Ideal vacuum®

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# XTREMEfreez cooling system by Ideal Vacuum LN2 -196 °C

# USER MANUAL


## For EXPLORAVAC™ Systems

XFLN2-08162023 - V 1.3

## WARRANTY

Ideal Vacuum warrants, to the original purchaser, this product to be free from defects in workmanship and materials, for a period of 1 year from the original delivery date. The liability of Ideal Vacuum, under this warranty, is limited to servicing, adjusting, repairing or replacing any unit or component part which, at Ideal Vacuum's sole discretion, is determined to have failed during normal, intended use. This warranty does not cover improper installation, process related damage, product use in any way other than defined in this manual, or any misuse, abuse, negligence, accident, or customer modification to the product.

Prior to returning any product, we require that you contact us by phone or email to determine if the issue can be resolved quickly. A technical support representative will work with you to resolve the problem. If the issue cannot be resolved in that manner, we will issue an RMA number and provide product return instructions.

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If you have any questions concerning the installation or operation of this equipment, or if you need warranty or repair service, please contact us. Customer Service and Technical Support is available weekdays, from 8am-5pm, Mountain Time.

| | |
|---|---|
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**Cover Image:**

- XtremeFreez-LN2 system with ExploraVAC Vacuum Test Chamber System (render).

# XTREMEFREEZ-LN2 SAFETY

Thank you for purchasing this equipment from Ideal Vacuum Products. We want you to operate it safely.

**The Ideal Vacuum XtremeFreez-LN2 liquid nitrogen cryogenic cooling system may only be installed, operated, maintained and serviced by trained, qualified personnel who have received and been certified in an approved cryogenics safety traing course.**

**Read this manual, the ExploraVAC manual, and the AutoExplor manuals before installing or operating this equipment. Obey all safety warnings. Keep all manuals in a safe location for future reference. Follow all codes that regulate the installation and operation of the equipment.**

**DANGER**

**Explosion Hazard. Never add, remove or circumvent any valve, relief valve, or burst disc on the XtremeFreez-LN2 valve manifold or on an $LN_2$ tank. Pressure in excess of system or tank ratings can occur.**

**DANGER**

**Asphyxiation Hazard. Do not use in a closed or unventilated room. Plumb the exhaust out of the facility. Large amounts of inert nitrogen gas are generated during operation.**

**CAUTION**

**Frostbite Hazard. Do not touch valves or nitrogen lines during operation. They can be extremely cold and may not show condensation.**

**CAUTION**

**Burn Hazard. Do not touch valves or nitrogen lines during operation. When cooling hot items, outlet valves and lines can reach up to 200°C.**

**CAUTION**

**Wear Hearing Protection. The system generates a loud, high pitched sound out of the exhaust. Plumb the exhuast line outside of the facility.**

**CAUTION**

**Wear Personal Protective Equipment. This includes a face shield, insulated gloves, a long-sleeved shirt, full-length pants, and closed footwear when working with liquid nitrogen.**

# 1. SYSTEM INFORMATION

## 1.1 INTRODUCTION

The Ideal Vacuum XtremeFreez-LN2 (XF-LN2) is a PID-controlled, cryogenic cooling system capable of delivering liquid nitrogen ($LN_2$) to a test item at a temperature of ≤ -170°C. $LN_2$ is used because it can provide the fastest cooling rates available for temperatures below -5°C.

The XF-LN2 system can operate as a stand-alone device, as an RS-232 computer software controlled device using Ideal Vacuum's AutoExplor software, or as an option for ExploraVAC thermal vacuum test instruments. For use with an ExploraVAC, the XF-$LN_2$ system is available only in combination with a heated platen. With the XF-LN2 cooling system installed, even hot objects affixed to the ExploraVAC platen can be rapidly cooled to cryogenic temperatures. An ExploraVAC so equipped is often used for space simulation and stress testing aerospace parts. The liquid nitrogen cooling system makes it possible for the platen temperature to change sufficiently fast to simulate an orbiting object moving from light into shadow. Other possible uses for the XF-LN2 system include freeze drying, biological sample freezing, reaction quenching, and cryopreservation.

