

Model K51M

Triple Point of Water Maintenance System
Operation and Maintenance Manual

by
Pond Engineering Laboratories, Inc.
2401 South County Road 21
Berthoud, CO 80513
(303) 651-1678
www.pondengineering.com

Table of Contents

1. BACKGROUND.....	2
2. GENERAL INFORMATION AND OPERATING PROCEDURES.....	2
3. QUICK START GUIDE	3
3.1 UNPACKING & POWERING UP	3
3.2 TPW REALIZATION	4
3.3 COMPARATOR OPERATION	4
4. SYSTEM CONTROLLER.....	5
4.1 NORMAL OPERATING MODE	6
4.2 THE "COMMAND FUNCTIONS".....	6
4.2.1 <i>TPW Cell Freeze Preparation and Maintenance Cycle</i>	7
4.2.2 <i>Comparator Mode Operation</i>	9
4.2.3 <i>Change Setpoint</i>	9
4.2.4 <i>Adjust System Variables</i>	11
4.2.4.1 Adjust Startup Setpoint	11
4.2.4.2 Configure TPW Cell Freeze Cycle Parameters	12
4.2.4.3 Configure to Display Degrees F.....	15
4.2.4.4 Set IEEE - 488 Address (optional).....	15
4.2.4.5 Access Vars Array	16
4.2.4.6 Save Changes to Variables	18
4.2.5 <i>Diagnostics Display Mode Select</i>	18
5. OPERATING THE SYSTEM USING A REMOTE INTERFACE	19
5.1 SYSTEM VARIABLE LIST.....	19
5.2 SYSTEM COMMAND SET	19
5.2.1 <i>Read System Variable</i>	19
5.2.2 <i>Write System Variable</i>	20
5.3 SERIAL INTERFACE HARDWARE DESCRIPTION	21
5.4 SERIAL INTERFACE EXAMPLE.....	22
6. OTHER CONSIDERATIONS	24
6.1 THERMOMETER SELF-HEATING.....	24
6.2 THERMOMETER STEM CONDUCTION	24
6.3 ANNEALING OF STRAINS IN TPW ICE.....	25
7. SYSTEM HARDWARE DESCRIPTION.....	26
7.1 FRONT PANEL.....	26
7.2 POWER INPUT	26
7.3 ELECTRONICS CHASSIS.....	26
8. CALIBRATION LOG.....	27

Model K51M

Triple Point of Water Maintenance System

1. Background

This manual documents the installation, operating and maintenance procedures for the Pond Engineering Number K51M Triple Point of Water Maintenance System. Information contained in this manual is proprietary to Pond Engineering Laboratories and is provided for use by the purchaser exclusively for instructional and maintenance purposes. Any other uses are prohibited.

2. General Information and Operating Procedures

Figure 1 shows the general configuration of the system and provides a reference for location of connection / service points discussed later in this manual.

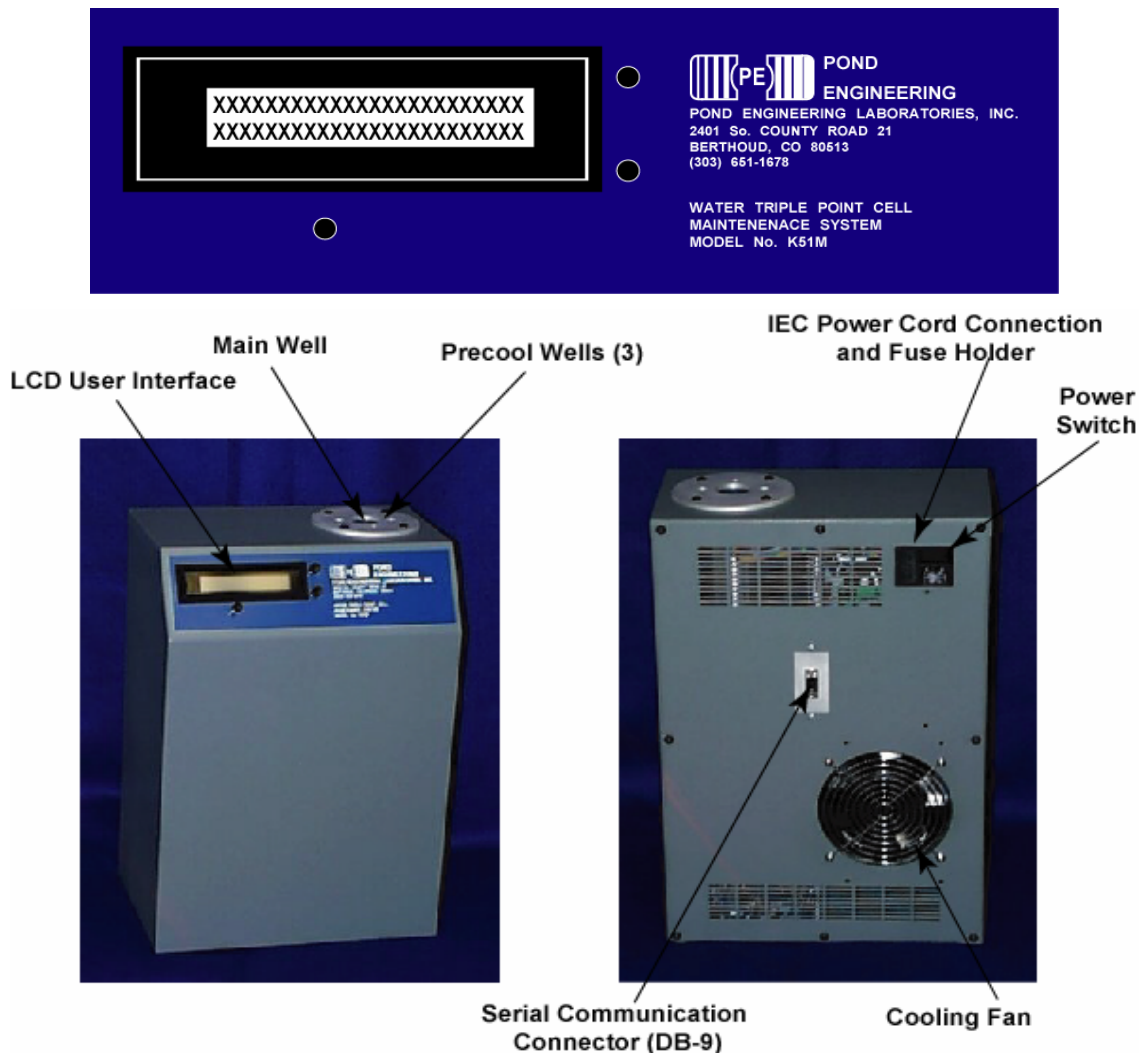


Figure 1 - System General Layout

As shown in **Figure 1**, the controller front panel is located on a sloping surface at the front of the outer chassis of the system. The system is designed primarily to provide a stable and uniform temperature environment for the preparation and maintenance of the Triple Point of Water (TPW) using Pond Engineering Model K51 TPW cells. The system is also supplied with a variety of comparison blocks which allow the system to be used for precision comparison calibrations over a range of -15.0°C to 122.0°C . When first switched on, the system is programmed to default to the TPW operation mode. If comparator operation is desired, the user must alter the configuration through the front panel interface. User adjustable parameters allow configuration of a "TPW Preparation Cycle" which automatically steps through the process of realizing the TPW, providing audible and text prompts when user action is required. Optional features include IEEE-488 or RS-232 remote interfaces to allow operation of the system as part of an integrated automatic test system. The operator interface is implemented using three front panel switches and a 2 line by 24 character Liquid Crystal Display (LCD) on the system front panel as shown in **Figure 2**.

