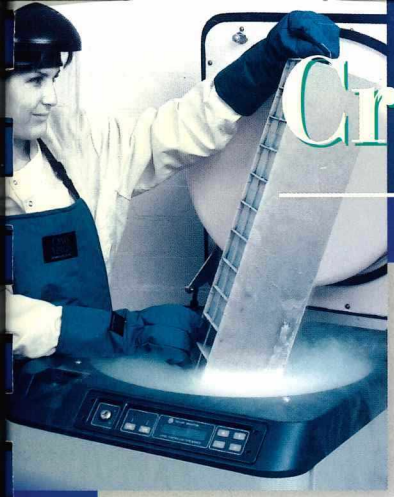
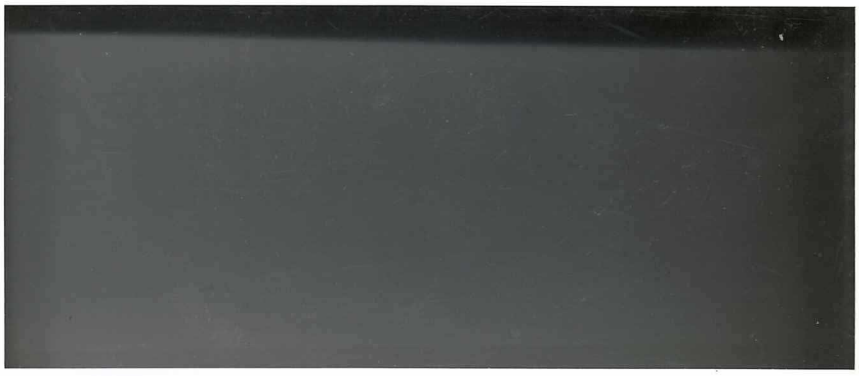


Cryogenics

HCI CRYOGENICS

TRENDSETTERS IN CRYOGENICS



HCI Cryogenics is een Hoek Loos-onderneming

Manual
10K / 24 K

CONTENTS

• Revised information or procedures throughout this manual (Version "A") are designated with a bullet mark "•".

SAFETY

Liquefied Gases

Extremely cold refrigerant - Cover Eyes and Exposed Skin - Accidental contact of the skin or eyes with any cryogenic liquid or cold gas may cause a freezing injury similar to frostbite. Protect your eyes and cover your skin when handling stored product and when transferring liquid, or in any instance where the possibility of contact with liquid, cold pipes, and cold gas may exist. Safety goggles or a face shield should be worn when transferring liquid. Long-sleeved clothing and gloves that can be easily removed are recommended for skin protection. Cryogenic liquids are extremely cold and will be at a temperature of -320°F (-196°C) under normal atmospheric pressure.

Keep Equipment Well Ventilated - Although the liquefied gas refrigerant used in this equipment is non-toxic and non-flammable, it can cause asphyxiation in a confined area without adequate ventilation. An atmosphere that does not contain enough oxygen for breathing will cause dizziness, unconsciousness, or even death. These gases cannot be detected by the human senses and will be inhaled normally as if they were air. Ensure there is adequate ventilation where this equipment is used and store liquid refrigerant supply containers only in a well ventilated area.

Liquid Nitrogen System - The liquid nitrogen supply pressure at the inlet to the refrigerator should be in the range of 10 psig (0.7 bar/69 kPa) to 20 psig (1.4 bar/138 kPa) for optimum performance. Higher operating pressures will increase transfer losses and create excessive turbulence of the liquid in the refrigerator which can generate false signals to the liquid level controller causing the refrigerator to underfill. In "liquid phase" storage applications, excessive turbulence can cause splashing which could result in personal injury and/or damage to the refrigerator. When installing piping or fill hose assemblies, make certain a suitable safety relief valve is installed in each section of plumbing between shut-off valves. Trapped liquefied gas will expand as it warms and may burst hoses or piping causing damage or personal injury. A relief valve is installed in the refrigerator plumbing to protect the line between the customer supplied shut-off valve and the refrigerator solenoid valve.

WARNING: **Inlet pressure must not exceed 22 psig (1.5 bar/152 kPa). Higher pressures could result in damage to equipment and/or sufficient depletion of oxygen in the atmosphere to cause dizziness, unconsciousness, or death.**

NOTE: For detailed information on the handling of cryogenic liquids, refer to the Compressed Gas Association publication: P-12 "Safe Handling of Cryogenic Liquids" available from the Compressed Gas Association Inc. 1235 Jefferson Davis Highway, Arlington, VA 22202.

Electrical

Electric Shock Can Kill - The liquid level controllers used with these refrigerators operate from 24VAC. However, the external transformer does have a 110/120VAC primary. Do not attempt any service on these units without disconnecting the electrical power cord.

NOTE: Units are supplied with Taylor-Wharton approved controllers. If other liquid level controllers are used please contact Taylor-Wharton before putting the refrigerator into service.

Freight Damage Precautions

Any freight damage claims are you responsibility. Cryostorage systems are delivered to your carrier from Taylor-Wharton's dock in new condition. When you receive our product you may expect it to be in that same condition. For your own protection, take time to visually inspect each shipment in the presence of the carrier's agent before you accept delivery. If any damage is observed, make an appropriate notation on the freight bill. Then, ask the driver to sign the notation before you receive the equipment. You should decline to accept containers that show damage which may affect serviceability.

GENERAL INFORMATION

Taylor-Wharton CryoStorage Systems are designed for applications where extremely low temperature storage of biological products is required. They are also appropriate for industrial or other functions where liquid nitrogen temperatures and high capacity are needed.

The 10K/24K and 38K refrigerators covered by this publication are designed for, but not limited to, the laboratory environment. The 10K and 24K feature square, modular cabinets that facilitate grouping several units together in a cryostorage area. The 38K features a cylindrical stainless steel cryochamber. All of the models will accommodate inventory control systems or provide unobstructed storage area for larger product. All models feature full access lid openings, and are supplied with casters where limited mobility for cleaning purposes is important.

These standard models are equipped with the Mark 2L electronic liquid level controller that will monitor and control the supply of liquid nitrogen to the unit. The Mark 2L controller features LCD vapor-phase temperature display. The addition of a liquid nitrogen supply and inventory control racks for systematic retrieval of stored product completes the total cryostorage system.

Maximum Refrigerator Contents

Your cryostorage system has a maximum weight capacity which is stated in the specifications. This capacity exceeds the maximum amount of liquid nitrogen the refrigerator is capable of holding. Generally, as product is added to liquid phase storage, the stored product and inventory control system are heavier than the liquid nitrogen they displace. In vapor-phase storage applications, where the liquid refrigerant is found only in the bottom portion of the refrigerator, the weight of contents is determined more by the weight of the stored product.

Liquid nitrogen at atmospheric pressure weighs 1.78 lb./liter (0.8 kg/liter). To ensure you are not exceeding the capacity of the cryostorage system, calculate the weight of the quantity of liquid nitrogen in your unit and subtract the result from the Total Allowable Capacity Weight found in the Specifications section of this publication. All K Series CryoStorage Systems are designed to support the full weight of liquid nitrogen and a complete stainless steel or aluminum inventory control system with boxes and specimens.

Specifications

		10K	24K	38K
Dimensions				
Height[1]	in.	44.0	44.0	49.0
	mm.	1118	1118	1245
Width	in.	23.1	34.0	42.0
	mm.	587	864	1067
Depth[2]	in.	30.5	38.0	48.0
	mm.	775	965	1219
Usable Height, Internal				
	in.	29.0	29.0	29.0
	mm.	737	737	737
Internal Diameter[3]				
	in.	21.0	31.0	39.0
	mm.	533	787	991
Capacity				
Space Volume				
	cu. ft.	5.8	12.7	20.0
	cu. m.	0.16	0.36	0.56
LN_2 Capacity	L	165	365	590
Evaporation Rate[4]				
	L/day	5.0	7.0	8.0
Weight, Empty				
	lb.	245	405	565
	kg	111	184	256
Total Allowable Capacity Weight[5] (Including liquid refrigerant and stored product)				
	lb.	292	641	1008
	kg	133	291	457
Maximum Gross Weight[6]				
	lb.	540	1050	1575
	kg	245	476	715
Inventory Control System Specifications				
No. 5 x 5 Racks[7]		7	17	28
No. Shelves/Rack		13	13	13
No. 3.0 x 3.0 Racks[8]		4	6	6
No. Shelves/Rack		13	13	13
Vial Capacity, 2 ml[9]		10400	24050	38350
Blood Bag[10]		175	360	560

Specifications are subject to change without notice.

Footnotes:

1. Maximum required clearance (with the lid open) for the 10K is 69 in. (1753 mm); 24K is 76 in. (1930 mm); and 38K is 90 in. (2286 mm).
2. Depth with lid open for 10K is 34 in. (864 mm); 24K is 48.5 in. (1232 mm); and 38K is 55 in. (1397 mm).
3. Temperature Gradient Suppression System reduces internal diameter by approx. 1/4 in. (6.4 mm). Does not apply to 10K.
4. Evaporation rate is nominal. Actual rate may be affected by the nature of the contents, atmospheric conditions, container history, and manufacturing tolerances.
5. Does not include the weight of the refrigerator itself. Refer to Maximum Refrigerator Contents section.
6. Includes the empty weight and total allowable capacity weight.
7. 5 in. x 5 in. (127 mm x 127 mm) 100 cell box.
8. 3.0 in. x 3.0 in. (76 mm x 76 mm) 25 cell box.
9. 2 ml vial size: 12.5 mm O.D. internal thread.
10. Fenwal 4R-5461 bag.

Liquid Nitrogen Supply Connection

The package included with the refrigerator includes a filter and an elbow. The liquid fill hose from a low pressure source of liquid nitrogen must be connected to the inlet through these two fittings. This liquid nitrogen source must have a shut-off valve, and may be any portable liquid cylinder or a bulk supply. The liquid nitrogen supply pressure at the inlet to the refrigerator should be in the range of 10 psig (0.7 bar/69 kPa) to 20 psig (1.4 bar/138 kPa) for optimum performance. Higher operating pressures will increase transfer losses and create excessive turbulence of the liquid in the refrigerator which can generate false signals to the liquid level controller causing the refrigerator to underfill. In "liquid phase" storage applications, excessive turbulence can cause splashing which could result in personal injury and/or damage to the refrigerator.

If the liquid nitrogen supply pressure at the inlet to the refrigerator rises above the opening pressure of the relief valve on the refrigerator, liquid nitrogen will be discharged into the surrounding area which can cause a rapid and very dangerous depletion of oxygen in the atmosphere. Once this pressure relief device has opened and cooled to liquid nitrogen temperature, it will not reseat until it has warmed to near ambient temperature. THIS COULD PERMIT THE ENTIRE CONTENTS OF THE LIQUID NITROGEN SUPPLY SYSTEM TO BE DISCHARGED INTO THE IMMEDIATE AREA OF THE REFRIGERATOR(S).

