The Kryos
LN$_2$ Liquid Level Control
&
Cryogenic Temperature Control

Created for
Taylor-Wharton Gas Equipment

By
Pacer Digital Systems, Inc.

Kryos LN2 Liquid Level Control

Introduction

Thank you for purchasing this product. This state of the art controller can control either the liquid level and/or the temperature range in an LN2 freezer. The features that it offers are designed to provide a safe environment for samples while at the same time tracking all relevant information associated with the freezer. This control provides a complete historical record of the environment in your freezer and therefore, the environment in which your samples have been stored.

Text Format Notation

In this owners manual we use some special text formats to denote certain portions of the system. These are listed below:

- **MENU** is indicated in BOLD.
- ACTUAL MENU CHOICES are indicated in small caps.
- START FILL and STOP FILL sensor are indicated in small caps.
- *Specific Menu descriptions* under a main category are listed in italics

System Components

Interface Panel

The panel, which the user will see, contains the vacuum fluorescent display as well as the number keypad, power button, help button and the soft-key control buttons.

Main Control

The "brain" for the control system, "talks" to the interface unit and makes all decisions regarding liquid levels, temperatures, valve opening/closing, etc.

Sensor Assembly

Can be a 4 thermistor, an 8 thermistor or a 7 thermistor (freeze-guard) sensor assembly. The 4 thermistor assembly maintains the liquid level between the 2 middle sensors. The 8 thermistor assembly maintains the liquid level between the high sensor and the low sensor chosen by the user. The 7-thermistor assembly is similar to an 8-sensor assembly in that the user can select the START FILL and STOP FILL positions. The eighth position on this assembly is tied into a thermistor, which detects whether the valve is stuck open.

Lid Switch

Determines whether or not the lid is open on the freezer. This also allows the control to determine whether to activate the Quickchill or Auto Defog feature.

Solenoid Valve

This control was designed to work with 24 VAC solenoid valves manufactured by Valcor, Parker-Hannifin, ASCO or Alcon. It also works with 12 VDC solenoid valves if the battery backup option is used.

Thermocouples

Type T thermocouples determine the temperature in the freezer. Either none, 1 or 2 thermocouples can be used with this control at any time.

Wall Transformer

A 24 VAC, 40 VA Wall transformer is specified for use with the Kryos. A 16.5 VAC, 40 VA Wall transformer is specified for the battery backup option. These wall transformers have UL approval. UL approval for the Kryos system as a whole is not required since the control operates on low voltage.

Remote Alarm

Provides a remote alarm signal if an error condition occurs for a user defined period of time. The 3-pin jack provides continuity between pin #2(common) and pin #1 in the normal condition. Continuity between pin #2 and pin #3 is provided in an error condition.

Operation

Power

The control can be turned on and off by pressing the Power button on the front panel. This feature can be password protected to prevent unauthorized users from turning the system on and off from the front panel. More details about password protection are available under the security section of this manual.

Main Display Screen

The main display screen consists of 4 lines of information.

Line 1: Displays the current status of the control. It indicates if all systems are working fine or if any errors have occurred. Error messages disappear when the error is corrected.

Line 2: Displays the level sensing in the control. If a 4 thermistor assembly is being used, the control will indicate low if the liquid level is below sensor #2, normal if the liquid level is between sensor #2 and sensor #3, and high if the liquid level is above sensor #3. In addition, Low Level Alarm is indicated when the liquid level is below sensor #1 and High Level Alarm is indicated when liquid level is above sensor #4. If the 7-thermistor or 8-thermistor assembly is being used, the control will indicate actual liquid level in the freezer.

Line 3: Displays the temperature indicated by thermocouples #1 and #2. If either thermocouple is disabled through the menu system, it is no longer displayed on the front panel. If both thermocouples are disabled, line 3 is blank

Line 4: Used to annotate the soft-key buttons and to provide information about the valve and the lid.

The Menu System

Pressing the Menu button on the front right side of the control will access the menu system of the Kryos control. Choose a menu option by pressing the appropriate number of your menu choice. If more menu choices are available than will fit on 1 screen (4 lines), the left-hand soft-key button will give the "More" choice. Pressing this button will give the user the additional menu choices. A shortcut is available to get to the proper menu choice by pressing the appropriate number button. The menu choice need not be visible on the screen to select it.

When the menu is accessed, all control functions cease until the control returns to the main status screen. Therefore, if a fill is occurring and the menu is accessed, the solenoid valve is closed until the menu system is exited and the control is again displaying the main screen. If the menu system is accessed but not used for 3 minutes, it will automatically revert to the main screen.

