Model K52

Argon Triple Point Cell

Operation & Maintenance Manual

by

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1. Background

This report documents the installation, operating and maintenance procedures for the Argon Triple Point Cell, Pond Engineering Model Number K52. 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 is capable of realizing the argon triple point with an uncertainty better than +/- 0.000 25 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 controls and service points discussed later in this manual.

Figure 1 - System General Layout

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 one capsule or long-stem Standard Platinum Resistance Thermometer (SPRT) at a time in the well in the center of the cell. Liquid Nitrogen, used as an expendable refrigerant and stored in an integrated 10 liter storage dewar, is used to cool the cell. The argon cell itself is positioned inside the storage dewar and is suspended below a second, smaller coolant cup. A single thermowell passes through the liquid nitrogen in the upper cup and down into the cell, providing good thermal guarding between the cell and the outside environment. Multiple thermal shields (referred to throughout this manual as the "GUARD") surround the sealed cell, which is suspended in a vacuum environment (referred to in this manual as the "cell vacuum jacket") 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 RS-232 or USB interface to allow operation of the Argon Triple Point Cell as part of an integrated automatic calibration system.

A removable lower back panel is attached to the cabinet frame with button head screws. By removing this panel, one may gain access to the inner system components. Both side doors are also removable by actuation of the upper hinge pins once the doors are opened. The cover panels may be removed for inspection and service without disconnecting any system cabling.

The K52 Argon Triple Point Cell is equipped with a 7-inch color touch screen which provides the operator interface, shown in **Figure 2,** as well as access to all system parameters.

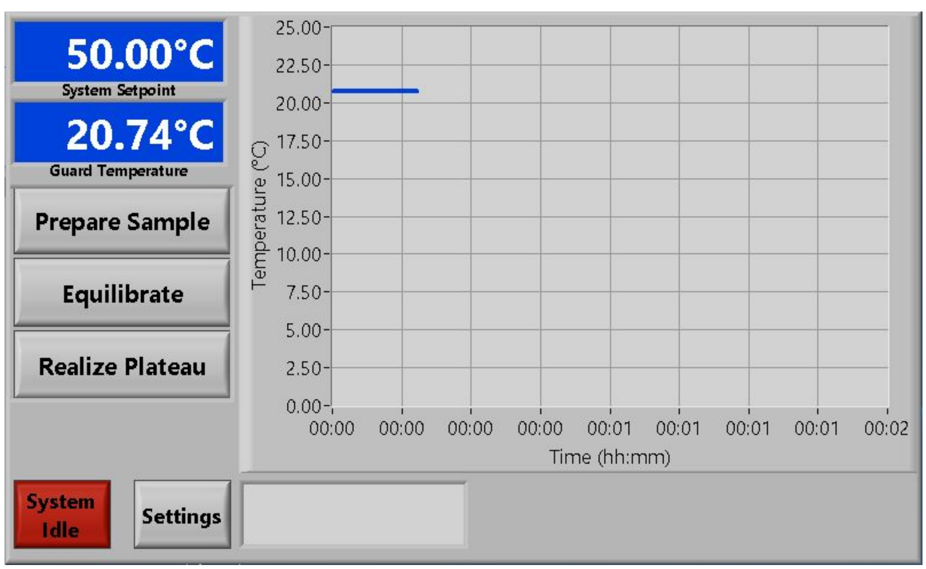

Figure 2 - Front Panel Layout

In the normal operating mode, this display presents the current temperature setpoint for the controller and the measured GUARD temperature in the top left corner of the screen. Measurements are taken at approximately 3-second intervals and the display updates following each measurement. An on-screen plot displays a history of the GUARD temperature, as well as stage-specific guide plots, where applicable.

As liquid nitrogen is added to the internal storage dewar, the apparatus is cooled. An internal pump moves liquid nitrogen to the upper cup, allowing the argon cell body and sample gas to be cooled by conduction through the copper shunt below the upper cup. Liquid nitrogen is also pumped onto a wicking sleeve fitted to the outside of the cell vacuum jacket to minimize the effects of the varying liquid levels in the internal storage dewar. As the cooling progresses, 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 GUARD causes the liquid argon sample contained in the cell to freeze. A more rapid cooling rate can be achieved by flooding the center well of the system with liquid nitrogen by starting a “freeze cycle”. 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 the 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 in the center well.

An internal microprocessor-based digital controller provides controller functions to facilitate preparation of the cell, control the heat pulses, and present diagnostic information. Control functions are accessed through the LCD touch screen display as outlined in the following sections.

2.1 System Controller

Providing unprecedented simplicity and ease of use, the 7" diagonal color LCD touch screen operator interface prompts user interaction and makes available video training modules for each step in the preparation and realization process. 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.

2.1.1 Normal Operating Mode

The Argon Triple Point Cell requires approximately 10 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.

In normal operation, the Argon Triple Point Cell controller will continuously display the current temperature setpoint and the measured cell guard temperature as shown in **Figure 3**. Measurements are taken at approximately 3-second intervals and the display is updated following each measurement.

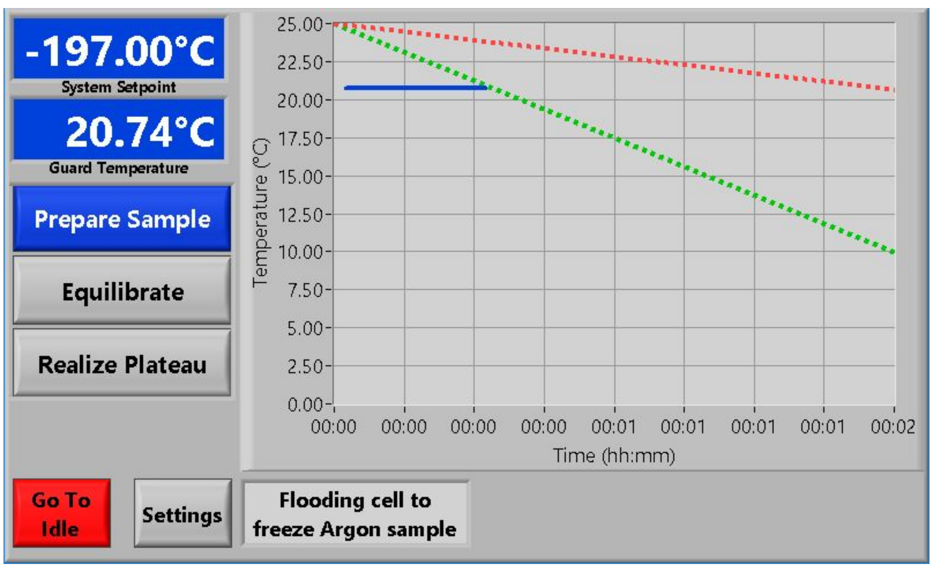

Figure 3 - Normal Operating Mode Display

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2.1.2 System Settings

This section discusses the interface used to adjust system parameters and settings. Numeric inputs can be adjusted by pressing the desired parameter, and adjusting it via the on-screen keypad.