WARNING: **In order to prevent the relief device on the nitrogen refrigerator(s) from opening when the system is in operation, the liquid nitrogen supply system must be protected by a pressure relief device that will open when the pressure at the inlet to the refrigerator(s) is approximately 22 psig (1.5 bar/152 kPa). Never install the supply system pressure relief device onto a liquid service line.**

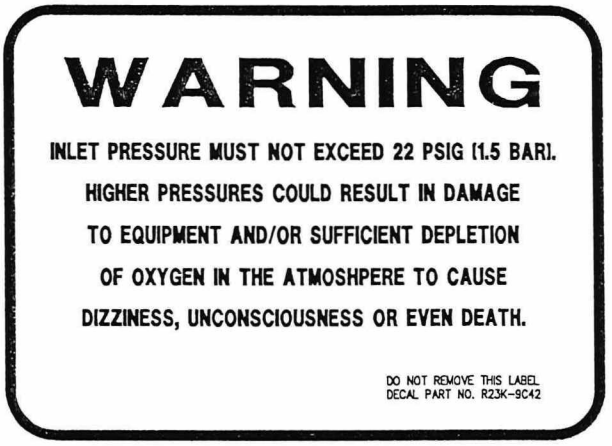


Figure 1. Warning Label (R23K-9C42)

Filling the Refrigerator (Initial Fill)

The 10K and 24K units using the MARK 2L controller come preset from the factory to operate. For the 38K units, refer to the **Installing the Controller** section in this manual.

The liquid nitrogen supply pressure at the inlet to the refrigerator should be in the range of 10 psig (0.7 bar/69 kPa) to 20 psig (1.4 bar/138 kPa) for optimum performance. Higher operating pressures will increase transfer losses and create excessive turbulence of the liquid in the refrigerator which can generate false signals to the liquid level controller causing the refrigerator to underfill. In "liquid phase" storage applications, excessive turbulence can cause splashing which could result in personal injury and/or damage to the refrigerator.

WARNING: **Maintain adequate ventilation to prevent asphyxiation hazard (See Safety Precautions)**

Power Supply Connection

Connect the 24 Volt AC power supply to the rear of the cryostorage system; then plug the power supply into a 110/120 VAC outlet. (See Figure 10 for the Electrical Supply Connections). Turn on the Mark 2L by turning the key-lock clockwise to the *"ON/LOCK"* position. The screen on the Mark 2L will light up indicating that the controller has started to operate. The audible alarm and high temperature indicator will sound during set-up; silence the alarm by pressing the button labeled MUTE.

WARNING: **If the fill fails to stop for any reason, quickly close the liquid supply valve to prevent overfilling until the cause of the problem can be determined.**

The unit is now under automatic fill control. Liquid will be added by the controller as long as the liquid supply and electrical power are maintained.

Operating Parameters

When materials are immersed in liquid nitrogen, they will assume the temperature of the liquid -320°F (-196°C) When material is stored in the vapor phase over the liquid, the liquid nitrogen is still a very cold refrigerant, but the refrigerator's interior temperature increases somewhat as product is stored higher above the liquid. This temperature differential is not significant in many biological storage applications, and is affected by the amount of product stored in the refrigerator, the type and size of inventory control system, and the liquid level in the unit.

The liquid level in the refrigerator is determined by the position of the sensor probes in the tube located at the front of the refrigerator. These probes are set at installation to maintain a specific liquid level. The controller operates a fill cycle that adds liquid at a low level, fills to a predetermined high level, then stops the fill. (See Figure 5) The cycle repeats when the liquid level drops to the low level sensor over time. Sensor probes may be moved to define new high and low levels, and these levels may be set independently to vary the liquid level differential between fills. For adjusting the sensor probes see **Systems Adjustments of the Mark 2L** section in this manual. For adjustments of the sensor probes for the Mark 3 controllers refer to document TW-291 P/N 7950-8291. Prior to the initial fill of the refrigerator, a determination must be made whether vapor phase or liquid phase storage will be utilized.

Vapor Phase Storage

Vapor phase storage is normally utilized when stored product is unable to withstand liquid nitrogen temperatures, or when the storage medium (vials, ampules, etc.) is not designed for liquid phase storage.

In a typical vapor phase storage system, the liquid level sensors are positioned to maintain the liquid level at or below the platform supplied with the inventory control system. This positioning allows stored product to be kept at cryogenic temperatures without being exposed to liquid nitrogen, reducing the possibility of leakage or cross-contamination. Care must be taken in the positioning of the level sensors to ensure an adequate level of refrigerant in the event of power outages, which may disable the controller for an extended period of time. Consideration must also be given to liquid nitrogen availability and delivery schedules.

Liquid Phase Storage

Liquid phase storage is normally utilized when liquid nitrogen temperatures are required to maintain stored product viability and the storage medium is adequate for storage in liquid nitrogen.

In a typical liquid phase storage system, the liquid level sensors are positioned to maintain the liquid level at or below the top level of the inventory control system. During operation, the upper levels of the inventory control system will at times become exposed as the liquid level fluctuates.

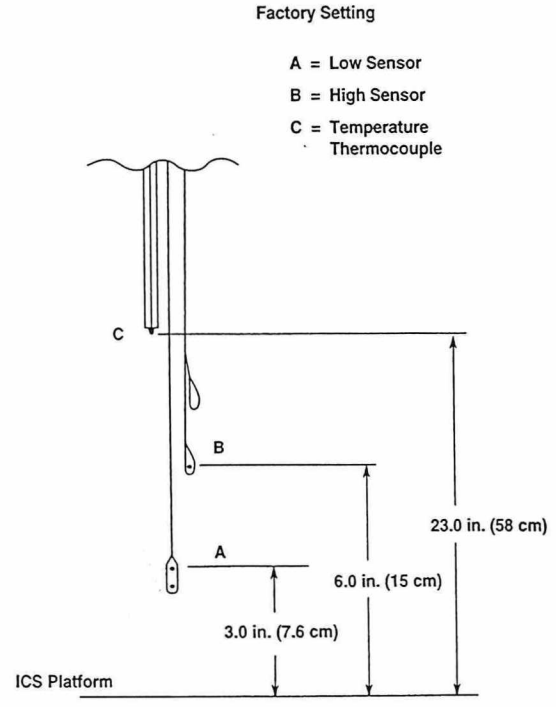
Care must be taken to ensure that the liquid level remains below the bottom of the refrigerator lid. Exposure to liquid nitrogen may result in physical damage to the lid. Additionally, operating the refrigerator with high liquid levels characteristic of liquid phase storage may result in turbulence during fill cycles. Caution must be exercised if the refrigerator lid is opened during a fill, and appropriate safety equipment should always be worn.

Thermocouple Positioning for the Mark 2L Controller

The thermocouple is a separate sensor designed in conjunction with the controller temperature readout to monitor the temperature within the refrigerator. The thermocouple should be positioned above the High Alarm sensor, and is typically located at or near the top of the inventory control system to measure the warmest condition in the refrigerator.

For specific information regarding the changing of level sensors and thermocouple, please refer to the **Systems Adjustments for the Mark 2L Controller** section of this manual.

The longest sensor probe contains the Low Level and Low Alarm sensors in one pod. The probe with two pods contains the High Level and the High Alarm sensors. The separate sensor in the housing that is connected to the sensor tube is the temperature thermocouple. The thermocouple is normally positioned above the High Alarm sensor to measure the warmest condition in the storage chamber. The factory sensor positions will maintain a liquid level between 3.0 in. (7.6 cm) to 6.0 in. (15 cm). The dimensions used for the factory sensor installation are shown in Figure 2.



• **Figure 2. Sensor Positioning for the Mark 2L Controller**

Using Inventory Control Systems (ICS)

The purpose of the inventory control system is to bring order to the storage of many small samples, and to allow direct retrieval of the particular sample you need at any time. It is important to be aware that when you lift an ICS rack from the refrigerator it is in a warmer environment. Learn to locate your sample quickly to avoid unnecessary warming of your stored product.

Keep ICS inserts (drawers or boxes) and dividers in good repair. Replacement inserts and dividers are available from your Taylor-Wharton distributor to keep your system as efficient as possible.

Always wear gloves when handling ICS racks or stored product, as they are very cold - read the precautions in the Safety section of these instructions, and in Taylor-Wharton publication TW-10 Handle With Care, for more detail on handling product stored in liquid nitrogen.

When removing ICS racks to retrieve product, protect the labels, plastic, and electronic areas of the refrigerator from liquid nitrogen that may spill from the rack inserts. These parts of the refrigerator are subject to damage from the extreme low temperature of the refrigerant.

If an alternate platform is supplied with your inventory control system, the liquid phase platform in the bottom of your refrigerator may need to be removed to accommodate your inventory control system platform.

Temperature Gradient Suppression System

Every Taylor-Wharton CryoStorage unit includes a Temperature Gradient Suppression System. The Temperature Gradient Suppression System is a thermal conductor designed to conduct heat downward toward the nitrogen reservoir, and by doing so, will significantly reduce the temperature gradient between the top of the inventory control system and the nitrogen reservoir.

While specific temperature profiles will vary with the use of the refrigerator and the type of inventory control system used, the Temperature Gradient Suppression System is an effective way to lower the temperature underneath the refrigerator lid without noticeably increasing liquid nitrogen consumption.

NOTE: Temperature Gradient Suppression Systems are specifically designed for use in vapor phase applications and will be of little value when liquid phase storage is used.

The chart below represents typical temperature gradients within a Taylor-Wharton CryoStorage System utilizing the Temperature Gradient Suppression System.

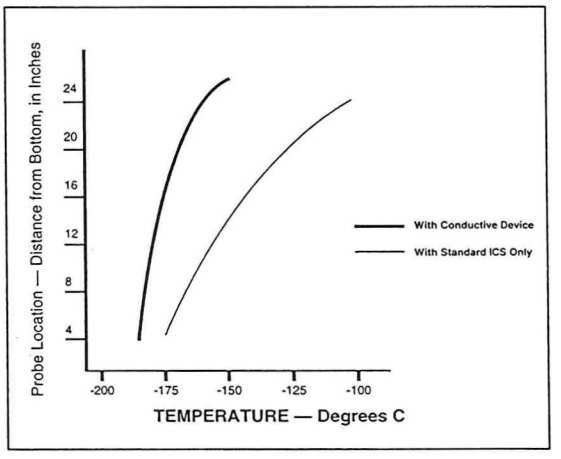


Figure 3. Temperature Gradient Suppression System Chart

CONTROLLER OPERATION

This section of the operating manual is for Taylor-Wharton approved equipment that uses the Mark 2L controller. For models that use the Mark 1L Controller refer to operating manual TW-303, P/N 7950-8303, for the Mark 3 Controller refer to operating manual TW-291, P/N 7950-8291.

Figure 4. Control Panel

Introduction

The "Mark 2L" LN_2 level controller is a microprocessor- based controller designed for easy operation and uninterrupted, reliable service. This controller will maintain the selected liquid level range of LN_2 in your refrigerator and will provide audible and visual alarms for any alarm conditions that may occur. In addition, a recent history log of all alarm conditions, events and data is maintained in the controller's memory. An "*alarm*" is any off-normal condition, such as a sensor short or open circuit, a temperature outside of the limit set by the user, or any other condition that would cause the controller to enter the *ALARM* mode. "*Events*" are lid openings and closings, solenoid valve openings and closings and operation of the controller's relay for remote alarm indication. "*Data*" refers to periodic alarm and event logging, the frequency of which is selected by the user.