Please note that the menu system can vary slightly depending on the configuration of the control. Menu choices will be included or excluded depending on the selected features in the Kryos control. This is illustrated in the menu system when the 4-sensor or the 8-sensor probe assembly is being used. The *START FILL* and *STOP FILL* sensor must be physically set when the 4 sensor probe is in use, so the *START FILL* level and *STOP FILL* level menu items are not displayed. When the control operates with the 8-sensor assembly, the user can set the *START FILL* and *STOP FILL* levels without physical intervention to the sensors so these menu options are displayed.

Help

The Help button provides help to the user at any point in the menu system. The help message is displayed and the user is then prompted to press a button to return to the menu system.

Temperature

Thermocouple Selection
The temperature is determined in the system through the use of 1 or 2 Type T thermocouples. The thermocouples should be placed in the system to accurately reflect the temperature at the point of placement. Please note that if the thermocouples are placed in the same tube as the sensor assembly, heat rising from the thermistors may warm the thermocouples sometimes affecting the temperature by as much as 15° to 30° C. Both thermocouples can be activated/deactivated through the menu system. (**MENU**, 1,1)

Calibration
The Kryos provides easy calibration of the thermocouples. To calibrate, the user should enter the menu system (**MENU**,1,2) and dip thermocouple #1 into ice water. The fourth line of the display will indicate "Wait" and will give a reading on the proximity of the temperature to 0° C. When the temperature reaches equilibrium the control will indicate "OK" and the user can press the left soft-key button. Dry the thermocouple. Next, the user should dip thermocouple #1 into LN2 and wait

as the temperature again reaches equilibrium. When it does, the control will again indicate "OK" and the user can again press the left soft-key button. The control will then indicate that the temperature has been calibrated. Please note that both thermocouples are calibrated by going through this process with Thermocouple #1.

Temperature Circuit Check

The temperature system can be checked at any time through the menu system (**MENU**, 1,3). This check will tell if the thermocouples are working or if they are "open". If a thermocouple is not connected to the control it will check as "open." If a thermocouple is "disabled" through the menu system, it will not show up on the check.

Level Sensing

The level sensing in the system is determined through the use of thermistor based sensor assemblies. Thermistors are thermal resistors whose resistances change as temperature changes. Their use in liquid level control is a time tested method to provide accurate results. The Kryos uses an 8, 7 or 4 thermistor assembly to determine liquid level in the freezer. The 4-sensor assembly provides general information about liquid level (high alarm, high, normal, low and low alarm) while the 7 and 8 thermistor assemblies provide liquid level readings accurate to the nearest inch.

When the LN_2 level drops below the *START FILL* sensor the control opens the solenoid valve to commence the fill process. This process continues until the LN_2 level reaches the *STOP FILL.* When the control "senses" that the LN_2 has reached the upper level, it flashes "Check" on the display while the Kryos insures that it has not received false signals. The fill process can be halted before it reaches the *STOP FILL* sensor by manually pressing the stop button.

Sensor Testing

The sensor assembly can be tested through the menu system (**MENU**, 2,1). The sensor diagnostics indicates the sensor number and the status of that sensor. If the control is set for an eight-thermistor or freeze-guard sensor it will indicate 8 sensors in the diagnostics. Likewise, if it is set for a four-sensor assembly, it will indicate 4 sensors. The status is indicated with either an "O" for open, a "G" for gas or an "L" for liquid. This is an easy means to tell if sensors are in or out of liquid or if a new sensor assembly is needed (open sensors).

Sensor Offset

A sensor offset can be set through the menu system of the control (**MENU**, 2, 2). The offset is used if the sensor assembly is raised off the floor of the freezer and the user wants to read the actual liquid level on the display. An example of this would be a *STOP FILL* setting of 23" and a *START FILL* setting of 20". The 8-thermistor sensor assembly would be set so that the bottom of the sensor assembly is raised 18" off the floor of the freezer. The level would then read from 18" to 26". The low level alarm would be set at 19" since the *START FILL* is 20" and the high level alarm would be 24" since the *STOP FILL* is 23." In normal operation, the liquid level would read between 20" and 23." The offset would be

set to 18." The control determines the liquid level by adding the offset to the number of thermistors in LN2. The offset can be set from 0 to 40 inches.

Level Selection

The *START FILL* and *STOP FILL* sensor positions can be set through the menu system of the control (**MENU**, 2,3). *START FILL* and *STOP FILL* need to be set if an 8-thermistor sensor or the freeze-guard sensor is being used. If an offset is being used, it is added to the sensor position to indicate the correct level of the sensor from the floor of the freezer. The *STOP FILL* sensor must always be higher then the *START FILL* sensor. Therefore, if *START FILL* is being increased where it would pass the *STOP FILL* point, the *STOP FILL* is also increased so that it is always 1" higher than *START FILL*. The converse is true for the *STOP FILL* when it is being decreased. A four thermistor sensor assembly requires that the *START FILL* and *STOP FILL* sensors be physically located at the correct position. Because of this the menu selection for setting the *START FILL* and *STOP FILL* becomes inaccessible when the 4-thermistor sensor is being used.

