MVE FUSION

Technical Manual

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Technical Manual

PN 20994124 Rev B

1 Preface

Chart Inc.

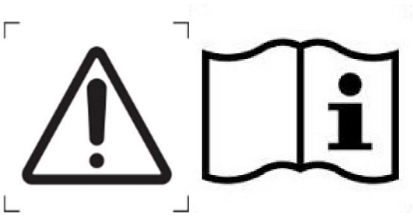
2200 Airport Industrial Drive, Suite 500

Ball Ground, GA 30107 USA

Customer / Technical Service:

Location	Phone	Fax	Email
The Americas	(800) 482-2473	(888) 932-2473	Customerservice.usa@chartindustries.com techservice.usa@chartindustries.com
Asia, Australia, Pacific Rim	+61 (2) 974 94333	+61 (2) 974 94666	csasia@chartindustries.com techservice.asia@chartindustries.com
Europe	+44 (0) 1344 403100	+44 (0) 1344 429224	Customerservice.europe@chart-ind.com Technicalservice.europe@chartindustries.com

This manual covers the use and maintenance of MVE Fusion Freezers. READ BEFORE USING THIS EQUIPMENT. Failure to follow the instructions in this manual can result in damage to the unit, injury to personnel, and/or poor equipment performance. It is intended for use by trained personnel only. All service and maintenance should be performed by an authorized MVE Distributor or Service Technician.



NOTE: All MVE Fusion models are Class I per IEC 61140, as the AC electrical supply requires a protective earth ground. These devices are externally powered and intended for continuous operation. They are not suitable for use with flammable anesthetics. These devices have been tested to and are in compliance with UL 61010-1:2012 Ed.3 & CSA C22.2#61010-1:2012 Ed.3 +G1.

This manual includes the following symbols.

Table 1: the symbols and their descriptions

Symbol	Title	Description
	Caution	Signifies a CAUTION of potentially hazardous situation when operating the device that may result in minor to moderate injury or property damage.
	Warning	Signifies a WARNING of a potentially hazardous situation when operating the device that may result in serious injury or property damage.
	Warning; Low Temperature	Indicates low temperature or freezing conditions. Take care to avoid exposure to skin, eyes, and clothing.
	Warning; Asphyxiating Atmosphere	Indicates the potential for an oxygen-depleted atmosphere due to nitrogen vapor. Take care to operate device in a well-ventilated area.
	Warning; Electricity	Indicates a potential electrical hazard. Take care to avoid contact with electricity.
	Warning; Explosive	Indicates a potential explosive hazard. The expansion ratio of liquid nitrogen to gas is 1:700 and can cause explosive conditions if placed into a sealed container.
	Wear Protective Gloves	Thermal gloves must be worn during indicated procedures.
	Wear a Face Shield	A face shield must be worn during indicated procedures.
	ETL Listed Mark	Chart Fusion Freezer conforms to UL STD 61010-1 and certified to CSA STD C22.2#61010-1.

2 Safety

READ BEFORE OPERATING THIS EQUIPMENT

2.1 General

Liquid nitrogen (LN2) is used in MVE Fusion Freezers as a refrigerant. Understanding and following certain safety precautions is extremely important when handling LN2 and cryogenic containers (commonly referred to as Dewar's).

2.2 Liquid Nitrogen Properties

Nitrogen is a colorless, odorless, tasteless gas. Gaseous nitrogen makes up about 78% of the Earth's atmosphere by volume. Once collected, cooled and isolated, nitrogen can be liquefied.

Table 2: Properties of LN2

Boiling Point at 1 atmosphere	-195.8°C, -320.3°F, 77.4 K
Thermal Conductivity (Gas)	25.83 mW/(m·K)
Heat of Vaporization (Liquid)	198.38 kJ/kg
Liquid density at 1 atmosphere	1.782 lbs/L, 807.4 g/L, 808.6 kg/m3

2.3 Liquid Nitrogen Safety

Transferring LN2 and operating the MVE Fusion should be done in accordance with the manufacturer/supplier instructions. It is important that all safety precautions recommended by the manufacturer be followed.

- **WARNING: Do not modify this equipment without authorization of the manufacturer.**

- **Nitrogen vapor is a potential asphyxiant as it displaces Oxygen (O_2) in confined spaces. Rapid suffocation can occur without warning in an Oxygen-deficient atmosphere (less than 19.5% O_2). Chart Cryogenic Freezers must be installed and operated in well-ventilated areas.**

- **DO NOT vent container in confined spaces.**
- **DO NOT enter confined spaces where excess nitrogen gas may be present.**
- **If exposure has occurred move to ventilated area or fresh air. If breathing is difficult, supplement oxygen may be required. If not breathing, give artifical respiration. SEEK IMMEDIATE MEDICAL ATTENTION.**

- **Contact with liquid nitrogen or uninsulated equipment containing nitrogen can result in cold contact burns or tissue damage. Nitrogen vapor can cause damage to skin or eyes.**
- **In case of frostbite, warm area with warm water not exceeding 105°F (40°C) and SEEK IMMEDIATE MEDICAL ATTENTION.**

- **Never place LN2 in a sealed container without a pressure relief device. The expansion ratio of liquid nitrogen to gaseous nitrogen is 1 to 700 (1 cubic foot of liquid nitrogen becomes 700 cubic feet of gaseous nitrogen when evaporated).**

The two most important safety aspects to consider when handling LN2 are adequate ventilation and eye and skin protection. Although nitrogen gas is non-toxic, it is dangerous in that the gas will displace oxygen in a normal breathing atmosphere. Liquid products are of even greater threat since a small amount of liquid evaporates into a large amount of gas. Therefore, it is imperative that cryogenic supply and storage dewars be stored and operated in well-ventilated areas.

Persons transferring LN2 should make every effort to protect the eyes and skin from accidental contact with liquid or cold vapor. Chart MVE recommends the following protective clothing and accessories when transferring LN2 or handling hoses, valves, and plumbing components:

- Cryogenic gloves (loose fitting)
- Full-face shield or chemical splash goggles
- Cryogenic apron

- Long sleeve shirt and cuffless pants
- Closed toe shoes (no sandals)

2.4 Equipment Usage

Cryogenic containers must be operated in accordance with the manufacturer/supplier instructions. Cryogenic dewars must be kept in a well-ventilated area protected from weather and away from heat sources. In applications that use a modular liquid cylinder as a source of LN2, the supply will need to be replenished at regular intervals to ensure proper operation of the freezer.

2.5 Recommended First Aid

Every site that stores and uses LN2 should have an appropriate Material Safety Data Sheet (MSDS) present. The MSDS may be obtained from the manufacturer/distributor. The MSDS will specify the symptoms of overexposure and first aid to be used. Here is a typical summary. If symptoms of asphyxia such as headache, drowsiness, dizziness, excitation, excess salivation, vomiting, or unconsciousness are observed, remove to fresh air.

If breathing has stopped, give artificial respiration.

CALL A PHSYICIAN IMMEDIATELY.

If breathing is difficult, supplemental oxygen maybe required. If exposure to cryogenic liquids or cold vapor occurs, restore tissue to normal, body temperature (37°C) as rapidly as possible, and then protect the injured tissue from further damage and infection.

Rapid warming of the affected areas is best achieved by bathing it in warm water. The temperature of the water used should not exceed 40°C. Under no circumstances should the frozen part be rubbed either before or after warming. If the eyes are involved, flush them thoroughly with warm water for at least 15 minutes. In case of massive exposure, remove clothing while showering with warm water. The patient should not drink alcohol or smoke. **CALL A PHYSICIAN IMMEDIATELY.**

3 System Components and Function

3.1 System Overview

The MVE Fusion system consists of several key components identified in Figures 1 and 2: dewar, Pressure Vessel, Liquefier, Shroud, Graphical User Interface (GUI), and Retractable Stairs.

Figure 1: MVE FUSION FREEZER

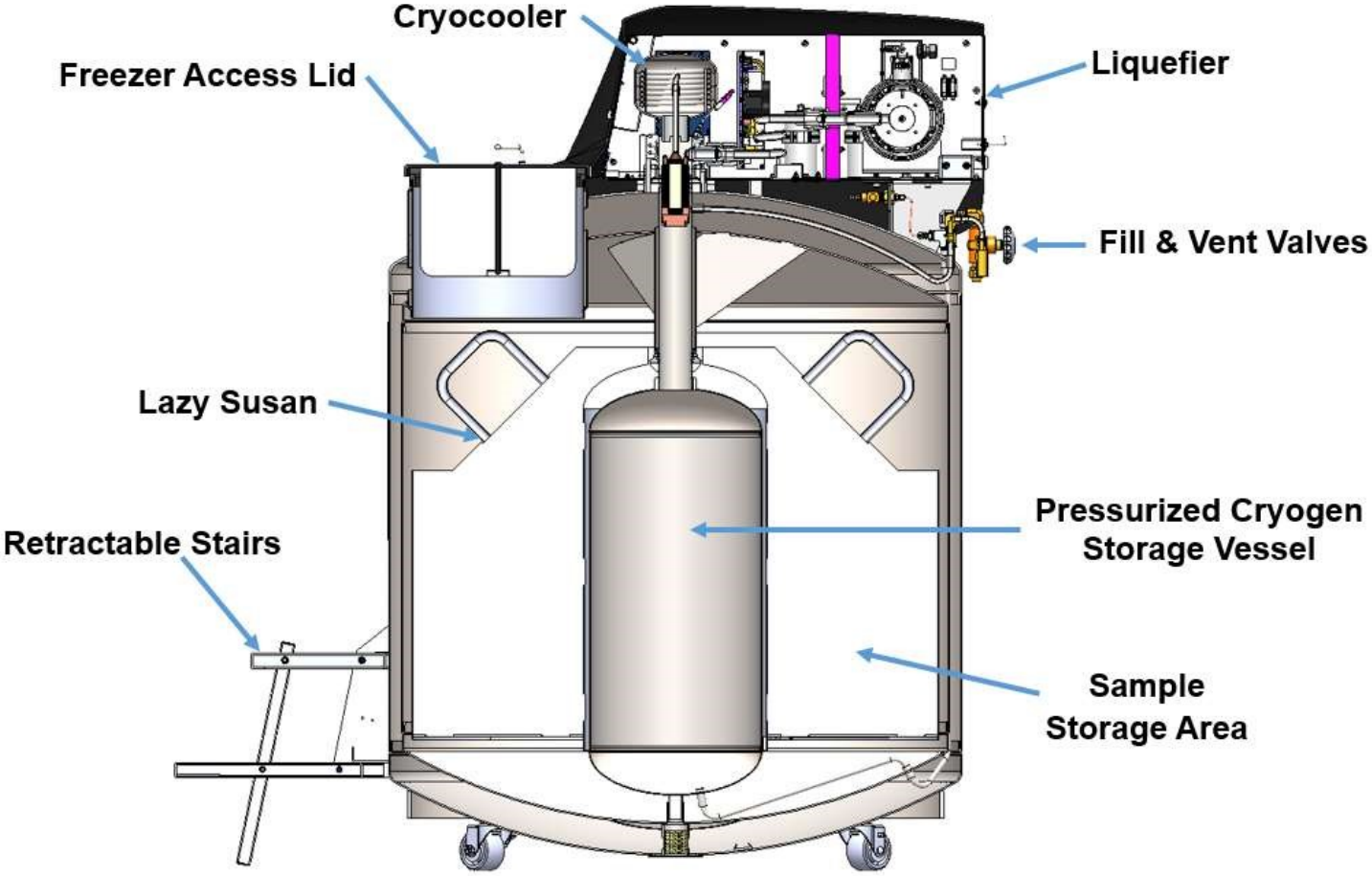


Figure 2: Cross Section of the MVE Fusion Freezer

3.2 Liquefier

The Liquefier contains the cryocooler and other support / interface control systems required to operate the MVE Fusion Freezer. Replacement of the liquefier should only be performed by a representative from Chart Inc. or trained authorized personnel.