The Mark 2L controller should require no additional attention to monitor temperature and maintain liquid level if an adequate supply of liquid nitrogen is maintained. If your protocol calls for you to "top-off" the cryostorage system at the end of a work day or work week, press the FILL button. The unit will fill to the upper allowable liquid level and stop automatically. You may choose to manually stop the fill by pressing the STOP button at anytime during the fill. You may choose to review your control setting during a fill. Pressing the "STATS" button will allow you to review the setting at anytime. As a safety precaution the Mark 2L controller will interrupt the fill until you are finished with your review. The unit will resume the filling until full or manually interrupted with the STOP button.

Downloading event memory, live or after the fact, is accomplished with the RS-232 (9 pin) serial port on the rear of the cryostorage system. You will need a printer with a serial port or a computer with a serial port and accessory software package. Refer to the operations section of that accessory software.

Normal Fill Cycle

When the refrigerator is filled and the controller is operating, the low level and low alarm sensors are immersed in liquid nitrogen. Their resistance values are interpreted by the controller as "in liquid". At the same time, the high level and the high alarm sensors are above the liquid pool sending the controller an "above liquid" signal. In this condition, the control panel will read "OK". As liquid nitrogen evaporates, the liquid level in the refrigerator drops slowly until eventually the low level sensor is above the liquid and sends a different signal to the controller. After a delay sufficient to ensure the signal is not false, the controller interprets this condition as low liquid and opens the fill solenoid valve admitting more refrigerant. At this time the control panel will read "FILL". The refrigerator fills slowly, the control panel will read "FILL" when the liquid level is above the low level sensor. It will continue to read "FILL" until the high level sensor is immersed in liquid. Once the level of the liquid reaches the point of the high level sensor the control panel will indicate "OK" and will indicate the start of a new fill cycle. Figure 5 illustrates this cycle in graph form where liquid level is plotted against time, and display graphics are shown as they appear at key points in the cycle.

Controller Features

In this section, you will learn the general description of the Mark 2L Controller features.

"Easy-to-Understand" Controller Panel

The main control panel is composed of a Liquid Crystal Display (LCD), 4 integral buttons (□ □ ▲ ▼), an alarm lamp and a keylock switch.

The LCD keeps the user informed of the current status of the refrigerator. It displays the liquid level of the LN_2 in the refrigerator as well as the temperature in the refrigerator at the thermocouple location. It also displays user settings and alarm conditions. The backlight on the LCD can be changed with

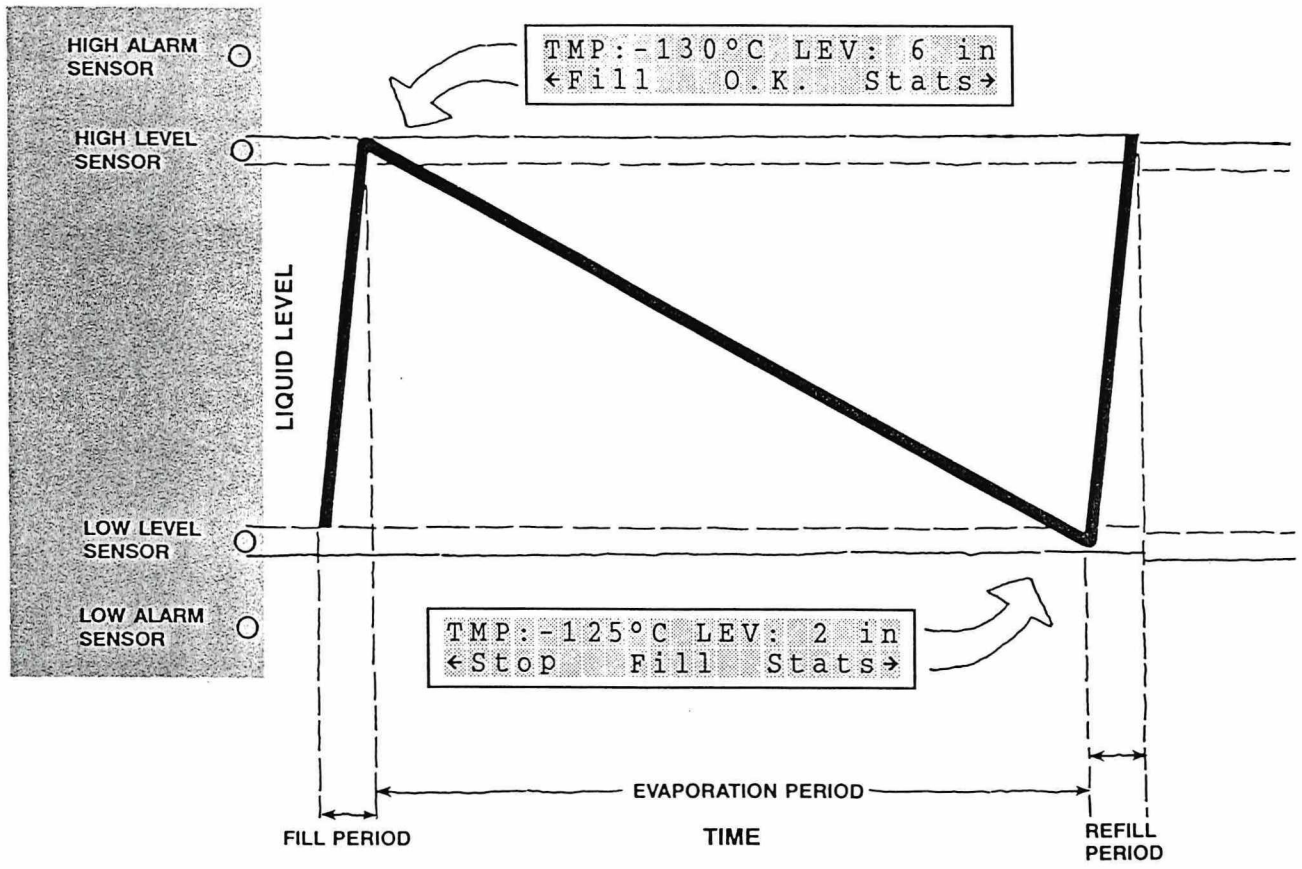


Figure 5. Normal Fill Cycle Chart for Mark 2L

the ▲ increasing the illumination and the ▼ decreasing the illumination. The user can set 1 of 8 different illumination levels.

The buttons allow the user to enter information into the controller as needed. The two ◘ buttons on each side of the LCD display are used to move through the menu system. The LCD indicates the function of the keys as the user steps through the menu system. If no information has been entered into the controller logic within 20 seconds, the controller will automatically return to the first setting of the menu.

The warning lamp is located to the left of the panel and is used to indicate when an alarm condition has occurred. When the light is flashing, it is also accompanied by an audible alarm. The particular alarm condition is displayed on the LCD. If more than one alarm occurs simultaneously, the display shows each alarm condition in a sequence of messages scrolled across the LCD screen.

The keylock switch located on the control panel is used to initially turn on the controller when power is supplied. It can also be used to limit access to the control settings. When the key is turned to the *"ON/SET"* position, all controller settings can be changed. When the key is turned to the *"ON/LOCK"* position, the settings cannot be changed - only reviewed.

LN_2 Level Controller

The controller is designed to maintain the LN_2 level in the refrigerator within a user-defined range. The LN_2 level will be maintained between the low level sensor and the high level sensor. When the liquid level reaches the low level sensor, LN_2 will be added to the refrigerator until it reaches the high level sensor. There are also two additional sensors located in the sensor assembly. The high *alarm* sensor is located 1 in. (2.54 cm) above the high *level* sensor. The high *alarm* sensor is used to shut-off the LN_2 if the liquid level were to go past the high *level* sensor. The low *alarm* sensor is located 1 in. (2.54 cm) below the low *level* sensor. The low *alarm* sensor is used to provide a warning that a LN_2 fill has not occurred as required to maintain the preset liquid level. Level readings can be displayed in inches or centimeters.

Temperature Display

The temperature in the refrigerator is measured at the location of the thermocouple. The controller will continuously monitor the temperature and display it on the LCD in Celsius, Kelvin or Millivolts.

Continuous Status Monitoring

Both the LN_2 level and the temperature are constantly monitored and displayed. In addition, the controller is continuously checking for any problems which may occur such as; a sensor fault, lid open too long, low LN_2 supply or remote alarm (multiple conditions are easily handled). In addition to monitoring the system, the Mark 2L takes appropriate action to respond to the condition and to log the condition.

Language Selection

The language used in the display is user selectable through a series of DIP switches on the lower end of the controller board. The languages available are: English, German, and Spanish.

Key-lock

The key-lock on the front panel has two functions. The first function is to turn the controller **ON**. The second function is to control access to the user settings. When the key-lock is in the *"ON/SET"* position, all settings can be changed by the user. When the key-lock is in the *"ON/LOCK"* position, the settings cannot be changed, only reviewed.

Power on/off

The power is initially turned on by plugging in the transformerand turning the key clockwise to the *"ON/LOCK"* position. The user may then want to turn the key counterclockwise to the *"ON/SET"* position to change any user selectable settings. After the controller is initially turned **ON**, the controller can be turned **OFF** only through the menu system. All user settings and operation logs are saved when the controller is turned off, however, alarm and event conditions as well as a signal to an external temperature recorder are not.

Temperature Alarm

A high temperature alarm point can be set through the menu system. If the temperature at the location of the thermocouple gets warmer than the high temperature alarm set point, an alarm is triggered. The alarm consists of a flashing light on the control panel, an audible alarm and the message High Temperature! indicated on the LCD. The error message will continue until the problem is corrected.

Low LN_2 Supply Alarm

If the LN_2 level has not reached the high level sensor within 30 minutes, after the solenoid valve is turned on the controller interprets this as an insufficient LN_2 supply and an alarm is activated. The alarm consists of a flashing light on the control panel, an audible alarm and the message Low LN_2 Supply! indicated on the LCD. The error message will continue until the problem is corrected.

Quick Chill Feature

The Quick Chill Feature (QCF) is selectable by the user through the menu system. If this feature is activated, closing the lid of the refrigerator causes the solenoid valve to open and gaseous N_2 to flow into the cryochamber for a user-specified amount of time. This causes the temperature in the refrigerator to be re-established quickly. The length of time that the solenoid valve stays open can be set by the user. (Disable; or 1 to 99 seconds). Longer QCF times will be needed for low liquid levels and short QCF times will be sufficient when higher liquid levels are being used.

Defog

The Defog feature is also selectable by the user through the menu system. If this feature is activated, opening the lid of the refrigerator causes the solenoid valve to open and gaseous N_2 to flow into the cryochamber for the specified time selected by the user. This clears the fog near the surface of the LN_2 pool, created when the moist room air and cold chamber gases meet.

Lid Open Alarm

If the lid remains open more than 30 minutes, an alarm condition is present and the audible and visual alarm will be activated. This alarm condition will be logged as a Lid Open Alarm. Normal lid openings will be logged when the lid is closed, giving time, date, and length of lid opening.

Error Logging, Event Logging and Data Logging

The Mark 2L controller keeps a record of all event and alarm conditions that occur in the operation of your refrigerator. As an alarm occurs, it is logged into memory, with a description, a date and a time. An entry is also added to the log as events occur such as lid opening, lid closing, fill start, fill stop, power turn-on or off and remote alarm relay activation and de-activation. As alarm conditions are corrected, the real time of the correction is logged. The log will be able to hold 4000 events, estimated to be sufficient to store in the memory the two years of normal operations.