Sensor Selection

The sensor type can be set through the menu system (**MENU**, 2, 4). The sensor type selection should match the sensor type that is being used in the system. This is a 4-sensor, a 7-sensor (Freeze-guard) or an 8-sensor array.

If the sensor assembly is unplugged and the main control is still on, the Kryos will indicate that a sensor error has occurred. In addition the level indicated would be 8" on an 8-sensor assembly, 7" on a freeze-guard assembly or "High Alarm" on a 4-sensor assembly. This occurs because the control cannot differentiate between a very high resistance (when a thermistor is in LN2) and an infinite resistance (when an open circuit appears in the level sensing circuitry).

Alarms

The Kryos control tracks many different conditions in the freezer and therefore, has a full complement of alarms associated with these different conditions. As alarms occur, they cause an audible beep as well as a flashing red light. A remote alarm relay is also triggered following a user designated period of time after the error condition occurs if it is not corrected. In addition the error condition is displayed on the top line until the error condition is corrected.

The High Temperature Alarm for Thermocouple #1 can be set through the menu system (**MENU**, 3, 1). This alarm is activated if the temperature rises above the designated temperature. The alarm temperature can range from 0° C to -190°C. It can also be Disabled.

The *High Temperature Alarm for Thermocouple #2* can be set through the menu system (**MENU**, 3, 2). This alarm is activated if the temperature rises above the designated temperature. The alarm temperature can range from 0° C to -190°C. It can also be Disabled.

The *Low LN2 Supply Alarm* can be set through the menu system (**MENU**, 3, 3, 1). This alarm is activated if the solenoid valve is not closed within a designated time

period after a fill starts. The solenoid valve can be closed either automatically (the LN2 level reaches the *STOP FILL* sensor) or manually (the stop fill button is pressed) to stop the timer which activates this alarm. The possible choices for this alarm are None, 15, 30, 45, 60 minutes, 2 or 3 hours.   This error does not correct itself until the fill is stopped (the solenoid closes).

The *Sensor Error Alarm* can be set through the menu system (**MENU**,3,3,2). This alarm is activated if the control detects a sensor error such as an open sensor. The possible choices are "enabled" or "disabled."

The *Remote Alarm Timer* can be set through the menu system (**MENU**,3,3,3). This is the amount of time allowed to pass before the remote alarm relay is triggered if an error condition is not corrected. The possible choices are None, Immediate, 30, 60 minutes or 2 hours.

The *Lid Open Too Long Alarm* can be set through the menu system (**MENU**,3,3,4). This is the amount of time the lid can be opened before it triggers an alarm condition. The possible choices are None, 1, 2, 5 or 10 minutes.

The *Thermocouple Alarm* can be set through the menu system (**MENU**,3,3,5). This alarm is activated if either thermocouple experiences an open circuit. The possible choices are "enabled" or "disabled."

The *audible, visual and remote alarms* can be tested at any time by the user through the menu system (**MENU**, 3,4). Follow the instructions on the display to hear the audible "chirping" indicator of an alarm or to see the red LED flash or to trigger an immediate relay closure of the remote alarm.

Logging

The on board memory logging function is one of the most powerful and useful features of the Kryos control. It provides a historical record for not only your freezer but also a complete record of the environment in which specimens were stored. Four separate logs are kept in the control: 1) System log 2) Error log 3) Temperature #1 log 4) Temperature #2 log. System logs are events that occur in the system such as lid opening/closing, LN2 filling, Quickchill, Defog, Etc. Error logs are off-normal conditions detected by the system.   The two temperature logs are simply records of the temperatures recorded by the two thermocouples in the system.   The system and the error log each hold 4096 events while the combined temperature logs hold 32,765 temperature events. All the logs are kept in non-volatile memory, meaning that the information is saved regardless of whether the control has power.