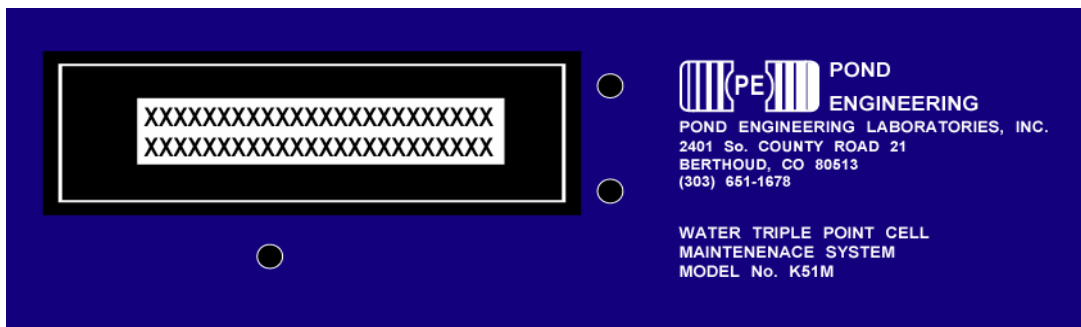


Figure 2 - Front Panel Layout

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 the measurement, indicating the measured core temperature. Additional controller functions (for the purpose of providing diagnostic information, sensor calibration etc.) are accessed in Command Functions mode, through display and switches, as outlined in the following sections.

3. Quick Start Guide

3.1 Unpacking & Powering Up

Supplied with the system are the following components:

1. Model K51M TPW Maintenance System.
2. Model K51 TPW Cell., Cell top and Thermal shunt.
3. Comparison Blocks – 2 pre-drilled, 1 blank
4. Comparison Block Removal Tool
5. Power Cord
6. Operation and Maintenance Manual
7. Quick Reference Card

Connect the system to any available AC power source within the range of 100 to 250 VAC, 47- 63 Hz using the supplied or other suitable IEC power cord. No changes or other setup is necessary for proper operation with AC input power.

3.2 TPW Realization

Preparation of the system for realization of the TPW involves the following steps:

TPW Realization Quick Reference Card



Connect the power cord and turn the system on. The audio alarm will sound for approximately 2 seconds while the system performs its power-on self-test. The display shown at left should be displayed with the measured core temperature within 10 seconds.



Fit the cell with the thermal shunt and insert the cell into the main well of the maintenance system. Place the cell top into the main well above the cell. The cell top should remain on the cell whenever the cell is in the maintenance system. A monitoring thermometer may be inserted in the cell if desired.



Press and hold the Command Switch for 2 to 3 seconds to access the COMMAND FUNCTIONS menu. The first option in the menu will then be presented on the display.



Start the FREEZE PREPARATION CYCLE by pressing the switch labeled YES on the display. For best results, make sure the thermal shunt is fitted to the cell. Press the switch labeled NO for the remaining three COMMAND FUNCTIONS.



Cell chilling requires 30 to 45 minutes. When the audible alarm sounds and the message shown at left is displayed, remove the cell from the system and shake the cell sideways to splash the water around in the top of the cell. This will initiate ice crystals and form a slush of ice and water throughout the cell. Remove the thermal shunt, replace the cell in the system and press the switch labeled OK. The system will then shift the setpoint and maintain the TPW for at least 8 hours time.

Figure 3 - TPW Realization

3.3 Comparator Operation

Configuration of the system for operation in Comparator Mode must be selected by the user each time the system is powered up. This requirement has been programmed into the system to minimize the possibility

of operating the system at high temperatures with the TPW cell installed. Reconfiguration and setup of the system is accomplished by following the steps outlined below:

Comparator Operation Quick Reference Card



Connect the power cord and turn the system on. The audio alarm will sound for approximately 2 seconds while the system performs its power on self test. The display shown at left should be displayed with the measured core temperature within 10 seconds.



Press and hold the Command Switch for 2 to 3 seconds to access the COMMAND FUNCTIONS menu. The first option in the menu will then be presented on the display.



Press the switch labeled NO to the first COMMAND FUNCTIONS until the display shown at left is presented. Configure the system for COMPARATOR OPERATION by pressing the switch labeled YES on the display shown at the left.



When the message shown at left is displayed, be sure the TPW cell is removed and replaced with a suitable comparison block. Press the switch labeled OK and continue through the remaining COMMAND FUNCTIONS.



Press the switch labeled UP or DN to step the setpoint up or down in increments or enter the COMMAND FUNCTIONS menu as outlined above and adjust the setpoint as desired within the full range of the system.

Note: Unless the system is configured for COMPARATOR OPERATION, the upper setpoint range is limited to +25.00 °C.

Figure 4 - Comparator Operation

4. System Controller

Detailed descriptions of the controller function and system setup are provided in this section. In an effort to maintain simplicity, while providing the flexibility to accommodate optional features, the operator interface is based largely on user-interactive software control. The software prompts the user through a set of

COMMAND FUNCTIONS, including START FREEZE PREPARATION CYCLE, ALLOW COMPARATOR OPERATION, CHANGE SETPOINT TEMPERATURE, ADJUST SYSTEM VARIABLES, and DISPLAY DIAGNOSTIC INFORMATION. The software displays messages on the LCD to direct the user through each command function using the three front panel switches surrounding the LCD. This manual includes an outline of the user interface and a detailed description of prompts along with instructions on how to edit system configurations and operate the system manually. Because of the multitude of functions that each switch will perform, all “labeling” of the switches is provided by the system software and presented to the user via the LCD. The labels attached to the switches in **Figure 5**, below, are for the benefit of the reader in understanding the notation in this manual. Such labels do not appear on the device front panel.

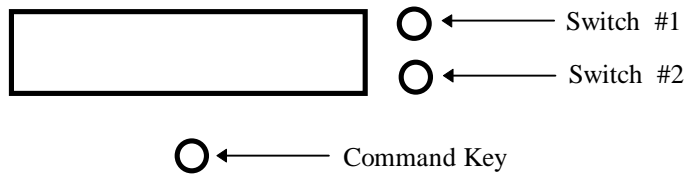


Figure 5 - Front Panel Switch Layout

4.1 Normal Operating Mode

During normal operation, the system controller continuously displays the TPW Cycle stage number, setpoint temperature and the current measured core temperature, as shown in **Figure 6**. Measurements are taken at approximately 3-second intervals and the lower line of the display updated following the measurement. This information is removed from the display when the user accesses the COMMAND FUNCTIONS portion of the program by pressing, and holding, the “Command Key” for a period of 2-3 seconds.

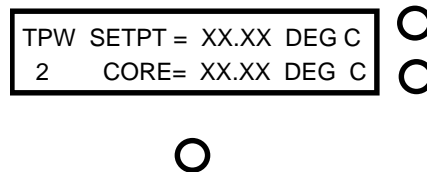


Figure 6 - Normal Operating Mode Display

4.2 The “Command Functions”

In order to perform system configuration functions, 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 will appear immediately on the lower line of the display. If the key is released, the normal operation screen will again be displayed and normal operation will continue. In order to proceed to “Command Functions”, the operator must press and hold the “Command Key” until the words COMMAND FUNCTIONS disappear, at which time the operator may release the key.