The Liquefier consists of the following major components and features:

- **Cryocooler –** This is the heart of the system that maintains the liquid nitrogen stored within the systems pressure vessel.

- **Graphical User Interface (GUI) –** This is a touch-screen interface with customized software intuitively designed for monitoring the MVE Freezer. The 155mm x 87mm backlit LED display provides system security through password protected admission. The main screen allows quick access to and displays key parameters such as the internal freezer temperature, the cryogen liquid level, cryocooler motor temperatures, the cryogen pressure and system alarms.

- **Battery Backup –** A 12V, 9.0Ah, sealed lead acid battery allows for monitoring of the freezer parameters and alarms for a minimum of 24 hours after a power loss.

- **Main Control Board –** An advanced printed circuited board (PCB) with control logic and memory for storage of settings, parameters and historical events.

- **Variable Frequency Drive (VFD) –** The cryocooler is powered by this variable frequency, variable voltage power supply. Control of the VFD is accomplished by signals sent from the main PCB based on the freezer status. Voltage to the cryocooler is modulated to maintain a constant freezer temperature and optimize power consumption.

- **Cooling Fans –** Two 12 VDC, 150CFM fans with “CPU” style heat exchangers reject heat from the cryocooler and electrical components within the liquefier to the ambient environment.

- **Alarms –** In addition to the visual alarms displayed on the GUI, an alarm speaker sounds when any preset threshold (freezer temperature, low battery, motor temperature, VFD temperature, gas pressure, etc.) is exceeded or if the freezer lid has been removed for more than 5 minutes.

- **Serial Communication –** Two full-duplex RS-232 communication ports are provided to monitor the VFD and control system and modify parameters. These are for use by trained service technicians or other qualified personnel only.

- **USB port –** A standard USB interface allows easy access to download the event historical logs.

- **Global Alarm Contacts –** A normally open and normally closed set of dry contacts are provided for monitoring alarm conditions. Chart MVE does not provide remote monitoring systems or programmable logic controller (PLC) but these contacts can interface with many commercially available remote alarm systems.

Figure 1: Front Perspective of Liquefier with the Cowling off

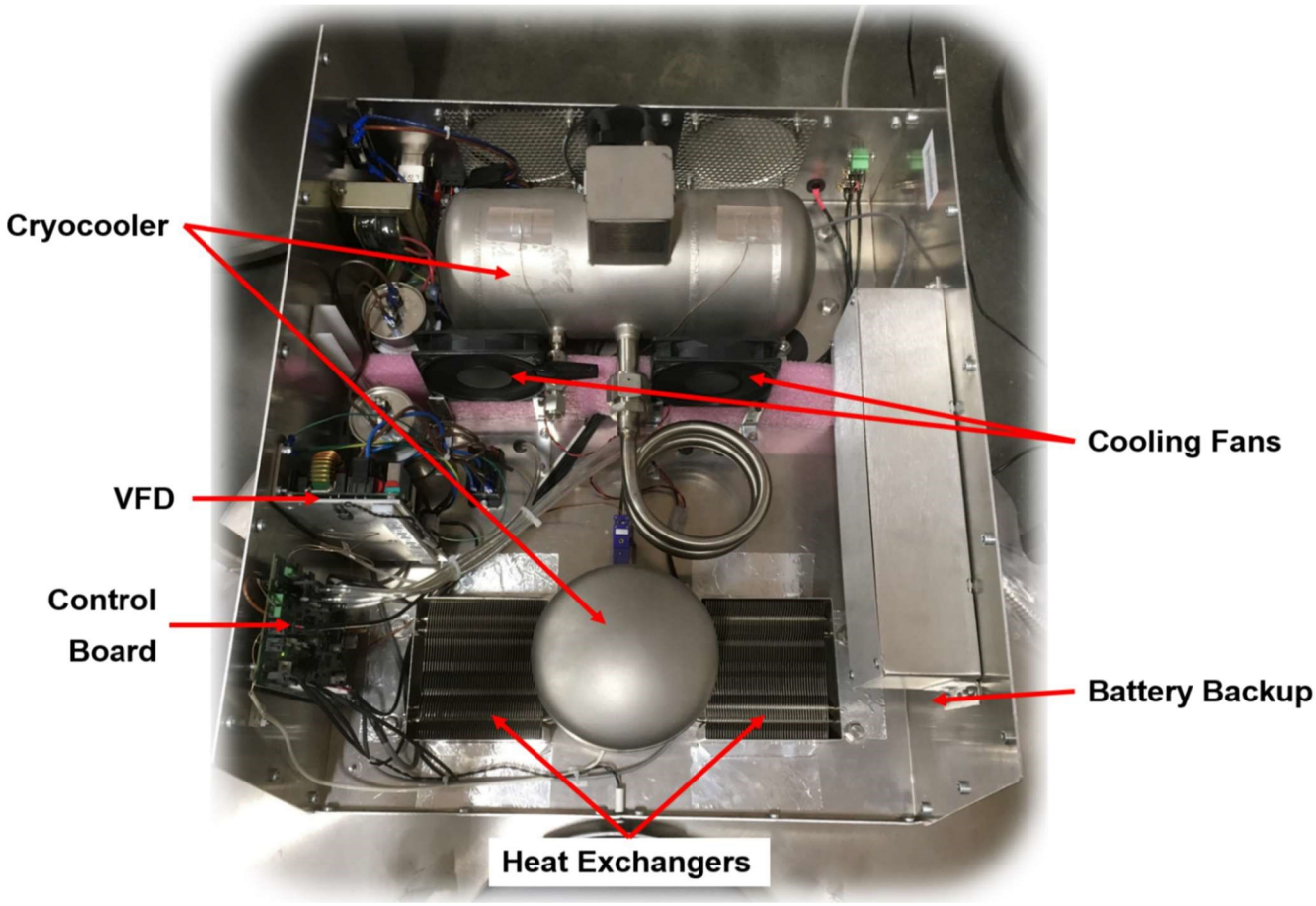


Figure 2: Internal Components of Liquefier

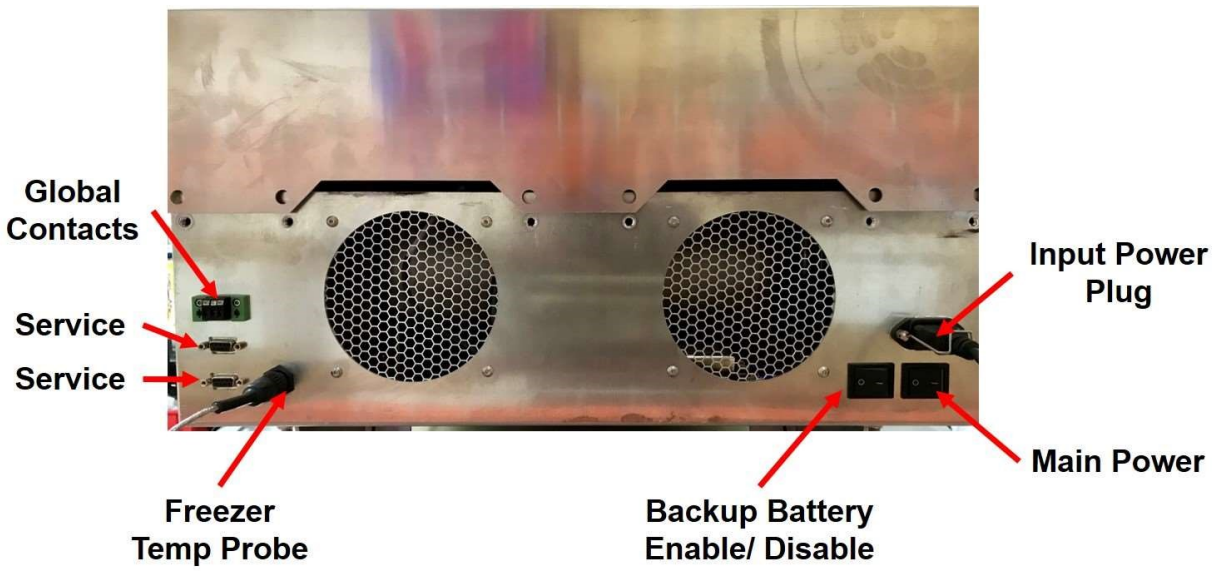


Figure 3: Liquefier back panel / Physical connections (Cowling off)

3.3 Cryocooler

The cryogenic cooler is the refrigeration device for the MVE Fusion. It is mounted on top of the MVE Fusion dewar. It provides cryogenic cooling by mechanically compressing and acoustically expanding the helium gas in a Stirling cycle. The base cryocooler unit consists of a pressure wave generator (PWG) and a coaxial Stirling (pulse tube) cold head (see Figure 6). As liquid nitrogen boils off it rises to the top of the pressurized inner LN2 storage tank. There heat is removed from the gaseous nitrogen by the cryocooler and converted back into a liquid. This highly efficient design eliminates the need for a constant supply of LN2 and allows for autonomous operation. Figure 6 shows a schematic representation of the cryocooler.

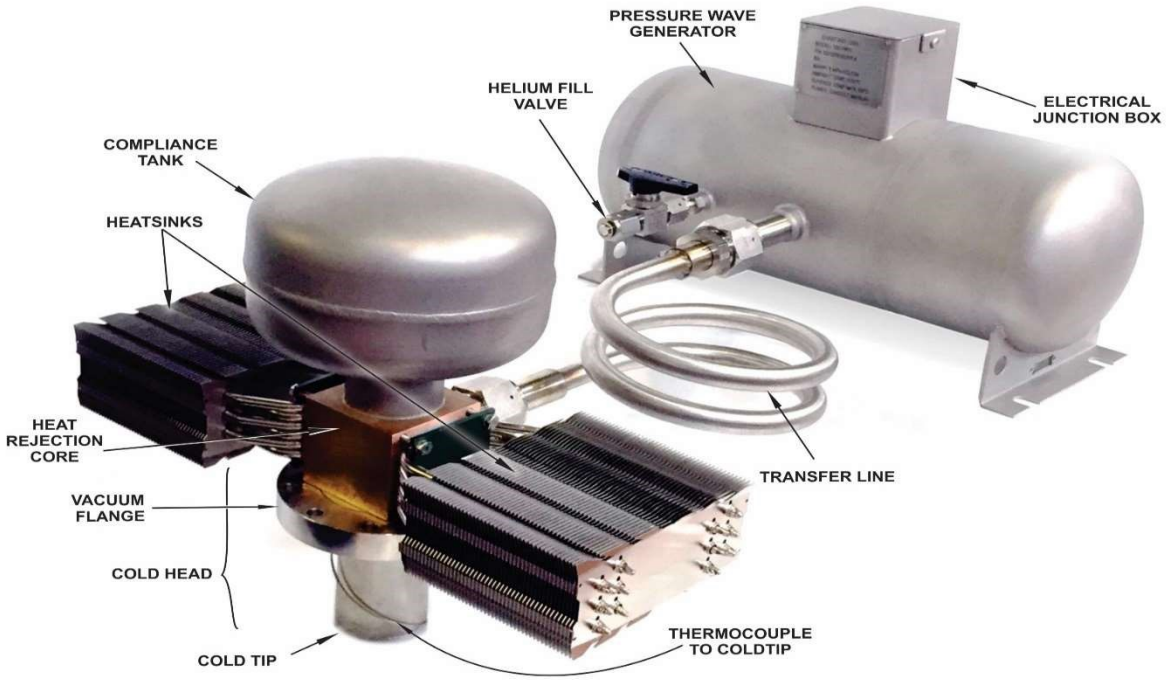


Figure 6: Cryocooler

The cryocooler system operates as follows (refer to Figure):

1. Helium gas is cyclically compressed and expanded relative to the mean pressure by the pistons of the PWG.

2. With each forward stroke of the piston's helium gas moves through the first warm heat exchanger (the "aftercooler") where heat is removed. Helium is next forced through the regenerator, which precools the gas before it reaches the cold heat exchanger (see Figure 7).