When an event (system, error or temperature) occurs, the Kryos does 2 things with the data: 1) It enters the beginning or the conclusion of an event in the internal memory of the controller 2) It sends the event data to the serial port of the freezer. The Kryos consolidates the events in the internal log (combining "start event" / "conclude event" information to provide one event with duration), however, when the data is sent to the serial port no consolidation of data occurs. As an example, a fill would provide 1 log entry in the internal log of the control,

indicated as follows: Fill occurred on 9/28/98 @ 8:07 for 24 minutes. The same data coming out of the serial port would cause two entries in a computer or printer and would be indicated as follows:

```
Fill Started on 9/28/98 @ 8:07
… {elapsed time}
Fill occurred on 9/28/98 @ 8:07 for 24 minutes
```

Menu Access causes the control to make some decisions on logging an event and they are handled in the following manner: Temperature is immediately logged (if it is enabled) and then a fresh time period is started when the Menu system is exited. System and error logs are placed in a suspended state until the control exits the menu system and then timing is started again.   Duration of system and error logs then are total time of the event less any time that the user was in the menu system.

When logs are dumped to the serial port, the oldest events are sent first. The control operates on the FIFO (First In First Out) method.

DUMP SYSTEM LOGS is accessible through the menu system of the control (**MENU**, 4,1,1). This option sends data from the Kryos system logs to the serial port of the freezer. When this option is chosen the display reports how many system logs are in the system. While the data is being sent to the serial port, it can be paused or completely cancelled through the menu system.

DUMP ERROR LOGS is accessible through the menu system of the control (**MENU**, 4,1,2). This option sends data from the Kryos error logs to the serial port of the freezer. When this option is chosen the display reports how many error logs are in the system. While the data is being sent to the serial port, it can be paused or completely cancelled through the menu system.

DUMP TEMP LOG #1 and *TEMP LOG #2* are accessible through the menu system of the control (**MENU**, 4,1,3 or **MENU**, 4,1, 4). This option sends data from the Kryos temperature logs to the serial port of the freezer. When this option is chosen the display reports how many temperature logs are in the system. While the data is being sent to the serial port, it can be paused or completely cancelled through the menu system.

SENS. ERR. LOGGING is accessible through the menu system of the control (**MENU**, 4,2,1). This menu choice turns on/off the logging of all sensor errors.   The choices are enable or disable. Records in the error log.

LOW SUPPLY LOGGING is accessible through the menu system of the control (**MENU**, 4,2,2). This menu choice turns on/off the logging of the low LN2 supply error. The choices are enable or disable. Records in the error log.

REMOTE ALARM LOGGING is accessible through the menu system of the control (**MENU**, 4,2,3). The menu choice turns on/off the logging of the remote alarm activation. The choices are enable or disable. Records in the error log.

THERMOCOUPLE OPEN Logging is accessible through the menu system of the control (**MENU**, 4,2,4). This menu choice turns on/off the logging of the thermocouple open alarm. The choices are enable and disable. Records in the error log.

HIGH TEMP #1 LOG is accessible through the menu system of the control (**MENU**, 4,2,5). This menu choice turns on/off the logging of the high temperature alarm for Thermocouple #1. The choices are enable and disable. Records in the error log.

HIGH TEMP #2 LOG is accessible through the menu system of the control (**MENU**, 4,2,6). This menu choice turns on/off the logging of the high temperature alarm for Thermocouple #2. The choices are enable and disable. Records in the error log.

TANK FILL LOGGING is accessible through the menu system of the control (**MENU**, 4,3,1). This menu choice turns on/off the logging of tank filling operations. The choices are enable or disable. Records in the system log.

LID OPENING/CLOSING LOGGING is accessible through the menu system of the control (**MENU**, 4,3 2). This menu choice turns on/off the logging of lid openings and closings. The choices are enable or disable. Records in the system log.

USER ACCESS LOGGING is accessible through the menu system of the control (**MENU**, 4,3 3). This menu choice turns on/off the logging of user access codes, which are requested when the lid is opened. Records in the system log.

Temperature Logging Rates for thermocouple #1 (*T/C #1 LOGGING*) and thermocouple #2 (*T/C #2 LOGGING*) are accessible through the menu system of the control (**MENU**, 4,4,1 or **MENU**, 4,4,2). This menu choice adjusts the rate at which temperatures are logged for the two thermocouples. The possible choices are Disabled, 15, 30 minutes, 1,2,4,6,12 or 24 Hours. Records in the temperature logs.

ERASE LOGS is accessible through the menu system of the control (**MENU**, 4,5). This menu choice erases any of the four logs found in the control. Please note that once a log has been cleared it is gone forever.

ERASE SYSTEM LOGS	(**MENU**, 4,5,1).
ERASE ERROR LOGS	(**MENU**, 4,5,2).
ERASE TEMPERATURE LOG #1	(**MENU**, 4,5,3).
ERASE TEMPERATURE LOG #2	(**MENU**, 4,5,4).

Security

The security features of the Kryos control restricts access to certain key features such as power and the menu system.