The XF-LN2 system includes two interchangeable 240 liter $LN_2$ tanks, each with 100 psig pressure relief valves and electronic liquid level sensor gauges, and an assembly consisting of an electronics control module and valve manifold. The assembly is attached to one of the tanks when delivered. The control module houses the PID and other electronics needed for operation, a setpoint controller, and a serial port for connecting to the ExploraVAC instrument, or a computer. The valve manifold has $LN_2$ compatible solenoid operated valves which appropriately route the flow of liquid and/or gaseous nitrogen based on internal logic.

Cryogenic liquid transfer is through two (2) flexible, vacuum insulated, armored hoses. The transfer hoses connect the ExploraVAC platen cooling tube or user's test item and the XF-LN2 valve manifold. Additional flexible transfer hoses connect the two tanks together and the tanks to the XF-LN2 valve manifold. All XF-LN2 hoses use standard 3/4”-16, 45° UN/UNF (SAE) flared fittings (CGA-295).

Liquid nitrogen is typically dispensed from the tank with the higher liquid level. XF-LN2 logic opens and closes the proper valves to produce differential vapor pressure between the two tanks. This forces $LN_2$ from the supply (dispensing) tank through the ExploraVAC platen, or user's test item. Depending on the temperature of the nitrogen exiting the platen or test item, it is either recovered as liquid in the secondary tank, or exhausted out of the system. XF-LN2 logic automatically determines the supply tank, and directs the exiting nitrogen for the most efficient use of the remaining $LN_2$.

User safety is paramount. All safety warnings and procedures must be followed for safe handling and transfer of cryogenic liquid. All XF-LN2 plumbing components are rated for cryogenic use. The system is engineered with 100 psig pressure relief valves on both tanks and on the valve manifold. As an additional safeguard, the manifold includes several 150 psig non-resettable burst discs. The strategic location of pressure relief valves and burst discs in the manifold ensure that every possible closed zone has a pressure relief pathway.

Technical specifications and performance data for the XtremeFreez-LN2 liquid nitrogen cooling system and all pertinent equipment manuals are included in printed and/or digital formats.

## 1.2 PHYSICAL SPECIFICATIONS

| SYSTEM | QUANTITY / TYPE |
|---|---|
| Liquid Nitrogen Tank Capacity | 240 Liter (368 lb) $LN_2$ each |
| Tank Internal Pressure Regulation | 100 psig |
| System Exhaust Pressure Regulation | 40 psig |
| Valve MTTR (mean time until repair) | 500,000 cycles (≈1-2 years)) |
| Maximum Solenoid Valve Temperature | 200 °C |
| Pre-Installed Tank Gauges | Cyl-Tec LevelEye nitrogen level gauge |
| Tank Weight | 408 lb. each (dry) |
| RecommendedFloor Space | 8.3 ft. x 7.7 ft. (≈ 64 $ft^{2)}$ |
| Shipping Dimensions | 2 crates, 44’ x 44’ x 82” each |
| Total Shipping Weight | 1275 lb. |

*Table 1 - Physical specifications*

## 1.3 PERFORMANCE SPECIFICATIONS

The performance parameters and values shown in Table 2 are for an ExploraVAC system with a stainless steel chamber and a heated and liquid nitrogen cooled platen.

| PARAMETER | 20” Chamber | 24” Chamber |
|---|---|---|
| Chamber Internal Dimensions | 20” x 20” x 20” | 24” x 24” x 24” |
| Platen Dimensions | 19” x 19” x 19” | 23” x 23” x 23” |
| Maximum Temperature | 375 °C | 375 °C |
| Maximum Heating Rate | 6 °C/min. | 10 °C/min. |
| Minimum Temperature | -170 °C | -170 °C |
| Maximum Cooling Rate | 10 °C/min. | 10 °C/min. |
| Setpoint Accuracy | ± 0.3°C* | ± 0.3°C* |
| Heating Power | 3300 W | 5000 W |
| Heating Power Density | 9.2 W/$in^2$ | 9.5 W/$in^2$ |
| Cooling Power | 5000 W | 5000 W |
| Cooling Power Density | 9.5 W/$in^2$ | 9.5 W/$in^2$ |

** Platen heating and cooling setpoint accuracy with a 1.*5°C overshoot with a 20 minute settling time.

*Table 2 - Performance specifications*

## 1.4 PERFORMANCE GRAPH

The performance curves below show the cooling rates of an ExploraVAC system with a 20” or 24” stainless steel chamber and a heated and liquid nitrogen cooled platen.