3. As the gas moves toward the cold heat exchanger, gas in the acoustic network (thermal buffer tube, warm heat exchanger, and reservoir) also moves in the same direction. Even as the driven gas stops advancing, when the pistons reach their upper limits, the helium gas continues moving in the inertance tube, driven by its own inertia. This acts like a virtual piston, moving away from the cold

exchanger, expanding the cold gas. As the cold gas expands, it gathers heat from the surroundings (the area or substance to be cooled).

4. The pistons begin withdrawing, and helium then moves back through the regenerator and aftercooler. Still delayed by its inertia, the gas in the inertance tube follows, and the cycle begins again.

The heat exchangers and pressure wave generator are cooled by the fans which blow air over the motor enclosure and main heat rejection core.

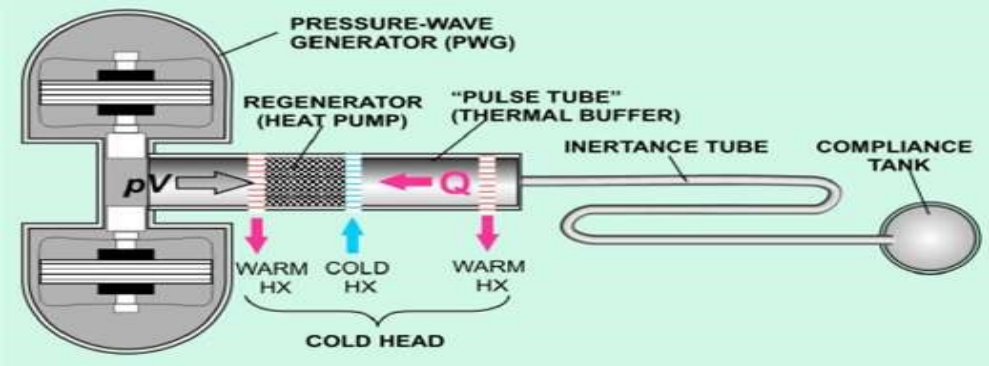


Figure 7: Schematic cross section of Cryocooler

3.4 Fusion Dewar

Chart is the leading global manufacturer of vacuum insulated biological storage freezers. Standard Chart MVE freezers use liquid nitrogen as the cooling medium; it boils off as heat leaks to the outside, which maintains the internal temperature, but requires a constant replenishing of liquid. This limits installations to areas where LN2 is readily available and easily transported to each freezer location. The MVE Fusion leverages Chart's vast experience and industry leading technology by incorporating these already proven freezers into a freezer that runs solely on electricity.

The only difference is that an internal cryogen storage pressure vessel is added along with a cryocooler to maintain the cryogen in a liquid state. The MVE dewar consists of the following major components and features:

- **Stainless Steel Construction –** All storage and pressure vessel components are constructed of welded stainless-steel offering decades of service life.

- **Vacuum Insulation –** The annular space around the sample storage compartment is vacuum insulated to virtually eliminated conduction and convection losses.

- **Retractable Stairs –** Offer safe, easy access to the freezer storage area.

- **Access Lid with Cork –** Light, easily removable lid with magnetic switch that indicates when the lid has been removed or improperly placed.

- **Storage Space –** The MVE Fusion is designed with a rotating tray, lazy Susan, which allows access to all samples without difficulty. An LN2 dip stick channel guide is not incorporated in the Fusion as LN2 below the lazy Susan is not a requirement for operation after the first fill of the Fusion freezer.

- **Temperature Monitoring –** An RTD is provided to monitor the upper storage space temperature and control the freezer operation.

- **Cryogen Storage Pressure Vessel –** 50-liter liquid nitrogen storage tank designed to ASME standards with safety pressure relief device and muffler.

- **Liquid Level Sensing –** Differential pressure sensors continuously monitor the liquid nitrogen level.

- **Fill and Vent Ports** – Easily accessible valves are provided for initial filling and venting of liquid nitrogen (see Figure 9).

Figure 4: Retractable Stairs, Removable Lid and lazy Susan within the Storage Space

Figure 5: Left to Right: Vent (Overfill) Valve, Relief Valve, and Fill Valve

3.5 Pressure Vessel and Sample Storage Area

The dewar is based on the Chart's MVE High Efficiency Freezers, with modifications to incorporate a cryogen tank and cryocooler. The "lazy Susan" Carousel for sample racks is suspended from the neck of the cryogen tank and can be turned easily using the handles provided. The inner cryogen tank is filled nearly to the top, so that the entire outside of the tank serves as heat-exchange surface to cool the air inside the storage space. The initial fill of the cryogen tank is performed when the unit is first delivered to the customer site (by Chart or an authorized distributor).

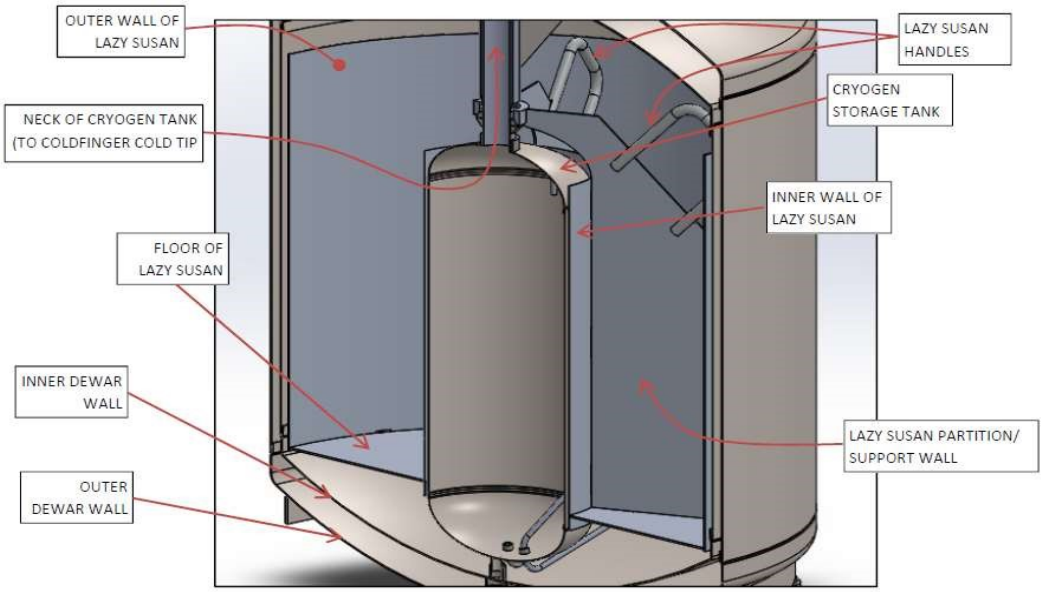


Figure 6: Cross-Section View of Cryogen Vessel within Sample Storage Area.

3.6 Ancillary Equipment

- **Lid and Cork** - The lid covering the storage space (shown in Figure 8), the gasket on the rim of the Dewar neck, and the gasket underneath the lip of the lid are all replaceable parts. Together, they provide insulation and a nearly airtight seal to prevent heat and moisture from entering the storage space.

- **Retractable Stairs** - The Built-in stairs make it easy to access the storage space. They can be folded up against the freezer when not in use, as shown in

Figure ***4***. A restraint is included to keep the stairs from being accidentally unfolded.

- **Transfer line –** In the event the MVE Fusion needs refilling or topping off (for instance after a prolonged power outage) a proper hose to transfer LN2 from a supply tank to the pressure vessel is required. See “filling the MVE Fusion” for more details. A vacuum-jacketed hose with ½” flare fittings on each is required; Chart recommends using a transfer hose with a “candy cane” pressure-relief included, to protect against bursting of the hose if the liquid inside should become superheated. Please see Figure 11 below for example of the transfer hose with the candy cane pressure relief valve included.

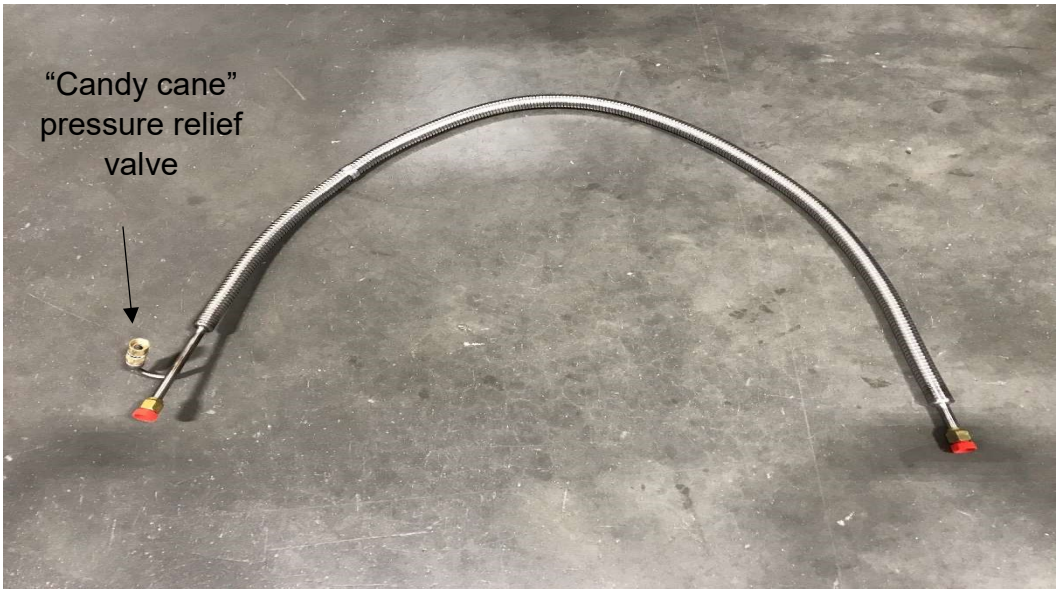


Figure 7: Transfer hose with the candy cane relief valve included

- **Temperature Probe** - The MVE Fusion freezer comes equipped with a factory installed Resistance Temperature Detector (RTD), with a connection that appears on the back side of the liquefier enclosure, shown in Figure 12. The RTD probe is supplied by Chart Industries and is pre-installed, silicone into place and calibrated. The temperature probe tube communicates directly with the air inside the storage space to read the air temperature. There is an additional temperature probe tube, plugged at the factory, that can be used by the customer to install a secondary probe based on the customer's requirements**. *The user's probe must be small enough to navigate through a 0.3" ID conduit with a 4 inch-radius bend.*** If the Chart-supplied RTD has any issues or requires calibration, please contact Chart Industries or an authorized distributor. Only certain RTDs are compatible with the Fusion electronics; in addition to the size requirement, the probe must be a shielded two-wire (+ and – signal wires, and shield), "PT1000" type, having a nominal resistance of 1000 ohm at 0 °C.