The *POWER-ON PASSWORD* can be set through the menu system of the control (**MENU**, 5,1). The power-on password requires entry of a 4 digit password before turning on or turning off the control. Follow the directions on the display to set a

new password or disable a password. Password 9999 is an invalid choice since this is used to access the procedure to clear the password if it is forgotten.

The *MENU PASSWORD* can be set through the menu system of the control (**MENU**, 5,2). The menu password requires entry of a 4 digit password before allowing access to the menu system to change any control settings. Follow the directions on the display to set a new password or to disable a password. Password 9999 is an invalid choice since this is used to access the procedure to clear the password if it is forgotten.

When the menu password is active, it is possible to review all of the control settings without having the password. When a password is activated and the user presses the menu key, two choices are available:

1) *MENU (PASSWD REQ)*
2) *CONTROL SETTINGS*

By selecting choice #2 the user can go through the menu system and see all of the settings in the control. In this mode, the user cannot change any settings.

If either the power-on or the menu passwords are forgotten, the user can reset the password by typing in 9999 when asked for the password. The Kryos will display an 8-digit number. Call your distributor or Taylor-Wharton with the 8-digit number to obtain a unique 8-digit number to type into the control. When this number is entered, the passwords will be cleared and full access to the control is restored.

User Options

The user options menu choice covers all other control settings not already covered. These include serial port settings, date and time settings, Lid Settings, Defog, Quick-chill, Temperature Control, Valve Freeze-guard, Display brightness and Control Information.

RS-232 SETTINGS can be changed through the menu system of the control (**MENU**, 6, 1). These settings can be changed to interface with different types of data terminal equipment such as printers, computers and modems. If the RS-232 is enabled the handshaking can be turned on and off. This feature allows two devices to communicate when sending data. Also the baud rate can be set. The following speeds can be chosen: 300, 1200, 2400, 4800, 9600 or 19200 baud.

TIME AND DATE SET can be changed through the menu system. (**MENU**, 6,2,1). The date and time will be set at the factory (Central Time), however, different time zones will need to adjust this according to their time zone. This control is Year 2000 compliant and operation will continue uninterrupted into the Millenium. A coin cell battery backs up the date and time on the control.

DEFOG TIMER SET can be changed through the menu system of the control (**MENU**, 6,2,2,1). This is the time interval that the valve is opened when the user presses the defog button. The possible choices are Disabled through 90 seconds.

LID SWITCH SETUP can be set through the menu system of the control (**MENU**,6,2,2,2). This option enables or disables the lid switch.

AUTO DEFOG TIMER SET can be changed through the menu system of the control (**MENU**, 6,2,2,3). This option sets the time interval that the valve is opened on an auto defog (when the lid is opened). The possible choices are Disabled through 90 seconds. The lid switch must be enabled to use this feature.

QUICK CHILL TIMER SET can be changed through the menu system of the control (**MENU**, 6,2,2,4). This option sets the time interval that the valve is opened on a quick chill (when the lid is closed). The possible choices are Disabled through 90 seconds. The lid switch must be enabled to use this feature.

CONTROL BY TEMP can be set through the menu system of the control (**MENU**, 6,2,3). This option provides that the Kryos will control by temperature around Thermocouple #1. The Temperature Control menu choices are only available if thermocouple #1 is enabled.

TEMP CTRL SETTINGS can be set through the menu system of the control (**MENU**, 6,2,3,2,1). The user can set the temperature that must be maintained in the freezer around thermocouple #1. The setpoint can be set from -180° to -100° C.

CONTROL RANGE can be set through the menu system of the control (**MENU**, 6,2,3,2,2). The user can set the acceptable range of temperature around the control point temperature. The system uses less LN2 to control within a wide range and more LN2 to control within a tight range. The range can vary from $\pm 1^{\circ}$ to $\pm 15^{\circ}$ C.

FREEZEGRD OPTIONS can be set through the menu system on the control (**MENU**, 6,2,4). This allows variables to be set which attempt to prevent the cryogenic solenoid valve from freezing open.

VALVE OPN DURATION can be set through the menu system of the control (**MENU**, 6,2,4,1). This is the maximum amount of time that the valve is allowed to stay open at any one time. If the valve begins to freeze open on long fills, the valve open duration time should be shortened. The possible options are Disabled, 1-15 minutes.

VALVE DE-ICING can be set through the menu system of the control (**MENU**, 6,2,4,2). This option works in conjunction with the freeze-guard sensor. If the freeze-guard sensor indicates that the valve is stuck open, the control attempts to free up the valve by quickly attempting to open and close the valve. It will make this attempt 5 times with a 2 minute time interval between attempts. De-icing is also attempted if the control senses a high level alarm condition.

DISPLAY BRIGHTNESS can be set through the menu system of the control (**MENU**, 6,3). This option changes the intensity of the display. The possible choices are 25%, 50%, 75% and 100%.