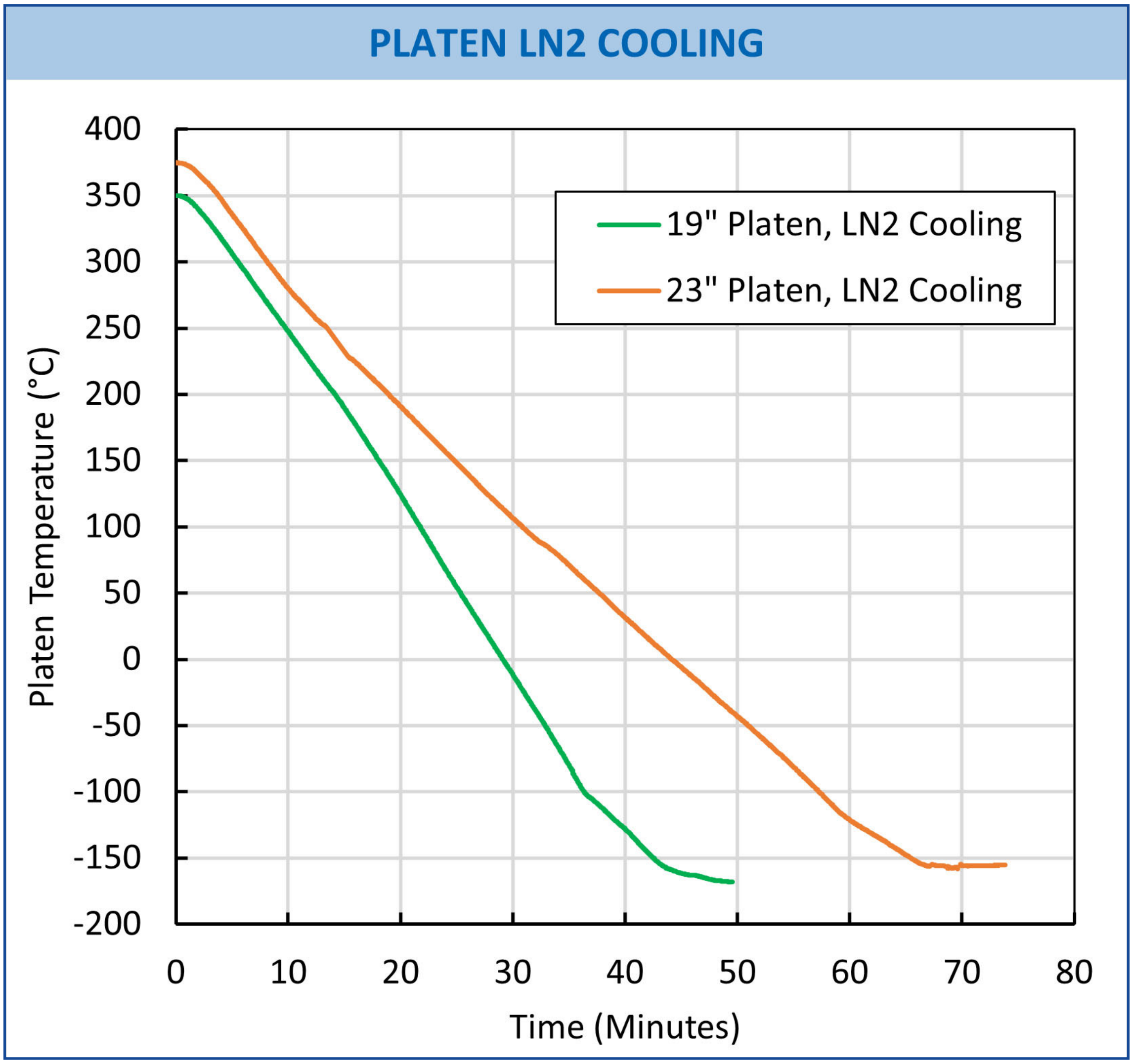



*Figure 1 - Performance graph*

## 1.5 CONTROL MODULE COMPONENTS

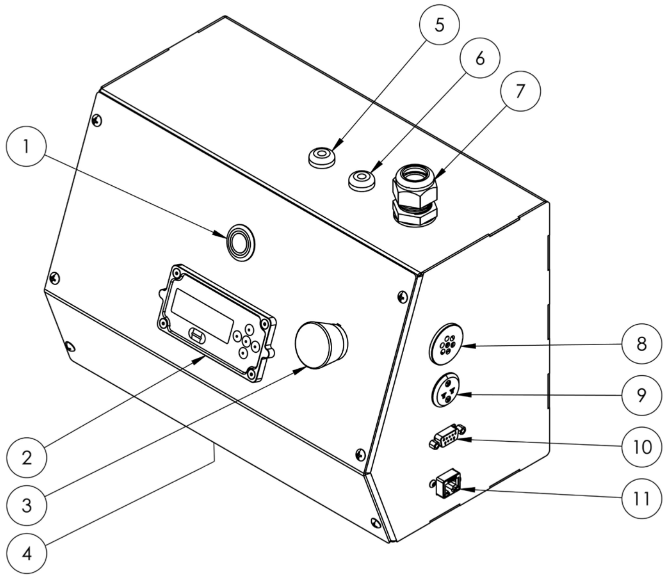



*Figure 2 - Control module components*

| Item | Description |
|---|---|
| 1 | Temp. Control Switch |
| 2 | XGC-820 Setpoint Controller |
| 3 | Emergency Stop Switch |
| 4 | C14 AC Power Input Receptacle |
| 5 | Tank 1 Level Gauge Cable |
| 6 | Tank 2 Level Gauge Cable |
| 7 | Valve Manifold Wiring Harness |
| 8 | Air Sensor |
| 9 | Type-K Thermocouple Receptacle |
| 10 | DB9 RS-232 Serial Port |
| 11 | IVP Use Only |

*Table 3 - Control module component descriptions*

The control module contains the PID and other necessary system electronics. Figure 2 illustrates the major control module components.

The XF-LN2 requires 120 VAC input power. The control module has a standard C14 input recepatcle **(4)** on its underside. A C13 to NEMA 5-15P power cord is included with the system. The control module does not have a separate on/off switch. As soon as power is applied, the system is powered and on standby. The emergency stop button **(3)** may be used to completely turn off the system.

The XGC-820 setpoint controller **(2)** is used to input target temperature and ramp rate. The TEMP. CONTROL pushbutton switch **(1)** above the setpoint controller mirrors the behavior of the HEAT/PLATEN switch on the ExploraVAC manual console, or the PLATEN TEMP icon in AutoExplor. When the controller is not in use, the switch is illuminated red. When the controller is in use (the system is trying to obtain a target setpoint temperature), the switch will illuminate green. The button will remain green when the controller is working, even if $LN_2$ is not flowing. Refer to Sec. 7.1, p. 20 for detailed information about how to use the setpoint controller and Sec. 7.3, p. 23 for the Platen Temp controller.

The DB9 RS-232 serial port **(10)** is used to connect to the ExploraVAC DB15 pin Auxiliary port, or to a computer for use with AutoExplor software. A DB9-to-DB15 serial cable is included for connection to the ExploraVAC instrument. For connection to a computer running AutoExplor, use serial to USB cable part number P1012232.

The system is equipped with an air sensor **(11)** used for operation. It is not a safety feature.

