Model K38

Argon Triple Point Cell

Operation & Maintenance Manual

by

Pond Engineering Laboratories, Inc.

2401 South County Road 21

Berthoud, Colorado 80513

(303)651-1678

www.pondengineering.com

Argon Triple Point Cell

1. Background

This report documents the installation, operating and maintenance procedures for the Argon Triple Point Cell, Pond Engineering Model Number K38. Information contained in this manual is proprietary to Pond Engineering and is provided for use by the purchaser exclusively for instructional and maintenance purposes; any other use is prohibited.

2. General Information and Operating Principles

This Liquid Nitrogen-cooled apparatus utilizes a sealed cryogenic triple point cell with an integrated microprocessor-controlled maintenance system to realize and maintain the Argon Triple Point. When properly used, the system has been verified to realize the Argon Triple Point with an uncertainty better than +/- 0.000 5 K.

Figure 1 shows the general configuration of the Argon Triple Point Cell to provide the reader a better visualization of its appearance, as well as a point of reference for location and use of the control switches and service points discussed later in this manual.
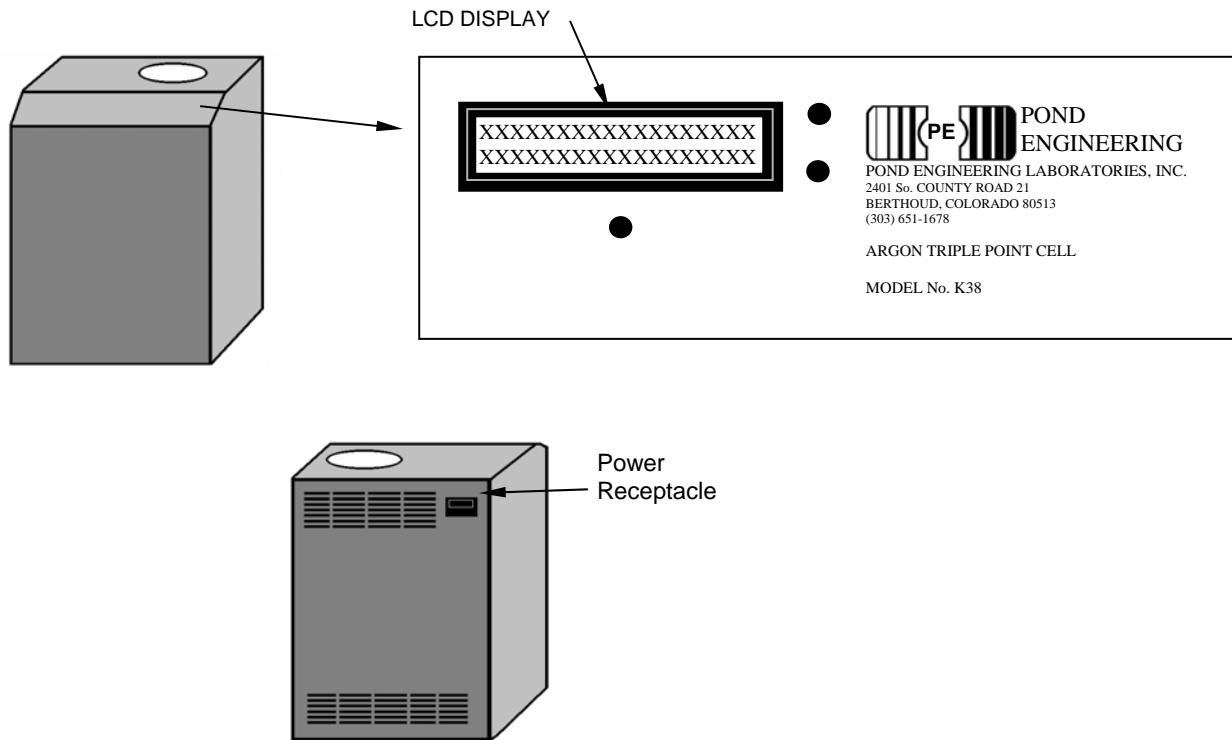
Figure 1 - System General Layout

As shown in **Figure 1**, the system controller's display panel is located on the sloping front surface of the Argon Triple Point Cell.   The cell is designed to provide a stable and uniform temperature environment for the realization and maintenance of the Argon Triple Point and is intended for use in calibration of primary temperature standards. The system accommodates a single capsule or one long stem Standard Platinum Resistance Thermometers (SPRTs) at a time in the central well of the cell. Liquid Nitrogen, used as an expendable refrigerant and stored in an integrated .75

liter dewar, cools the cell. Because the coolant storage dewar is positioned above the cell itself, the stem of the thermometer passes through the liquid nitrogen, providing good thermal guarding between the cell and the outside environment. Multiple thermal shields surround the sealed cell, which is suspended in vacuum for excellent thermal isolation. Active temperature control of the thermal shields provides an isothermal environment within which the argon sample can be held in a condition to realize the triple point.

Both the cell and the external sample storage vessel are constructed of cleaned, polished type 304 stainless steel - to withstand the approximate 40 atmospheres pressure of the gas sample at room temperature as well as preserve the purity of the sample. The .999 999 pure Argon sample in the cell ensures consistent, flat temperature plateaus.

Optional features include an IEEE-488 or RS-232 interface to allow operation of the Argon Triple Point Cell as part of an integrated automatic calibration system. These optional features are available as factory installable options.

A removable panel attached to the frame by button head screws provides internal access to the system. The cover panel may be removed for inspection and service without disconnecting any system cabling.

Three front panel switches and a 2 line by 24 character Liquid Crystal Display (LCD) located in the front panel of the Argon Triple Point Cell provide the operator interface shown in **Figure 2**.
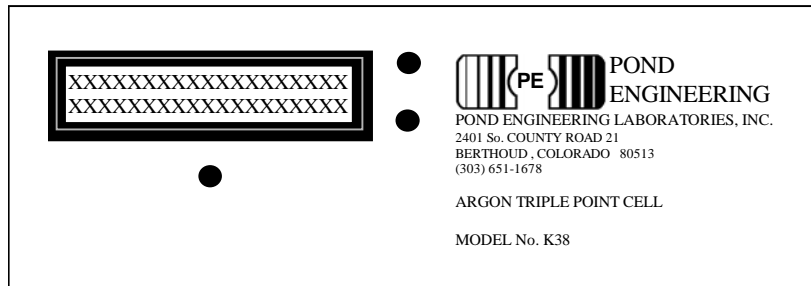

Figure 2 - Front Panel Layout

In the normal operating mode, this display presents the current temperature setpoint for the controller and the measured core shield 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 updated following measurement.

As liquid nitrogen is added to the internal storage dewar, the apparatus and the argon gas in the cell is cooled and the Argon will begin to condense in the cell. Within a relatively short period of time, the majority of the argon gas sample will have condensed into the cell and reduced the pressure in the sample storage vessel to less than one atmosphere. At this point, further cooling of the cell thermal guarding shields (referred to throughout this manual as "GUARD") causes the liquid argon sample contained in the cell to freeze. Following the operating principles for cryogenic fixed points outlined in NIST Technical Note 1265, the triple point is realized in this apparatus by controlling the temperature of thermal shields ("GUARD") surrounding the cell to a temperature very close to the triple point temperature and applying heat pulses directly to the cell using a separate heater in thermal contact with the outer cell envelope. As each heat pulse is applied to the otherwise adiabatic cell containing a completely frozen argon sample, a considerable temperature increase will be observed. When the cell reaches the triple point, a small amount of solid argon is melted around the periphery of the cell with each pulse of heat, but no temperature increase will be observed in the center well. Once a number of heat pulses have been applied to the cell, the "shell" of solid argon will be deteriorated to the point where some transient effects of the heat pulse will be observed as sensible temperature changes. This

process of applying heat pulses to a frozen cell is referred to in this manual as "Pulsing the cell through the plateau" and is discussed in greater detail later in this manual.

An internal microprocessor-based digital controller provides controller functions to facilitate preparation of the cell, control the heat pulses, present diagnostic information, calibrate sensors, etc. Control functions are accessed through the front panel switches and messages are presented by the LCD display as outlined in the following sections.