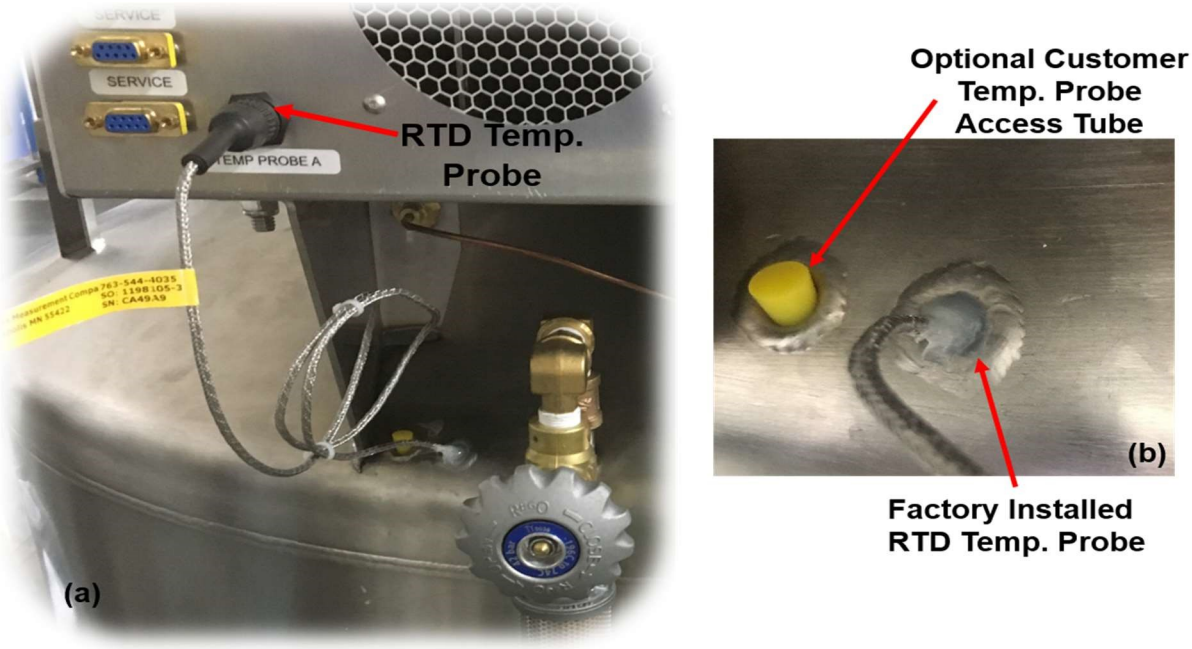


Figure 12: Fusion temperature probe. (a) Temperature probe on the back panel of the liquefier, (b) Additional temperature probe access tube for the secondary temperature probe

3.7 Product Specifications

Table 3: MVE Fusion Product Specifications

Safety for Electrical Equipment and Lab Use	ETL marked for use in the United States and Canada according to: UL 61010-1:2012 (Edition 3.0) CSA/CAN 22.2 #61010-1:2012 (Edition 3.0) ASME Section VIII (Cryogen pressure vessel)
Physical Dimensions	Height: < 65 inches (1625 mm) Width: 43.5 inches (1088 mm) Depth: 57 inches (1450 mm) Weight (Empty): < 750 lb (340 kg) Weight (Full): < 830 lb (377 kg) without racks Weight (Full): <1100 lb (500 kg) with 20 “13-2 large racks”, Lift over Height: 37.1 Inches (944mm)
Electrical Power	Power Adapter: Class I, 9A @ 120V, 60Hz Consumption: ~750 W (Maximum) **NOTE: Chart recommends the use of a dedicated 15-amp circuit breaker outlet for operating one Fusion or a dedicated 20-amp circuit breaker for operating two Fusions off the same electrical outlet.**
Operating Conditions	Temperature: 18°C – 27°C (65°F – 80 °F) Humidity: ≤50% (non-condensing) Pressure: 8.2 PSI (57.2 kPa) to 14.7 PSI (101 kPa)

Standard Performance	Sample temperatures: under -150°C in top box unless: a) More than two warm 13-2 large racks are added to the freezer at one time, or b) Power is lost for more than 5 days with no lid openings or c) Lid left open for 15 minutes
Pressure Vessel	Cryogen: Liquid Nitrogen Volume: 50 Liters Pressure Relief Valve: 50 PSI (± 5%)
Storage Specifications	Number of Racks: 20 Standard 13-2 racks (13-shelves for 2" boxes), plus 16 Mini 13-2 racks. Number of Vials: 26,000 (standard racks only; 31,200 with mini-racks) Vial type: 0.5 to 2mL
Controller Operating System	Android based GUI

3.8 Installation and Startup

This section will review the basic receiving, installation, and startup procedures for MVE Fusion freezer. Always inspect the bill of lading for accuracy and external crate/packaging for damage before accepting the shipment.

Included with each Fusion freezer:

- Literature Packet
  - Fusion Quick Start Reference Guide – PN 21205647
  - Warranty Statement / Registration / Certificate
- 6 ft. transfer hose having "candy cane" pressure relief valve (inside freezer)
- Liquid Nitrogen handling instructions
- Desiccant bag (inside freezer) – To be removed and discarded before use
- Silicon tube
- A/C electrical power cord
- MVE Checklist

3.9 Filling the MVE Fusion

Following the careful uncrating and unpacking of the freezer, install using these basic instructions.

CAUTION: This information is included primarily for reference. Chart recommends any cryogen filling/refilling be done by Chart personnel or a Chart-authorized distributor.

CAUTION: Always wear protective gloves and face shield when work in with liquid nitrogen.

NOTE: Do not power on the Fusion until all steps are followed. Make sure to have two full 230-liter LN2 cylinders at 22-35 PSI for the first fill.

1. Load all racks and empty boxes or alternate inventory systems into the MVE Fusion. Refer to Figure 13 for a view inside a Fusion having storage racks installed and common inventory systems and Figure 14 for a standard Fusion rack layout.

NOTE: VERY IMPORTANT TO ADD RACKS AND BOXES BEFORE FILLING.

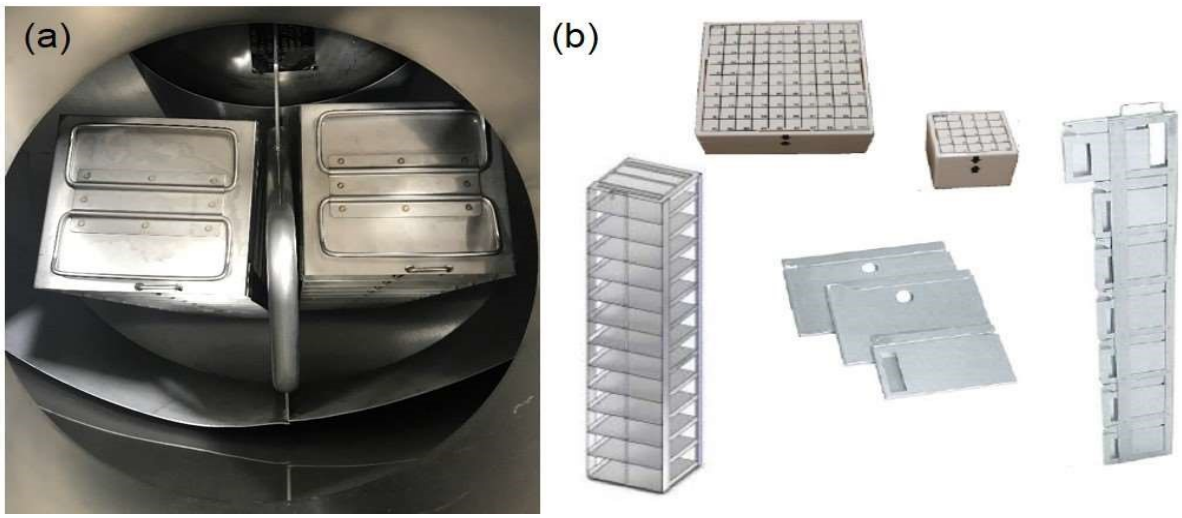


Figure 13: (a) View inside storage container, (b) Inventory systems

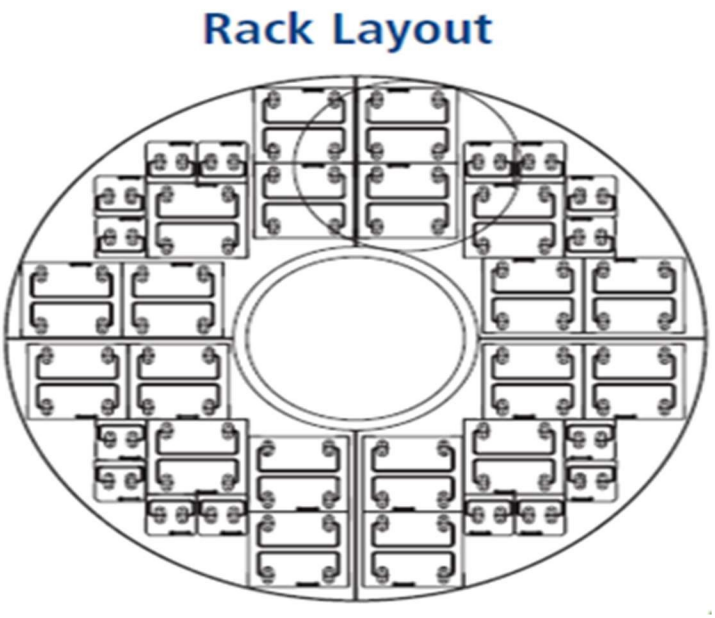


Figure 14: Rack Layout for MVE FUSION

2. Connect the end of the supplied transfer hose having the “candy cane” pressure relief valve on it to the liquid port on the 230-liter LN2 supply tank with the “candy cane” oriented in the vertical position (i.e. the pressure relief valve (PRV) venting downwards).

3. Insert the other end of the transfer hose into the Fusion dewar storage space. Chart recommends that a phase separator be placed on this end of the transfer hose for this filling process. (see Figure 15)

4. Open the liquid supply valve on the 230-liter LN2 supply tank.

5. Dispense approximately 20-30 liters of LN2 into the storage space of the Fusion freezer. To achieve a quicker cooldown, the lazy Susan can be rotated while LN2 is being dispensed into the storage space. Dispensing LN2 directly over top of the racks can also aid in reducing the cooldown time but should be avoided if samples are present.