Note: The system has been designed such that control functions operate normally even when the user is accessing the command functions. The IEEE-488 or RS-232 serial commands will not work, however, until the system is returned to normal operating mode. Attempting to send remote interface commands while in COMMAND FUNCTIONS will cause a remote interface error that will clear itself in 10 to 30 seconds.

4.2.1 TPW Cell Freeze Preparation and Maintenance Cycle

The TPW Cell Freeze Preparation Cycle control allows the user to initiate a cycle to prepare a TPW cell to realize the Triple Point of Water. This cycle consists of four stages, initial cooling, subcooling, freeze initiation and TPW maintenance. When the TPW cycle is active, the normal operating mode display is altered to display the TPW Cycle “Stage Number” in the lower left corner of the display, with the stages as outlined below.

When the cycle is started, the system moves through the following sequence of stages:

STAGE

1. **Initial Cooling**: The system setpoint is changed to the FREEZE PREP temperature and the cell is cooled from room temperature. This stage ends when the core temperature cools below -7.0°C for a programmed period of time (default 5 minutes), and the system moves to stage 2.
2. **Sub Cooling**: The core setpoint temperature changed to the CELL CHILL SETPOINT (default -8.0°C) temperature for a period of time set by the CHILL TIME variable (default 5 minutes). This stage ends when a timer started at the transition between stage 1 and 2 is greater than the CHILL TIME variable.
3. **Freeze Initiation**: The system setpoint is maintained at the CELL CHILL SETPOINT temperature and a timer is started. An alarm is sounded periodically and a text message is presented to prompt the user that the cell is ready to be removed from the system and shaken to initiate ice crystal formation. The cell must be removed from the system and shaken to initiate ice crystal formation, the cell is then returned to the system and the controller advanced to the MAINTAIN phase by responding OK to the prompt. If the system is not advanced to the MAINTAIN phase within the period of time established by the CYCLE ABORT variable (default 12 minutes), the cycle is terminated and the system setpoint is changed immediately to the “end of cycle” setpoint.
4. **TPW Maintenance**: The system will shift the setpoint to the MAINTAIN TEMP variable (default -0.2°C) value (unless the cycle is aborted automatically as outlined above) and maintain the cell at the triple point for a period of time established by the MAINTAIN TIME variable (default 480 minutes or 8 hours).

At the end of the cycle, all mode settings are reset and the system setpoint is again set to the “end of cycle” setpoint.

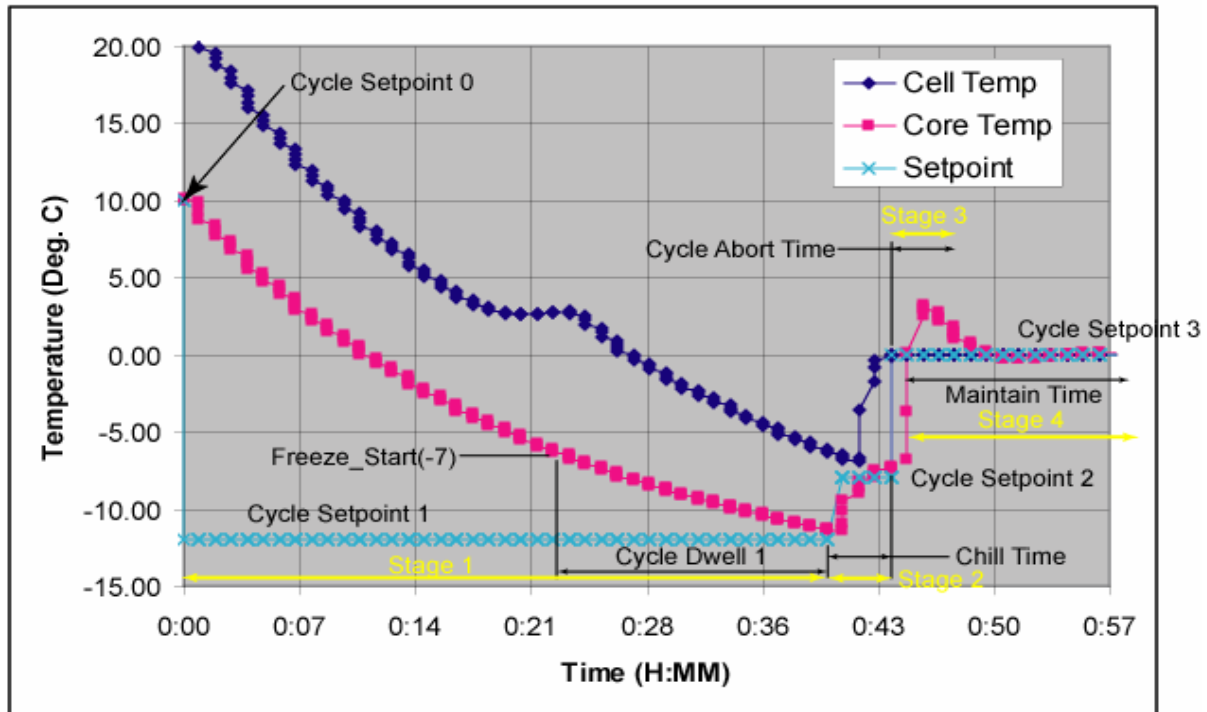


Figure 7 - Typical TPW Cycle

To modify the cycle variables, the user must access the system variables, explained in section 3.2.3.

To start the cycle, select YES when prompted, as shown in **Figure 8**. To remain in normal setpoint mode, press the key labeled NO.

START FREEZE	YES	<input type="radio"/>
PREPARATION CYCLE?	NO	<input type="radio"/>

☐

Figure 8 – Start Cycle Prompt

If the system is currently running with the TPW cycle active, the COMMAND FUNCTIONS will display the prompt in **Figure 9**. Choosing YES to this prompt will cancel the cycle. When TPW cycle is canceled, the system setpoint is changed immediately to the “end of cycle” setpoint and the system will drive the core temperature to the setpoint as quickly as possible.

CANCEL CYCLE?	YES	<input type="radio"/>
	NO	<input type="radio"/>

☐

Figure 9 – Cancel Cycle Prompt

Choosing NO to either of these two prompts maintains the current settings. Pressing either YES or NO will move the user on to the next function.

4.2.2 Comparator Mode Operation

In order to operate the system over the full setpoint range, the system must be configured to operate in COMPARATOR MODE by responding YES to the prompt in **Figure 10**.

ALLOW COMPARATOR	YES	<input type="radio"/>
OPERATION?	NO	<input type="radio"/>

☐

Figure 10 – Allow Comparator Operation Prompt

It is important to note that the TPW cell must be removed to safely operate the system over the full range of temperature. For this reason, when comparator operation is selected the prompt in **Figure 11** is presented and the user is required to either acknowledge removing the cell or cancel the configuration change before proceeding.

REMOVE TPW CELL	OK	<input type="radio"/>
FROM SYSTEM	CANCEL	<input type="radio"/>

☐

Figure 11 – Remove Cell Prompt

NOTE: The system is programmed to start in TPW mode at the time of power up, the user must manually configure the system for comparator mode operation.

