics	42R37
4	Fan	Comair Rotron	FE12B3

7.3 Schematic



8. Calibration Offset Record

Core: Date: Comments:

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9. K29M / K29ML Top Level Schematic

The following is a top level schematic of the K29M / K29 ML system.