6. Close the liquid supply valve on the 230-liter LN2 supply tank.

7. Remove the phase separator (if used) end of the transfer line from the storage space.

8. Remove the phase separator (if used) from the end of the transfer line, then connect that end to the Fusions inlet port (refer to Figure 17).

Figure 15: Connecting Supply Tank to the MVE FUSION

9. Confirm that both isolation valves located underneath the shroud, one on each side of the liquefier, are closed (see Figure 16). If they are not, close both valves.

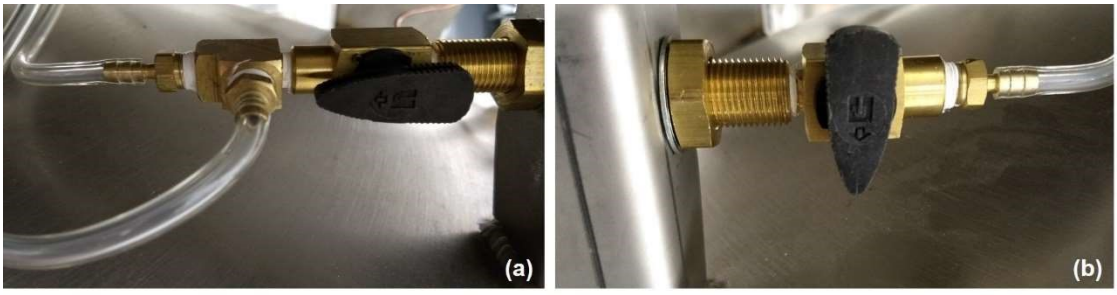


Figure 16: Isolation valve; (a) Open state, (b) Close state

10. Open the liquid supply valve on the 230-liter LN2 supply tank.

11. Open the vent valve on the Fusion (refer to Figure 17). This will prevent over pressurization and lifting the relief valve during the filling process. **Note: The Fusion pressure vessel is shipped with a small amount of low-pressure, gaseous nitrogen, thus when the vent valve is opened an audible venting noise may be heard.**

12. Open the fill valve on the Fusion (refer to Figure 17). Both the fill and vent valves will remain open until the Fusion freezers pressure vessel is filled with LN2.

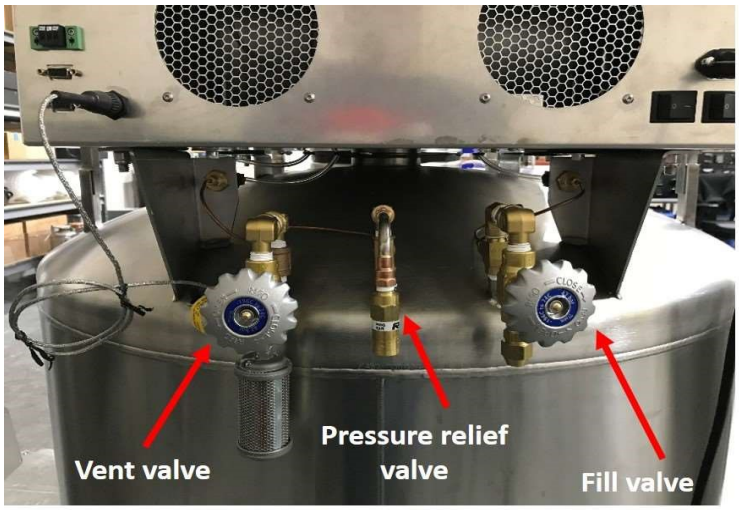


Figure 17: Vent and Fill Valve

13. Once LN2 begins to flow steadily out of the vent port, close the vent valve, then close the fill valve. Immediately thereafter, close the liquid valve on the 230-liter LN2 supply tank.

NOTE: When using a supply source of 22-35PSI, the inner pressure should fill in approximately 30 minutes.

14. Open both isolation valves located underneath the shroud (refer to Figure 16).

15. Connect the supplied A/C electrical power cord to MVE Fusion power receptacle at the rear (see for Section 5 further details on system powering).

Figure 18: AC power supply

WARNING

To avoid risk of electrical shock, this equipment must only be connected to a properly grounded power source or outlet.

CAUTION: Do not position the Fusion freezer in an orientation that makes it difficult to remove the power cord from main power receptacle.

16. Shortly after filling the pressure vessel, the pressure relief valve on the Fusion will begin releasing gaseous nitrogen as the storage space and racks within cool down. This is a result of the liquid boiling off and pressure building above 50 PSIG inside of the pressure vessel. As the storage space and installed racks and trays cool down to a stable temperature, the “relief” events will subside, and the pressure vessel will need to be topped off with LN2. Under steady state operating conditions the indicated gas pressure within the pressure vessel and displayed on the user interface should stabilize between 15 and 25 PSIG.

CAUTION: Venting will occur which will result in a loss of liquid inside the pressure vessel if warm racks are installed after the Fusion’s first fill and if more than 1, 2, or 3 warm racks are installed during its subsequent operation. Be prepared to have a 230 LN2 cylinder @ 22-35 PSIG to refill pressure vessel if this occurs.

4 Operation

4.1 Basic Operation

The MVE Fusion is a “self-sustaining” cryogenic storage freezer which normally requires limited user intervention once it has been installed at the customers site and Chart (or an authorized distributor) performs the first fill. However, there are circumstances (power outages, for instance) when the system will require attention. There are alarms and other information provided by the GUI (graphical user interface) to convey important messages and warnings to the user. Understanding and familiarizing yourself with the Fusion freezer and its GUI is recommended for the user for the smooth functioning of the system. The MVE Fusion uses an Android tablet with a custom-built software application to monitor the freezers operation.

CAUTION: The user should never operate the Fusion freezer without the Android running the custom-built software application and should never exit the application during operation.

4.2 Starting the Fusion Freezer Safely

This section of the manual will detail the functions and features of the Android application and demonstrates how to access and monitor the freezer operation.

CAUTION: The Fusion must have LN2 inside the pressure vessel before electrical power is supplied to it (see Section 3.9.1 for how to fill the Fusion).

1. Connect the included electric power cord to the back of the unit.
2. Switch the System Power and the Battery Backup power switches (see Figure 19) to the “On” position (I).

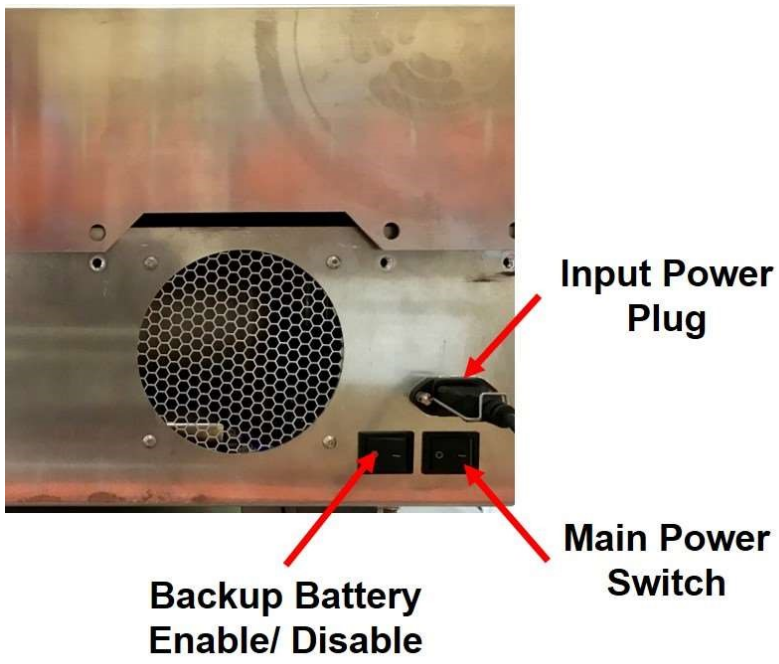


Figure 19: Main and Battery Backup power switches

3. Once powered on, the MVE Fusion controller will start up with two screens displaying the Android logos shown in Figure 20 before the main menu of the Fusion application is loaded.

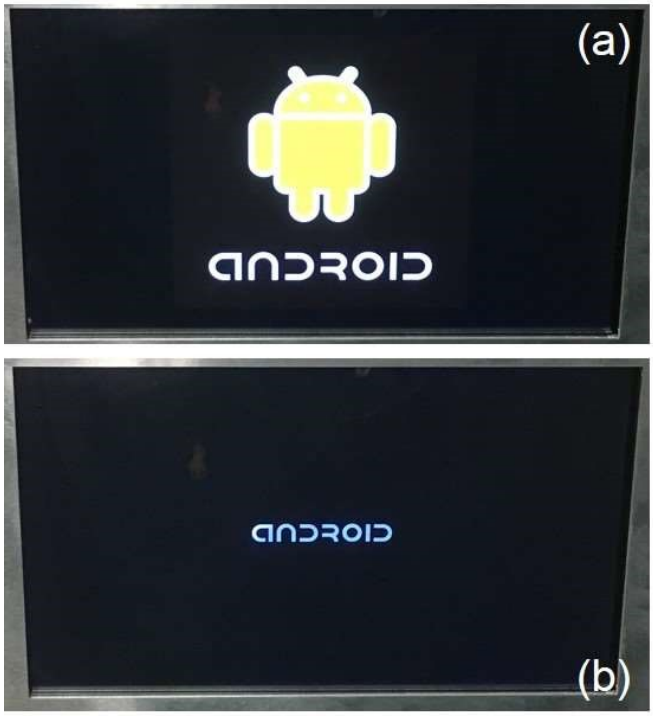


Figure 20: Android logo screen that appears when the Fusion system is powered up

4.3 Operating the Android User Interface

4.3.1 Navigating the GUI

There are several screens available within the fusion android application to monitor the system performance and doing specialized tasks such as resetting alarms or changing the system password. To reach other screens within the app, swipe sideways with a finger, or touch the tabs in the upper left-or right-hand corners of the screen the user is in. For instance, to reach the “Levels” screen from the “Main” screen, touch the “Level” heading on the upper right-hand corner, or swipe a finger from the right to left (as if dragging the screen sideways). Then the “Main” screen will be replaced by the Level” screen.

4.3.2 Main Screen

The main screen displays several key parameters including Freezer temperature, cryogen level, and temperature distribution (see Figure 21). Some parameters can be

changed from the screen(s); any change takes a minute to become effective, as this is the sampling interval of the control loop.