## 1.6 VALVE MANIFOLD COMPONENTS

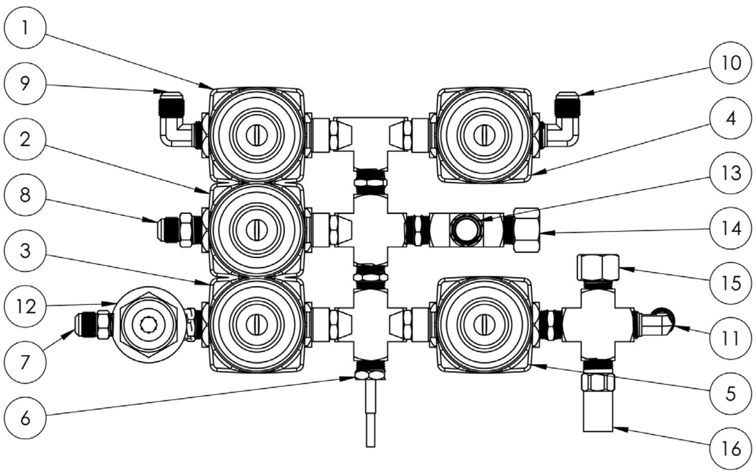



*Figure 3 - Valve manifold components*

| Item | Description |
|---|---|
| 1 | Tank 2 Vent Valve (NO) |
| 2 | Tank 1 Vent Valve (NO) |
| 3 | Exhaust Solenoid Valve (NC) |
| 4 | Tank 2 Liquid Bypass Valve (NC) |
| 5 | Tank 1 Liquid Bypass Valve (NC) |
| 6 | Exhaust Temp. Thermocouple |
| 7 | Exhaust Connection |
| 8 | Tank 1 Vent Connection |
| 9 | Tank 2 Vent Connection |
| 10 | Tank 2 Liquid Bypass Connection |
| 11 | Tank 1 Liquid Bypass Connection |
| 12 | Exhaust Pressure Regulator |
| 13 | Manifold Pressure Relief Valve |
| 14 | Manifold Burst Disc |
| 15 | Cooling Loop Burst Disc |
| 16 | Cooling Loop Pressure Relief Valve |

*Table 4 - Valve manifold component descriptions*

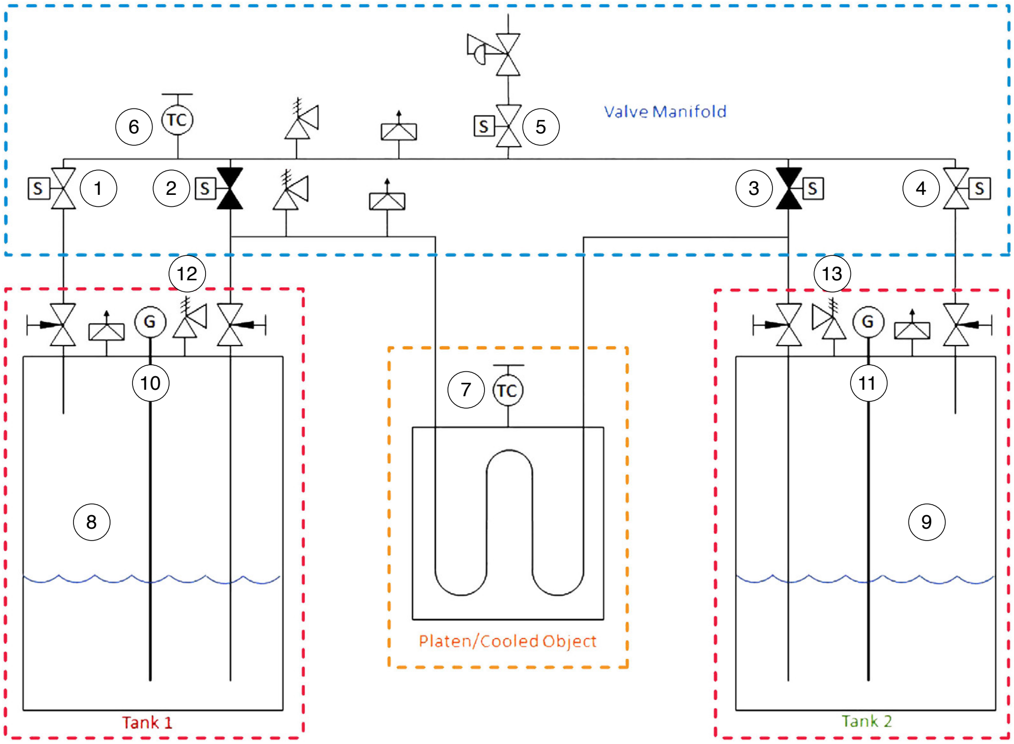
The valve manifold has five solenoid operated valves. Two valves are normally open (NO), three are normally closed (NC). XF-LN2 system logic automatically determines the state (open or closed) of each valve while the system is operating.

The state of each valve depends on the vapor pressure and liquid level in each tank, as well as the temperature of the nitrogen exiting the platen or user's test item, measured by the exhaust temperature thermocouple **(6)**. For safety, there are two pressure relief valves **(13)** and **(16)**, as well as two burst discs **(14)** and **(15)**, plumbed such that any possible closed portion of the manifold and the coolant lines have a pressure relief outlet.

Refer to Sec. 2.3, p. 13 for transfer hose connections.

Refer to Chapter 4, Operational States, beginning on page 15, for block diagrams and explanations of the various valve states possible during operation.