2.1.2.1 Setpoints

Figure 4 shows the "Setpoints" tab. This tab contains all of the memory setpoints utilized by the system in operation.

****Note: The setpoint can also be changed by pressing the setpoint indicator on the normal display. This allows the user to change the setpoint during any part of the realization process, without having to adjust one of the memory setpoints.**

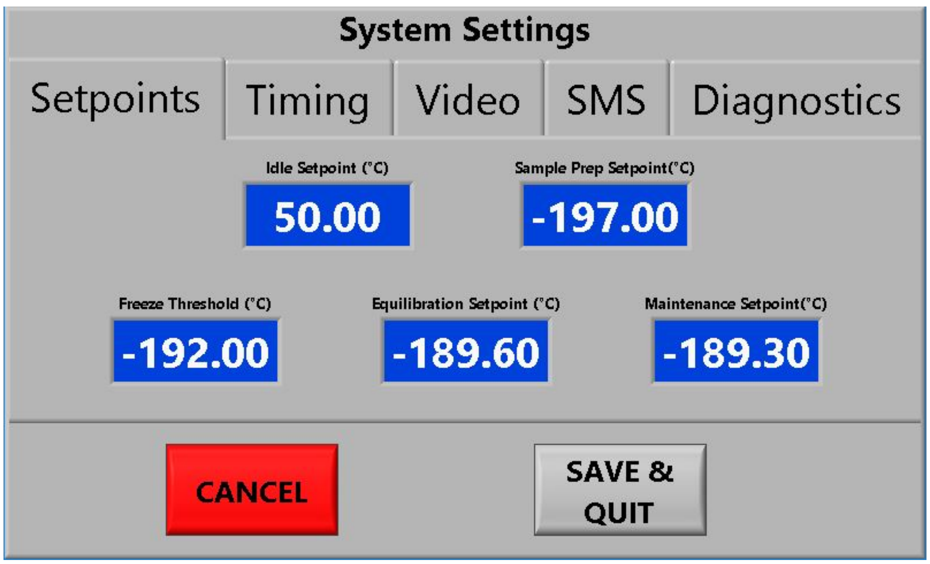


Figure 4 - Setpoint Settings Tab

2.1.2.2 Timing

Figure 5 shows the "Timing" tab. This tab contains all of the timing parameters utilized by the system in operation, including freeze time, equilibration time, remote fill enable, default heat pulse, and auto-advance.

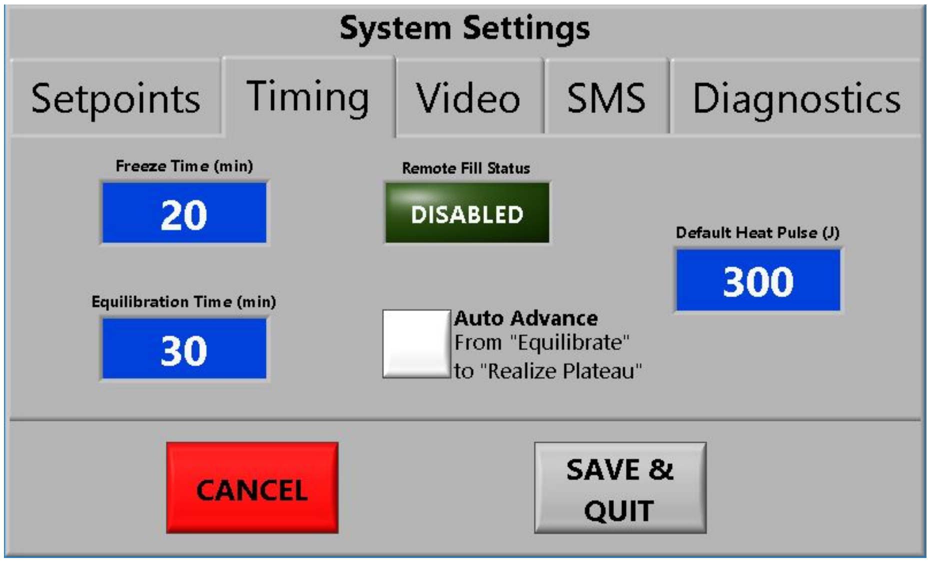


Figure 5 - Timing Settings Tab

2.1.2.3 Video

Figure 6 shows the "Video" tab. This tab contains links to all of the training videos embedded in the system, as well as check boxes that allow the user to enable/disable the system prompts to view these videos in context.

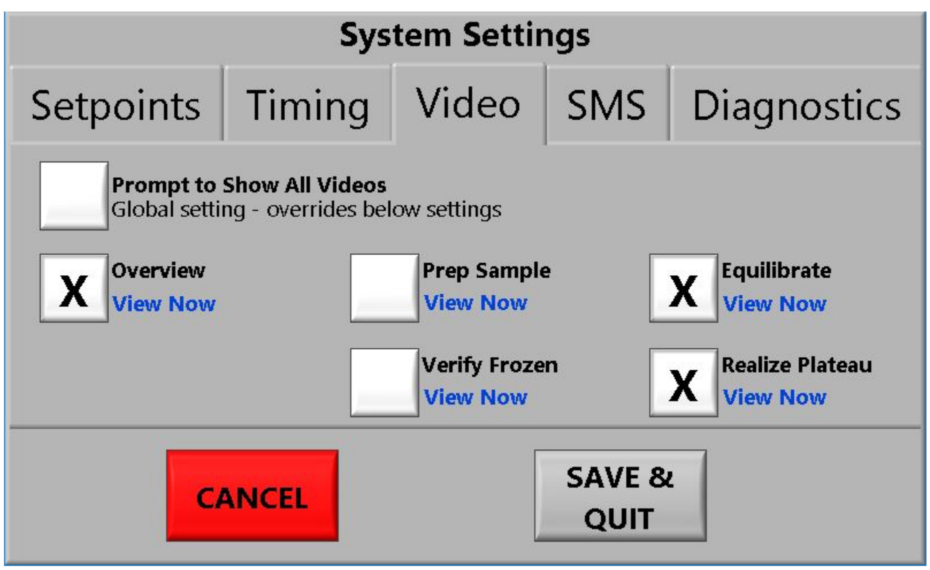


Figure 6 - Video Settings Tab

2.1.2.4 SMS

Figure 7 shows the "SMS" tab. This tab contains settings associated with text alerts. From here, the user can connect the system to a local Wi-Fi network. This will allow the system to send text alerts, if enabled. On the right side of the screen, the user can enter their cell phone details. A "Test" button is also accessible, which allows the user to ensure the system is properly set up to send alerts.