Temperature Logging

The Mark 2L controller will also log the temperature in the refrigerator (at the location of the thermocouple) at a user-specified time interval. Each event recording includes the temperature reading, the time and the date. The interval is selectable by the user during initial set-up.

EXAMPLE:
Temperature -156°C 13:24 October 2 1994

Temperature Recorder Output

The Mark 2L controller provides connections for an external temperature recorder. The output provides 0 volts at -196°C and increases at 10mv/degree C° to a maximum of 2.46 volts at 50°C. The temperature recorder output is located on the back panel of the refrigerator on the 10K/24K and on the bottom of the controller box for the 38K.

NOTE: DIP switches 1 & 2 can be used to display the millivolt output of the controller. Calibrate your recorder to match the millivolts indicated on the controller panel. The Temperature Recorder port will always provide a millivolt output. The units displayed in the log and on the LCD are those units selected by the user.

Remote Alarm Output

A remote alarm output connection is provided on the back panel of the refrigerator on the 10K/24K and on the bottom of the controller box for the 38K. The normally open and normally closed dry contacts will actuate a circuit capable of conducting 2 amps of current. The user supplied remote alarm will be activated if an alarm condition is not corrected within 30 minutes.

RS-232 Data Output

The controller provides access to the log with a standard data port RS-232, (9 pin). The RS-232 port is located on the back panel of the refrigerator on the 10K/24K and on the bottom of the controller box for the 38K. By connecting a printer modem, or a computer to the serial port, the log can either be printed or downloaded to a computer. Each event can be down loaded live as it occurs or you may choose to down load the last 4000 events only when needed.

Mark 2L Software

The Mark 2L controller is capable of downloading its memory to a computer or printer. The system requirements for the software is any IBM or compatible PC that can run MicroSoft Windows 3.x in a Standard or Enhanced Mode. (The software will not run if Windows is in Real Mode). A mouse and a hard disk with approximately 500kb free disk space is highly recommended although not entirely necessary. To acquire a copy of the software program please contact:

Pacer Digital Systems Inc.
6854 Hillsdale Court
Indianapolis, IN 46250
Tel: (317) 849-7887
Fax: (317) 849-3859

24 Volt Power

The controller is designed for and operates on 24 Volts AC. Simply connect the power supply to the electrical connections of the controller and then plug the small wall transformer into an outlet and the controller is ready for service. No UL or CSA approval is required. The transformer is capable of supplying 1 ampere continuous draw at 24 VAC; 50-60 hertz.

Factory Settings

The CryoStorage System comes from the factory preset with the following default values. Thermistor locations are measured from the ICS platform up.

Low Level = 3.0 in. (7.6 cm)
High Level = 6.0 in. (15 cm)
Thermocouple Level = 23.0 in. (58.4 cm)
High Temperature Alarm = -100°C
Temperature Log Rate = 15 minutes
QCF (Quick Chill Feature) = 15 seconds
Defog settings = 15 seconds

SYSTEM ADJUSTMENTS for the MARK 2L CONTROLLER

Operational Flow Chart

This operational flow chart should be used as a guide in setting up or resetting the controller parameters.

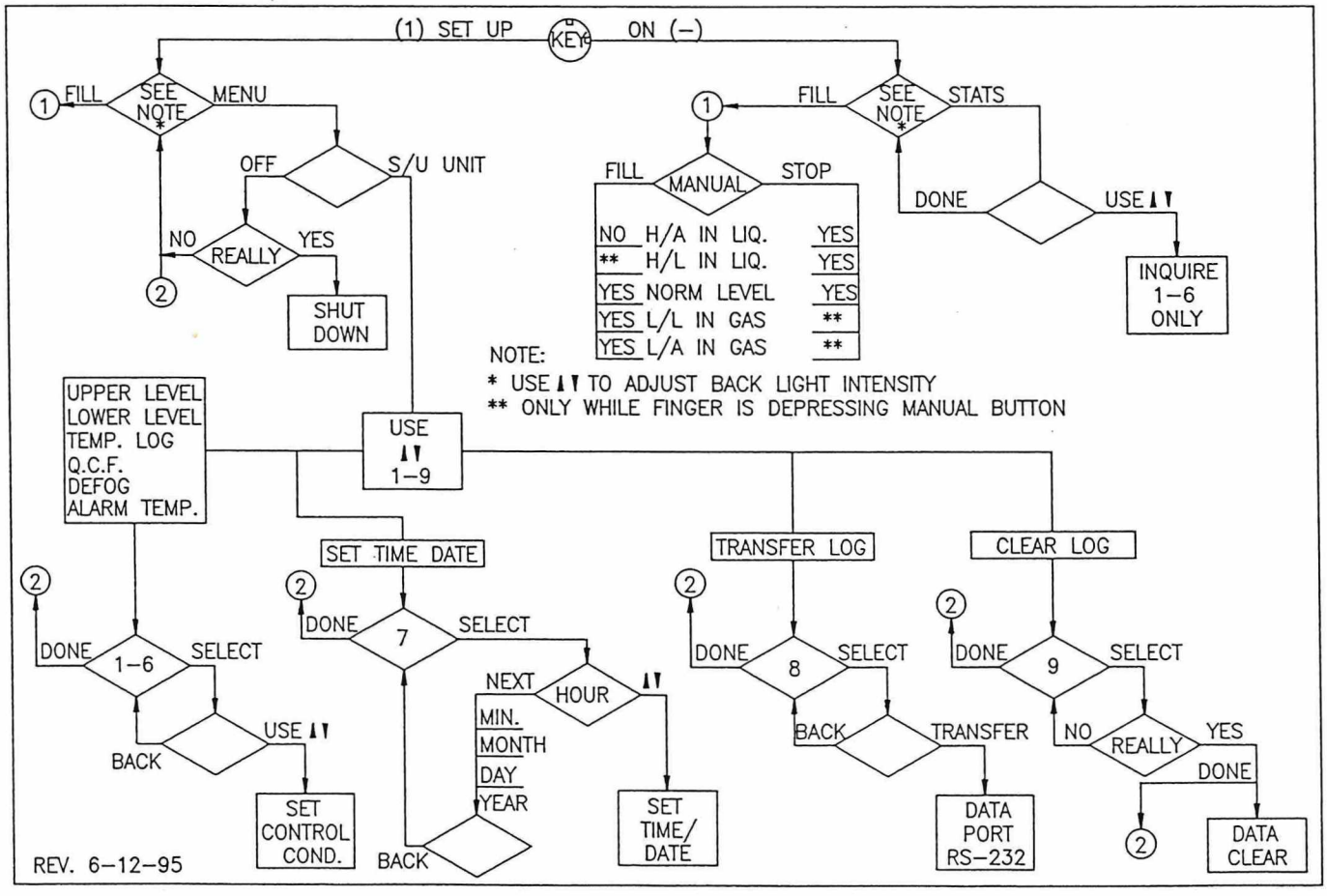


Figure 6. Operational Flow Chart

DIP Switch Setting

Refer to the Figure 7. Internal Electrical Connections for the location of the DIP switches.

Temperature Units	**DIP Switch 1**	**DIP Switch 2**
milliVolts	OFF	OFF
milliVolts	ON	OFF
Kelvin	OFF	ON
Celsius	ON	ON
Liquid Level Units of Measure	**DIP Switch 3**	
Centimeters	ON	
Inches	OFF	
Log Message Length	**DIP Switch 4**	
Short	OFF	
Long	ON	
Century	**DIP Switch 5**	
20th (1900)	ON	
21st (2000)	OFF	
Lid Switch	**DIP Switch 6**	
Lid switch installed	OFF	
No lid switch installed	ON	
Language	**DIP Switch 7**	**DIP Switch 8**
English	ON	ON
Spanish	OFF	ON
German	OFF	OFF

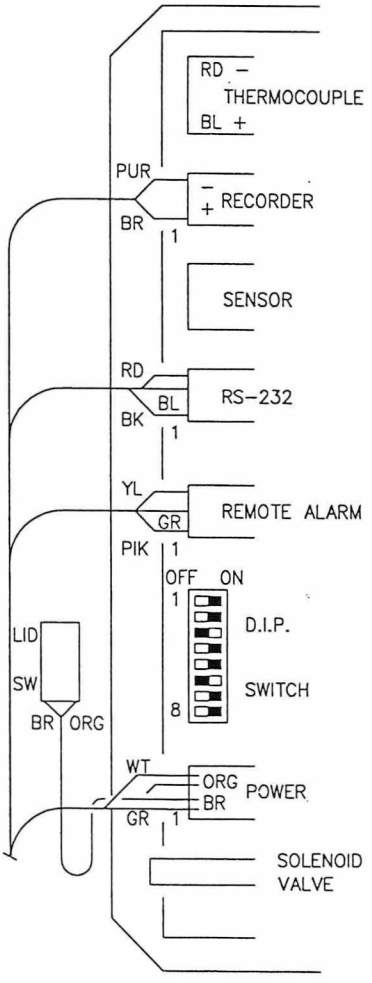


Figure 7. Internal Electrical Connections

Control Display Descriptions

Mute: Mutes the audible alarm when an alarm condition occurs. Does not mute any remote alarms.

Fill: Opens the Solenoid valve and allows LN_2 to flow into the refrigerator. Will be interpreted during an inquiry.

Stop: Closes the Solenoid valve and stops the flow of LN_2 into the refrigerator.

Turn Unit Off: Turns the controller off.

Set-up Unit: Allows the user to change controller settings.

Menu: Allows the user to change settings after initial start-up. Message displays when key-lock position is in *"ON/SET"* position.

Stats: Allows the user to see controller settings, however, will not allow changes to the settings. Message displays when the key-lock position is in *"ON/LOCK"* position.

Upper Liquid Level[1]: Lets you tell the controller where you have positioned the high level sensor in the sensor tube for the LN_2. [Lower Liquid Level +2 in. (5.1 cm) up to 89 in. (226 cm)].

Lower Liquid Level[1]: Lets you tell the controller where you have positioned the low level sensor in the sensor tube for the LN_2. [0 up to Upper Liquid Level -2 in. (5.1 cm)].

Temp. Logging Rate: Sets the time interval that you would like to log the refrigerator temperature. (Disabled, 1 min, 5 min, 10 min, 15 min, 30 min, 1 hour, 5 hours, 12 hours, 24 hours).

Quick-Chill Feature: Sets the interval for the controller to open the solenoid valve and allow gaseous N_2 into the refrigerator after the lid is closed. (Disabled; or 1 to 99 seconds)

Auto-Defog: Sets the interval to open the solenoid valve that allows gaseous N_2 into the refrigerator after the lid is opened. (Disabled; or 1 to 99 seconds)

Alarm Temperature: Permits you to set the alarm temperature in the controller. +59°C to -196°C).

Set time/date: Permits you to set the current time and date in the controller.

Logging: Transfers data to the external RS-232 port for printing or transferring to a computer.

Clear the Logs: Clears the controller's memory logs.