2.1 System Controller

In an effort to maintain simplicity while providing 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 "CHANGE SETPOINT TEMPERATURE" and "ADJUST SYSTEM VARIABLES". The user-interactive software displays messages on a 24 character by 2 line Liquid Crystal Display (LCD), prompting the user as necessary to perform all command functions through the use of three front panel switches surrounding the LCD. An outline of the user interface is provided in the following text and figures. It will provide a detailed description of the prompts and user actions necessary to set up the system edit configurations and operate the system manually.

Because of the multitude of functions that each switch will be called upon to perform, all "labeling" of the switches is provided from the software program presented to the user via the LCD display. (The labels attached to the switches in **Figure 3** are for the benefit of the reader in understanding the documentation herein. Such labels do not appear on the device front panel.)
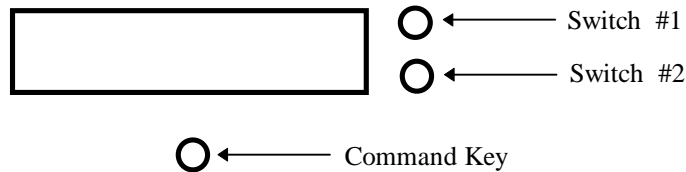
Figure 3 - Front Panel Switch Layout

2.1.1 Normal Operating Mode

The Argon Triple Point Cell requires approximately 2.5 liters of liquid nitrogen to realize the Triple Point and maintain the plateau for several hours. Normally, the Dewar will need to be filled once to cool the system from room temperature to the working temperature and once more to maintain the plateau through the pulsing period. Maintenance of the plateau for extended periods of time requires only periodic addition of liquid nitrogen to the internal storage dewar.

Pour the liquid nitrogen directly into the internal storage dewar via the large hole in the aluminum bezel located at the top of the system, shown in **Figure 4** on the next page.

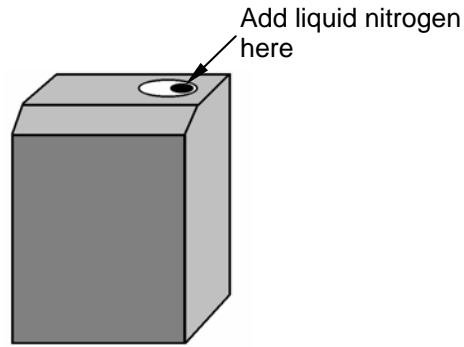Add liquid nitrogen here

Figure 4 - Adding Liquid Nitrogen

In normal operation, the Argon Triple Point Cell controller will continuously display the current temperature setpoint and the measured cell shield temperature as shown in **Figure 5**. Measurements are taken at approximately 3-second intervals and the lower line of the display is updated following 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, accessing the "COMMAND FUNCTIONS" portion of the program.
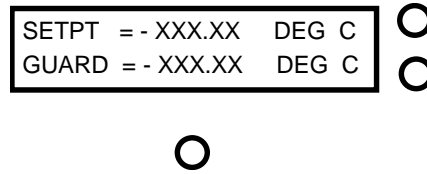

Figure 5 - Normal Operating Mode Display

2.1.2 The "Command Functions"

In order to perform the many functions necessary for operation, the user must leave the normal operating mode and enter the "COMMAND FUNCTIONS" mode. To do this, the user should depress and hold the Command Key. As the key is pressed, the words "COMMAND FUNCTIONS" will immediately appear 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. The operator should then release the key.

Note

The system has been designed to operate normally even when the user is accessing the control functions. However, the display of system conditions and remote communication will be suppressed until the system returns to the normal operating mode.

2.1.2.1 Change Setpoint Temperature

This function allows the user to change the setpoint temperature of the system controller to any temperature within the range of 50.000 to -198.000 °C. As shown in **Figure 6**, the label "YES" is adjacent to the top switch, which we 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 proceed to access to the next function. However, if the user selects "YES" by pressing the corresponding switch, the display shown in **Figure 7** will be presented on the LCD.
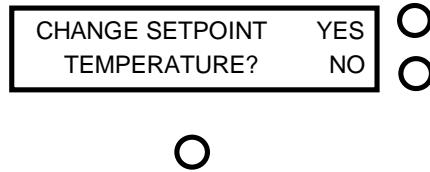
```
┌─────────────────────────────────┐   ○
│ CHANGE SETPOINT      YES         │
│ TEMPERATURE?         NO          │   ○
└─────────────────────────────────┘
```

○

Figure 6 - Setpoint Access Prompt

The system controller is programmed with three memory "SETPOINT" temperatures. The user may select the first memory setpoint temperature by pressing the corresponding "YES" switch. A "NO" selection will advance the system to the next memory setpoint. A "NO" response to all of the three memory setpoint temperatures will allow the user to change the setpoint manually as shown in **Figure 8**.
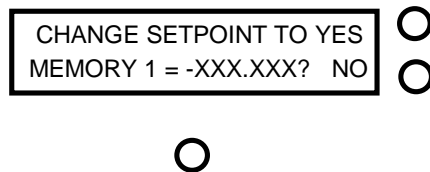
```
┌─────────────────────────────────┐   ○
│ CHANGE SETPOINT TO YES           │
│ MEMORY 1 = -XXX.XXX?   NO        │   ○
└─────────────────────────────────┘
```

○

Figure 7 - Memory Setpoint Change Prompt

To adjust the "SETPOINT" manually, use the two switches on the side corresponding to the labels "UP" and "DN" displayed on the LCD. Each depression of a switch increments or decrements the selected digit one unit. The "COMMAND" switch, located directly below the LCD, advances the cursor to each of the digits. The number presented on the display will be used as the current setpoint by the system controller even while in the command functions mode.

```
┌─────────────────────────────────┐   ○
│ SETPOINT =  -XXX.XX      UP      │
│  PRESS v TO SET          DN      │   ○
└─────────────────────────────────┘
```

○
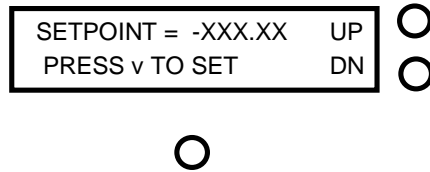
Figure 8 - Manual Setpoint Change Prompt

As the cursor is scrolled past the last digit, setpoint adjustment is complete and the user advances to the next command function, described in the following section.

2.1.2.2 Apply Heat to Cell

This function allows the user to apply a specific amount of heat to the cell. This function is only available when the temperature is at or below -40 degrees C. This function warms the cell once it is completely frozen. Responding "YES" to the prompt shown in **Figure 9** will apply the specified amount of heat to the cell and, thus, begin warming the solid argon in the cell.   A "NO" response will move to the next command function.

```
ADD  XXX JOULES OF    YES      ◯
   HEAT TO CELL?        NO      ◯
```
◯

Figure 9 - Apply Heat to Cell Prompt
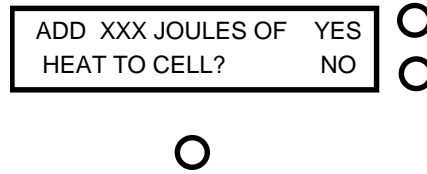

2.1.2.3 Pulse Cell Through Plateau

The pulse cell through plateau function gives the user the ability to set up the controller to periodically apply heat pulses to the cell. This will move the cell on to the plateau and ensure that the cell is still on plateau. Responding "YES" to the prompt in **Figure 10** will begin pulsing heat to the cell, a "NO" response will move to the next command function.
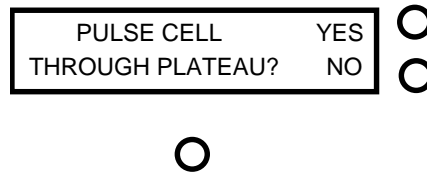
```
   PULSE CELL          YES      ◯
 THROUGH PLATEAU?       NO      ◯
```
◯