When the system is already configured for comparator operation, the user will be prompted as illustrated in **Figure 12** to configure the system for TPW mode operation, allowing toggle between the two modes.

CONFIGURE FOR TPW	YES	<input type="radio"/>
OPERATION?	NO	<input type="radio"/>

☐

Figure 12 – Configure for TPW Operation Prompt

4.2.3 Change Setpoint

The next command function accessed is CHANGE SETPOINT TEMPERATURE. Through this function, the user may manually adjust the setpoint temperature within the range of –15.0 to 122.0°C. As shown in

Figure 13, the YES is located adjacent to the top switch, which was identified earlier in **Figure 5** as “Switch #1”. The NO is adjacent to the switch identified as “Switch #2”. If the NO selection is made, the program will present the next function.

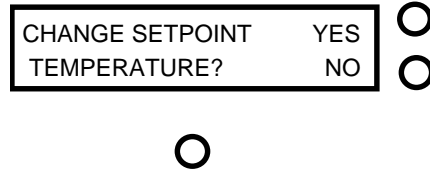


Figure 13 - Setpoint Access Prompt

NOTE: Manually changing the setpoint is not presented as an option when in a “TPW Cycle”. In this cycle, setpoint temperatures are established by the TPW cycle configuration discussed later in this section.

If the user selects YES by pressing the corresponding switch, the display shown in **Figure 14** will be presented on the LCD.

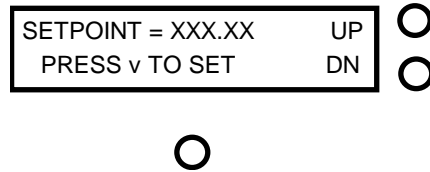


Figure 14 - Manual Setpoint Change Prompt

Manual adjustment of the SETPOINT is accomplished using the two switches on the side corresponding to the labels UP and DN displayed on the LCD. The cursor starts in the ten’s position. Choosing UP will cause the value to increase by 10 until it reaches a maximum of 122 °C. Choosing DN will cause the value to decrease by 10 until it reaches -15 °C. The COMMAND switch, located directly below the LCD, is used to advance the cursor to the one’s digit and so on. The number presented on the display is used as the current setpoint as soon as the user advances the cursor past the last digit.

NOTE: When the system is in TPW Mode, manual changes to the setpoint are limited to the range of +25.0 °C and 0.0 °C. Setpoints beyond this range may be set only when operating the system in COMPARATOR Mode.

Once the cursor is scrolled past the last digit, setpoint adjustment is complete and the user is allowed access to the next Command Function as described in the following section.

Note: When the user finishes adjusting the configuration and exits COMMAND FUNCTION, returning to OPERATING MODE the interface will display information in the Comparator Operating Mode as illustrated in **Figure 15**.

SETPT = XX.XX	DEG C UP	<input type="radio"/>
CORE = XX.XX	DEG C DN	<input type="radio"/>



Figure 15 - Comparator Operating Mode Display

4.2.4 Adjust System Variables

The next command function accessed is ADJUST SYSTEM VARIABLES and is provided to allow user examination and adjustment of the system variables used by the controller.

ADJUST SYSTEM	YES	<input type="radio"/>
VARIABLES?	NO	<input type="radio"/>



Figure 16 - System Variables Access Prompt

Pressing the switch labeled YES will allow access to the first system variable, shown in **Figure 17**, while responding NO will terminate the function and allow the user access to the next COMMAND FUNCTION.

4.2.4.1 Adjust Startup Setpoint

The first variable accessed is the POWER-ON or system startup setpoint temperature, as shown in **Figure 17**. Responding YES to the prompt allows the user to adjust the setpoint as shown in **Figure 18**, a NO response accesses the next system variable described in the following section.

ADJUST POWER-ON	YES	<input type="radio"/>
SETPOINT = XXX.XX?	NO	<input type="radio"/>



Figure 17 - System Memory Setpoint Prompt

The adjustment of the POWER-ON (the initial setpoint on power up) is accomplished through the two switches on the side corresponding to the labels UP and DN displayed on the LCD shown in **Figure 18**. The COMMAND key, located directly below the LCD, is used to advance the cursor to each of the digits.

MEMORY 0 = XX.XX	UP	<input type="radio"/>
PRESS v TO SET	DN	<input type="radio"/>



Figure 18 - Adjust System Memory Setpoint Prompt

Modification of the variable is accomplished by pressing either of the two switches to the right of the LCD. 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 one. As the cursor is scrolled past the last digit, setpoint adjustment is completed and the user is allowed access to the next system variable, as described in the following section.

4.2.4.2 Configure TPW Cell Freeze Cycle Parameters

CONFIGURE TPW	YES	<input type="radio"/>
CYCLE PARAMETERS?	NO	<input type="radio"/>

☐

Figure 19 – Configure Cycling Parameters Prompt

The next system variable allows the user to customize the system's cycle profile. Selecting YES to the prompt in **Figure 19** steps the user through the cycle settings, as follows. Selecting NO allows the user access to the next system variable.

4.2.4.2.1 Freeze Preparation Time

ADJUST CELL CHILL	YES	<input type="radio"/>
TIME = XXX MINUTES ?	NO	<input type="radio"/>

☐

Figure 20 – Adjust Cell Chill Time Prompt

Responding YES to the prompt in **Figure 20** allows the user to customize the “cell chill time”- the number of minutes the system will maintain the setpoint at the cell chill setpoint. Responding NO will access the next variable.

The user may adjust the time through use of the two switches on the side corresponding to the labels UP and DN displayed on the LCD shown in **Figure 21**. The COMMAND key, located directly below the LCD, is used to advance the cursor to each of the digits.

TIME =	XX	MINUTES	UP	<input type="radio"/>
PRESS	v	TO SET	DN	<input type="radio"/>

☐

Figure 21 - Adjust Chill Time Prompt

4.2.4.2.2 Freeze Preparation Temperature

ADJUST CELL CHILL	YES	<input type="radio"/>
SETPOINT 2 = XX.X?	NO	<input type="radio"/>

☐

Figure 22 – Adjust Setpoint 2 Prompt

Responding YES to the prompt in **Figure 22** allows the user to customize “SETPOINT 2”- the setpoint temperature for the system while in TPW cycle stage 2 . Responding NO will access the next variable.

The user may adjust “SETPOINT 2 by pressing either of the two switches on the side corresponding to the labels UP and DN displayed on the LCD shown in **Figure 23**. The COMMAND key, located directly below the LCD, is used to advance the cursor to each of the digits. As the cursor is scrolled past the last digit, setpoint adjustment is completed and the user is allowed access to the next system variable, as described in the following section.

CYCLE SP 2 = XX.XX	UP	<input type="radio"/>
PRESS v TO SET	DN	<input type="radio"/>

☐

Figure 23 - Adjust Cycle Setpoint 2

4.2.4.2.3 Cycle Abort Time

ADJUST CYCLE ABORT YES	<input type="radio"/>
TIME = XX MINUTES? NO	<input type="radio"/>

☐

Figure 24 – Adjust Cycle Abort Time Prompt

Responding YES to the prompt in **Figure 24** allows the user to customize “Cycle Abort Time”- the number of minutes the system will remain in TPW Cycle Stage 3 waiting for the user to initiate ice crystal formation. Responding NO will access the next variable.