• Changing Liquid Level

The liquid level in the refrigerator is determined by the position of the sensor probes in a tube near the front of the refrigerator on the 10K and 24K and near the fill tube on the 38K. These probes have been set at installation to maintain a specific liquid level. The controller operates a fill cycle that adds liquid at a low level, fills to a predetermined high level, then stops the fill. The cycle repeats when liquid drops to the low level over time.

Sensor probe positions may be changed to define new high and low liquid levels, and these levels may be set independently to vary the liquid level differential between fills. If a higher liquid level is desired, raise the sensor probes in the sensor tube; for a lower level, the sensors must be moved further into (down) the sensor tube.

CAUTION: **Ice or frost in the sensor tube may restrict the movement of sensor probes in the tube. Do not pull excessively on the sensor wiring while attempting to change sensor position. It may be necessary to remove the sensor tube from the container and allow it to thaw before the sensors can be repositioned.**

NOTE: When resetting liquid levels it is the responsibility of the operator to make sure that the sensor location in the sensor tube and controller display settings are in agreement.

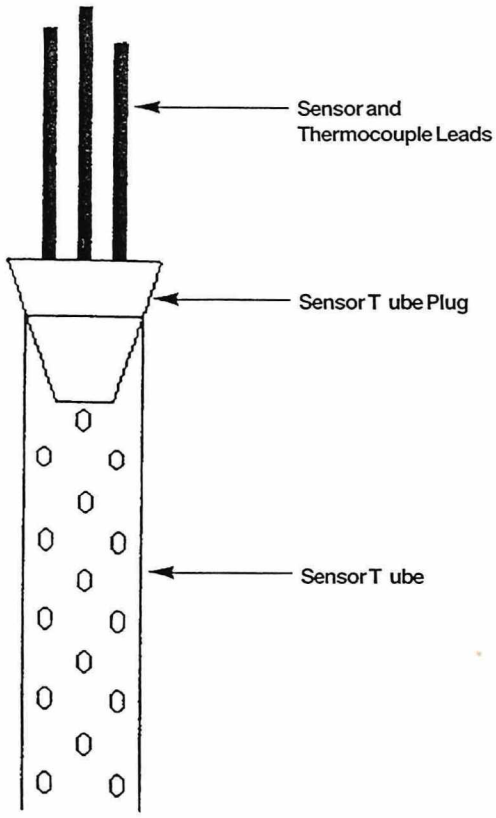
Increasing the distance between the low and high sensor probes allows greater liquid level fluctuation, less frequent filling and reduced fill losses; decreasing the distance has the opposite effect.

To set the liquid level to a different point, or to change the level differential, the sensors must be repositioned. Their position within the sensor tube is held in place by the sensor tube plug which is split to allow the sensor leads to pass through. The sensor tube plug holds the sensors at the position necessary to maintain a specific liquid level.

Two different sensor heights are specified by their position within the sensor tube (See Figure 2.). The low and high sensor pods are separately positioned to set the liquid levels at which the controller will start or terminate each fill cycle. Insert the high and low level sensor leads into the perforated sensor tube to the desired height. Mark the sensor leads at the top of the sensor tube. Insert the sensor temperature thermocouple to a height equal to the height of the storage samples or lower (See Figure 8.). Pull the leads out just enough to install the sensor tube plug around the marks on the sensor leads. Insert sensor plug securely into the mouth of the tube. Perform this operation carefully so the sensor leads are not damaged Follow the High Level Sensor instructions to complete the liquid level change procedure.

NOTE: The High level sensors must be at least 2.0 in. (5.1 cm) above the Low level sensor pod.

[1] Modifying the liquid level will require relocating of sensors located in the freezing chamber inside the sensor tube. See Figure 8 and its instructions.



• **Figure 8. Mark 2L Sensor Installation**

CAUTION: **The High Level sensor pod must be at least 8 in. (20 cm) below the top of the sensor tube container to prevent the lid from floating on liquid.**

NOTE: When resetting liquid levels it is the responsibility of the operator to make sure that the sensor location in the sensor tube and controller display settings are in agreement.

After repositioning sensors, check to be sure the tie wrap is secure, and turn the controller on. The controller should fill the refrigerator to the new liquid level. After sensors are repositioned, the controller should maintain the liquid pool at the new operating level. Turn the key to the *"ON/SET"* position. Press ◘ on the control panel marked MENU. This will bring up the **SET-UP-UNIT** display on the controller. Refer to Figure 6. Operational Flow Chart for instructions.

High Level Sensor

The High Liquid Level will be the first category to define in resetting the control parameters. Press the select ◘ button and use the control buttons ▲ ▼ to select the new measurement. Increase this number if you have raised the top sensor pod in the sensor tube. When the new measurement is selected, press the button ◘ labeled **BACK**. This will enter the new measurement into the controller logic and will take you to the next step of defining the Low Level Sensor.

Low Level Sensor

The Low Liquid Level will be the second category in resetting the parameters. Press the select ◘ button and use the control buttons ▲ ▼ to select the new measurement. Increase or decrease this number by the distance you raised or lowered the sensor in the sensor tube. When the new measurement is selected, press the button ◘ labeled BACK. This will enter the new measurement into the controller logic. To get back to the initial *"ON/SET"* mode press the button ◘ labeled DONE. This will bring the mode of the controller back to the *"ON/SET"* mode. Turn the key to the *"ON/LOCK"* position to finalize the resetting of the liquid levels and prevent others from modifying your selections.

At this point, the Mark 2L will add liquid or allow evaporation to the new level in your refrigerator.

The controller settings can be changed by working through the menu system and making the appropriate choices. A brief description of each menu choice follows with valid setting in parenthesis.

• Remote Alarm Plug Connection

Relay connections are provided on an external plug for user installation of a remote alarm circuit (See Figure 9). Wiring, external power supply, and alarm devices must be supplied by the user. During an alarm condition, contacts 1 & 2 are closed and contacts 2 & 3 are open. During normal operation, contacts 1 & 2 are open while 2 & 3 are closed.

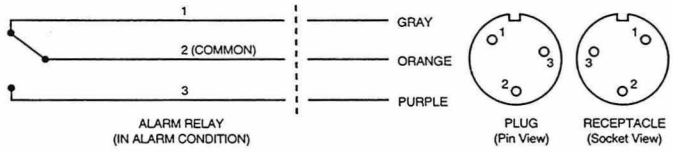


Figure 9. Remote Alarm Plug Connection

Temperature Recorder

The Mark 2L controller features connections for an external temperature recorder. To connect a recorder, remove the controller as described under **Removing the Controller** section. The recorder output provides 0 volts @ -196°C and the output voltage increases at a linear rate of 10 mv/degree Celsius, to a maximum output of 2.46 volts @ 50°C. The recorder must be attached to connections (+) and (-) on the controller.

Solenoid Electrical Test

Solenoid Electrical Tests - If the fuse on the power supply chassis repeatedly opens, disconnect the power from the unit and measure the resistance across the solenoid coil. The resistance should be greater than 90 ohms. There should also be no continuity between either coil conductor and the metal cabinet of the refrigerator. If the coil resistance is less than 90 ohms, or a short to ground is indicated, replace the coil.

Downloading Mark 2L Data

To down load the memory of the controller to a computer or serial printer turn the key to the *"ON/SET"* position. Press ◘ on the control panel marked MENU. This will bring up the set-up-unit display on the controller. Refer to Figure 6. Operational Flow Chart for instructions. The Transfer Log will be the eighth category in controller parameters. Press the select ◘ button to bring up the next readout message on the LCD. Press the button ◘ labeled TRANSFER to download the memory. When the transfer is complete, press the button ◘ labeled BACK to get back to the transfer mode. To get back to the initial *"ON/SET"* mode press the button ◘ labeled DONE. This will bring the mode of the controller back to the *"ON/SET"* mode. Turn the key to the *"ON/LOCK"*.

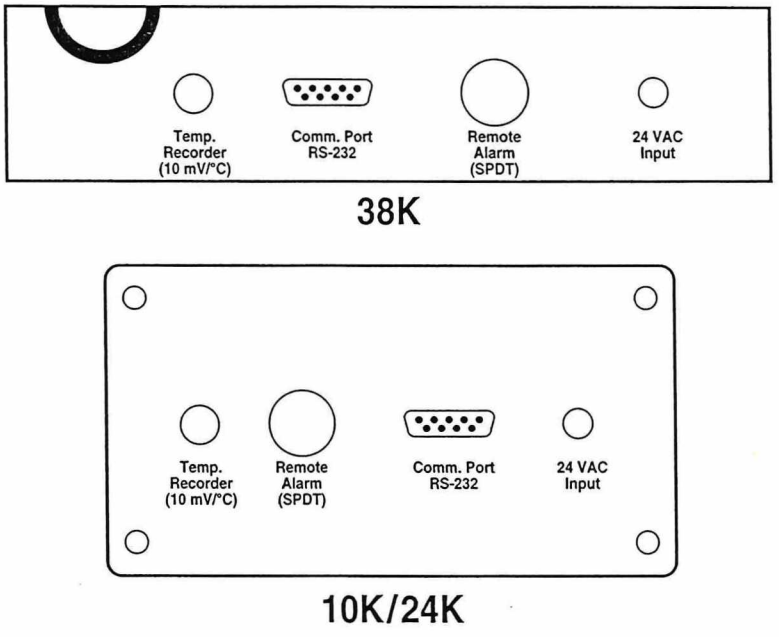


Figure 10. Electrical Supply Connections for 10K/24K/38K

MAINTENANCE

K Series CryoStorage System Maintenance

Filter Cleaning Instructions

The container might not fill properly if the filter is clogged with ice or dirt. To clean the filter first close the supply valve to the refrigerator. Vent the fill line of all pressure. Remove and warm the filter to ambient temperature. Purge the filter from both directions with dry nitrogen gas or dry oil-free air. Rinse the filter off with alcohol and purge it again with dry nitrogen gas or dry oil-free air to clear contaminants. If the cleaning process doesn't clear the blockage, replace with a new filter (P/N 3106-9C98).

Defrosting your K Series CryoStorage System

All liquid nitrogen storage systems are subject to ice and frost buildup over time. Regular preventive maintenance programs should be instituted to remove ice and frost from the sensor and fill tubes and from the refrigerator lid.

Ice and frost buildup in the sensor tube may result in false readings being relayed to the controller from the sensors. Ice can form a thermal barrier around a level sensor, rendering it insensitive to the temperature differences between vapor and liquid. Sensors and thermocouple should be removed regularly and inspected for ice and frost buildup.

NOTE: Ice or frost in the sensor tube may restrict the movement of sensor probes in the tube. Do not pull excessively on the sensor wiring while attempting to change sensor position. It may be necessary to remove the sensor tube from the container and allow it to thaw before the sensors can be repositioned.

Ice and frost buildup in the fill tube may block the flow of liquid nitrogen into the refrigerator during fill. This blockage can result in the liquid level dropping to dangerously low levels, and may result in the Low Alarm sensor being activated. In addition, a fill line blockage may cause the Low LN_2 Supply Alarm to be activated. If the fill line becomes blocked, it must be removed from the refrigerator, allowed to thaw to room temperature, and purged with dry nitrogen or oil-free dry air to remove all traces of moisture before being re-installed.