ABOUT THIS CONTROL can be found in the menu system (**MENU**, 6,4). This option provides information about the control. In particular it tells the serial number of the control and the software version that the control is running.

Quick-chill

The *QUICK CHILL* (**MENU**, 6,2,2,4) feature provides a burst of LN2 to the freezer to lower the temperature after the lid has been closed. This is activated through the lid switch. If the lid switch is deactivated this feature will be disabled. The choices for quick-chill are Disabled through 90 seconds.

Auto Defog

The *AUTO DEFOG* (**MENU**, 6,2,2,3) feature provides a burst of LN2 to the freezer to clear the fog when the lid has been opened. This is activated through the lid switch. If the lid switch is deactivated this feature will be disabled. The choices for auto defog are Disabled through 90 seconds.

Manual Defog

The *DEFOG TIMER* (**MENU**, 6,2,2,1) feature provides a burst of LN2 to the freezer to clear the fog when the user presses the defog button from the front panel. The choices for this feature are Disabled through 90 seconds.

Splash-Guard

Splash Guard is a process to reduce or eliminate false signals detected by the thermistor sensor assembly. In particular this reduces sporadic valve operation when the sensor assembly is splashed with LN2. When a fill operation has completed because the level has reached the *STOP FILL* sensor, the display will flash "Check" and the control will check the validity of the signals received from the sensor assembly. The splash-guard check occurs for 20 seconds and the bottom line of the display indicates this by flashing "Check"

Freeze Guard

Freeze Guard is a process designed to reduce the risk of an overfill condition caused by solenoid valves freezing open. Freeze-guard consists of two options to reduce the risk of a frozen valve: 1) The maximum valve open duration can be set by the user. (*VALVE OPEN DURATION*) 2) The valve can be rapidly turned on and off trying to free it up (*VALVE DE-ICING*). Option 2 occurs if either the optional freeze-guard sensor detects that the valve is stuck open or if the control goes into a High Alarm. The special "Freeze-guard" sensor assembly includes a plumbing "T" with an installed thermistor which is placed in the plumbing directly downstream from the solenoid valve. The control monitors the "freeze-guard" thermistor and detects if the valve is frozen open.

VALVE OPEN DURATION can be accessed through the menu system (**MENU**, 6,2,4,1). This allows the user to set the maximum amount of time, which the valve will stay open at any one time. If a fill operation exceeds the valve open duration time set by the user, the valve closes for 15 seconds and then opens again for another cycle. The allowable settings are Disabled and 1-15 minutes.

VALVE DE-ICING can be accessed through the menu system (**MENU**, 6,2,4,2). This feature can be turned on or off. If enabled, the control will try to free up the valve by rapidly turning it on and off. This feature is triggered when the freeze-guard sensor detects a stuck valve or when the control detects a High Alarm condition. The Kryos will attempt to free up the valve by De-icing 5 times with a two minute delay between tries.

Valve Monitoring

An optional freeze-guard sensor assembly is available which places a plumbing "T" with a thermistor directly downstream from the solenoid valve. This thermistor detects if the valve is frozen open and then takes necessary steps to attempt to free it up. If the Kryos detects that a flow of LN2 is occurring even when the solenoid valve is supposedly closed, an error message will appear on the screen indicating "Valve Stuck Open." The control waits for 10 seconds after it determines that the valve should be closed before it will indicate that the valve is stuck open.

Temperature Control

The Kryos control system can also provide a vapor chamber temperature control for specimens that must be stored in a particular temperature range. The temperature control function actually operates in addition to the level control function. The level control always takes precedence. If the liquid level of LN2 is maintained between the *START FILL* sensor and the *STOP FILL* sensor, the control attempts to maintain a selected temperature around Thermocouple #1.

CONTROL TEMP can be accessed through the menu system of the control (**MENU**, 6,2,3,2,1). The Kryos attempts to maintain this temperature within a specified range around Thermocouple #1. The possible user settings range from -100° to -180° C.

CONTROL RANGE can be accessed through the menu system of the control (**MENU**, 6,2,3,2,2). The Kryos maintains a temperature range around the user selected temperature. A tighter range maintains a temperature very close to the selected temperature at the cost of greater LN2 usage. A broad range provides more temperature variability but the LN2 usage is less. The range can be varied from $\pm1^{o}$ to $\pm15^{o}$ C above and below the selected temperature. The total range therefore, is between 2° C (1° below and 1° above the selected temperature) and 30° C(15° below and 15° above the selected temperature). When the Kryos is attempting to control by temperature, it flashes "T.Recov" (Temperature Recovery) in the center of the bottom line.