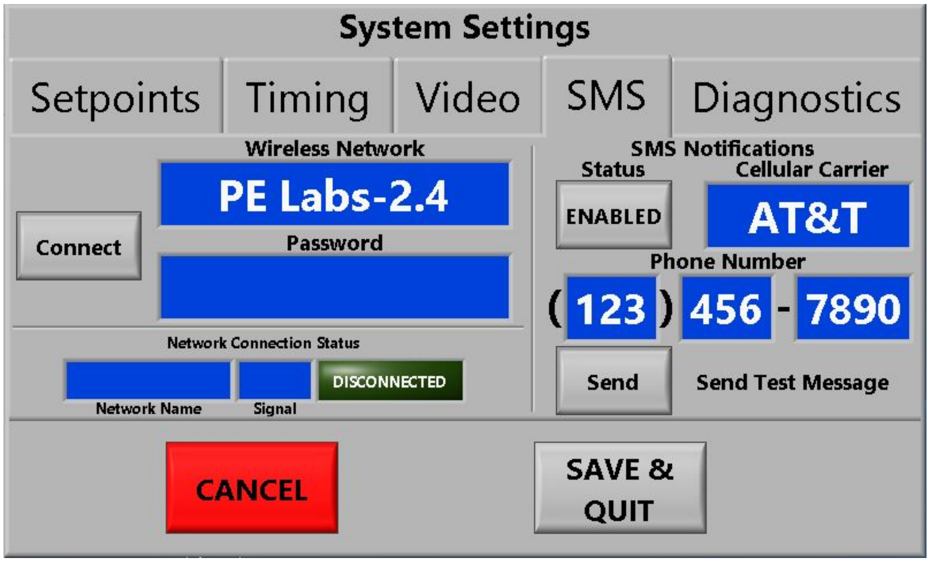


Figure 7 - SMS Settings Tab

2.1.2.5 Diagnostics

Figure 8 shows the "Diagnostics" tab. In the event that the system requires diagnostics/debugging, this tab contains information that will be helpful in identifying any fault that may be present in the system. From this screen, the user also has access to the Vars Array. These controls allow access to variables stored in the system's memory. It is strongly recommended that before modifying any of these variables, 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.

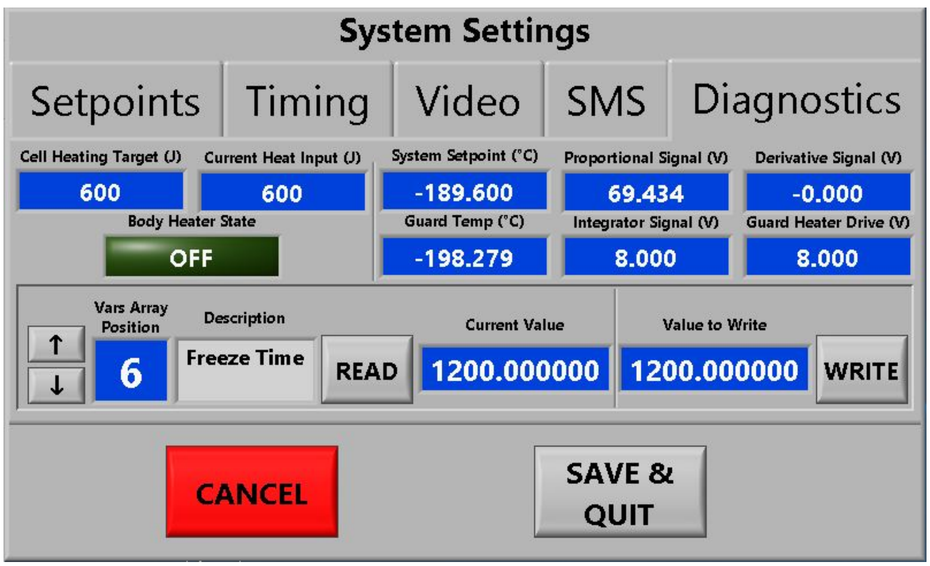


Figure 8 - Diagnostics Tab

****DO NOT ADJUST VARS ARRAY WITHOUT FIRST CONSULTING FACTORY!!!**** Doing so can cause severe damage to the system and could be very dangerous.

****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 +50 degrees C
1	Idle Setpoint Temperature (Power ON)	-191.0 degrees C	+25 to +50 degrees C
2	Maintenance Setpoint Temperature	-189.2 degrees C	-197 to -189 degrees C
3	Sample Prep Setpoint Temperature	-197.0 degrees C	-197 to -189 degrees C
4	Equilibration Setpoint Temperature	-189.0 degrees C	-197 to -189 degrees C
7	Cell Heater Enabled		1- Enabled, 0 - Disabled
11	TPW value for core sensor – Ohms	100.0	See Calibration Log
12	ITS-90 A Coefficient Below 0.01	0.0	See Calibration Log
13	ITS-90 B Coefficient Below 0.01	0.0	See Calibration Log
15	Automatic freeze cycle control	0.0	0 = normal 1 = Initiate automatic freeze cycle
14	Guard Offset - Deg. C	0.0	-10.0 to 10.0
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
34	Remote Fill Control	1.0	0 = Inhibit Fill 1 = Normal Fill Mode 2 = Force Fill (Once full reverts to 1)
38	Measured guard sensor PRT resistance – Ohms	Current reading	
39	Measured guard Temperature– Deg. C	Current reading	
40	Averaged guard Temperature– Deg. C	Current reading	

2.2 Remote Interface Commands

If the K52 Argon Triple Point has been equipped with the optional USB/RS-232 Remote Interface, any host computer which can be set up as a system controller may be used to operate the K52 over the interface. Pond Engineering has software available for interfacing with the system variables using an IBM compatible or Macintosh computer with an available USB or RS-232 port. Custom software packages are also available to integrate the K52 as part of an automated lab. The system variables which can be accessed over the remote interface can be found in **Section 2.1.2.5**. Also available from our website is a copy of Pond Engineering's Remote Communication software. See section **2.2.1** for operation.

2.2.1 Pond Engineering Interface Software

Available for download from www.pondengineering.com is a copy of the Pond Engineering Remote Communication Software. This utilizes a simple command set by referencing a variable and setting the program to read or write to that variable.

Installation

To begin the installation, open the *.exe* file downloaded from www.pondengineering.com. From there follow the prompts to install the software.

Usage

To start the software go to Start – Program Files – PE Interface_vXX. The screen should appear as shown in **Figure 9**.