Excessive ice and frost buildup may occur on the refrigerator lid if the lid is left open or the liquid level is too close to the underside of the lid. To defrost the lid, open the lid to the fully open position. Clean the ice and frost from the underside of the lid by allowing it to thaw slightly and wiping with a clean,

lint-free cloth. Care must be taken to insulate the inventory control system from high temperatures, which may affect the viability of the stored product.

Excessive ice and frost buildup on the lid may occur if the lid is mis-aligned or the insulative gasket material is damaged. Should this occur, please contact your Taylor-Wharton distributor for assistance.

Cleaning your K Series CryoStorage System

The cryogenic vessel of all K Series CryoStorage Systems may need to be cleaned and sterilized if the type of stored product is changed or the unit is taken out of service. The vessel must be cleaned and sterilized, regardless of the type of stored product, prior to return to Taylor-Wharton for repair or maintenance.[2]

To clean and sterilize your K Series CryoStorage System, first turn the unit off. Disconnect the power source and the liquid nitrogen source. Remove all stored product and inventory control system components. Allow the residual liquid nitrogen to evaporate and the cryogenic vessel to warm to ambient temperature.

Spray the entire inner vessel surface with ample amounts of an approved disinfectant[3]. Allow surface contact to be maintained for a minimum of five minutes. Rinse the inner vessel with water, remove all water and debris, and towel dry the surface. Spray the inner vessel surface with a 70% alcohol to water solution and maintain surface contact for fifteen minutes. Rinse the inner vessel surface with water and towel dry.

WARNING: **Never use chlorine-based disinfectants to clean a K Series CryoStorage System.**

Normal Evaporation Rate (NER) Test

If the nitrogen consumption of your K Series CryoStorage System seems excessive, it may be appropriate to perform an estimated Normal Evaporation Rate (NER) test on the unit. To perform an NER test:

1) Fill the CryoStorage unit to the "High Level" sensor.

2) Measure the liquid nitrogen level with a plastic or wooden rule.

WARNING: **Never use hollow rods or tubes as dipsticks. When a warm tube is inserted into liquid nitrogen, liquid will spout from the top of the tube and may cause personal injury.**

3) Close and lock the lid of the CryoStorage System for forty-eight (48) hours.

4) Open the CryoStorage System and measure the liquid nitrogen level. Typically, liquid nitrogen levels will drop approximately 1 in. (25.4 mm) per day. If your measurement indicates a drop in excess of 2.0 in. (51 mm) per day, please contact your Taylor-Wharton distributor or Taylor-Wharton Customer Service at (334) 443-8680 for further information.

Mark 2L Controller Maintenance

WARNING: **The source power supply at 110/120VAC can cause a lethal electrical shock. Unplug the power cord before proceeding with any repairs.**

The Mark 2L has been designed for easy setup and maintenance. All connectors on the controller are uniquely identified snap-on plugs. The thermocouple, sensor assembly, solenoid valve, power, remote alarm, temperature recorder and data lines can be connected or disconnected in seconds. For the 10K and 24K the controller is connected to the back electrical panel with a 10 wire cable with the appropriate snap-on connectors.

Installing the Controller

10K/24K Units

Remove the cabinet top, follow the steps illustrated in Figure 11 to remove the four (4) screws holding the trim (escutcheon) where the controller will be mounted. Remove four (4) screws from the top of the refrigerator and lift the cabinet top to gain access to the area between the cabinet and the insulated inner vessel. The cabinet top may only be raised as shown in Figure 11 because of the lid hinges. Do not remove the hinged lid. After the cabinet top is loosened and propped up, this will allow access to the location where the electrical supply connections will be mounted.

Install the electrical supply connections panel to the back of the refrigerator. (See Figure 14.). Feed the wiring harness from the electrical supply connections panel to the front of the refrigerator and through the opening to where the controller will be mounted. Attach the electrical supply connections to the controller board Be sure to follow all of the installation procedures for the thermocouple, sensor probes and solenoid valve before you reattach the cabinet top. Reattach the cabinet top by screwing in the (4) four screws that were taken out to remove the cabinet top. Carefully lower the controller into the cabinet. Attach the controller to the cabinet top with the (2) two supplied screws. Place the trim (escutcheon) over the control panel of the controller and screw in the (4) four screws. Be sure that all of the necessary installation procedures have been completed before you start to fill the refrigerator. To start filling refer to **Filling the Refrigerator (Initial Fill)** section of this manual.

38K Units

Unscrew the six (6) screws that hold the back panel of the controller in place. Leave the two (2) screws attached that are located at the top of the controller box; one on either side of the control panel (See Figure 12.). Lift the back panel of the controller up far enough to gain access to the internal electrical connections. Connect the thermocouple, sensor probes

[2] All K Series CryoStorage Systems must be cleaned and sterilized prior to return to Taylor-Wharton for repair or maintenance and must be accompanied by a written statement to this effect. Any K Series CryoStorage System received without this statement will be returned to the sender, freight collect. Contact Customer Service at (334) 443-8680 for further information.

[3] For cleaning and sterilizing of the K Series CryoStorage Systems, Taylor-Wharton recommends EXSPOR™ Cold Sterilant, manufactured by Alcide Corp., One Willard Rd., Norwalk CT 06851 or equal. Write or call Alcide Corp. at (203) 847-2555 for complete information, pricing, and availability.

and solenoid valve leads to the controller board. Close the back panel and replace the six (6) screws that hold the back panel in place.

For the 38K unit open the lid of the refrigerator and locate the two (2) sets of mounting holes on the refrigerator. When facing the container, these holes will be located at the 10 o'clock and 2 o'clock positions. Remove the two (2) screws in the position that has been chosen. Mount the controller to the outside of container using these two (2) screws. Be sure to follow all of the necessary installation procedures for the thermocouple, sensor probes and solenoid valve before you start to fill the refrigerator. To start filling refer to **Filling the Refrigerator (Initial Fill)** section of this manual.

Removing the Controller

10K/24K Units

To remove the cabinet top, follow the steps illustrated in Figure 9 to remove the four (4) screws holding the trim (escutcheon) around the controller mounting opening at the front of the refrigerator. Remove two (2) screws from the controller and lift it from the refrigerator far enough to detach its electrical connection wiring. Remove four (4) screws from the top of the refrigerator and lift the cabinet top to gain access to the area between the cabinet and the insulated inner vessel. On the 10K and 24K the cabinet top may only be raised as shown in Figure 11 because of the lid hinges. Do not remove the hinged lid. After the cabinet top is loosened and propped up the electrical connection wiring may be detached to allow access to its back panel connection. At the completion of maintenance or repairs, reattach the electrical connection wiring to the controller. Install the controller using the procedure outlined for your refrigerator in **Installing the Controller** section.

38K Units

Open the lid of the refrigerator and unscrew the two (2) screws that attach the controller to the container. Remove the controller and close the lid of the refrigerator. Unscrew the six (6) screws that hold the back panel of the controller in place. Leave the two (2) screws attached that are located at the top of the controller box; one on either side of the control panel. (See Figure 12.). Lift the back panel of the controller up far enough

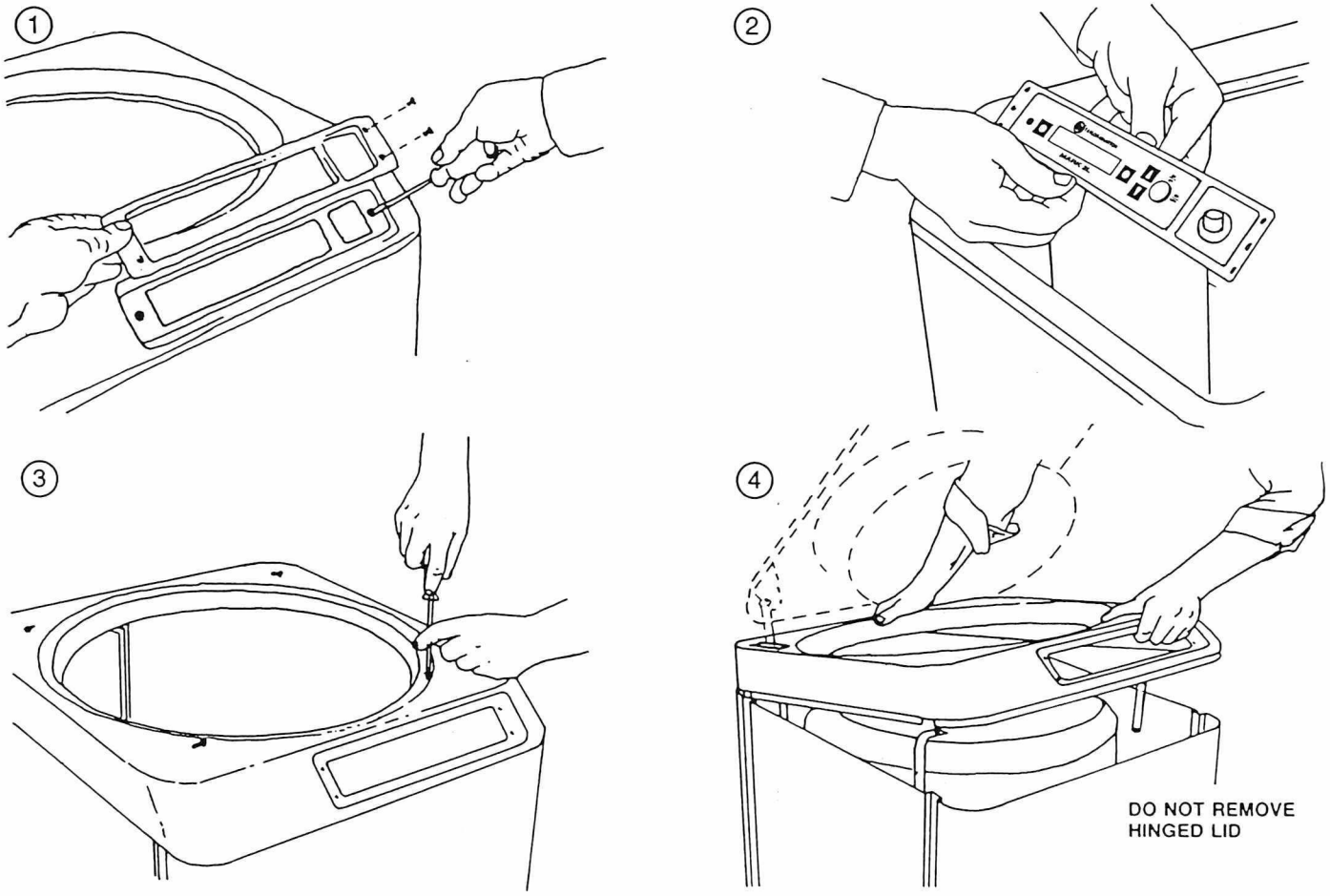


Figure 11. Removing the Cabinet Top of the 10K or 24K

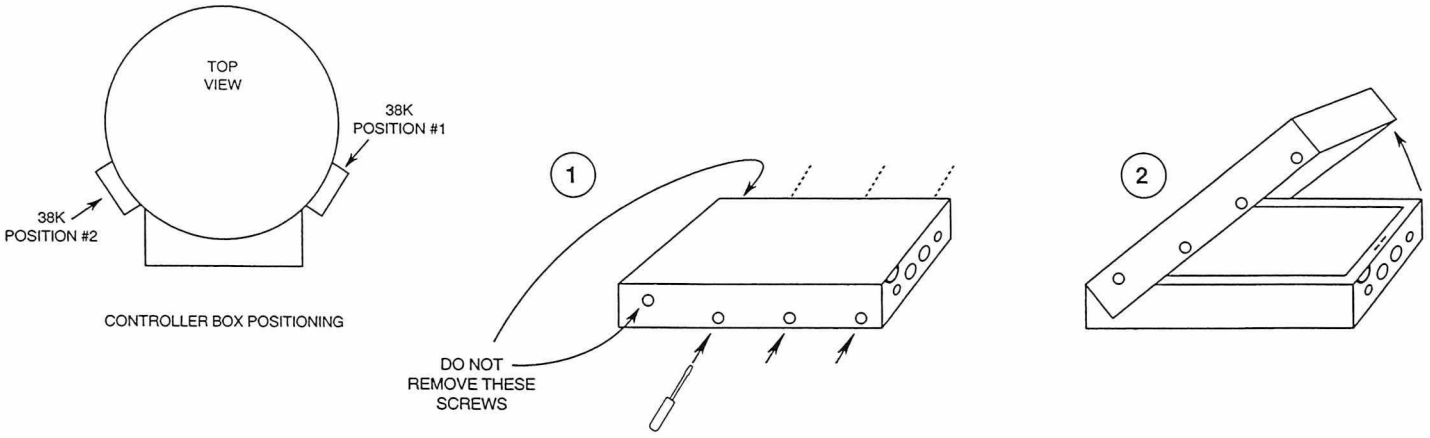


Figure 12. Removing the Controller Back Panel for the 38K.