The user may adjust the Cycle Abort Time through the two switches on the side corresponding to the labels UP and DN displayed on the LCD shown in **Figure 25**. The COMMAND key, located directly below the LCD, is used to advance the cursor to each of the digits. As the cursor is scrolled past the last digit, cycle abort time adjustment is completed and the user is allowed access to the next system variable, as described in the following section.

TIME = XXX	UP	<input type="radio"/>
PRESS v TO SET	DN	<input type="radio"/>

☐

Figure 25 - Adjust Cycle Abort Time

4.2.4.2.4 Maintenance Setpoint Temperature

ADJUST CELL MAINT.	YES	<input type="radio"/>
SETPOINT 3 = XX.X ?	NO	<input type="radio"/>

☐

Figure 26 – Adjust Maintenance Setpoint Temperature Prompt

Responding YES to the prompt shown in **Figure 26** allows the user to customize “SETPOINT 3”- the setpoint temperature for the entire TPW maintenance period (Cycle Stage 4). Responding NO will access the next variable.

The user may adjust the slew rate by pressing either of the two switches on the side corresponding to the labels UP and DN displayed on the LCD shown in **Figure 27**. The COMMAND key, located directly below the LCD, is used to advance the cursor to each of the digits. As the cursor is scrolled past the last digit, setpoint adjustment is completed and the user is allowed access to the next system variable, as described in the following section.

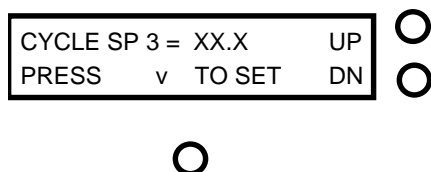


Figure 27 - Adjust Maintenance Setpoint Temperature

4.2.4.2.5 Cycle End Time

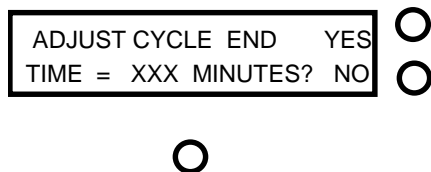


Figure 28 – Adjust Cycle End Time Prompt

Responding YES to the prompt in **Figure 28** allows the user to customize “CYCLE END TIME”- the number of minutes the system will maintain the TPW cell before ending the cycle and warming the cell to room temperature. Responding NO will access the first dwell time.

The user may adjust the second setpoint temperature by pressing either of the two switches on the side corresponding to the labels UP and DN displayed on the LCD shown in

Figure 29. The COMMAND key, located directly below the LCD, is used to advance the cursor to each of the digits. As the cursor is scrolled past the last digit, cycle end time adjustment is completed and the user is allowed access to the next system variable, as described in the following section.

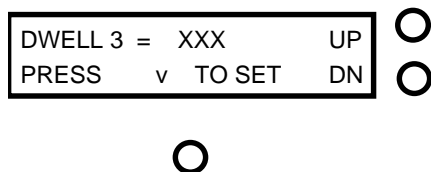


Figure 29 - Adjust Cycle End Time

4.2.4.3 Configure to Display Degrees F

CONFIGURE TO	YES	<input type="radio"/>
DISPLAY DEG F ?	NO	<input type="radio"/>

☐

Figure 30 – Degrees F Display Prompt

Responding YES to the prompt in **Figure 30** allows the user to customize the system to display setpoint and measured core temperatures is Degrees F. Responding NO will allow the user access to the next system variable, discussed in the next section.

If the system is currently configured to display in Degrees F, the prompt will appear as shown below in **Figure 31**, allowing the user to toggle between the two units of measure.

CONFIGURE TO	YES	<input type="radio"/>
DISPLAY DEG C ?	NO	<input type="radio"/>

☐

Figure 31 – Degrees C Display Prompt

4.2.4.4 Set IEEE - 488 Address (optional)

The next variable presented is, SET IEEE-488 ADDRESS, the parameter that determines the address at which the system can be accessed over the IEEE-488 Buss. This is an optional accessory to the system that will not be accessed if not installed. Please skip this section if the IEEE-488 feature has not been installed.

ADJUST GPIB	YES	<input type="radio"/>
ADDRESS = X	NO	<input type="radio"/>

☐

Figure 32 - IEEE-488 Address Adjust Prompt

This variable may be examined or adjusted by the user by responding YES to the prompt in **Figure 32**. A NO response will allow access to the next system variable in the sequence as described in the following section.

ADDRESS = X	UP	<input type="radio"/>
PRESS v TO SET	DN	<input type="radio"/>

☐

Figure 33 - Address Adjust Prompt

Here the user has the ability to choose the address at which the IEEE-488 can be located as shown in **Figure 33**. The adjustment of address may be accomplished by using either of the two switches on the side corresponding to the labels UP and DN displayed on the LCD. This variable can be set within the range of 1 to 30. The COMMAND switch, located directly below the LCD, is used to advance the cursor to each of the digits. Pressing the switch adjacent to UP will cause the value of the selected digit to increment one, while pressing the switch adjacent to DN will cause it to decrement one. As the cursor passes the last digit the value is stored as a temporary system variable, and the user is allowed access to the next Command Function.

4.2.4.5 Access Vars Array

This function allows access to variables stored in the system's memory. It is strongly recommended that before responding YES to the prompt in **Figure 34**, one carefully reviews what each variable represents (see chart below). It is also 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 system and could be very dangerous! If the message UNABLE TO LOAD VARIABLES should appear on the front panel display call Pond Engineering [(303)-651-1678] immediately for service.

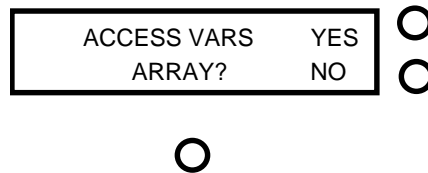


Figure 34 - Access Variables Array Prompt

Responding YES to the prompt in **Figure 34** will cause the prompt in **Figure 35** 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.

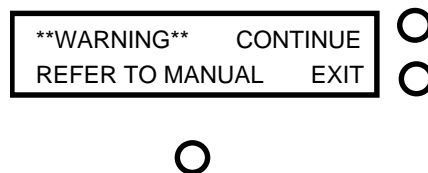


Figure 35 - Warning Prompt

If CONTINUE is selected, variables will be presented in series as shown in **Figure 36** and can be changed as shown below. The variables are presented by number and are not text labeled. Please refer to the following chart for information about each variable.

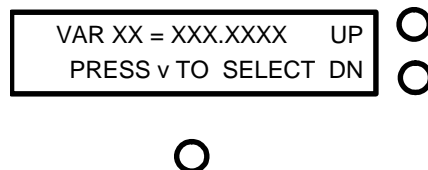


Figure 36 - Variable Adjustment Prompt

To scroll through the variables, press 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.

Once a variable has been selected, pressing the switch adjacent to the UP prompt shown in **Figure 36** will cause the value of the selected digit (of the variable value) 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 limit 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 commonly accessed system variables and their locations.