## 1.7 PHYSICAL SYSTEM SCHEMATIC




| KEY OF SYMBOLS | |
|---|---|
| | Manual Valve |
| | Solenoid Valve - NO |
| | Solenoid Valve - NC |
| | Pressure Relief Valve |
| | Pressure Regulator |
| | Burst Disc |
| | Gauge |
| | Thermocouple |

*Figure 4 - Physical system diagram with key*

Figure 4 illustrates how the various valves, pressure relief valves, burst discs, thermocouples, and gauges are connected. The two interchangeable XF-LN2 system liquid nitrogen tanks **(8)** and **(9)** have the normal compliment of manual valves, pressure relief valves, and burst discs.

**Note that the pressure relief valves on XF-LN2 system tanks have a cracking pressure of 100 psi (12) and (13).** This allows the liquid nitrogen to maintain a slightly lower temperature than on a standard tank (less headspace pressure equals decreased $LN_2$temperature). It also limits the pressure inside the platen/cooled object to 100 psi.

The platen or a sample thermocouple **(7)** is used to measure the temperature of a test item. That temperature is used by the setpoint controller to achieve a target temperature (Chap. 7, p. 20). When the XF-LN2 system is used without an ExploraVAC system, the user must attach a thermocouple to their test item and connect it to the XF-LN2 control module (item 9, Figure 2).

The thermocouple attached to the valve manifiold **(6)** is used to measure the nitrogen temperature exiting the platen/cooled object. The temperature of the exiting nitrogen determines whether it is recovered as liquid in the secondary tank, or if it is exhausted out of the system. (Chap. 4, p. 15).

Pre-installed CylTec Level-Eye® sensor gauges **(10)** and **(11)** measure the liquid level in each tank. Each gauge shows the liquid level in percentage of tank capacity. The gauges are factory calibrated.


*Figure 5 - CylTec Level-Eye gauge*

# 2. INSTALLATION

## 2.1 LOCATION REQUIREMENTS

**⚠ CAUTION** **Seismic restraints may be required if the system is installed in a seismically active area. Consult with a structural engineer to determine code requirements and if restraint hardware is needed.**

The XF-LN2 system requires indoor installation in a relatively clean environment on a flat floor, preferrably concrete. The XF-LN2 must be situated to the left side of the ExploraVAC instrument or user's test item. Minimum recommended floor space for the ExploraVAC and XF-LN2 combination is approximately 8 ft. wide and 8 ft. deep (≈ 64 ft$^2$).

The XF-LN2 system is shipped in two (2) crates, each containing an $LN_2$ tank. The control module and valve manifold assembly is delivered mounted to one tank.

All necessary cryogenic transfer hoses, a communication cable, and input power cord are included with the XF-LN2 system.

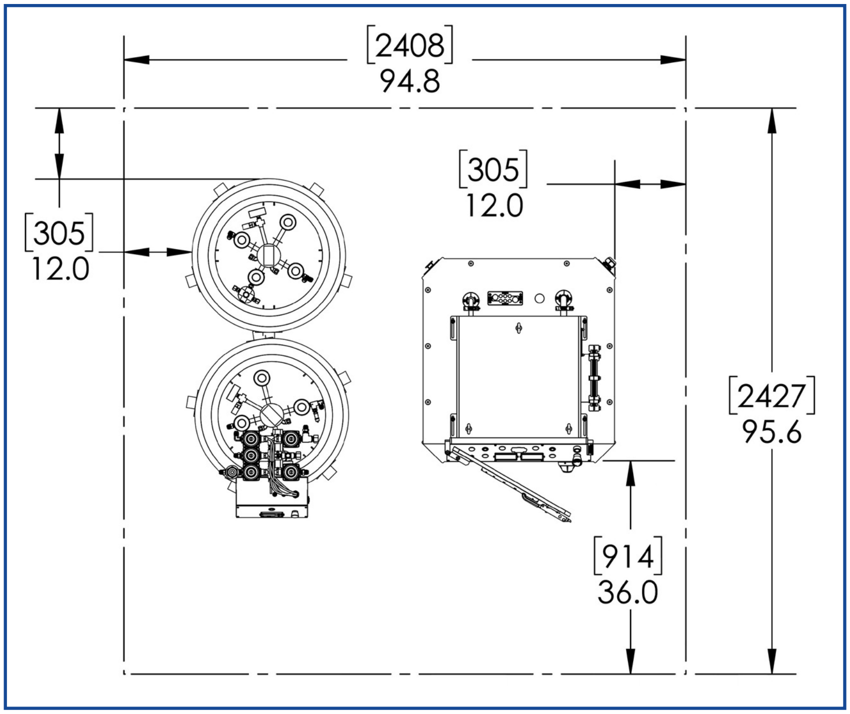
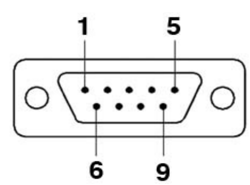



*Figure 6 - ExploraVAC & XF-LN2 recommended footprint*

Once the tanks are uncrated, they may be filled immediately and positioned near the ExploraVAC or user's test apparatus.