to gain access to the internal electrical connections. Disconnect the thermocouple, sensor probes and solenoid valve leads from the controller board. After maintenance or repairs have been made to the controller refer to the procedure outlined for your refrigerator in **Installing the Controller** section.

Installing the Thermocouple

To install a thermocouple, feed the thermocouple lead through the clear plastic tubing on the sensor tube and into the thermocouple housing. Let the end of the thermocouple probe stick out the bottom of the housing approximately 1/8 in. (3.1 mm) to 1/4 in. (6.4 mm). Using a tie wrap secure the thermocouple wire to the sensor tube bracket. Trim off the excess tie wrap. Connect the thermocouple to the controller board. At the completion of maintenance or repairs, install the controller using the procedure outlined for your refrigerator model in the **Installing the Controller** section.

Removing the Thermocouple

Remove the controller using the procedures outlined for your particular refrigerator model in **Removing the Controller** section. Disconnect only the thermocouple lead connection from the controller board. Carefully cut the tie wrap away from the sensor bracket that holds the thermocouple in place and gently pull the thermocouple from the thermocouple housing. To install a new thermocouple refer to the procedure **Installing the Thermocouple** section.

Installing the Sensor Probes

For procedures for installing the sensor probes refer to the section titled **Changing Liquid Level** in this section of the manual.

• Removing the Sensor Probes

Remove the controller using the procedures outlined for your particular refrigerator model in **Removing the Controller** section. Disconnect the sensor probe lead connection from the controller board. Carefully remove the sensor tube plug from the sensor tube and remove the sensor leads from the plug.

NOTE: Ice or frost in the sensor tube may restrict the movement of sensor probes in the tube. Do not pull excessively on the sensor wiring while attempting to remove sensors. It may be necessary to remove the sensor tube from the container and allowed it to thaw before the sensors can be removed.

To install the new sensor probes refer to the procedure **Changing Liquid Level.**

Installing the Solenoid Valve

To install a new solenoid valve, attach the connecting plumbing to the inlet and outlet connections of the valve using Teflon tape. Refer to Figure 14 for plumbing arrangement. Attach the compression fitting to the fill tube first and then connect the compression fitting to the elbow that is connected to the outlet side of the solenoid valve. Position the solenoid valve onto the solenoid valve bracket and tighten the two (2) mounting screws. Attach the solenoid valve lead connection to the controller board. At the completion of maintenance or repairs, install the controller using the procedure outlined for your refrigerator model in the **Installing the Controller** section.

Removing the Solenoid Valve

Remove the controller using the procedures outlined for your particular refrigerator model in the **Removing the Controller** section. Disconnect only the solenoid valve lead connection from the controller board. Remove the back plumbing cover of the refrigerator to gain access to the plumbing and solenoid valve. (See Figure 15.).

NOTE: After disconnecting the solenoid valve leads do not pull on wires. The wires are tied and spiral wrapped together.

To remove the solenoid valve loosen the compression fitting that connects the plumbing tubing to the fill tube. Unscrew the two (2) mounting screws that hold the solenoid valve to the solenoid bracket. Then remove the solenoid valve and its associated plumbing. Disconnect the plumbing from the inlet and outlet side of the solenoid valve. To install a new solenoid valve refer to the procedure **Installing the Solenoid Valve** section.

Temperature Readout Calibration

The temperature readout circuit on controllers equipped with this feature is calibrated at the factory and should need no additional attention. If the controller board is replaced, or if the temperature reading is judged inaccurate for other reasons, the following procedure should be followed to recalibrate the controller electronics to the probe.

If the controller and refrigerator have been in service, adjust the liquid level so that both the Low Alarm and Low Level sensors are submerged. The High Level and High Alarm sensors should both be above the liquid pool. This is the normal operating condition of the refrigerator, and can be simulated without filling the refrigerator by placing the probes in a liquid dewar. The lower sensors must remain submerged while the high sensors are exposed to the coldest possible nitrogen vapor above the liquid. The temperature readout calibration may now be conducted as follows:

For the 10K/24K first turn off the power, then, remove the trim (escutcheon) around the controller (four screws) and the two screws securing the controller (See figure 11). Slide the controller up out of the cabinet high enough to locate an opening in the metal cover marked: -196°C ADJUST. and ZERO TEMP. ADJUST. These adjustments are located on the side of the controller board that is toward the rear of the refrigerator.

For the 38K, first turn off the power, and follow the procedure for **Removing the Controller**. Locate two openings marked: -196°C ADJUST and ZERO TEMP. ADJUST. These adjustments are located in the left bottom edge of the chassis.

NOTE: A second thermocouple may be used for this purpose rather than removing a thermocouple that has been in service from the refrigerator sensor tube.

Place the thermocouple probe in a beaker of ice-water to establish a 0°C reference. Turn on the power to the controller, and with a small screwdriver turn the ZERO TEMP. ADJUST control for a zero reading on the display. Use a dry cloth to completely dry the thermocouple. An ice formation (in liquid nitrogen) will cause false results.

NOTE: The most accurate adjustment is made by adjusting to the point where the minus (-) sign just blinks on and off.

Next, place the thermocouple probe in liquid nitrogen and adjust the -196°C ADJUST the point where the display changes from -195°C to -196°C When you complete the temperature calibration, turn the power off, reinstall the controller, and restore power when you have finished.

NOTE: Always adjust ZERO TEMP. first and -196°C ADJUST last.

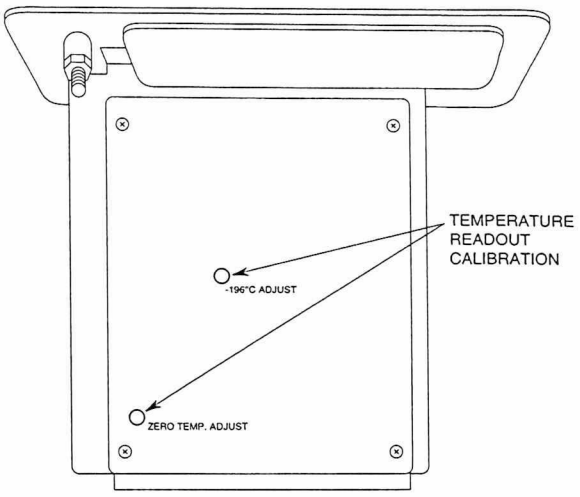


Figure 13. Temperature Display Calibration

Controller Electrical Tests

If a controller is removed from the refrigerator for service, the liquid refrigerant level must be maintained manually to protect stored product. The fill solenoid valve will be inoperative with the controller removed. A flexible fill line terminated with a phase separator may be used periodically through the open refrigerator lid to conduct manual fill operations until automatic operation is restored.

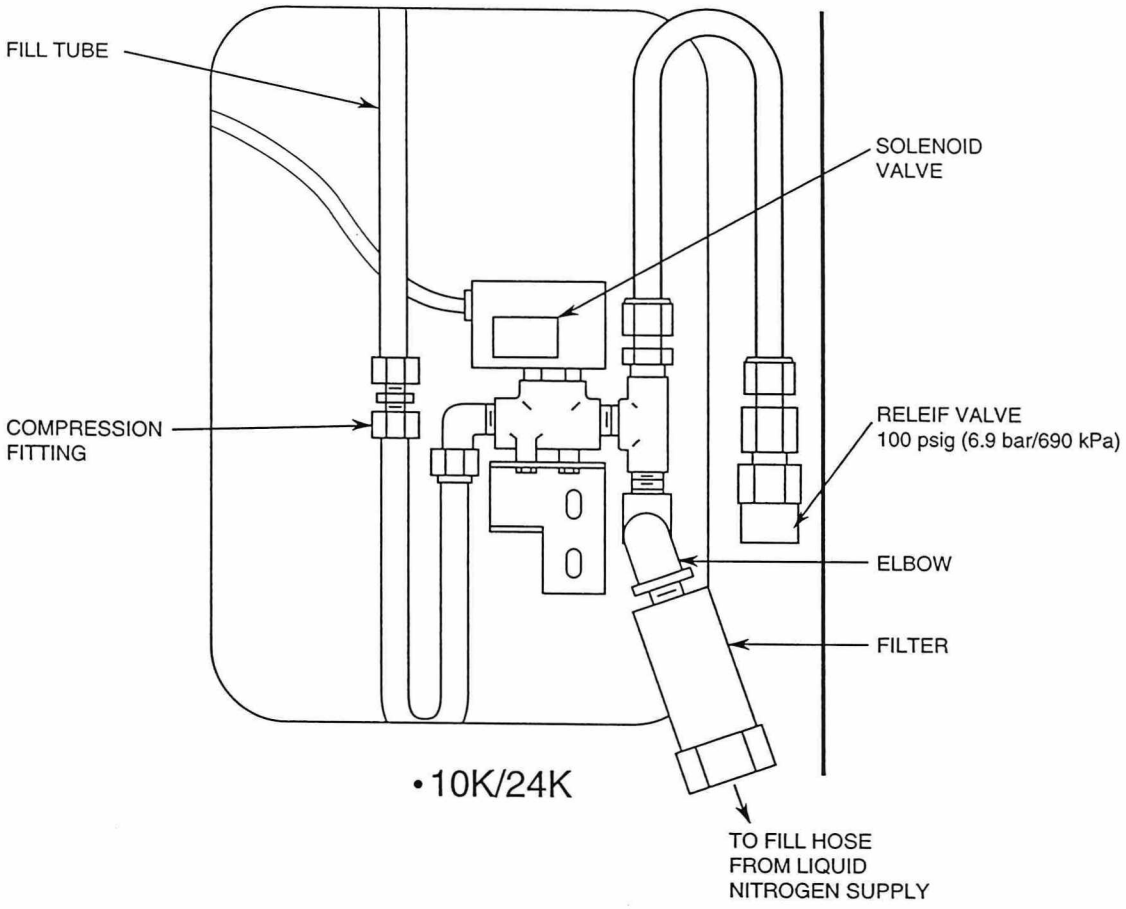
Sensor Probes. The sensor probes used to detect liquid level by Taylor-Wharton controllers are temperature-sensitive resistors called "thermistors." Their resistance to electrical current flow changes greatly with their temperature. The resistance of a typical thermistor used in these controllers varies with its temperature as follows:

- At Room Temperature ..... 2 ohms to 10 ohms
- In Cold Nitrogen Gas ..... 8K ohms to 12K ohms
- In Liquid Nitrogen ..... 25K ohms to 35K ohms

Controller Logic. The liquid level controllers read the values of the sensors as indications of liquid level. The function of a sensor, and its value, are interpreted by solid-state logic circuitry to set normal operating, fill, fill termination, and alarm conditions. In addition, the refrigerator temperature is monitored and an alarm is triggered if the temperature raises above a pre-determined point. The following values will be interpreted by a controller as cause for a logic change -- either an alarm, or in some cases, a fill or fill termination action.