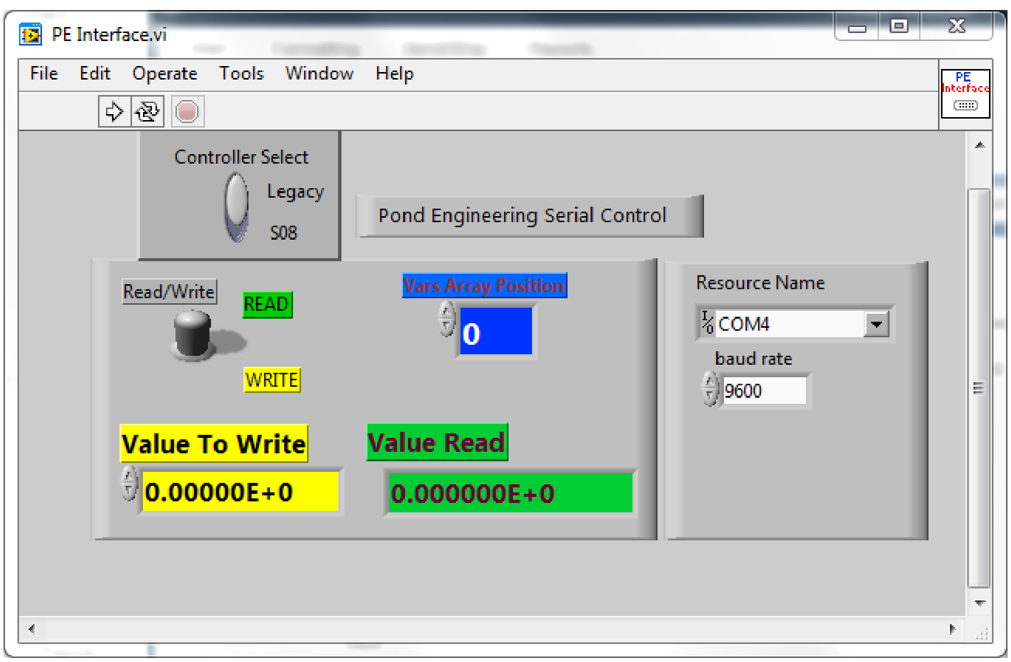


Figure 9 - PEL Interface Screen

From here you can select the Variable Number (blue) that you wish to change/read, set the program to Read or Write to the selected variable. If you wish to write to a variable, enter the number in the yellow "Value To Write" box. Click the white "run" arrow in the top left corner to run the program and receive or write the value. The values read will show in the green "Value Read" box. If you need to change the timeout, byte count, or Instrument Address you can do so here in the indicated windows.

2.2.2 K52 Argon Triple Point Command Set

The command set for the system is outlined in the following paragraphs. The commands are issued from the host computer which acts as the controller. The K52 acting as the slave listens when addressed as a listener, talks when addressed as a talker, but does not issue a service request (SRQ).

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 over the bus. The system has a one second write time-out, 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 system's alarm temperature, the user would send the character string: R05. The controller in charge would then address the system as a talker and wait for the data to be returned.

> ****Note: Control of the K52 remains the highest priority even when the system is in remote mode and may put off responding to remote commands for as long as 500ms.**

For Example, having been addressed as a talker, the K52 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.

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 a decimal with at least seven significant digits, not to exceed 15 digits in length.

> ****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 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 variable was received by the system correctly. This is especially important when setting the RTPW's and calibration coefficients, since an errant RTPW or coefficient may cause the system to go out of calibration.

3. Normal Operating Procedures

Outlined below are recommended operating procedures for realizing the argon triple point utilizing the Model K52 apparatus with liquid nitrogen as the coolant.

3.1 Preparing the System

Connect the system to an appropriate power source consistent with the input power designation on the system serial number placard (Normally 85 to 265 VAC at 2 Amps) and the compressed air source (40 to 150 psig). Also connect the Liquid Nitrogen source. Switch on the power and verify proper operation of the controller and normal display in accordance with the controller description as contained in **Section 2.1.1**. Establish a system setpoint of -189.6 °C or below. This can be done automatically by pressing the “Prepare Sample” button on the front panel.

Automatic Fill - Units need only to have LN2 available at the LN2 connection port to begin the cool down process and fill the internal storage dewar. This connection is made by attaching one end of a suitable liquid transfer line (preferably insulated) to a pressurized LN2 source, and the other to the 1/2” O.D. flare fitting located on the back of the unit. Ensure any valves on LN2 source are opened at this point. The filling process should be completed automatically within approximately 30 minutes.

****NOTE: The automatic fill solenoid valve will open and close periodically during the fill process. This is normal, and is meant to help prevent the valve from freezing in either state.**

****NOTE: During an automatic fill, some frost may develop on the solenoid valve and internal LN2 lines. As these lines warm up following a fill, the frost will melt, and may appear as though the system is leaking. This is not the case. Rather, the "leakage" is actually moisture that has condensed out of the room air, and is dripping from the exterior of the valve and exposed sections of the fill line.**

****NOTE: The system can be forced to fill from the pressurized LN2 source by pressing the “Force Fill” button on the normal display. Conversely, an automatic fill can be cancelled by pressing the “Cancel Fill” button.**

Manual Fill - Filling the internal storage dewar (approx. liquid capacity 10 liters) with liquid nitrogen will begin the cool-down process. Take the usual cautions to accommodate the escaping nitrogen gas and 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 approximately 7” (18 cm) below the top of the cabinet and the system allowed to cool unattended.

To manually fill the system, 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 10** below.

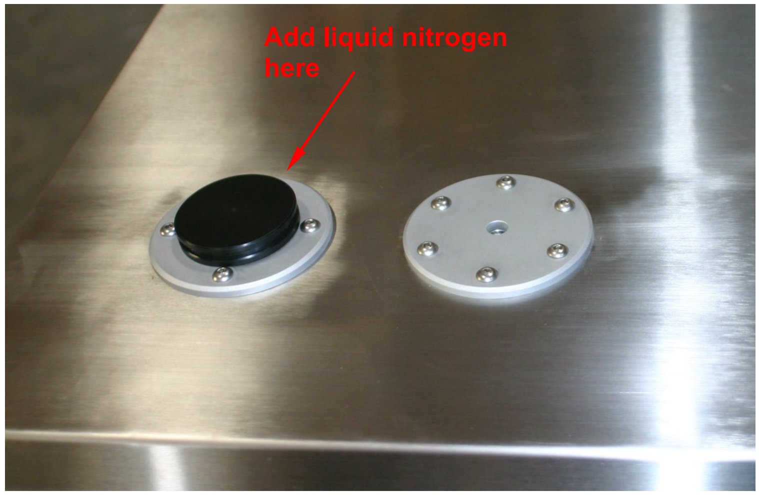


Figure 10 - Manual Liquid Nitrogen Fill Port

3.2 Prepare Sample

The realization process is started when the user presses the “Prepare Sample” button. Doing this will change the setpoint to the “Sample Prep Setpoint”, and cause the system controller to increase the upper dewar fill level and allow liquid nitrogen to enter the cell thermometer well through the liquid ports, flooding the thermowell. This is referred to as a “freeze cycle”. The amount of nitrogen vapors escaping the top of the thermowell will increase during this process. The liquid nitrogen is then able to remove heat directly from the cell center well and cool the system much more rapidly, completely freezing the argon sample. While this cycle is in process, the message window will display ”Flooding cell to freeze Argon sample”. During this process it is normal for the guard temperature to be cooled to well below the system controller setpoint since the presence of LN2 in the thermowells overwhelms the controller heater output by a large margin.