Figure 10- Pulse Cell Through Plateau Prompt

When set up to "PULSE THE CELL THROUGH THE PLATEAU", the controller will immediately begin to apply a heat pulse to the cell. The amount of heat applied is established by the system variable JOULE PULSE. After exiting the "COMMAND FUNCTIONS" alternating displays will alert the user that heat is being applied. **Figure 11** shows the two prompts that are displayed during the cycle. The left display, above the shaded area, will be updated approximately every three seconds to allow the user to observe the number of joules applied. Twelve joules are applied in each update until a total of 300 joules have been applied. The right prompt is displayed when the system has completed applying 300 joules to the system. This prompt displays how many seconds until the system starts applying joules again. The total default pulse cycle takes 1200 seconds or twenty minutes.   These settings are adjustable and will be discussed later in the manual.

```
PULSING HEAT TO CELL      ◯
XXX OF 300 JOULES         ◯
           ◯

                          PULSING THROUGH PLATEAU   ◯
┌──────────────┐          NEXT PULSE IN XX SECONDS  ◯
│              │                    ◯
│  300 Joules  │
│              │
└──────────────┘──────────────────────────────────
        1800 seconds
```
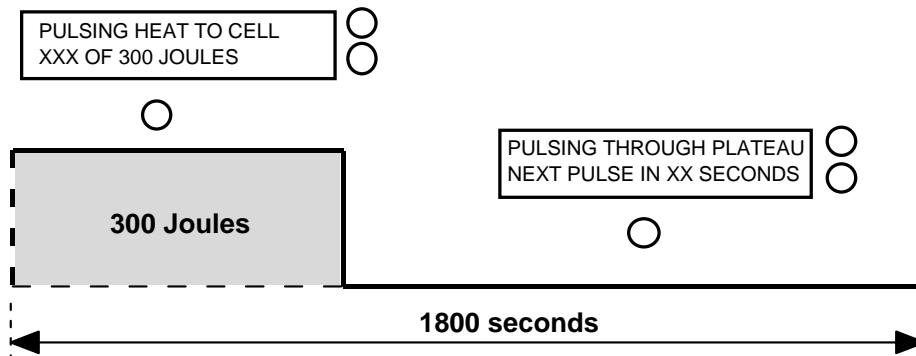
Figure 11 - Pulse Cycle Diagram

If one reenters the "COMMAND FUNCTIONS" a new prompt, **Figure 11**, will be displayed. This prompt allows the user to cancel the auto pulsing routine. A "YES" response will cancel the auto pulsing routine and a "NO" response will not cancel the routine and move to the next command function.
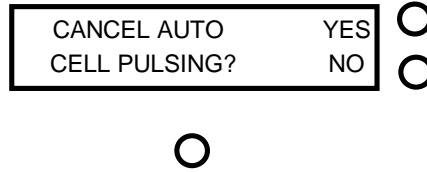
```
┌──────────────────────────────┐   ○
│  CANCEL AUTO        YES       │
│  CELL PULSING?      NO        │   ○
└──────────────────────────────┘

              ○
```

Figure 11 - Cancel Auto Pulsing Prompt

2.1.2.4 Adjust System Variables

This command function allows the user to examine and adjust the system variables used by the controller as well as the calibration variables for the system core temperature measurement.
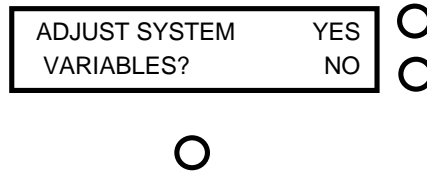
```
┌──────────────────────────────┐   ○
│  ADJUST SYSTEM      YES       │
│   VARIABLES?        NO        │   ○
└──────────────────────────────┘

              ○
```

Figure 12 - System Variable Access Prompt

Pressing the switch by the display "YES", in **Figure 12**, will allow access to the first system variable by presenting the messages shown in **Figure 13**, responding with a "NO" command will terminate the function and advance to the next command function.

2.1.2.5 Adjust Memory Setpoint Temperatures

The first variable accessed by the "Adjust System Variables" function is the " Memory 0", shown in **Figure 13**. The "Memory 0" variable is the system startup setpoint. Responding "YES" to the prompt will allow the user to adjust the setpoint, a "NO" response will move to the next memory setpoint.

```
┌──────────────────────────────┐   ○
│  ADJUST SYSTEM       YES      │
│  MEMORY 0 = XXX.XXX?   NO     │   ○
└──────────────────────────────┘

              ○
```
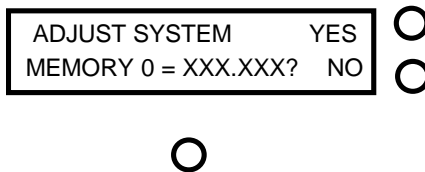
Figure 13 - Adjust Setpoint Memory Prompt

The adjustment of MEMORY 0 may be accomplished 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.

As the cursor is scrolled past the last digit, memory setpoint adjustment is completed and the user is advanced to the next memory setpoint. When all memory setpoint adjustments have been

POND
ENGINEERING
Pond Engineering Laboratories, Inc.
2401 S. County Road 21, Berthoud, CO 80513 USA
(303) 651-1678   FAX (303) 651-1668

presented, the system advances to the next System Variable, as described in the following section.

2.1.2.6 Adjust Cell Heat Pulse

The next variable accessed by this function is ADJUST CELL HEAT PULSE, the number of joules that will be applied by the cell heater per heat pulse. To adjust this variable, respond YES to the prompt in **Figure 14**.

```
 ADJUST CELL HEAT     YES
PULSE = XXXX JOULES?  NO
```

Figure 14 - Adjust Heat Pulse Access Prompt

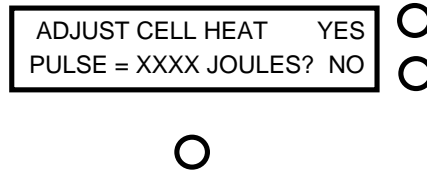Responding "YES" to the prompt will allow the user to modify the variable as described below, a "NO" response will allow access to the next system variable as described in the following section.
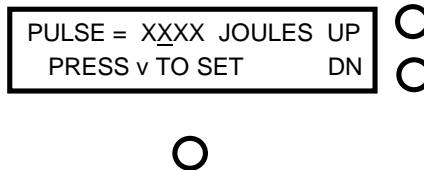
```
PULSE =  XXXX  JOULES  UP
   PRESS v TO SET       DN
```

Figure 15 - Heat Pulse Adjust Prompt

Modification of the variable is accomplished by pressing the two switches on the right of the LCD. The command key located directly below the LCD is used to advance the cursor to each of the digits. Pressing the switch adjacent to the "UP" prompt will cause the value of the selected digit to be incremented by one, while pressing the switch adjacent to the "DN" decrements it by one. The range of the variable is from 0 to 2000 joules. As the cursor passes the last digit, the value is stored as a temporary system variable.

2.1.2.7 Adjust Cell Pulse Period

The next variable presented is "ADJUST CELL PULSE PERIOD", the period of time for an entire pulse ON/OFF cycle.

```
ADJUST CELL PULSE     YES
PERIOD = XXXX SEC?     NO
```
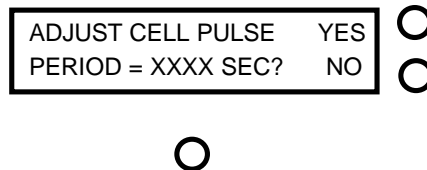
Figure 16 - Adjust Pulse Period Access Prompt

Responding with a "NO" to the prompt will cause no change in the Pulse period and the next variable access function will be started. A "YES" response will allow the user to change the pulse period as shown in **Figure 17.**
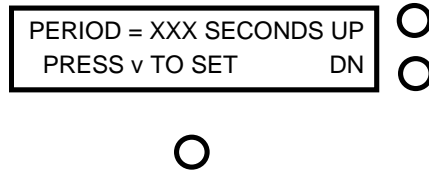
```
┌─────────────────────────────────┐
│  PERIOD = XXX SECONDS UP         │  O
│    PRESS v TO SET         DN     │  O
└─────────────────────────────────┘

              O
```

Figure 17 - Cell Pulse Period Adjust Prompt

Modification of the variable is accomplished by pressing the two switches on the right of the LCD. The command key located directly below the LCD is used to advance the cursor to each of the digits. Pressing the switch adjacent to the "UP" prompt will cause the value of the selected digit to be incremented by one, while pressing the switch adjacent to the "DN" will decrement it by one. This variable has a range from 0 to 3600 seconds. As the cursor passes the last digit the value is stored as a temporary system variable.