VALVE ON can be accessed through the menu system of the control (**MENU**, 6,2,3,2,3). This selection allows the user to adjust the amount of time that the valve stays open when controlling by temperature. The possible user setting ranges from .25 seconds to 20.0 seconds in .25 second increments. The control adjusts automatically to maintain the setting that provides for the most efficient operation.

VALVE OFF can be accessed through the menu system of the control (**MENU**, 6,2,3,2,4). This selection allows the user to adjust the amount of time which the valve stays closed when controlling by temperature. The possible user setting ranges from 30 seconds to 90 seconds.

User Access Logs

The *USER ACCESS LOGS* (**MENU**, 4,3). track all personnel who enter the freezer by asking for an identification number. Identification numbers range from 00 to 99. When this feature is enabled, the control asks for an Identification number any time the lid is opened. An entry is then recorded in the log indicating the time, date and identification of the person entering the freezer. The user has 30 seconds to enter an ID code (the 30 seconds is counted down on the screen). If an ID is not entered within the 30 seconds time frame, the log indicates that an unidentified user accessed the freezer.

Serial Communications

The Kryos control system is designed with a 2-way serial communication feature. *RS-232* (**MENU**, 6,1) allows the user to configure the serial port to "talk" with other DTE (Date Terminal Equipment). The control can send data through it's serial port to a computer, a printer or a modem. System logs, error logs or temperature logs are always available for download. In addition to downloading data the Kryos control can accept commands through the serial port from a remote site. Control settings can be viewed or changed at any time. Also remote diagnostics can be performed.

Error Conditions

All error conditions are indicated in the control by a visual alarm (red LED) and an audible alarm (beeper). The error condition, which caused these alarms, is displayed on the top line of the screen. Also, if an error condition is not corrected in a specified amount (user defined) of time, a remote alarm relay is activated. When the error condition is corrected the visual and audio alarms are extinguished and the control display returns to its normal mode.

Error *ALARMS* (**MENU**, 3) can be disabled and enabled through the menu system of the control. Also, the logging of each error condition can be enabled and disabled.

High Temperature Alarm

The high temperature alarms are factory set at -100° C. They can be adjusted between 0 and -190 C. If the temperature on thermocouple #1 or #2 gets warmer than its associated preset alarm temperature the control will signal an alarm.

LN2 Supply Alarm

The *LN2 SUPPLY ALARM* (**MENU**, 3,3,1) is activated if the liquid level drops below the *START FILL* thermistor, the valve opens and the solenoid valve does not close in the preset amount of time. The default value for Low LN2 Supply Alarm is set for 15 minutes.

Sensor Error Alarm

The *SENSOR ERROR ALARM* (**MENU**, 3,3,2) is activated if the control determines that a problem exists with the sensor assembly. An open sensor can be confirmed through the *TEST LEVEL SENSORS* option in the menu system (**MENU**,2,1).

Lid Open Too Long

The *LID OPEN TOO LONG* (**MENU**, 3,3,4) error occurs if the lid is opened for a time period greater then the value set by the user.

Thermocouple Open

The *THERMOCOUPLE OPEN* (**MENU**, 3,3,5) error occurs if a thermocouple is enabled and the control sees an open circuit.

Interface Software

Optional software is available which allows a computer system to communicate with the Kryos control through the serial port on the freezer. The software provides the capability to download the logs, review control settings, change control settings and perform system functions such as open/close the solenoid valve, mute the alarm etc.

Troubleshooting

The key to troubleshooting your Cryo-storage system is to determine which component in the system is the source of the problem. Determine if the problem is occurring in any of the following sub-systems: Supply Vessel, Transfer Line, Power, Temperature, Level Sensing, Security, Lid Switch, Solenoid Valve, Control Display, Alarm System, Communications. After determining which sub-system is having the problem, isolate the problem further by performing sub-system tests. Once the problem is isolated and defined, it will be easier to solve.

Factory Settings

To restore factory settings at any time the Kryos control can be re-initialized. Please note that a re-initilization clears out all of the logs and the passwords and resets settings to those listed in the table below. To reset factory settings in the control, go to the menu choice *ABOUT THIS CONTROL* (**MENU**, 6,4) and while looking at this screen type in 1973. The control will lead you through the process required to reset the factory settings.