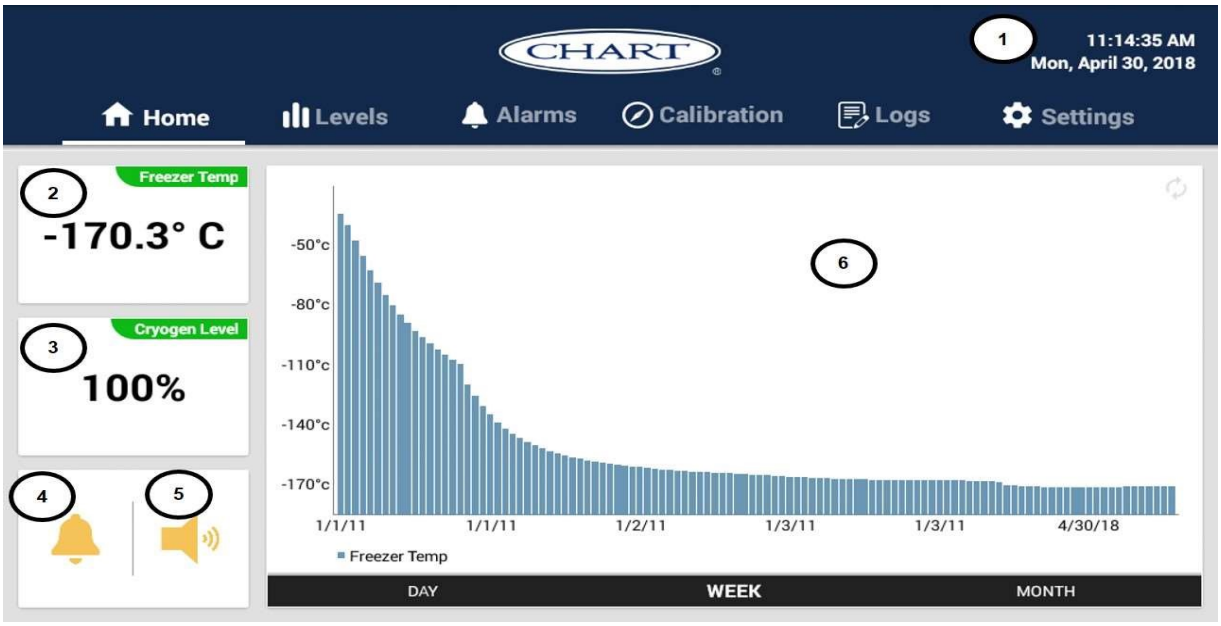


Figure 21: Graphical User Interface Main Screen

1. **Current Time and Date** – The user can update the Time and date by tapping on the top right-hand corner.

2. **Freezer Temp** – This value is the air temperature measured at or near the “top box” level of standard storage racks.

3. **Cryogen Level** - Liquid nitrogen level of the cryogen storage tank (displayed as a percentage of full level). The level normally does not change, unless there is a prolonged power outage and some cryogen is sacrificed to maintain the storage space temperature. If the cryogen level is below the 50%, user should refill the cryogen tank and should call for tech service and inform the situation.

4. **Alarm Mute Button** – This button can be used to mute the alarms. The alarms can be un-muted by pressing the button again (the system will update after one minute).

5. **Speaker toggle button**- This button renders the speaker silent for non-alarm sounds.

6. **Temperature Timeline** – The freezer temperature data points displayed on the graph reflect the measured freezer temperature at the top of every hour of operation. At the top of every hour a new data point is added to the graph which matches the displayed freezer temperature on the left. Graphing one measured freezer temperature per hour is to improve performance and increase the overall stability of the firmware. This display has the capability to display the data for the selected day, week or month. In Figure 21, if the user selects day option (indicate below the time line), the bar graph shows the average Freezer temperature recorded for the respective hour.

4.3.3 Level Screen

The level screen displays the amount of cryogen as a percentage available at the given moment. The same screen provides several other key parameters such as Freezer temperature, Cold tip temperature, Gas pressure of the cryogen tank, Left and Right motor temperatures, and the Reject temperature of the cold tip.

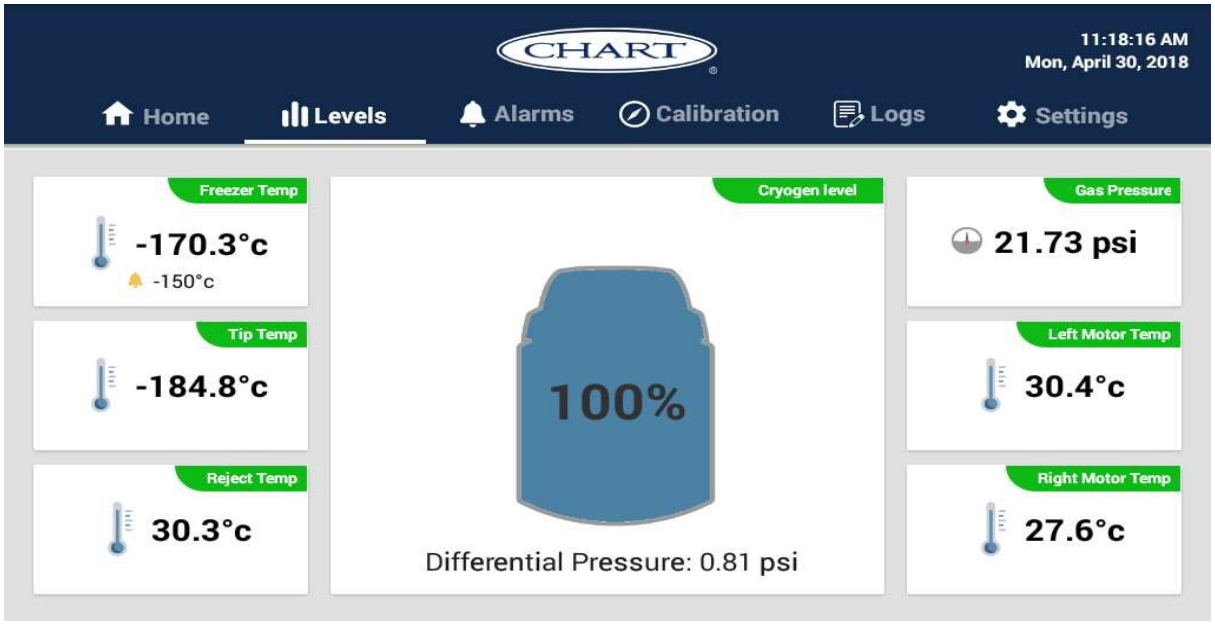


Figure 22: "Level" screen in the GUI.

4.3.4 Alarms Screen

See Alarms section below.

4.3.5 Calibration Screen

The “Calibration” screen is for calibrating the built in RTD that comes with the MVE Fusion (see Figure 23). As mentioned earlier, the user does not normally use this feature. This product has the two-point calibration capability.

CAUTION: This information is included primarily for reference. Chart recommends the RTD calibration be done by Chart personnel or a Chart-authorized distributor. The RTD probe must be removed from the freezer in order to be calibrated.

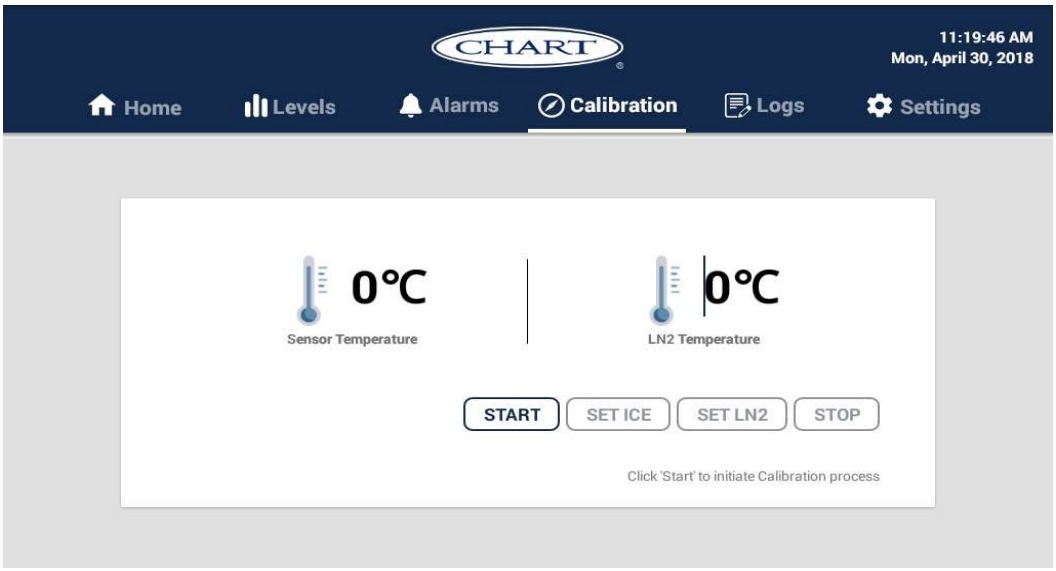


Figure 23: Calibration screen

1. Touch the “Start calibration” button.
2. Enter the password in the “Password” field.
3. Select the “Start calibration” button.
4. The default boiling temperature for liquid nitrogen will appear in the “LN2 Temp” field. This is an altitude-dependent value: enter the appropriate LN2 boiling temperature for the altitude in which the unit is operating.

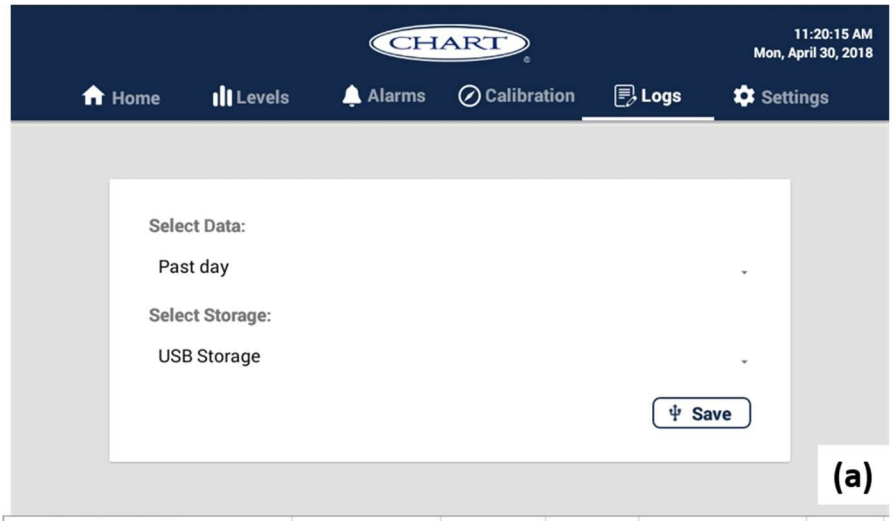
5. Submerge probe into LN2 or an ice bath, depending on the type of calibration being performed. The temperature values displayed are raw data (meaning they are very sensitive and will change very quickly), so wait for the values to stabilize before proceeding to the next step.
6. Optional: The calibration step may be cancelled by selecting the “End Calibration” button now. If cancelled, a message will be displayed indicating that no calibration was performed.
7. Select the “Set LN2” or “Set Ice” to perform the applicable calibration.
8. Calibrations can be repeated, or a different calibration may be performed, by repeating steps 4-7 as applicable.
9. When finished, select “End Calibration.” The measured RTD values will go back to filtered instead of raw data.

4.3.6 Logs Screen

The Log Screen allows the user to save a log file to a thumb drive or other external USB drives by connecting the storage device to the USB port shown in Figure 23 entering the password and pressing the “SAVE FILE” button. The user can select the time frame of interest (under the “data to save” tab). The log file type is a .csv (comma-separated values) text file, with the filename in the format **FusionLog_yyyy-mm-dd-hh-mm-ss.csv** (the year, month, day, and time the file was written).