2.1.2.8 Adjust GPIB Address

The next variable presented, "ADJUST GPIB ADDRESS", is the parameter that determines the address at which the system can be accessed over the IEEE-488 interface.

```
┌─────────────────────────────────┐
│  ADJUST GPIB          YES        │  O
│  ADDRESS = XX          NO        │  O
└─────────────────────────────────┘

              O
```

Figure 18 - IEEE-488 Address Adjust Prompt

The user may examine or adjust this variable by responding "YES" to the prompt, while a "NO" response will allow access to the next Command Function.
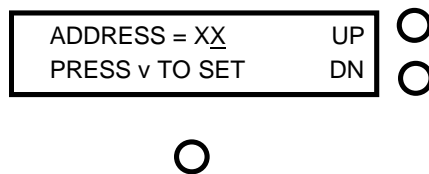
```
┌─────────────────────────────────┐
│  ADDRESS = XX          UP        │  O
│  PRESS v TO SET        DN        │  O
└─────────────────────────────────┘

              O
```

Figure 19 - Address Adjust Prompt

Here the user can modify the IEEE-488 address of the instrument as shown in **Figure 19**. The adjustment of address may be accomplished by using the two switches on the side corresponding to the labels "UP" and "DN" in **Figure 19**. This variable may be set within the range of 1 to 30. The Command Key, located directly below the LCD, is used to advance the cursor to each of the digits. Pressing the switch adjacent to the "UP" prompt will cause the value of the selected digit to increment one, while pressing the switch adjacent to the "DN" will decrement it by one. As the cursor passes the last digit, the value is stored as a temporary system variable.

2.1.2.9 Calibrate Guard Temperature Sensor

The next variable accessed by this function is the calibration variable for the guard sensor.   The user is given access to these variables by responding "YES" to the prompt shown in **Figure 20**.

A "NO" response will allow access to the next system variable in the sequence, as described in the following section.
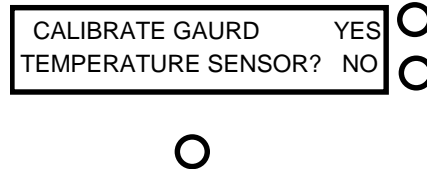
```
 CALIBRATE GAURD        YES    O
 TEMPERATURE SENSOR?   NO     O

                 O
```

Figure 20 - Calibration Access Prompt

The first display presented allows the user to calibrate the system's guard temperature sensor. This calibration procedure adjusts the offset of the system's guard sensor to match the reading from an external SPRT. The calibration adjustment should be made near the argon triple point, and after the external SPRT and the system have reached stability. The calibration adjustment is accomplished by changing the offset variable for the guard sensor.
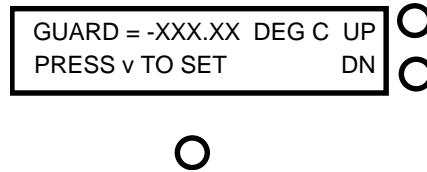
```
 GUARD = -XXX.XX  DEG C  UP    O
 PRESS v TO SET          DN    O

                 O
```

Figure 21 - Guard Sensor Calibration Prompt

The number shown in **Figure 21** is the current guard temperature as calculated by the measured guard temperature plus a temporary guard offset. This temporary guard offset is initially set to the current value of the guard offset being used by the control routines. Adjusting this temporary variable will have no effect on the measured guard temperature in the control routines until this function is completed.

Modification of the guard temperature, through adjustment of the offset value, is accomplished by pressing the two switches on the right of the LCD. Pressing the switch adjacent to the "UP" prompt will cause the apparent measured guard temperature to increase and pressing the switch adjacent to the "DN" will cause the apparent measured guard temperature to decrease. It is important to note that the "UP" switch actually increase the temporary guard offset variable and the "DN" switch decreases the temporary guard offset variable. The system will continually update the measured sensor temperature and displays the corrected temperature value so all changes are reflected on the display as they occur.

After the desired value has been established, by incrementing or decrementing the temporary offset variable, pressing the Command Key causes the value to be stored as a guard offset. Then the user is given the opportunity to examine or modify the guard offset value by the following prompt shown in **Figure 22.**

Note

At this point the value that is displayed as the GUARD OFFSET is being used in the control routines.

```
                                    MAN   O
GUARD OFFSET = -XX.XX  USE   O

                  O
```
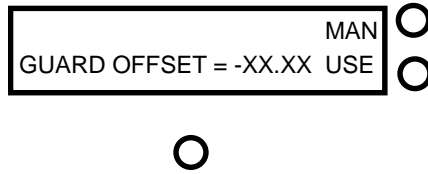
Figure 22 - Manual Guard Offset Access Prompt

It is recommended that the user record any new Guard Offset resulting from a calibration in a log similar to the log provided at the end of this manual. The prompts shown allow the user to manually adjust the offset value, by pressing "MAN", or "USE" this value as the calibrated offset. In the event that the user chooses to "USE" this value the system will skip the manual adjustment function discussed in the following section, while a choice to "MAN", or manually adjust the system, will display the prompt shown in **Figure 23**.
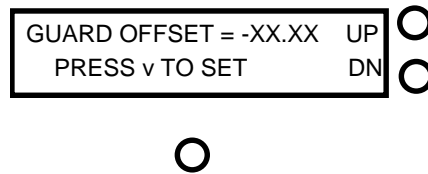
```
GUARD OFFSET = -XX.XX    UP   O
     PRESS v TO SET       DN   O

                  O
```

Figure 23 - Manual Guard Offset Adjustment Prompt

 Manual adjustment of Guard Offset may be accomplished using the two switches on the side corresponding the labels "UP" and "DN" displayed on the LCD. 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, Guard Offset adjustment is completed and the system sets the variable to the newly established value and advances to the next System Variable, as described in the following section.

2.1.2.10 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** 24, 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.

```
ACCESS VARS      YES   O
   ARRAY?          NO   O

                  O
```
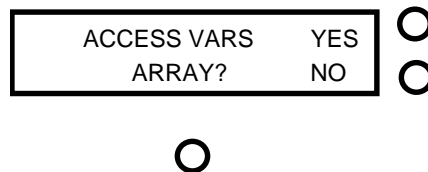
Figure 24 - Access Variables Array Prompt

Responding YES to the prompt in **Figure** 24 will cause the prompt in **Figure 25** 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.
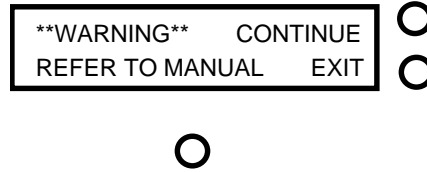
```
+----------------------------------+   O
| **WARNING**      CONTINUE        |
| REFER TO MANUAL      EXIT        |   O
+----------------------------------+
```

O

Figure 25 - Warning Prompt

If CONTINUE is selected, variables will be presented in series as shown in **Figure** 26 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.
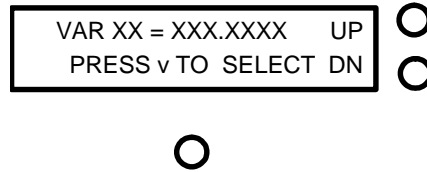
```
+----------------------------------+   O
| VAR XX = XXX.XXXX       UP       |
|    PRESS v TO  SELECT  DN        |   O
+----------------------------------+
```

O

Figure 26 - 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 26** 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	-189.6 degrees C	-197 to -189 degrees C
1	Memory 0 Setpoint Temperature (Power ON)	-191.0 degrees C	-197 to -189 degrees C
2	Memory 1 Setpoint Temperature	-189.2 degrees C	-197 to -189 degrees C
3	Memory 2 Setpoint Temperature	-197.0 degrees C	-197 to -189 degrees C
4	Memory 3 Setpoint Temperature	-189.0 degrees C	-197 to -189 degrees C
5	UNUSED		
6	GPIB Primary Address	6.0000	1.0000-30.0000
7	UNUSED		
8	UNUSED		
9	Cell Heater Enabled		1- Enabled, 0 - Disabled
10			
11			
12			
13			
14	TPW value for core sensor – Ohms	100.0	See Calibration Log
15	ITS-90 A Coefficient Below 0.01	0.0	5.0 to 25.0
16	ITS-90 B Coefficient Below 0.01	0.0	5.0 to 25.0
17			
18	Guard Offset - Deg. C	0.0	-10.0 to 10.0
19			
20	ACCESS CODE for protected variables (variables 21 and up)	0.0000	Contact Factory
27	Proportional Gain	8.0	4.0 to 16.0
28	Integral Gain	0.1	0.05 to 0.20
31	Derivative Gain	-70.0	-35.0 to -140.0
39	Measured core sensor PRT – Ohms	Current reading	
40	Measured Core Temperature– Deg. C	Current reading	
41	Averaged Core Temperature– Deg. C	Current reading	

2.1.2.11 Save changes to Variables

The prompt in Figure 27 provides the opportunity to 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 this prompt stores the variables in the non-volatile memory within the system controller. The variables will then be utilized as the systems power-on defaults.

```
┌─────────────────────────────┐   O
│  SAVE CHANGES TO      YES   │
│       VARIABLES?       NO   │   O
└─────────────────────────────┘
              O
```

Figure 27 - Save Variables Prompt

Responding "NO" to this prompt causes the system to exit the function without saving the variables to non-volatile memory. This allows the user to temporarily establish new values for the system variables without permanently altering the default values. If the power were to be shut off or interrupted before the new information was stored in the non-volatile memory, however, the newly established values would be lost and the system would utilize the default values. Following verification of performance of the newly established variable values, they may be stored by entering the "ADJUST SYSTEM VARIABLES" routine, stepping directly through the prompts and responding "YES" to the "SAVE CHANGES" prompt.