Temperature:		Alarms:	
Thermocouple #1	Enabled	LN2 Supply Alarm	30 minutes
Thermocouple #2	Disabled	Sensor Error	Enabled
Hi Temp #1 Alarm	-100° C	Remote Alarm	30 minutes
Hi Temp #2 Alarm	-100° C	Lid Open Too Long	10 minutes
Level Control:		Thermocouple Open Alarm	Enabled
Offset	0 inches	**Security:**	
START FILL Sensor	3 inches	Power On Password	Disabled
STOP FILL Sensor	6 inches	Menu Password	Disabled
Sensor Assembly	8 sensor	**Logging:**	
System:		Sensor Error Log	Enabled
RS-232	Enabled	Low LN2 Supply Log	Enabled
Handshaking	CTS/RTS	Remote Alarm Log	Enabled
Baud Rate	19200	Open Thermocouple Log	Enabled
Date & Time	Central Time	Hi Temp #1 Log	Enabled
Brightness	100%	Hi Temp #2 Log	Enabled
Defog Timer	15 seconds	Fill Logging	Enabled
Lid Switch	Enabled	Lid Open/Closed Log	Enabled
Auto Defog Timer	15 seconds	User Access Log	Disabled
Quick-chill	15 seconds	Thermocouple #1 Rate Log	Disabled
Temperature Control:		Thermocouple #2 Rate Log	Disabled
Temperature Control	Disabled	**Freeze-Guard:**	
Temperature	-150° C	Valve Open Duration	Disabled
Temperature Range	± 2° C	Valve De-icing	Enabled
Valve On	Varies with range		
Valve Off	45 seconds		

Specifications

Configurations:	Designed for the Taylor-Wharton Cryostorage Systems 10K, 20K, and 38K and Kryos freezers
Power Supply:	24 VAC, 40 VA - Standard 16.5 VAC, 40 VA with Battery Backup Option
Sensor Assembly:	4-Thermistor Assembly - Optional 8-Thermistor Assembly - Standard Freeze-guard Assembly - Optional
Thermocouples:	Operates with none, 1 or 2 Type T Thermocouples (1 piece standard)
Solenoid Valve:	Any 24 VAC cryogenic solenoid valve - Standard Optional 12 VDC solenoid valve for use on battery backup
Control Type:	Liquid Level Control or Liquid Level Control with Temperature Control
Security:	Keyless entry via 4 digit password Power On/Off Password Menu Access Password
Alarms:	Activates an audible and a visual alarm. Description of the alarm condition displays on front panel Activates remote alarm after user defined delay
Diagnostics:	Circuit diagnostics at start-up Sensor diagnostics from front panel Thermocouple diagnostics from front panel Manual Test for audible, visual and remote alarms
Temp. Calibration:	Automatic calibration from the front panel.
Communications:	RS-232 Serial Port for 2-way communications
Logging Capacity:	System Logs (4096 events) Alarm Logs (4096 events) Temperature logs (32,768 events)
Battery:	A CR2032 coin cell battery is used to back up time/date

Menu System:

1. Temperature
    - 1.1 Thermocouple Select
    - 1.2 Calibrate Temperature
    - 1.3 Test Temperature System
2. Level Sensing
    - 2.1 Test Level Sensors
    - 2.2 Set Sensors Offset
    - 2.3 Sensor Positions
        - 2.3.1 Start Fill
        - 2.3.2 Stop Fill
    - 2.4 Sensor Type
3. Alarms
    - 3.1 High-Temp Alarm #1
    - 3.2 High-Temp Alarm #2
    - 3.3 System Alarms
        - 3.3.1 LN$_2$ Supply Alarm
        - 3.3.2 Sensor Error Alarm
        - 3.3.3 Remote Alarm Timer
        - 3.3.4 Lid Open Too Long
        - 3.3.5 Thermocouple Alarm
    - 3.4 Test Alarms
        - 3.4.1 Test Audible
        - 3.4.2 Test Visual
        - 3.4.3 Test Remote
4. Logging
    - 4.1 Dump Logs
        - 4.1.1 Dump System Logs
        - 4.1.2 Dump Error Logs
        - 4.1.3 Dump Temp Log #1
        - 4.1.4 Dump Temp Log #2
    - 4.2 Error Logs
        - 4.2.1 Sensor Error Logging
        - 4.2.2 Low Supply Logging
        - 4.2.3 Remote Alarm Logging
        - 4.2.4 Open Thermocouple Logging
        - 4.2.5 High Temperature Alarm Logging #1
        - 4.2.6 High Temperature Alarm Logging #2
    - 4.3 System Logs
        - 4.3.1 Fill Logging
        - 4.3.2 Lid Action Logging
        - 4.3.3 User Access Logs
    - 4.4 Temperature Logs
        - 4.4.1 Thermocouple #1 Log Rate
        - 4.4.2 Thermocouple #2 Log Rate
    - 4.5 Erase Logs
        - 4.5.1 Erase System Logs
        - 4.5.2 Erase Error Logs
        - 4.5.3 Erase Temperature Log #1