Figure 23: Front Perspective of Liquefier with the Cowling off

The file itself has a header that contains the freezer and cryocooler serial numbers, and firmware versions of GUI, Fusion, and cryocooler. Data measurements are taken and recorded hourly and includes the date, freezer temperature, liquid nitrogen level, alarm code, alarm status code, and status. Most of the data are self-explanatory. But, the alarm codes are in hexadecimal. Alarm status provide a brief description that user can easily understand. The software provide capability to download the data per day, week or even for months.



(b)

Fusion log file: All data					
Date written:08/20/2018 12:09:23 PM					
Fusion SN:CAB2117371232					
Cryocooler SN:K319					
GUI:v2.0					
Fusion firmware:v1.30					
CryoCooler firmware:v1.18					
Date	Freezer Temp (°C)	LN2 Level (%)	Alarm code	Alarms Status code	Status
8/17/2018 14:00	-171.9	100	0		0
8/17/2018 16:00	-172	100	0		0
8/17/2018 17:00	-172.2	100	0		0
8/17/2018 18:00	-172.3	100	0		0
8/17/2018 19:00	-172.3	100	0		0
8/17/2018 20:00	-172.4	100	0		0
8/17/2018 21:00	-172.4	100	0		0
8/17/2018 22:00	-172.4	100	0		0
8/17/2018 23:00	-172.3	100	0		0
8/18/2018 0:00	-172.3	100	0		0
8/18/2018 1:00	-172.2	100	0		0

Figure 24: (a) Format of the Data logs screen, (b) Format of the Data file

4.3.7 Settings Tab

This tab provides the capabilities of changing the password, resetting the password, and several other options. Password changing process is given below;

1. Select the “Password” screen.
2. Enter the current password in the “Current Password” field.
3. Enter the desired new password in the “New Password” field.
4. Re-enter the new password in the “Verify New Password” field.
5. Click the “Update” button.
6. Wait for a message indicating the password was successfully changed. If the GUI is unable to change the password, an error message will be displayed.

There is an option to “Reset” the password in case if user forgot it.

1. Touch the “Reset Password” option (see Figure 25).
2. Then, there will be a pop-up window asking “Are you sure” that the user wants to change the password.
3. If the user selects yes, it’ll be reverted back to “Default” password of “Fusion01”.

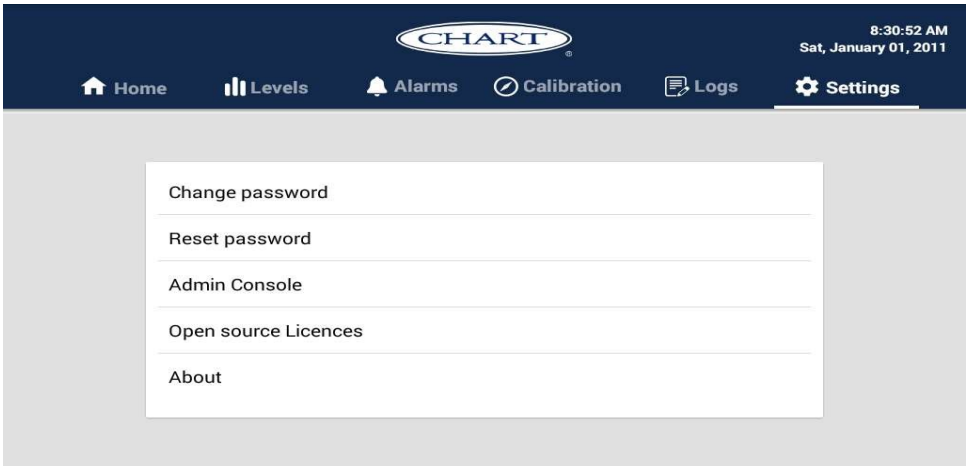


Figure 25: Password screen

The Admin Console provide the opportunity to enter the Fusion and cryocooler serial numbers along with the Admin password. Next two tabs, open source license details and serial numbers and GUI versions details will be displayed. The user doesn’t have capability to change any of these details.

5 Alarms

5.1 Service Ports and Global Alarm Relay

For advance troubleshooting, the Fusion has additional ports on the back panel that allow an authorized service technician to connect a computer to the control board and log detailed real time data and error codes.

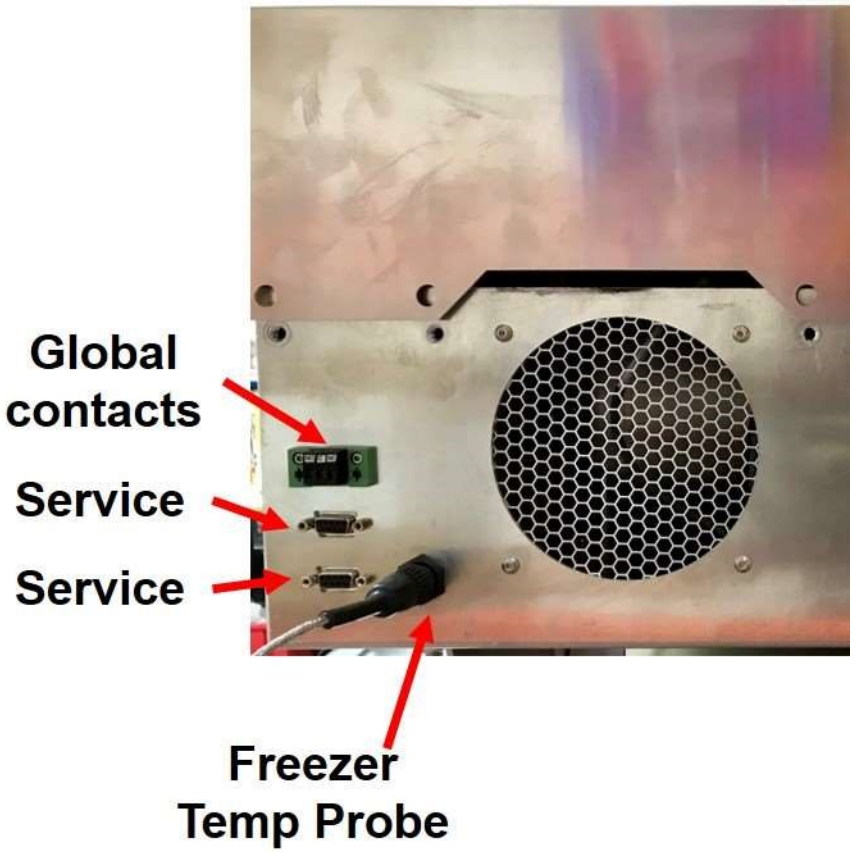


Figure26: Advance troubleshooting ports on the back panel

The data streams on the RS232 ports can be accessed by a command-line terminal application such as TeraTerm. This can only be accessed by MVE Techs/Engineers. Please contact Chart or an authorized representative to connect to these ports (passwords are required to access the data or make changes to parameters).

5.2 Description of Alarms

The following table describes all alarms that available in the Fusion. The codes in parentheses (in the right-hand column) are the identifiers for each variable in the serial data one may obtain from the RS232 ports on the back panel. These alarms are only for information. There is an audible alarm buzzer available in Fusion and that can be disabled. This will not disable the alarms, only the audible buzzer. Alarms will still be displayed visually on the screen if the alarm buzzer is inactive.

Table 5: Alarm parameter ranges

Parameter	Set Points		Define by
	LOW	HIGH	
Freezer Temperature Alarm	No limit	-150 °C	User can adjust HIGH value but limited to -160 °C
Tip Temperature Alarm	No limit	-170 °C	System
Reject Temperature	No limit	50 °C	System
Left Motor Temperature	No limit	50 °C	System
Right Motor Temperature	No limit	50 °C	System
Cryogen Level (%)	35	100	System
Liquid Pressure (PSIG)	15	45	System

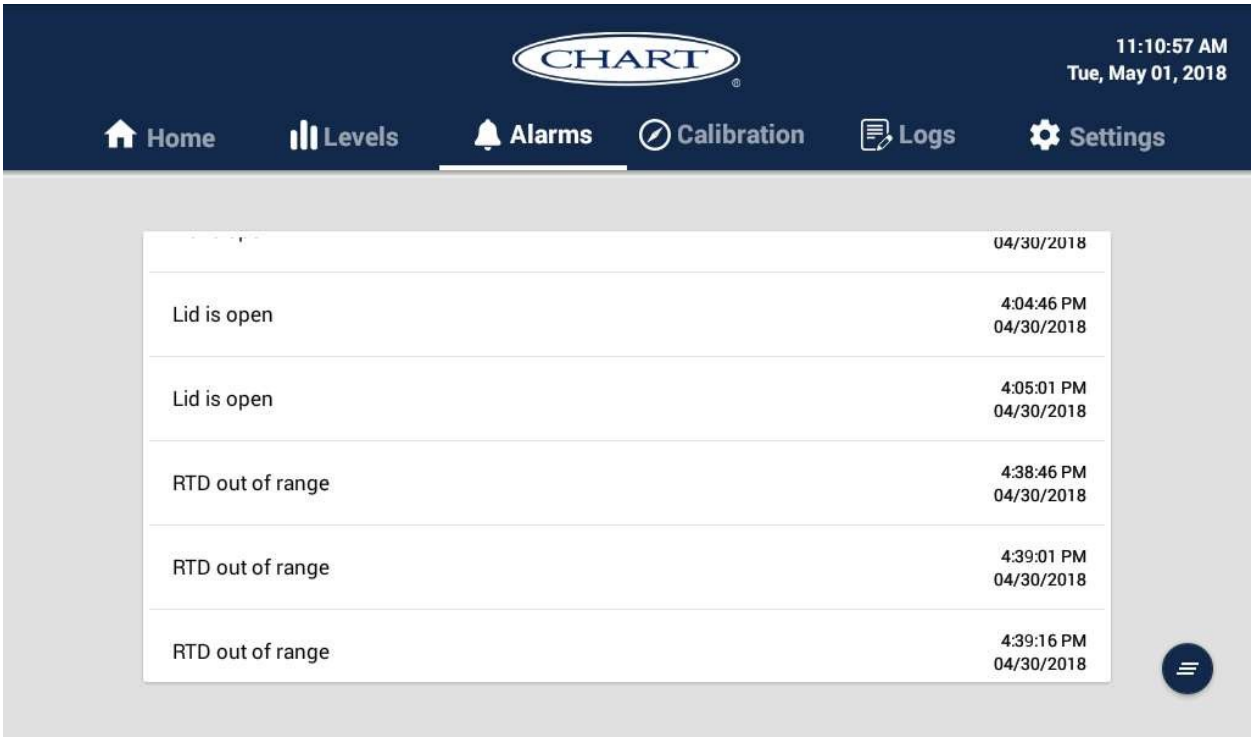


Figure 27: Sequentially recorded Alarm

5.3 Clearing the Alarm Messages

There are several ways to inform an alarm to the user. First, an audible sound starts along with a dialog box popup message in the middle of the screen when a parameter is out of it default range. The same time, same message is stored under the alarm tab for user to observe them later (Figure 27). Buzzer will stop after 30 seconds. The popup message can be cleared by pressing the “close” button appeared on the right-hand corner of the message. To clear all the messages in the “Alarms” tab, hit once on the icon given in the bottom- right corner of the window.