2.1.2.12 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 options are available, "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.

```
┌─────────────────────────────┐   O
│  DISPLAY DIAGNOSTIC    YES  │
│      INFORMATION?       NO  │   O
└─────────────────────────────┘
              O
```

Figure 28 - 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.
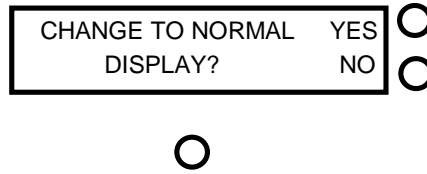
```
CHANGE TO NORMAL    YES   O
DISPLAY?            NO    O

              O
```

Figure 29 - Normal Mode Display Prompt

The "DIAGNOSTIC INFORMATION" display presents an array of numeric information for system diagnostics for the "CORE" zone and the "GUARD" zone. An example of the core diagnostic information is shown below in **Figure 30**.

```
300.0    300.0    993   ==>C   O
192.0    1.00     1200    G    O

              O
```
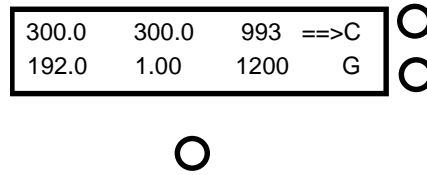
Figure 30 - Core Diagnostics Display

The information presented by the CORE DIAGNOSTICS display is as follows. Top row from left to right: target joules at end of pulse cycle, joules per cycle, seconds to start next pulse. Bottom row left to right: number of joules currently added, heater relay status (1=picked or ON, 2=unpicked or OFF), number of seconds between pulse periods.

Pressing switch #2 will allow the user to toggle between the core and guard diagnostics display. The arrow indicates the currently presented diagnostic display.

```
-189.30   0.01    -0.10  ==>G   O
-189.30   1.50     1.41     C    O

              O
```

Figure 31 - Guard Diagnostics Display

The information presented by the GUARD DIAGNOSTICS display is as follows. Top row left to right: guard zone setpoint temperature (degrees C), guard proportional signal, guard derivative signal. Bottom row left to right: current guard temperature, guard integrator signal, current guard zone heater 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 system will again return to the normal operating mode, presenting the normal display or diagnostic display information as selected by the user.

2.2 Remote Interface Commands

If the Temperature Calibration Furnace has been equipped with the optional IEEE-488 Remote Interface, any host computer which can be set up as a system controller may be used to operate the Calibration Furnace over the interface. Pond Engineering has software available for interfacing with the furnace variables using an IBM compatible or Macintosh computer with a National Instruments 488 interface card. Custom software packages are also available to integrate the furnace as part of an automated lab. The system variables which can be accessed over the 488 interface can be found in section *3.2.2.5. Access Vars Array*. Also included on the CD-ROM is a copy of Pond Engineering's GPIB Communication software, see section 5.1 for operation.

2.2.1 Pond Engineering GPIB Software

Included on the CD-ROM is a copy of the Pond Engineering GPIB Communication Software. This makes the ease of the command set of just pointing to the variable and setting the variable to read or right.

2.2.1.1 Installation

To begin the installation insert the CD-ROM into a windows x86 PC, let the auto run start and click on *Install Pond Engineering GPIB Driver.* Alternatively you can go to D:\ PEL GPIB Driver Setup.exe and double click the icon to start the installation where D is your CD-ROM drive. From there follow the prompts to install the software.

2.2.1.2 Usage

To start the software go to Start – Program Files – Pond Engineering GPIB Driver. The screen should look like this.
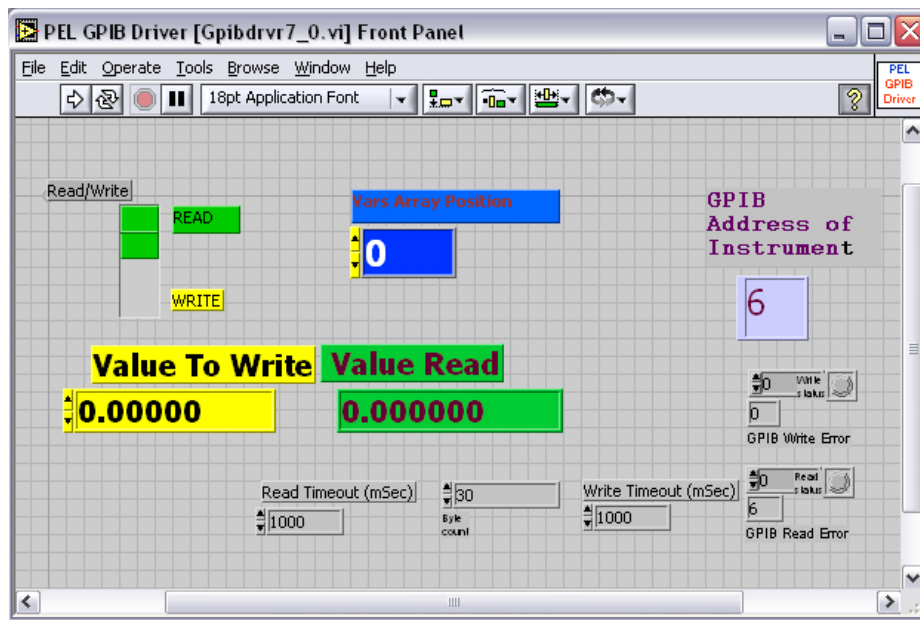

Figure 32 - PEL GPIB Screen

From here you can select the Variable Number (blue) in which you wish to change/read, select Read or Write (Yellow), and run the program to receive or write the value. (Note: the variable numbers are on page 11-12 of this manual) The values read will show in the green Value Read box, those you wish to write you enter in the yellow Value to Write box. To run the program each

time you push the arrow button in the upper left part of the toolbar. If you need to change the timeout, byte count, or GPIB Address you can do so here in the indicated windows.

2.2.2 Primary Metrology Furnace Command Set

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

2.2.2.1 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 furnace will wait to be addressed as a talker to return the data over the bus. The furnace has a one second write time-out, thus the controller in charge must read from the furnace within one second after sending the "R" command to receive data. For example: If the user wants to see the value stored as the system's alarm temperature, the user would send the character string: R05. The controller in charge would then address the furnace as a talker and wait for the data to be returned.

    **Note: Control of the Furnace core remains the highest priority even when the furnace is in remote mode and may put off responding to 488 commands for as long as 500ms.

For Example, having been addressed as a talker, the furnace will return the text string +4.300000e+02(space)05 as soon as it is not performing control functions. This indicates that the value 430 (°C) is the current value for Variable 05 (the Alarm Temperature). Values returned are always in the above scientific format followed by a space and address number for the given value.

2.2.2.2 Write System Variable

The "WRITE" command, executed 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 be decimal with at least 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 300 °C, the user would send: W05,300 and the alarm temperature variable would then be set to 300 °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 users 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 variable. All other variables can be set to any value received over the 488. Extreme caution must be used when setting any variable over the 488. The user should read back any variable after setting it to insure the variable was received by the furnace correctly. This is especially important when setting the RTPW's and calibration coefficients, since an errant RTPW or coefficient may cause the furnace to overheat and damage the core.