From cold gas to liquid	Resistance greater than 22K ohms.
From liquid to cold gas	Resistance less than 16K ohms.
Defective Sensor	Resistance greater than 50K ohms, or less than 5 ohms.

In addition to the above, an alarm condition may be triggered by a fill mode that lasts for more than 30 minutes.



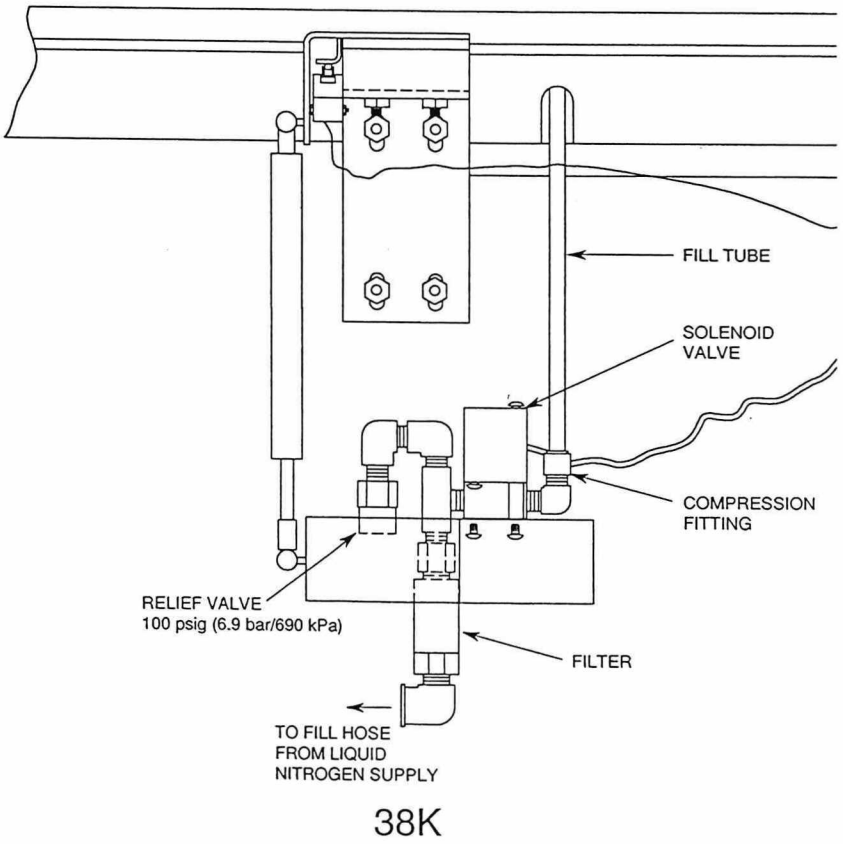


Figure 14. Rear Panel/Plumbing for 10K/24K and 38K.

TROUBLESHOOTING

The Mark 2L is designed to diagnose most problems which it encounters reducing the amount of troubleshooting required.

TROUBLESHOOTING		
Symptom	**Probable Cause**	**Corrective Action**
No response from controller.	a. No power.	a. Check plugs and power source. Check POWER key-switch.
Liquid Crystal Display not lit up and no messages on it.	a. Controller not getting power.	a. Check power connection to make sure that it is plugged in. b. Check back panel to make sure power plug is attached to the power plug port. c. If plugged in, your supplier should make sure that the internal wiring harness is connected to the controller board.
High nitrogen consumption.	a. High NER on supply container. b. Liquid level too high. c. Container has lost vacuum. d. Excessive nitrogen evaporation between source and refrigerator.	a. Contact your nitrogen supplier. b. Lower high level sensor. c. Check evaporation rate against nominal values in Specifications. d. Shorten inlet plumbing if possible - insulate pip ing to refrigerator.
Excessive frost or frozen lid.	a. Liquid level too close to underside of lid.	a. Lower high level sensor.
LOW ALARM indication.	a. Liquid level below low sensor.	a. Press "START FILL". If refrigerator still won't fill see "Fill Will Not Start".
Fill will not start (No refrigerant entering unit).	a. Refrigerant source empty. b. Open wiring to solenoid valve. c. Faulty solenoid valve. d. Filter/dryer plugged or saturated with moisture. e. Refrigerant boils away before reaching unit due to excessive fill line length.	a. Replenish supply. b. Check all connections. c. Replace solenoid valve. d. Clean or replace Part No. 3106-9C98. For cleaning procedure see section titled **Filter Cleaning Instructions.** e. Insulate and/or shorten fill line plumbing from LN_2 supply.
HIGH ALARM indication.	a. Liquid level above the highest sensor.	a. Close liquid source valve and see "Fill Will Not Stop."

TROUBLESHOOTING

Symptom	Probable Cause	Corrective Action
Fill Will Not Stop.	a. Solenoid valve frozen open. b. Faulty solenoid valve.	a. Close supply valve and thaw solenoid valve. b. Replace Solenoid Valve.
Electrical shock from contact with metal housing.	a. Internal short circuit.	a. Discontinue use. Service controller.
SENSOR FAULT indication.	a. Sensor probe connections. b. Defective sensor probe.	a. Remove controller and check thermocouple probe connections. b. Replace sensor.
No temperature display.	a. Plug to controller disconnected. b. Open thermocouple probe.	a. Remove controller and check thermocouple probe connections. b. Replace thermocouple probe.
HIGH TEMP indication.	a. Refrigerator temperature greater than alarm setpoint. b. Thermocouple probe defective.	a. Change setpoint, or raise sensor location to increase liquid level in refrigerator. b. Replace Thermocouple.
LOW LN_2 SUPPLY indication.	a. Refrigerant supply insufficient to complete fill in 30 minutes. b. Fill tube clogged. c. Filter/dryer plugged or saturated with moisture. d. Refrigerant boils away before reaching unit due to excessive fill line length.	a. Replenish supply. b. Thaw or replace tube. c. Clean or replace Part No. 3106-9C98. For cleaning procedure see section titled **Filter Cleaning Instructions.** d. Insulate and/or shorten fill line plumbing.

REPLACEMENT PARTS

The replacement parts list includes the description and part numbers necessary to allow you to identify and order parts to keep your cryostorage system in service. When placing orders, please use the nomenclature and part numbers in this section.

Figure 15. 10K/24K Refrigerator

Refrigerator Parts (10K/24K)	10K	24K
Cabinet, Back, Panel	R10K-9C35	R23K-9C35
Cabinet, Front, Panel	R10K-9C33	R23K-9C33
Cabinet, Side, Panel	R10K-9C34	R23K-9C34
Cabinet, Top, Panel	R10K-9C10	R17K-9C10
Gasket Kit	R10K-9C60	R10K-9C60
Lid Assembly	R10K-9C86	R23K-9C85
Lid Boot	R10K-9C82	R23K-9C82
Lid	R10K-9C83	R23K-9C83
Escutcheon, Control Panel Trim	R06K-9C21	R06K-9C21
Back Cover, Plumbing	R06K-9C32	R06K-9C32
Caster, (Four Required)	7300-9020	7300-9020
Fill Tube Assembly	R10K-9C66	R23K-9C66
Sensor Tube, Perforated, Stainless Steel	R23K-9C96	R23K-9C96
Sensor Tube Plug	R10K-9C69	R10K-9C69
Pneumatic Spring, 7 in. (178 mm) Stroke 20# Force	8958-0130	8958-0130
Hinge, Top Section	R17K-9C52	R17K-9C52
Hinge, Bottom Section	R17K-9C53	R17K-9C53
Decal, Lid Warning	R17K-9C42	R17K-9C42
Decal, Warranty	R033-9C27	R033-9C27
Decal, Warning	R23K-9C42	R23K-9C42
Temperature Gradient Suppression System	N/A	R20K-8C71
Temperature Gradient Suppressor Straps	N/A	R20K-8C72
Inventory Control System (ICS) Platform	R10K-9C05	R17K-9C05
Inventory Rack 25 Vials [13 shelves tall for 2 in. (51 mm) boxes]	R10K-9C44	R10K-9C44
Inventory Rack 100 Vials [13 shelves tall for 2 in. (51 mm) boxes]	R23K-8C35	R23K-8C35

Figure 16. 38K Refrigerator

Refrigerator Parts (38K)	**38K**
Lid Assembly	R27K-9C00
Caster, (Four Required)	R27K-9C30
Fill Tube Assembly	R23K-9C66
Sensor Tube, Perforated, Stainless Steel	R23K-9C96
Sensor Tube Plug	R10K-9C69
Pneumatic Spring, 6 in. (152 mm) Stroke 90# Force	8958-0135
Decal, Lid	R08K-9C63
Decal, Warranty	R033-9C27
Decal, Warning	R23K-9C42
Decal, Warning	R27K-9C54
Temperature Gradient Suppression System	R33K-8C71
Temperature Gradient Suppressor Straps	R33K-8C72
Inventory Control System Platform	R27K-8C00
Inventory Rack 25 Vials [13 shelves tall for 2 in. (51 mm) boxes]	R10K-9C44
Inventory Rack 100 Vials [13 shelves tall for 2 in. (51 mm) boxes]	R23K-8C35

Level Controller Electrical/Mechanical Parts	**10K/24K**	**38K**
Control Panel Mark 2L	R08K-9C00	N/A
Controller Mark 2L (Self Cabinet)	N/A	R20K-9C00
Sensor Assembly Mark 2L	R08K-9C01	R08K-9C01
Remote Alarm Plug	R06K-8C20	R06K-8C20
Transformer (Mark 2L)	R08K-9C04	R08K-9C04
Electrical Panel Assembly	R08K-9C02	N/A
Thermocouple Assembly	R08K-9C51	R08K-9C51
Lid Switch	5160-1042	5160-1041
Cable Lid Switch	R23K-9C71	R20K-9C66
Plumbing Assy. Mark 2L 24VAC	R23K-8C62	R38K-8C62
Solenoid Valve 24VAC	5190-3109	5190-3109
Relief Valve 100 psig (6.9 bar/690 kPa) 1/4 in. NPT	1750-9C90	1750-9C90
Filter Assembly	3106-9C98	3106-9C98

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