****NOTE: Some liquid nitrogen may escape from the system at the top of the cabinet during this process.**

Keeping the system setpoint between -189.2 and -189.8 °C during this process will allow the system to begin warming the cell toward the argon triple point temperature as soon as the cycle ends. The freeze cycle will end once the guard temperature has been below the “Freeze Threshold” for the “Freeze time. These parameters can be adjusted through the system settings, as explained in **Section 2.1.2** of this manual. After the cycle is completed (approximately 15 to 30 minutes, depending on the system temperature when the cycle was started) the internal shields and cell will have been cooled to the point where the argon gas sample will have condensed in the cell envelope and been frozen.

Once the freeze cycle completes, the message window will display “Freeze Cycle Complete. Verify LN2 Presence”. If configured, the system will also send an alert via text message, notifying the user that the freeze cycle has completed. (See **Section 2.1.2.4** for instructions on setting up text alerts) It is recommended that a room temperature thermometer or glass rod be fully inserted into (and immediately withdrawn) the well to displace and boil off any liquid nitrogen remaining in the well. This process is repeated until all of the LN2 has been displaced from the thermowell. The system will prompt the user to report the presence (or absence) of LN2 in the thermowell. If the user presses the “LN2 Present” button, the system will automatically advance to the “Equilibrate” stage. If there is no boil off or sputtering once the room temperature thermometer or glass rod is inserted, the user should press the “LN2 Not Present” button. This will initiate another freeze cycle, as the absence of LN2 in the thermowell indicates the cell may not be completely frozen.

****NOTE: Be careful to protect yourself from the cold gas and liquid that will escape from the thermowell as the nitrogen is displaced.**

3.3 Equilibrate

Once the cell has been verified to be frozen, A check thermometer (inserted near room temperature if desired) may be used to monitor the temperature of the cell at this time as the system is allowed to equilibrate to a temperature close to the argon triple point (a setpoint of -189.6 °C is recommended). It is recommended that a paper towel be secured around the exposed stem of the thermometer, adjacent to the aluminum bezel. This prevents condensation from entering the thermowell around the thermometer, potentially freezing the thermometer in place. Heat pulses may be applied using the system controller functions if desired to decrease the time necessary to complete the warming process. To apply a heat pulse, press the “Add Pulse” button, set the desired number of Joules to be added in the pulse, and press the green “check” mark. During a heat pulse, the message window will display the cumulative energy added, as well as the energy target.

****NOTE: A 300 joule pulse will increase the temperature of the cell and solid sample approximately 1.5°C when the sample is completely frozen.**

****HINT: An 800 joule pulse, along with insertion of a room temperature thermometer for monitoring will increase the temperature of the cell and solid sample from -196°C to -189.6°C starting with the sample completely frozen.**

The length of the equilibration process is determined by the “Equilibration Time” setting, and must be approximately 30 minutes. This setting defines the amount of time during which the measured guard temperature must be within ±0.15°C of the Equilibration Setpoint. The equilibration stage concludes when this criteria has been met.

If the system is configured to send text alerts, the user should receive a text at the conclusion of this stage, notifying the user that the system is ready to proceed to the next stage. See **Section 2.1.2.4** for more information on setting up text alerts.

3.4 Realize Plateau

When the sample is confirmed to be completely frozen, and has been allowed to equilibrate for a minimum of 30 minutes at a temperature between –190.0°C and –189.5°C (–189.6°C recommended), the user should press the “Realize Plateau” button. Alternatively, the system can be configured to automatically advance from the “Equilibrate” stage to the “Realize Plateau” stage (See **Section 2.1.2.2** for more information). This will change the setpoint to the “Maintenance Setpoint”. The system will then prompt the user to form the outer melt, or layer of liquid argon adjacent to the inner wall of the stainless steel cell wall. The user should initiate delivery of a 300 to 1000 Joule pulse of heat to the cell. This will cause the system to move up onto a plateau at the argon triple point as indicated by a check thermometer.

****NOTE: Additional heat pulses may be applied during the life of the plateau to verify that the system is on plateau. A 300 Joule heat pulse will typically result in less than a 0.000 3 °C spike in the sensed temperature of a check thermometer, with the spike lasting less than 10 minutes. Application of additional heat pulses will shorten the useable duration of a plateau.**

Once the outer melt is formed, the system will prompt the user to form an inner melt. This may be easily accomplished by removing the check thermometer and allowing it to warm. After the thermometer is near room temperature, it can be reinserted into the cell to form the inner melt. Alternatively, a quartz rod, initially at room temperature, can also be used to form the inner melt. If using a rod, remove it from the system after approximately 5 minutes.

With the inner melt formed, the user should insert a check SPRT (if not already inserted), and verify the plateau with an external measurement system.

At this point the liquid nitrogen level in the storage dewar should be checked and the storage dewar refilled if necessary. Liquid nitrogen may be added to the storage dewar at any time without disturbing the thermal equilibrium of the system.

****NOTE: It is recommended that the user periodically (weekly to quarterly depending on conditions) verify that the calibration of the internal guard control sensor is within +/- 0.05 °C using a check thermometer. It is critical that the sample be completely frozen when verifying calibration or calibrating the internal sensor. During this check, supporting the check 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 and results in a much shorter time constant in the equilibration process. With the thermometer at the bottom of the well, several hours' time are typically required to equilibrate the system.**

3.5 Calibrating Multiple Thermometers

Multiple thermometers may be calibrated on a single plateau by inserting chilled thermometers into the thermowell.

****NOTE: The storage dewar fill port may conveniently be used to chill thermometers by directly inserting them into the fill port.**

Readings taken with a check thermometer before and after calibration of additional thermometers should agree within 0.000 5 °C.

****NOTE: The setpoint temperature may be varied while the system is on plateau to verify proper operation of the system. (See Section 2.1.2.1) A system setpoint change of 0.05 °C typically results in a sensible change on the order of 0.000 12 °C when measured by a check thermometer when the system is on plateau.**

3.6 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 cell, 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 17.7 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 thermowell, 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 or 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 12 hours or more to drive off excessive moisture.

4.1.1 Cleaning

The system cabinet is constructed of durable stainless steel, which is not affected by most solvents and cleaning agents. It is recommended that exterior surfaces be cleaned with alcohol or a mild, non-abrasive commercial cleaning agent.