2.2.2.3 Remote Mode

After receiving a command over the 488 Buss, the furnace enters remote mode. In remote mode the LCD will display the message shown in Figure 33.
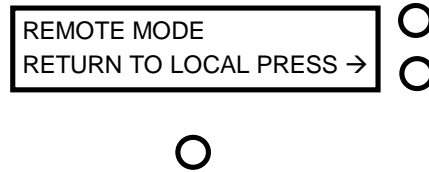
```
┌─────────────────────────────────┐   ◯
│ REMOTE MODE                     │
│ RETURN TO LOCAL PRESS →         │   ◯
└─────────────────────────────────┘

              ◯
```

Figure 33 - Remote Mode Display

In remote mode, the system will only respond to the return to local switch (switch #2). After returning to local control the system will respond normally to all switches.

3. Normal Operating Procedures

Outlined below are recommended operating procedures for realizing the Argon Triple Point utilizing the model K38 apparatus with liquid nitrogen as the coolant.

3.1 Preparing the System

Filling the internal dewar to the bottom of the filler neck (see page 21) with approximately .75 liters liquid nitrogen begins the cool-down process. Take the usual cautions to accommodate the escaping nitrogen gas that will limit the rate of filling until the dewar surfaces cool down close to liquid nitrogen temperatures. Once the rapid boiling subsides, the dewar can be filled to the bottom of the filler neck and the system allowed to cool unattended.

NOTE: Increasing the fill level 1 to 2 cm up into the filler neck allows liquid nitrogen to enter the cell thermometer well through the liquid overflow drainage port, flooding the center well. The liquid nitrogen will then be able to remove heat directly from the cell center well and cool the system much more rapidly.

Be certain that the system setpoint is at -195.0 or lower during this process. After approximately 2 to 3 hours, (less than one hour if the center well is kept flooded) the internal shields and cell will have been cooled to the point where the bulk of the Argon gas sample will have condensed in the cell envelope. Once the guards and cell have been cooled to a temperature of -193.0 °C or below, the dewar should be refilled and the center well flooded. The system setpoint should be changed to -190.0 °C and the system should then be allowed to equilibrate with the setpoint at -190.0 °C for a period of approximately one hour. At this point, a check thermometer should be used to verify that the sample is completely frozen.

NOTE: A check thermometer may be kept in place in the center well of the cell during the entire preparation procedure if desired. If it is inserted at this point, be sure to chill it in liquid nitrogen before inserting.

If a check thermometer in the thermometer well indicates a temperature more than 3°C below the setpoint temperature, there is likely still some liquid nitrogen in the center well surrounding the thermometer. Either allow the remainder of the nitrogen to boil off or apply a few 300-Joule pulses to the cell to boil off the excess liquid and again allow the system to equilibrate.

NOTE: A 300 joule pulse will increase the temperature of the cell and solid sample nearly 0.6 °C for each pulse.

3.2 Pulsing the Cell onto the Plateau

When the sample is confirmed frozen solid, and has been allowed to come into equilibrium for a minimum of 45 minutes at a temperature between –190.5 °C and –189.5 °C, the system setpoint

should be changed to -189.34 °C, and the user should initiate delivery of a 900 Joule pulse of heat to the cell; allowing the system to move up onto a plateau at the Argon Triple Point as indicated by a check thermometer. This procedure should form an "outer melt" or layer of liquid argon adjacent tot he inner wall of the stainless steel cell wall.

NOTE: It is recommended that the user periodically verify that the calibration of the internal guard control sensor is within +/- 0.05 °C using a check thermometer. During this check, supporting the thermometer approximately 12 cm above the bottom of the cell well places the sensing element of the thermometer in much better thermal contact with the guard shells and result is much shorter time constants in the equilibration process. With the thermometer at the bottom of the well, several hour time are typically required to equilibrate the system.

For best results, an "inner melt" should be formed at this point and may be easily be accomplished by removing the check thermometer and inserting a room temperature thermometer into the cell. Alternatively a 7mm diameter quartz rod may be used to form the inner melt.

If desired, automatic pulsing may be enabled continuously to pulse the cell completely through the plateau. As the cell nears the end of the plateau, the check thermometer should indicate an increase in temperature shortly after each heat pulse is applied, then slowly fall and approach the triple point plateau before the next pulse. Once the check thermometer indication does not fall back to the triple point temperature, the cell has melted through the plateau.

3.3 Calibrating Multiple Thermometers

Multiple thermometers may be calibrated on a single plateau by inserting room temperature thermometers into the center well. Pre chilling may be necessary if more than three thermometers must be inserted on a single plateau. Readings taken with a check thermometer before and after calibration of additional thermometers should agree within 0.0005 °C.

3.4 Hydrostatic Head Correction

Triple point conditions are maintained inside the cell at the vapor /liquid /solid interface which occurs only at the upper surface of the argon. Since there is hydrostatic head pressure imposed by the column of liquid argon at the depth of immersion of this cells, a correction must be applied to the theoretical triple point temperature to account for the static head pressure present at the sensing point. For all practical purposes, the liquid surface of the argon is 13.2 cm above the bottom of the thermometer well resulting in an increase of 0.0004 degrees C and variability between cells is negligible. This results in a temperature, at the center of the sensing element of a SPRT inserted in the central well, of –189.3438 degrees C (ITS-90). Data concerning cell construction is provided in Section 7 of this manual for reference and to allow independent verification of hydrostatic head corrections applied.

4. Handling and Maintenance

4.1 System Maintenance

The Argon Triple Point Cell is designed and fabricated to require minimal periodic maintenance. The following information is provided to guide the user in maintaining the system. Care should be taken to avoid accumulation of excessive moisture in the thermometer well or in the system dewar. After each use when significant moisture accumulation is observed, the system setpoint should be set to 50.0 °C and the system allowed to remain stable at this temperature for 2 hours or more to drive off excessive moisture.

4.1.1 Cleaning

Exterior surfaces of the cabinet are coated with a durable polyurethane coating which is not affected by most solvents and cleaning agents. It is recommended that exterior surfaces be cleaned with alcohol or a mild commercial cleaning agent.

4.1.2 Evacuation Procedures

Under normal operation, the system should maintain an adequate vacuum level in the internal dewar for several years. If considerable condensation on the exterior on the dewar outer envelope or unusually short plateau durations are noted, the dewar may be evacuated using the following procedure. An external high vacuum pump (capable of pumping to 10^{-5} Torr or lower) and appropriate connecting lines to mate with the KF 16 flange vacuum fitting provided inside the back cover are needed.

Jamb Nut

Valve

Collar
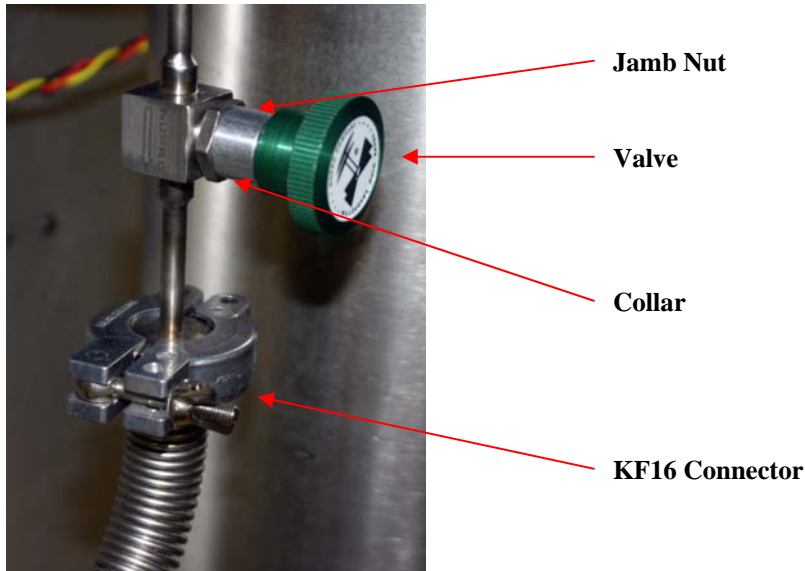
KF16 Connector

Figure 34 - Vacuum Connector Assembly

1. **Connect to the external vacuum pump and evacuate line to 10^{-3} Torr or lower.**

2. Loosen valve jamb nut approximately ½ turn, by turning the nut counter-clockwise with an appropriate wrench. Loosen nut back and slide collar back.