## 2.2 COMMUNICATION CONNECTIONS

When using with an ExploraVAC, plug in the supplied DB9-to-DB15 communication cable (part number P1012594) from the DB9 serial port on the right side of the control module to the DB15 Auxiliary port on the digital feedthrough panel at the back right side of the ExploraVAC cabinet.




| PIN | FUNCTION |
|---|---|
| 2 | TX |
| 3 | RX |
| 5 | GND |

*Figure 7 - Control module serial port pinout*

When using with AutoExplor but without an ExploraVAC instrument, connect the supplied serial-to-USB cable (part number P1012232) from the control module DB9 port to the computer.

## 2.3 PLUMBING CONNECTIONS

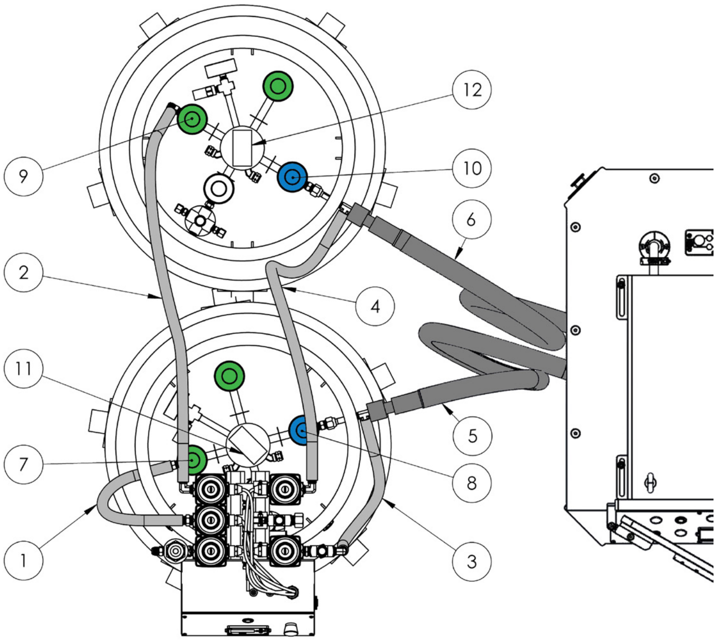



Figure 8 - LN$_2$ transfer line connections

| Item | Description |
|---|---|
| 1 | Tank 1 Vent Line |
| 2 | Tank 2 Vent Line |
| 3 | Tank 1 Liquid Bypass Line |
| 4 | Tank 2 Liquid Bypass Line |
| 5 | Tank 1 Insulated Cooling Loop Line |
| 6 | Tank 2 Insulated Cooling Loop Line |
| 7 | Tank 1 Manual Vent Valve |
| 8 | Tank 1 Manual Liquid Valve |
| 9 | Tank 2 Manual Vent Valve |
| 10 | Tank 2 Manual Liquid Valve |
| 11 | Tank 1 CylTec Liquid Level Gauge |
| 12 | Tank 2 CylTec Liquid Level Gauge |

Table 5 - Lines and tank valve descriptions

The system is delivered with two 1-1/2 ft. and two 3 ft. armored, flexible transfer hoses, used to interconnect the LN$_2$ tanks and XF-LN2 valve manifold. Two 6 ft. armored, vacuum insulated transfer hoses connect the valve manifold to the ExploraVAC platen, or the user's test item. All hose fittings are 3/4"-16, 45° UN/UNF (SAE) Flared Female (CGA-295) for 1/2" OD Tube.

Use a 7/8" (22mm) or adjustable wrench to tighten fittings. All connections should be wrench tight plus 1/8-1/4 turn. If any fitting leaks when cooling is turned on, tighten an additional 1/8 turn.

Refer to Figure 8 above and Figure 3, p. 10. Connect transfer lines as shown.