4.1.2 Evacuation Procedures

Under normal operation, the system should maintain an adequate vacuum level in the internal dewar and cell vacuum jacket for several years. If considerable condensation on the exterior on the storage dewar or unusually short plateau durations are noted, or if the system exhibits inadequate cooling power, the dewar and cell vacuum jacket may be evacuated using the following procedure. If the system was recently manufactured, these symptoms may become evident within the first year of system use, and the dewar and/or vacuum jacket will need to be evacuated in order to return to optimal operation.

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.

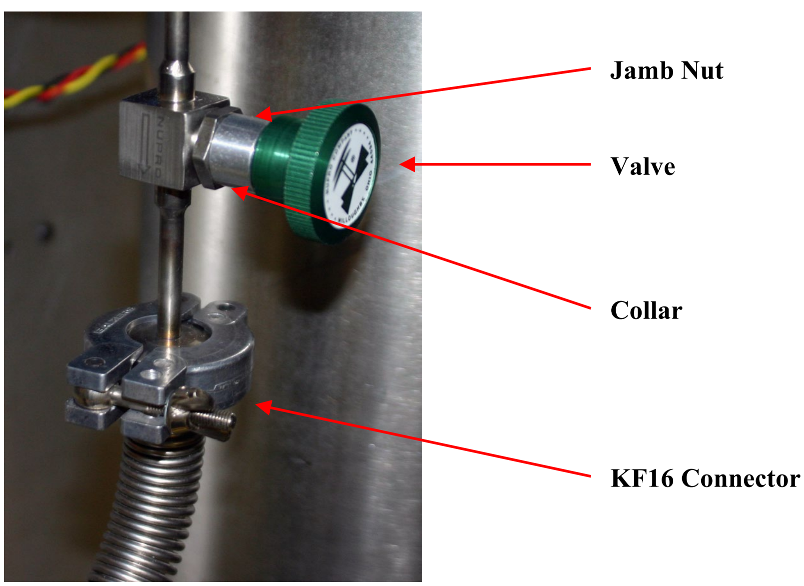


Figure 11 - Vacuum Connector Assembly

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.

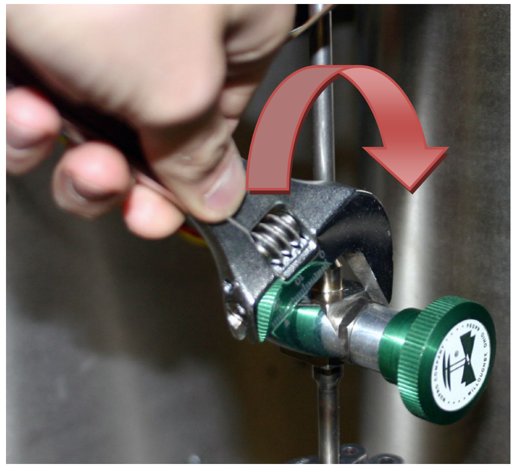


Figure 12 - Loosen Jamb Nut

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

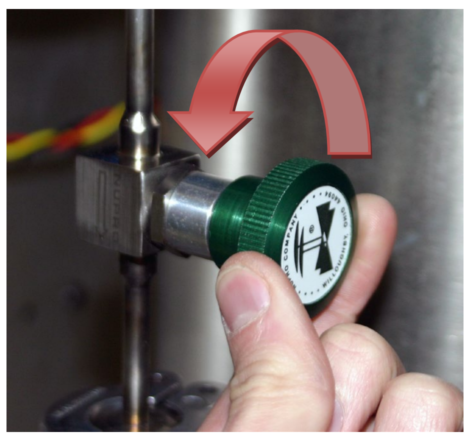


Figure 13 – Open Valve

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.

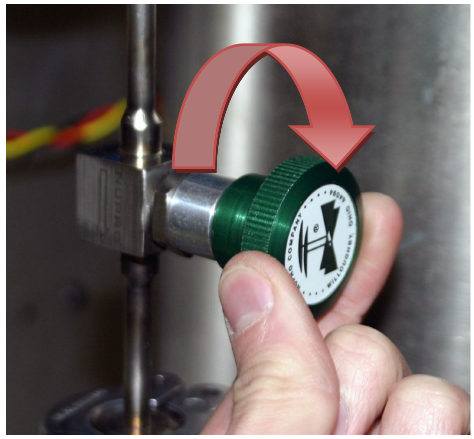


Figure 14 – Close Valve

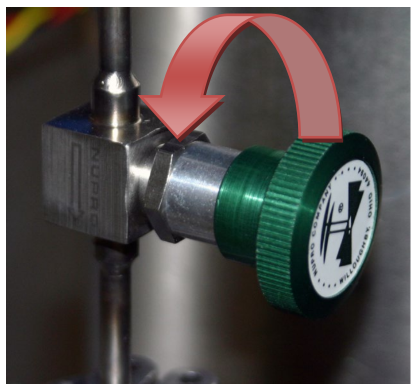


Figure 15 - Tighten Jamb Nut

6. Remove external high vacuum pump

5. 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.