#	Variable \ Description	Default Values	Recommended Range
0	Current Setpoint Temperature	15.00 degrees C	-15 to 125 degrees C
1	Display Units Configuration	0 - 1	1- Deg F, 0 – Deg C
2	Freeze Start	-7.0 degrees C	+10 to -10 degrees C
3	Power - On Setpoint Temperature	20.00 degrees C	-15 to 125 degrees C
4	UNUSED		
5	Dwell Counter - Minutes		
6	UNUSED		
7	GPIO Primary Address	6.0000	1.0000-30.0000
8	UNUSED		
9	UNUSED		
10	Measured Core Temperature– Deg. C		
11	TPW Mode Flag	0 (Disabled)	1- Enabled, 0 - Disabled
12	Setpoint Increment – Deg. C	5.0	0.01 to 20.0
13	Cycle end / abort Setpoint – Deg. C	10.0	5.0 to 25.0
14	Cycle Setpoint 1 – Deg. C		5.0 to 25.0
15	Cycle Setpoint 1 – Deg. C		5.0 to 25.0
16	Cycle Setpoint 1 – Deg. C		5.0 to 25.0
17	Cycle Dwell Time 1 – Minutes	20	5.0 to 25.0
18	Cycle Dwell Time 2 – Minutes	15	2.0 to 120.0
19	Cycle Dwell Time 3 – Minutes	480	30.0 to 999
20	ACCESS CODE for protected variables (variables 21 and up)	0.0000	Call Factory
35	ITS-90 A Coefficient Above 0.01		See Calibration Log
36	ITS-90 B Coefficient Above 0.01	0.0	See Calibration Log
37	ITS-90 A Coefficient Below 0.01		See Calibration Log
38	ITS-90 B Coefficient Below 0.01		See Calibration Log
39	TPW value for core sensor – Ohms		See Calibration Log
62	Measured core sensor PRT – Ohms		

4.2.4.6 Save Changes to Variables

The user can now save the newly established system variables as the power-up default values. As mentioned earlier, the newly established system variables are stored as temporary system variables at this point, responding YES to the prompt in **Figure 37** causes the variables to be stored in non-volatile memory within the system controller to be utilized as the system variables the next time the system is turned on.

SAVE CHANGES TO	YES	<input type="radio"/>
VARIABLES?	NO	<input type="radio"/>



Figure 37 - Save Variables Prompt

Responding NO to the prompt in **Figure 37** causes the system to exit the function without saving the variables to non-volatile memory, allowing the user to temporarily establish new values for the system variables without permanently altering the default values. If the power is interrupted before the new information is stored into the non-volatile memory, the newly established values are lost and the system will utilize the default values previously stored in non-volatile memory when power is restored to the system. 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 presented.

4.2.5 Diagnostics Display Mode Select

Here, the user is given the opportunity to choose which set of information is presented by the display during normal operating mode. 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 command function to allow display of DIAGNOSTIC INFORMATION by answering YES to the command function prompt shown in **Figure 38**.

DISPLAY DIAGNOSTIC	YES	<input type="radio"/>
INFORMATION?	NO	<input type="radio"/>



Figure 38 - Diagnostics Mode Display Prompt

If the system is currently displaying DIAGNOSTIC INFORMATION, the prompt will be modified to allow the user to toggle back to the NORMAL DISPLAY mode by answering YES to the command function prompt shown in **Figure 39**.

CHANGE TO NORMAL	YES	<input type="radio"/>
DISPLAY?	NO	<input type="radio"/>



Figure 39 - Normal Mode Display Prompt

The DIAGNOSTIC INFORMATION display presents an array of numeric information for system diagnostics of the primary system control loop.

25.00	- 5.0	- 0.2
25.11	7.52	2.50



Figure 40 - Diagnostics Display

The information presented by the display shown in **Figure 40** is as follows.

Top row from left to right: core controller setpoint, controller proportional signal and derivative signal.

Bottom row left to right: measured core temperature, controller integrator signal and core controller PID sum.

Note: Once the DIAGNOSTIC INFORMATION mode has been entered the display will only present the diagnostic information; return to normal display mode can be configured through the COMMAND FUNCTIONS options as described above. When the system is in COMPARATOR mode; although the UP and DN labels are not presented, the two switches on the right-hand side will still increment or decrement the setpoint as described earlier.

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

5. Operating the System Using a Remote Interface

The system has been equipped with an RS-232 serial interface (or optional IEEE-488 Remote Interface) to allow any host computer that can be set up as a system controller to be used to operate the system over the interface. Pond Engineering has software available for reading the system variables by an IBM compatible computer with a National Instruments 488 interface card. Custom software packages are also available to integrate the system into an automated lab. The system variables that can be accessed over the remote interface and the command set recognized by the system are listed below.

5.1 System Variable List

Please refer to section 3.2.2.4 *Access Vars Array* for a list of the system variables.

5.2 System Command Set

The command set for the system is outlined in the following paragraphs. The commands are issued from the host computer that acts as the controller. The system, acting as the slave, listens when addressed as a listener, talks when addressed as a talker, and does not issue a service request (SRQ).

5.2.1 Read System Variable

The "READ" command, called by sending an "R" (upper or lower case) followed by the two digit address of the variable, enables the user to read or interrogate the current values for system variables. The syntax for the read command is "Rxx", where xx is the address of the variable to interrogate. The address must be two digits in length, therefore addresses less than 10 MUST HAVE LEADING ZEROS.

After receiving a read command, the system will wait to be addressed as a talker to return the data at the read location over the bus. The system has a one-second-write timeout, thus the controller in charge must read from the system within one second after sending the R command to receive data. For example: If the user wants to see the value stored as the systems alarm temperature, the user would send the character string:

R05<cr>

The controller in charge would then address the system as a talker and wait for the data to be returned.

****Note: The system must maintain control of the system core as the highest priority and may put off responding to remote interface commands for as long as 500ms. The system being addressed as a**

talker and not in the control cycle would return the alarm temperature (variable address 05), as follows:

+4.300000e+02(space)05

The values returned are always in the above scientific format followed by a space and address number for the given value.

5.2.2 Write System Variable

The “WRITE” command, called by sending a “W” (upper or lower case) followed by the two digit address, a comma, and the desired new value, enables the user to write or set the values for system variables. The syntax for the write command is “Wxx,(value)”, where xx is the address of the variable and (value) is the new desired value for the variable. The format for (value) must have a positive or negative sign followed by a decimal number with at most seven significant digits not to exceed 15 digits in length.

For example: If the user wants to change the value stored as the alarm temperature to 25.34 °C, the user would send:

W05,+25.34<cr>

and the alarm temperature variable would then be set to 25.34°C.

****Note: As variables are written to the system the new value is immediately used by the system. However this new value is not stored as a permanent system variable until the user saves the variable using the “Save variables” command through the front panel. IMPORTANT! SAVING CHANGED VARIABLES WILL PERMANENTLY CHANGE THE SYSTEMS VARIABLES. Pond Engineering strongly recommends the user keep a log of any changed variables. Also, Pond Engineering is in no way responsible for any damage caused by the failure to use these commands properly. DO NOT set a variable outside the recommended range.**

In order to maintain flexibility the only variables that are limit checked are the Setpoint variables and the Alarm variables. All other variables can be set to any value received over the remote interface. Extreme caution must be used when setting any variable over the remote interface. The user should read back any variable after setting it to insure the system received the variable correctly. This is especially important when setting the calibration RTPW and calibration coefficients, since an errant RTPW or coefficient may cause the system to overheat and damage the system core.