5.4 Routine Operation

Under Normal Operation, the MVE Fusion Freezer operates without any user intervention. The user has simply to load (Precooled) or remove samples from the storage space as desired. Nonetheless, there are a few guidelines that will result in the most successful operation.

- **Pull the lid up very slowly when removing.** This will allow the air inside the storage space to remain stratified and maintain high clarity and visibility. Pulling the lid and cork out quickly will disrupt the inside air and cause warm, relatively moist air to be drawn in, resulting in fog obscuring the view into the storage space.

- **Return racks to the freezer as quickly as possible.** This maintains the “cold chain of custody,” ensuring the samples never get warm.

- **Reinstall the lid as soon as possible.** The Gaskets on the lid and the neck opening are designed to maintain a nearly airtight seal as long as the lid is left in place. This prevents moisture from entering the dewar and building up ice and frost on the surfaces.

- **No more than 2 warm racks can be added to the freezer at a time.** Adding more than two racks at a time may cause nitrogen pressure to exceed the allowed limit and vent from the tank. (Be prepared to fill with a 22-35 PSI (1.5 - 2.4 bar) liquid nitrogen cylinder if this happens).

- To maximize the storage capacity of the freezer, the racks need to be arranged in an optimum fashion. Figure 13 shows the ideal arrangement of standard racks. Mini racks may be inserted in some of the remaining unoccupied spaces.

5.5 Shutdown MVE Fusion

- Switch off the Main Power and Battery backup switches to shut down the MVE Fusion freezer.
- Remove the input power cable to isolate from the wall outlet.
- There is no system shutdown option in the firmware.

5.6 Instructions to empty the pressure vessel:

1. Remove all racks from inside the Fusion storage space and move into another MVE cryogenic stainless freezer of similar in size.
2. Move Fusion to a safe location to vent the liquid nitrogen.
3. Open the vent valve to empty the inner pressure vessel.

6 Preventative Maintenance

6.1 Preventative Maintenance Schedule

This section describes the preventative maintenance that should be performed on the MVE Fusion to ensure optimum operation and performance, as well maximum service life. As with any technical piece of laboratory equipment, preventative maintenance is key to equipment success.

NOTE: This is the MVE recommended preventative maintenance schedule. MVE Distributors may have a more comprehensive maintenance/service plan.

Table 6: Preventative Maintenance Schedule

	Weekly	6 Months	12 Months	24 Months	60 Months
Level verification	X				
Thaw Lid/Lid Inspection		X			
Folding Step Inspection		X			
Inspect Pressure Vessel welds			X		
Gasket Replacement				X	
Top off the Inner Vessel with LN2 (only if required)				X	
Fan and Internal Cabinet Cleaning				X	
Pressure Relief Valve Replacement				X	
Internal Battery Backup Replacement					X

Note: Check freezer at a 5-year interval and thaw only if ice builds up enough to impede proper rack insertion, access and retrieval of samples. See Complete Freezer Thaw and Moisture Removal Section.

Note: Inspect the LN2 pressure vessel in accordance with any local laws and regulations regarding pressure vessel maintenance.

Table 7: Preventative Maintenance Procedures

Item No	Action	Procedure
1	**Level Verification**	1. Liquid Level can only be verified via the GUI. **Note:** Unlike traditional MVE freezers, the liquid level in the MVE Fusion freezer cannot be manually verified with a dipstick measurement.
2	**Lid Inspection**	1. Remove the lid slowly from the MVE Fusion. 2. Inspect lid for any damage and replace parts if necessary
3	**Lid Thaw Procedure**	1. Remove the lid slowly from freezer. 2. It is recommended that the freezer opening be covered with a spare lid or in another non-airtight manner to prevent moisture from entering the storage space and to minimize the top box temperature change while the lid is open. 3. Allow lid to sit at room temperature for approximately 30 minutes. (Caution-the lid open alarm will sound, press alarm mute to temporarily silence the alarm) 4. Once thawed, thoroughly dry lid, cork, and liner. 5. Inspect lid for damage and replace parts if necessary.

4	**Folding Step Inspection**	1. Verify that hinges and free of cracks and all connections are secure. 2. Check that the anti-slip strips on the steps are in good condition and replace if necessary (PN 4810179). 3. Ensure the step locking strap can securely hold the steps in their folded position. If the pivot bolts continuously loosen, apply thread locker (PN 11087674) and retighten.
5	**Gasket Replacement**	1. Depending on the condition of the current gasket, the gasket, the gasket material can be removed and replaced or more material can simply be added to the existing gasket. 2. The replacement gasket material will be a neoprene tape 3. Simply clean the surfaces, remove the tape back to expose the adhesive and install gasket material. 4. Trim to size as needed.
6	**Refill Pressure Vessel**	1. Please refer to Section 5.1 Filling the MVE Fusion on how to fill the inner vessel of the MVE Fusion.
7	**Fan and Internal Cabinet Cleaning**	 Chart Authorized person should only carry out this activity. 1. Make sure the power supply and the battery backup are disconnected. 2. Remove cowling (see Figure 28) and the shroud from the Liquefier, by removing the four bolts that fasten the shroud to the top of the freezer. 3. Remove top cover off the Liquefier, by unscrewing the 28 screws that hold the top cover of the liquefier in place. Use a screw driver.

		 **Figure 28: After removing the Screws on the liquefier** 1. If necessary, blow dust and debris out of the interior of the cabinet with compressed air to clean the cabinet. 2. Take a cloth and wipe away any dust or debris off the two fans. **Note:** Depending on the operation environment of the MVE Fusion, this fan and cabinet cleaning may need to be performed more frequently to ensure optimal performance of the freezer.
8	**Relief Valve Replacement**	**CAUTION**: Ensure that the LN2 supply valve is closed and the pressure vessel is completely vented before removing the relief valve. 1. Close the fill valve on the Fusion plumbing. 2. Open the vent valve on the Fusion until the gas pressure in the vessel is depleted. 3. If equipped with a relief valve deflector, loosen the deflector clamp and slide off the deflector. 4. Loosen the relief valve and remove it from the plumbing assembly. Be sure to support the attachment tube with wrench to prevent damage from twisting. 5. Install new relief valve (PN 1810032) applying new Teflon tape if needed. Ensure relief valve is rated to 50 PSI (3.4 bar). **CAUTION:** Installing a relief valve with a different pressure rating could prevent proper operation and lead to a dangerous over pressurized condition. Additionally, this will void any warranty.

9	**Complete Freezer Thaw and Moisture Removal**	1. Unplug the main power and battery backup if equipped. 2. Open or remove lid from freezer. 3. Open the vent valve Allow LN2 to completely evaporate and the freezer space to warm to room temperature. Placing a fan blowing into the freezer will accelerate this process. 4. After it has reached ambient temperature, thoroughly remove any moisture from the freezer space. **ENSURE ALL MOISTURE IS COMPLETELY REMOVED PRIOR TO REFILL LIQUID NITROGEN AGAIN.**
10	**Internal Battery Backup Replacement**	**General** The GUI will start to lose functionality when the Battery Backup is NOT capable of generating the required VDC. To test any suspect BB, disconnect the AC power and allow freezer to run for 30 minutes; the power failure (PF) alarm should trigger. The voltage should measure 12 to 13 VDC for each battery. In any case, the best approach is to always replace a suspect battery or if the battery age is more than five years old. **Note:** New batteries may need to be charged for several hours before it is able to power the GUI. The GUI will constantly monitor, charge, and sense the current in its battery circuit. With its main power connected, the GUI will constantly produce a 27 VDC trickle charge to keep the batteries fully charged. **INTERNAL BATTERY REPLACEMENT PROCEDURE** 1. Make sure the power supply and the battery backup are disconnected. 2. Remove Cowling (see Figure 29from the Liquefier, by removing the four screws that fasten the shroud to the top of the freezer. 3. Remove top cover off the Liquefier, unscrewing the screws that hold the top cover of the liquefier in place (see Figure).

		4. Remove the foam insert that sits over the fan and battery backup. 5. Remove the four Phillips screws holding the backing plate (Figure 29). 6. Replace the new Battery Backup (PN 21183303).  **Figure 29: Battery Backup**
11	**Firmware Updates**	MVE Fusion firmware should only be updated by authorized Chart personal or MVE Distributors. Improper firmware updates can render the controller inoperable. Please contact Chart Technical Service for further details.

7 Replacement Part List

Table 8: Replacement Part List

Part Number	Descriptions
2S132K-30274	Liquefier
21183303	Battery Backup
21081273S	Battery Cell
1810032	Relief Valve – 50 PSI (3.4 bar)
11499812	MUFFLER 1/4"MPT WITAN M02
20570663	Temperature Probe
21183724	Lid Assembly
14010103	Power Cord (North America Power Cord – 110 VAC)
21183330	On/Off Switch
21135284	GUI Coin Cell Battery (235 mA-h to 2.0 Volts)

8 End of Life Disposal

The Fusion freezer should be returned to Chart at the end of its useful life for proper disposal. Please contact a Chart Customer or Technical Service Representative to discuss arrangements.

9 Troubleshooting

List of all potential alarm displays, and brief descriptions

Alarm	Description	Action
NO AC POWER	AC power loss	Operating on backup battery. Find alternative power source.
DATA LOGGING OFF	Data logging is off	Contact service technician.
LID OPEN	Lid is open	Replace or reposition lid.
TIP TEMP FAULT	Tip temp. open	Contact service technician.
SYSTEM SHUTDOWN	Cryocooler Shutdown	Contact service technician.
REJECT TEMP FAULT	Reject temp. open	Contact service technician.
MOTOR TEMP L FAULT	L motor temp. open	Contact service technician.
MOTOR TEMP R FAULT	R motor temp. open	Contact service technician.
FREEZER RTD OPEN	RTD open	Contact service technician.
MOTOR R OUT OF RANGE	Right motor out of range	Consult technical manual or contact service technician.
TIP TEMP OUT OF RANGE	Tip temp. out of range	Consult technical manual or contact service technician.
REJECT T OUT OF RANGE	Reject temp. out of range	Consult technical manual or contact service technician.
MOTOR L OUT OF RANGE	Left motor out of range	Consult technical manual or contact service technician.

FREEZER RTD OUT OF RANGE	RTD out of range	Consult technical manual or contact service technician.
FREEZER TEMP SHORT?	RTD wiring shorted	Contact service technician.
VIBRATION FAULT*	Vibration fault	Contact service technician.
LID OPEN	Lid is open	Replace or reposition lid.
BATTERY LOW	Backup battery voltage is low	Consult technical manual or contact service technician.
CRYOGEN OUT OF RANGE	Cryogen level out of range	Consult technical manual to replenish cryogen supply.
GAS PRES OUT OF RANGE	Gas pressure high	Consult technical manual or contact service technician.
VFD HARDWARE FAULT	Electronics fault	Contact service technician.
VFD OVER TEMPERATURE	Electronics over temp.	Contact service technician.

*The “VIBRATION FAULT” is the one fault not displayed in the GUI but will result in a system shutdown that can only be cleared by a service technician.

CAUTION: This information is included primarily for reference. Chart recommends any advance troubleshooting or RTD calibration be done by Chart personnel or a Chart-authorized distributor.

NOTES:

2200 Airport Industrial Dr., Ste 500
Ball Ground, GA 30107, U.S.A.
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