3

5.1 Rear Panel

½" O.D Flare for Liquid Nitrogen fill

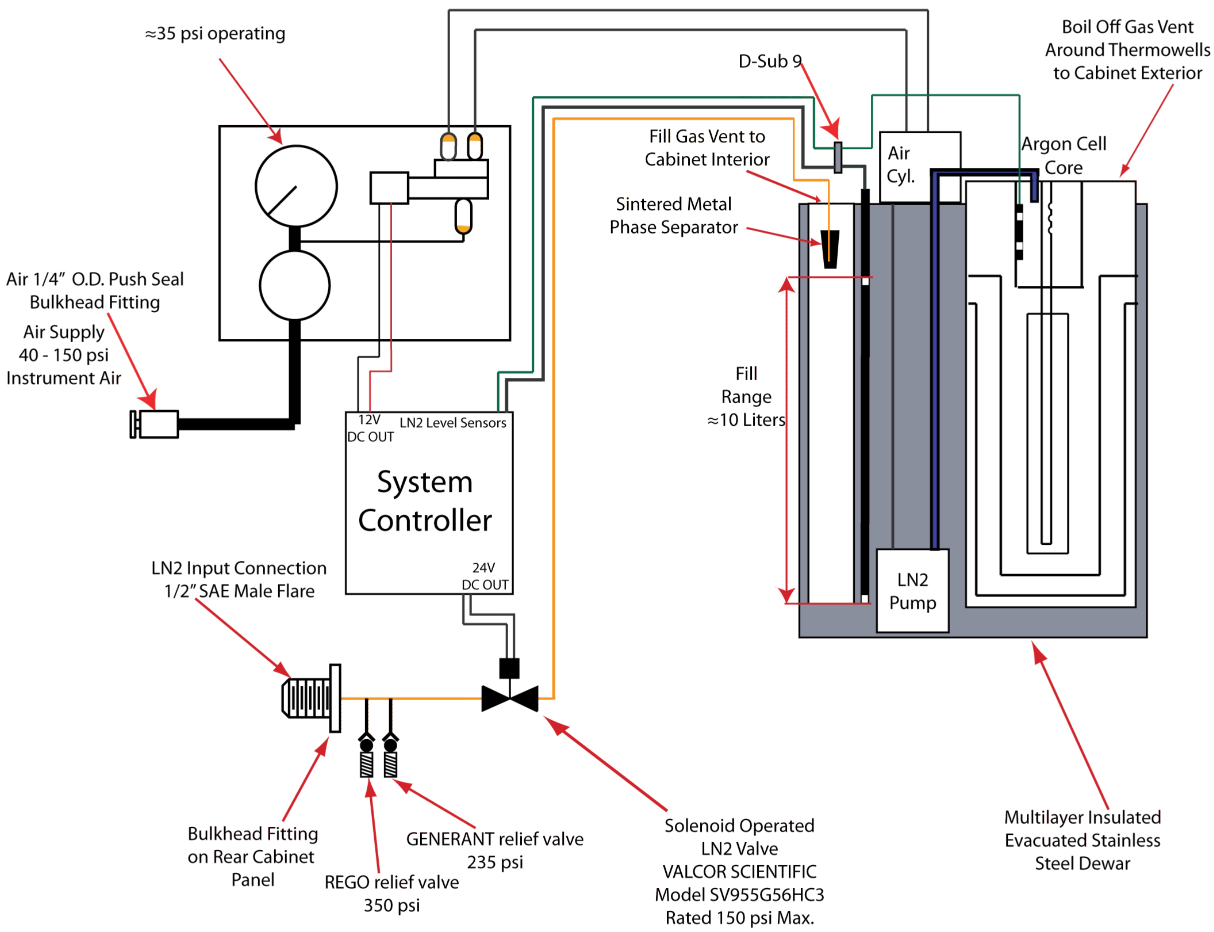
¼" Push-To-Connect Air Fitting

Communications Port (IEEE-488 shown)

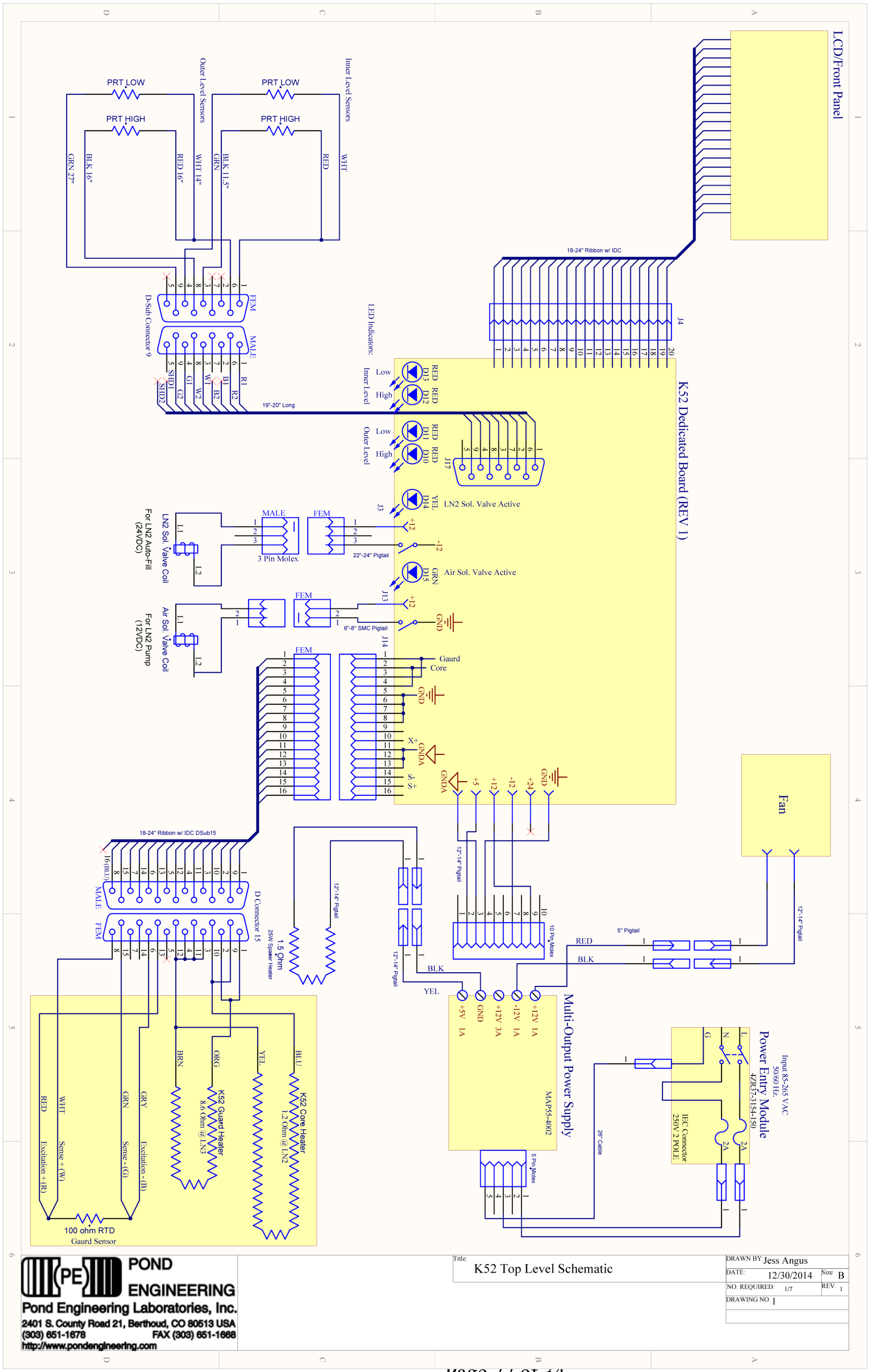
Power Entry Module

For push-to-connect fitting:
To insert hose, press into fitting
To remove hose, press on bulkhead and gently pull on hose