Figure 35 - Loosen Jamb Nut

3. Slowly open valve 1 turn counter-clockwise, valve will then be open .

Figure 36 – Open Valve

4. Pump on core until 10^{-5} torr achieved at pumping system

5. Close the valve tightly by turning the knob clockwise, slide collar towards valve, tighten jamb nut against collar.


Figure 37 – Close Valve

Figure 38 - Tighten Jamb Nut

6. Remove external high vacuum pump

System Hardware Description

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

4.2 Front Panel
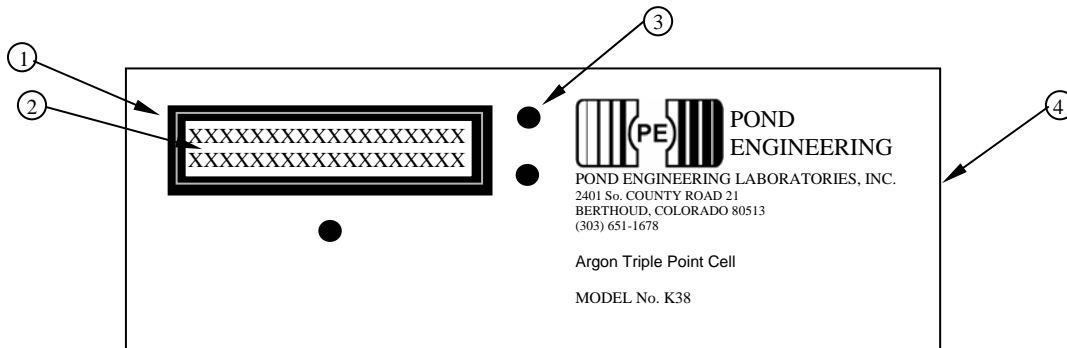
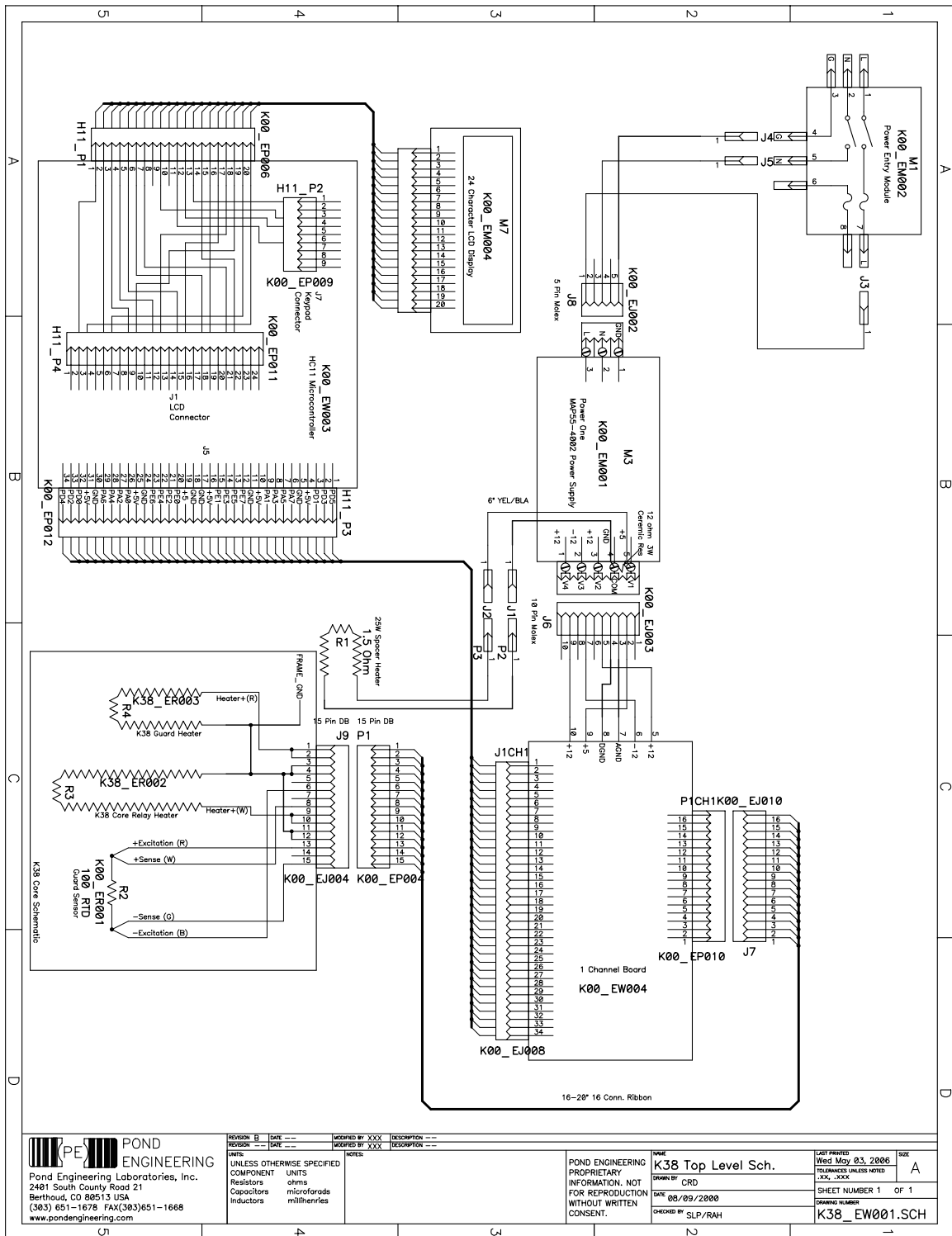| REF.#	NAME	MAKE	MODEL
1	Die Cast Metal Bezel	JMJ Technical Products	1-458
2	24X2 Dot Matrix LCD Module DMC Series	Optrex	DMC20261
3	Miniature Push-button panel Mount SPDT Switches - 3 each - with Caps for Miniature	Eaton Cutler-Hammer	PS1-100Q

| | Switches | Eaton Cutler-Hammer | W-KN-17 |
| 4 | Engraved Laminate Front Panel | Pond Engineering | K38-FP |