5.3 Serial Interface Hardware Description

Hardware connection to the serial interface is provided at a 9 pin D Sub connector on the rear panel of the system. Communication over the serial interface is accomplished asynchronously at 9600 baud with no hardware flow control. The command set, variable list and syntax is the same as that for the IEEE-488 interface option. Pinout and connection to standard PC serial ports is shown in **Figure 41**

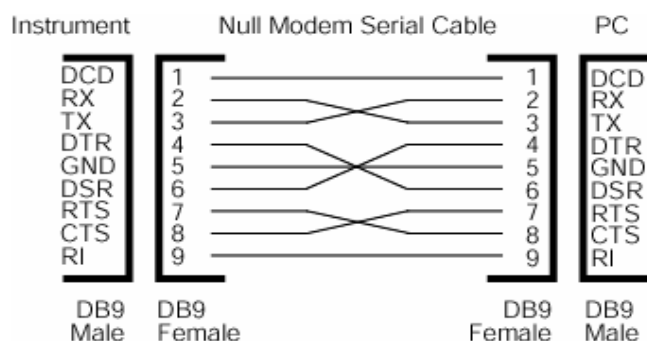
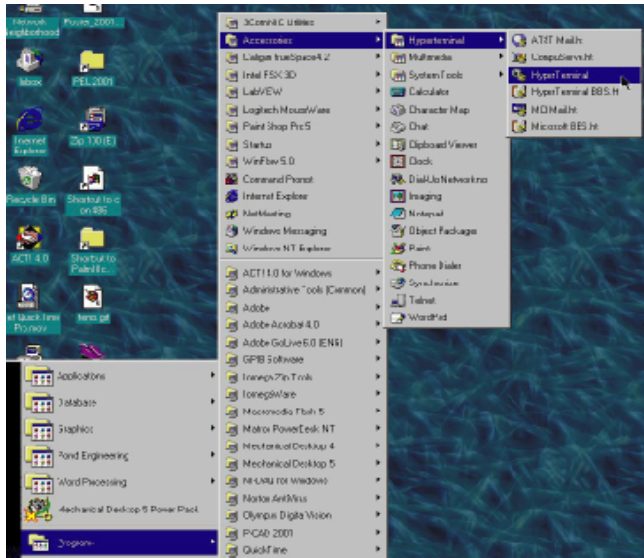


Figure 41 - Serial Interface Connection

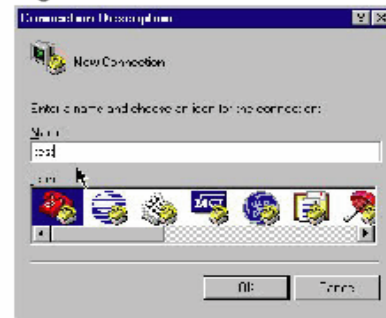
5.4 Serial Interface Example

Communication with the system may be accomplished using the Windows utility application HyperTerminal as outlined below in Figure 39.

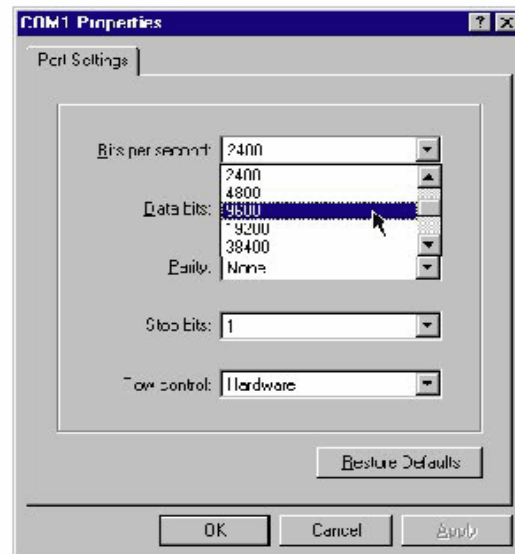


Accessing Hyperterminal is accomplished by clicking the Windows Start button and following the paths shown at left.

Assign a name to the communication session as shown in the window below, in this example the name assigned was test



Verify that the COM PORT the system is connected to is the one select in the window shown at left, then click OK.



Confirm (or select) the "Bits per second" or baud rate of 9600 and click OK

Figure 42 - Connecting with HyperTerminal

When the connection has been established, communication with the system may be accomplished as in the following example

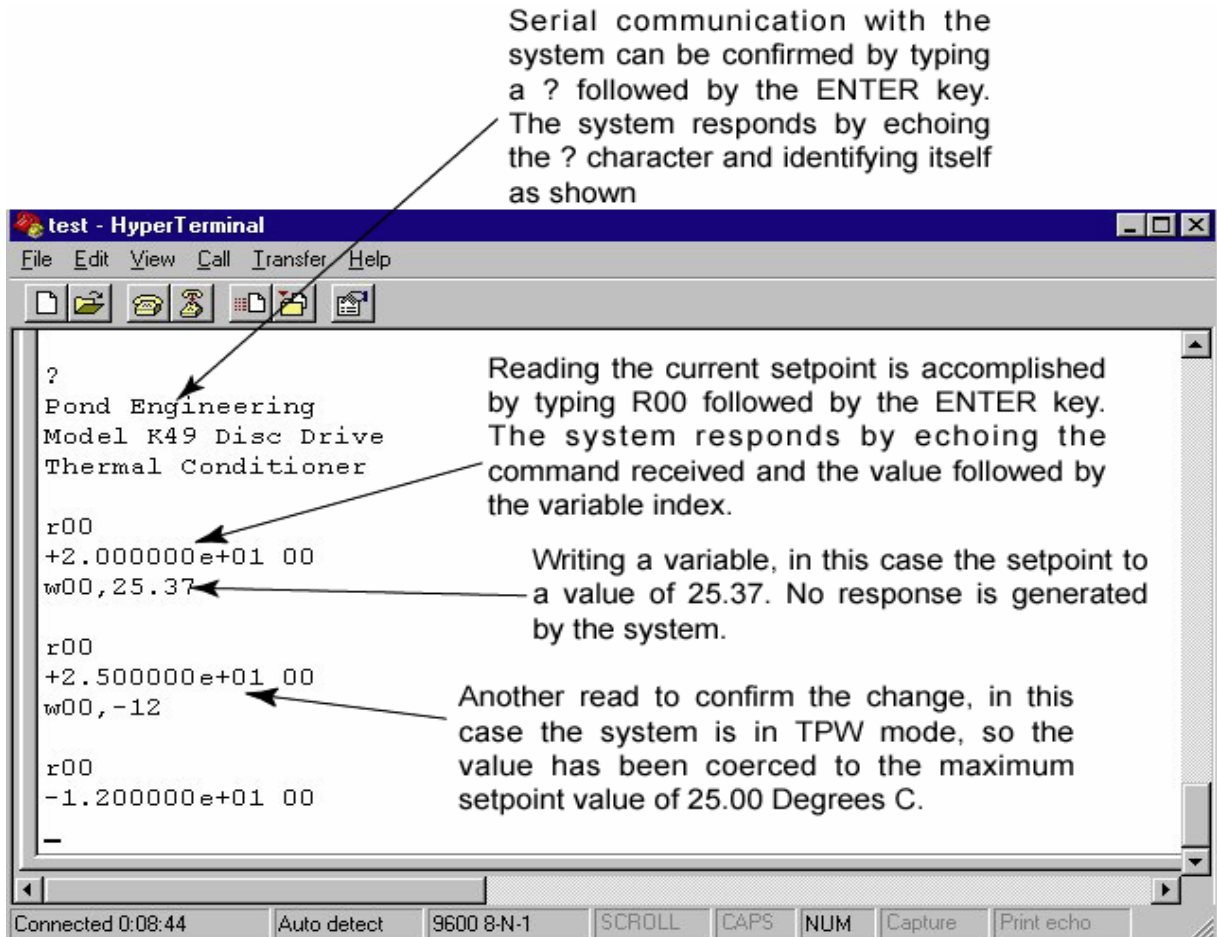


Figure 43 - HyperTerminal Communication Example

6. Other Considerations

6.1 Thermometer Self-Heating

Thermometer self-heating should be taken into consideration in all precision thermometry measurements and values reported as zero power values.