5.2 LN2 Control System Block Diagram



5.3 Top Level Schematic



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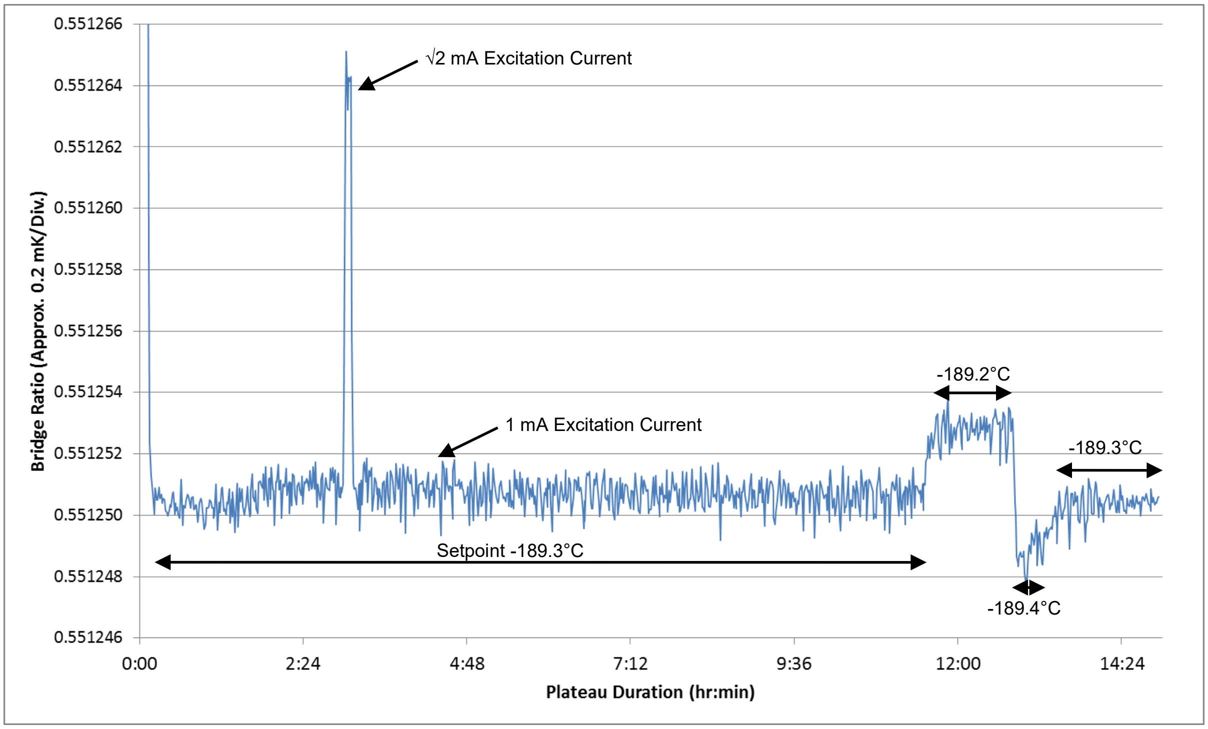
6. Calibration Record

Factory Calibrations:

RTPW: ______________ Coefficient A: ______________ Coefficient B ______________

Guard Offset	Date	Comments

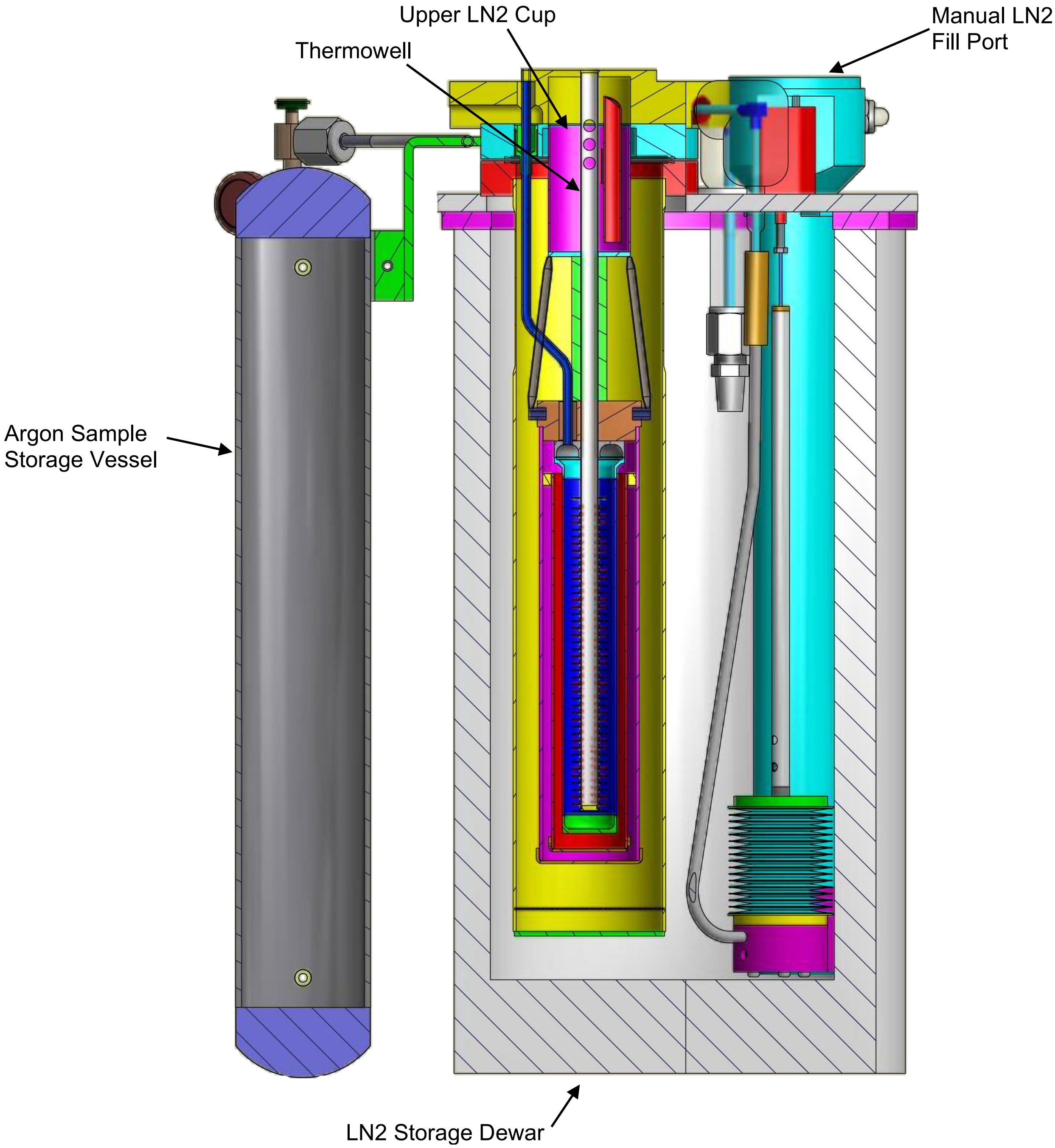
7. Graph of a Typical Plateau



YSI 8167 vs 10Ω standard in oil as measured by ISOTECH Micro-K 100

8. Cross-Sectional View of the K52

Following is a cross-sectional view of the Argon Triple Point Cell to assist the user in understanding the operation of the system.



9. Fixed Point Cell Certificate of Sample Purity

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