4.3 Electronics Chassis
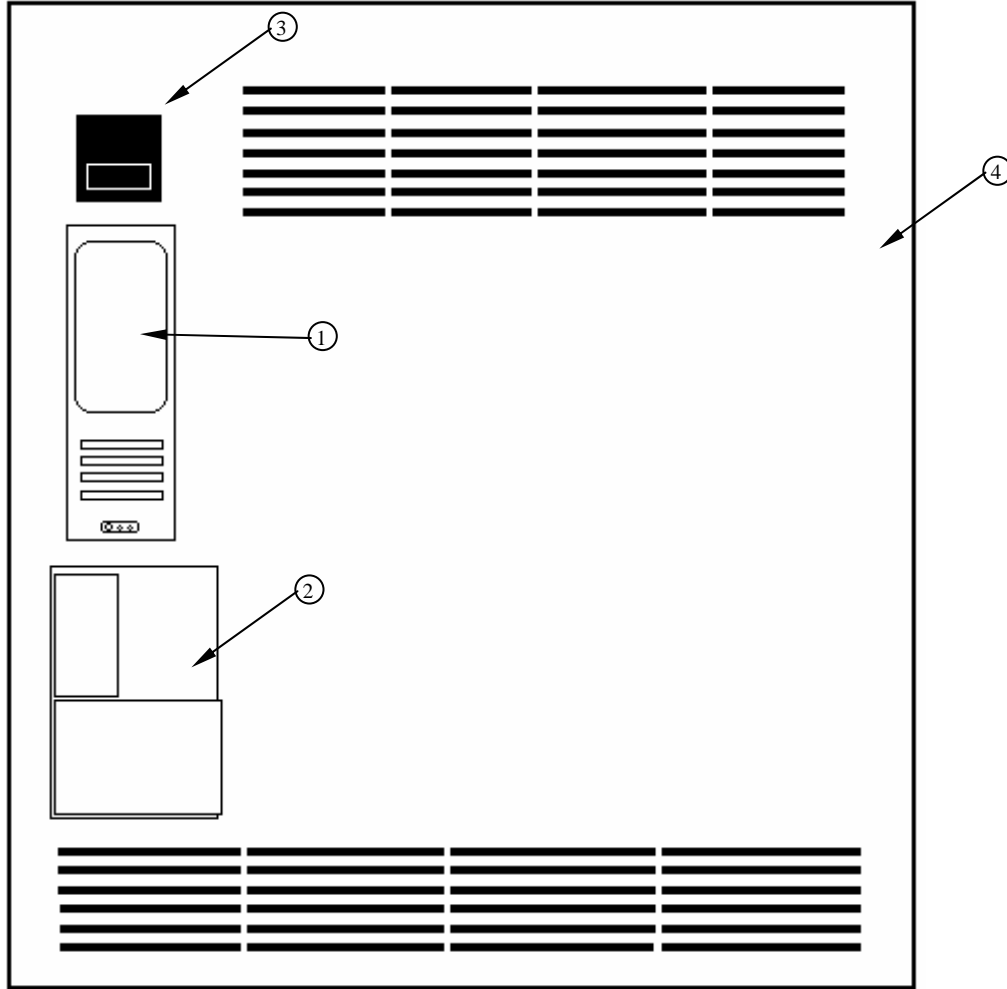
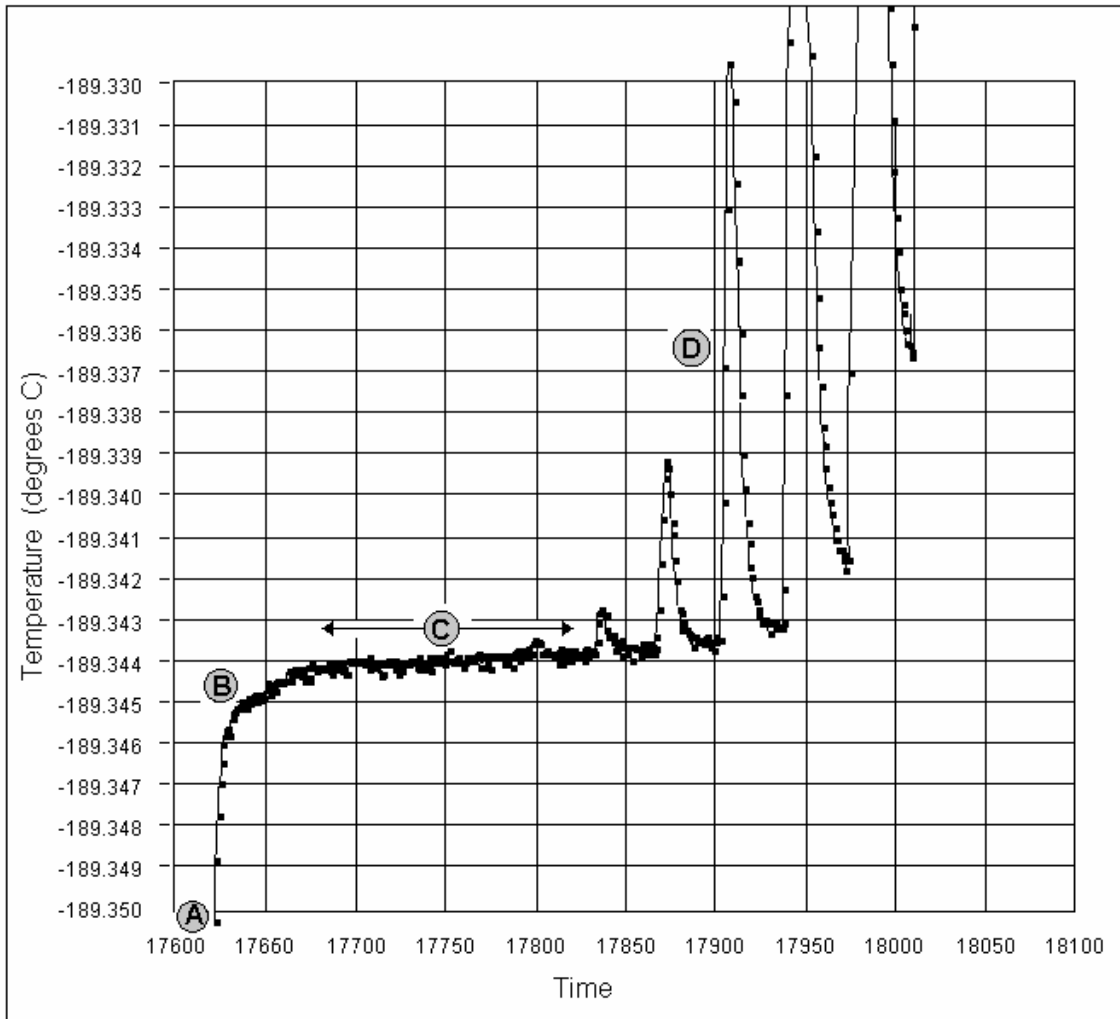| REF.#	NAME	MAKE	MODEL
1	Power Supply	Power-One Inc.	MAP55-4002
2	Microprocessor/Controller	Pond Engineering Labs.	K38M-400
3	System ON/OFF Switch	Power Dynamics	42R37
4	Ventilated Small Box Back	Pond Engineering Labs.	

4.4 Top Level Schematic

5. Calibration Record

Factory Calibrations:

RTPW: _____ Coefficient A: _____ Coefficient B _____

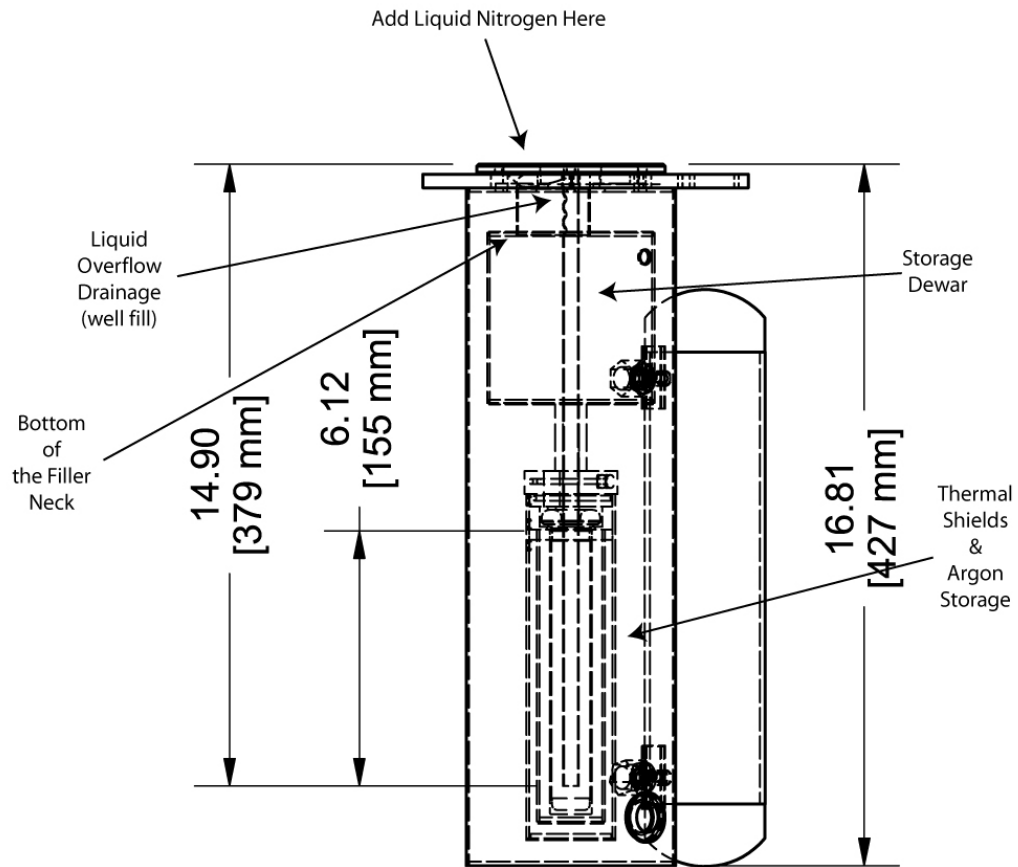| Guard Offset	Date	Comments

6. Graph of a Typical Plateau

A Frozen cell is approaching the triple point of argon.

B Advancing from a solid state to the plateau.

C Plateau region with heat pulses being applied.

D Sensed temperature spikes following each heat pulse indicate the mantle is reaching the end of life. Heat pulses of 300 Joules each were applied at 1800-second intervals over the full time period shown in this diagram.

7. Cross-Sectional View of the K38

This is a cross-sectional view of the Argon Triple Point Cell.

Pond Engineering Laboratories, Inc.
2401 S. County Road 21, Berthoud, CO 80513 USA
(303) 651-1678   FAX (303) 651-1668

Fixed Point Cell Certificate of Sample Purity

The following page contains the Fixed Point Cell Certificate of Purity.