6.2 Thermometer Stem Conduction

Some considerable differences exist in the stem conduction characteristics of thermometers, even those typically used for standards thermometry. If the immersion characteristics for the type of thermometer being used is not known, an immersion profile should be generated for the thermometer. By way of example, Figure 44 shows three immersion profiles generated for different thermometers. It is important to note that all three thermometers are 25.5 ohm SPRT's.

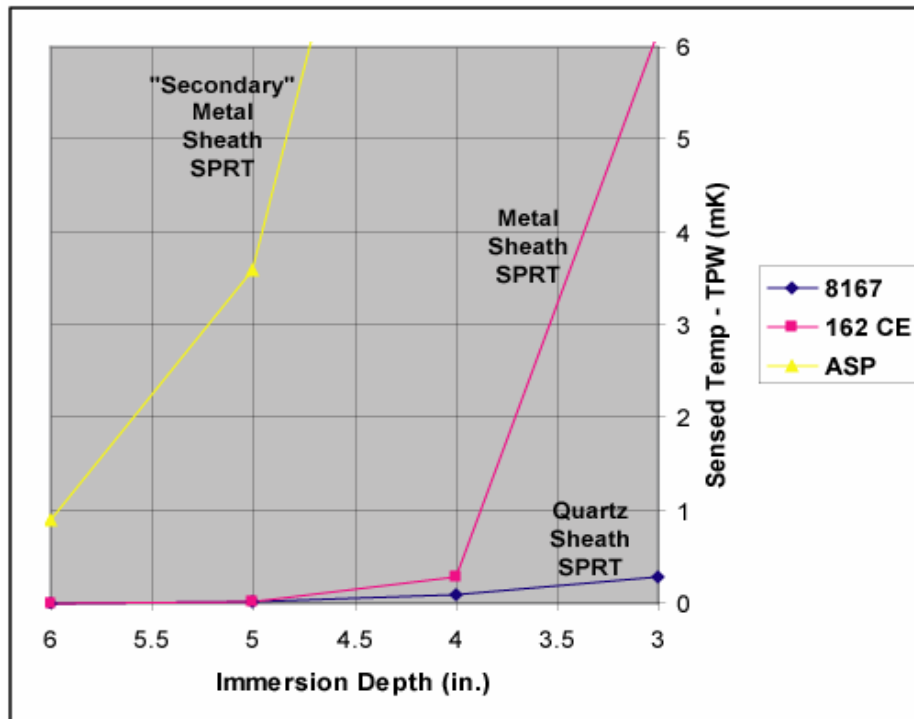


Figure 44 - Immersion Profiles

6.3 Annealing of Strains in TPW Ice

Mechanical strain in the ice crystals are known to depress the temperature realized in a TPW cell. For ice mantles formed in conventional size cells using techniques which freeze the mantle over a period of time on the order of one hour, the depression is about 0.2 mK. Forming the ice in supercooled water results in ice crystal formation much more rapidly. As shown in Figure 45, the initial depression observed in the slush formed in a supercooled cell is many times the value in a conventional TPW cell and the depression decays rapidly. Depending on the application and uncertainty desired, this effect must be taken into consideration.

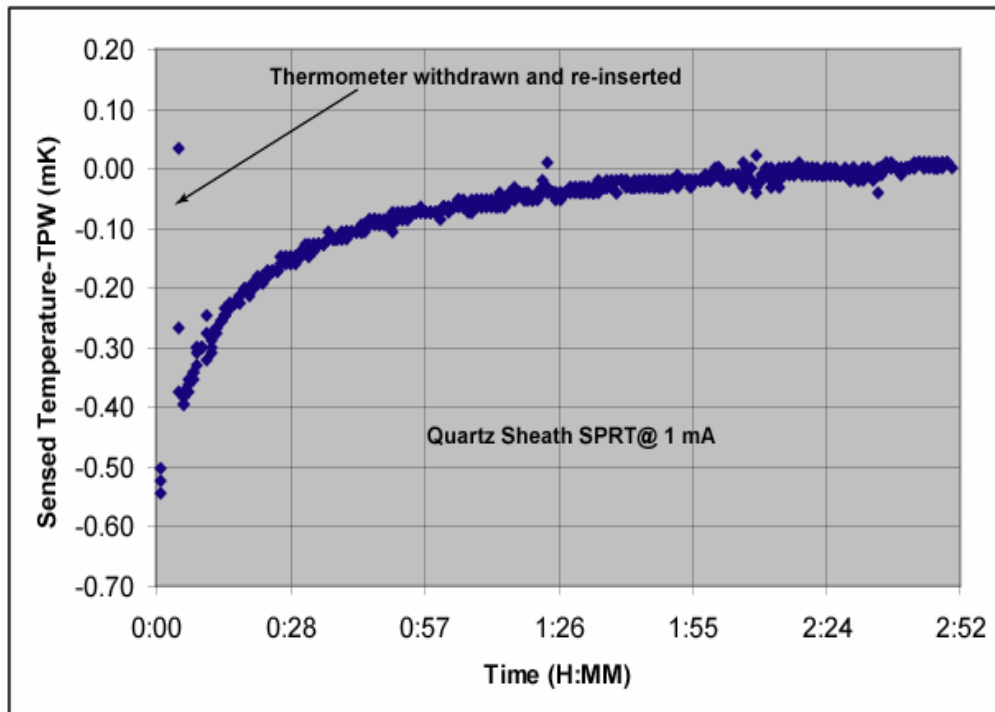


Figure 45 - Annealing Strain in a Slush

7. System Hardware Description

A brief description of system hardware is provided in this section as a reference to aid the user with periodic maintenance of the system. In the event that significant maintenance or repair is required, it is 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 Pushbutton panel Mount SPDT Switches - 3 each – with Caps for Miniature Switches	Eaton Cutler-Hammer Eaton Cutler-Hammer	PS1-100Q W-KN-17
4	Engraved Laminate Front Panel	Pond Engineering	K51-FP

7.2 Power Input

NAME	MAKE	MODEL
Power Cord	10A/220AC (50/60HZ)	NEMA 5 -15P

7.3 Electronics Chassis

NAME	MAKE	MODEL
Power Supply(9A)	Condor Inc	GPFC250-28
Microprocessor/Controller	Pond Engineering Labs	K51M-400
System ON/OFF Switch	Power Dynamics	42R37
Power Driver	Pond Engineering	K51-EA100

8. Calibration Log

[illegible]