1. Tank 1 vent line (**1**): from Tank 1 vent valve to manifold Tank 1 vent connection.
2. Tank 1 liquid bypass line (**3**): from Tank 1 liquid valve to manifold Tank 1 liquid bypass connection.
3. Tank 2 vent line (**2**): from Tank 2 vent valve to manifold Tank 2 vent connection.
4. Tank 2 liquid bypass line (**4**): from Tank 2 vent valve to manifold Tank 2 liquid bypass connection.
5. Connect Tank 1 Cooling Loop Line (**5**): from Tank 1 liquid valve to ExploraVAC cooling connection.
6. Connect Tank 2 Cooling Loop Line (**6**): from Tank 2 liquid valve to ExploraVAC cooling connection.

## 2.4 SYSTEM STARTUP

After the tanks are filled and all transfer line connections are made, open each tank's vent and liquid valve one at a time and check for leaks. These valves remain open during use. Plug the power cord into a 120 VAC outlet. When power is supplied, the system is powered and on standby, ready for use. The setpoint controller reads the current temperature of the ExploraVAC platen, sample thermocouple, or XF-LN2 external thermocouple. If the system loses communcation, or cannot find a thermocouple, the system reverts to standby. See Sec. 6.1, p. 19 regarding stand-alone control.

# 3. PRINCIPLE OF OPERATION

The XtremeFreez-LN2 system dispenses liquid nitrogen by closing the gas headspace of the liquid nitrogen supply tank **(8)**. This allows it to build pressure as the liquid nitrogen naturally evaporates. The liquid nitrogen line is then opened to atmospheric pressure (or any pressure lower than the 100 PSIG tank pressure) through the manifold exhaust line **(5)**. The difference in gas pressure between the tank headspace and the exhaust line pushes liquid nitrogen out of the supply tank's liquid nitrogen line **(10)**, and through the ExploraVAC platen or user's test item **(11)**.

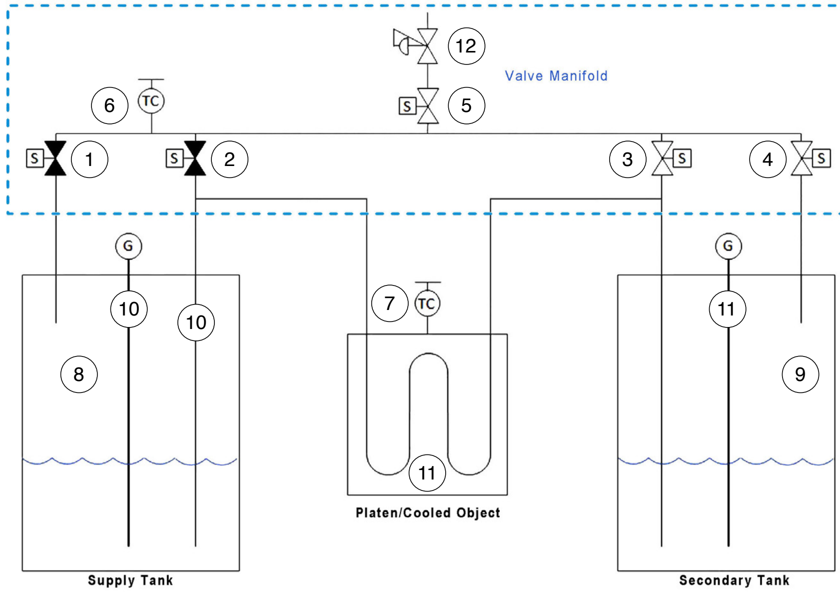



*Figure 9 - Differential vapor pressure between tanks*

In Figure 9, above, supply tank manifold valves **(1)** and **(2)** are closed, the secondary tank manifold valves **(3)** and **(4)**, and the exhaust valve **(5)** are open. The headspace in the supply tank builds pressure while the headspace pressure in the secondary tank **(9)** is reduced since it is being constantly exhausted. The differential pressure between the two tanks forces liquid nitrogen out of the supply tank, and through the platen/user's test item.

As the nitrogen exits the platen or test item, its temperature is measured by the manifold thermocouple **(6)**. Depending on its exit temperature, the nitrogen is either collected as liquid in the secondary tank, or exhausted out of the system through the manifold exhaust, bypassing the secondary tank entirely (Sec. 4.2, p. 16 and Sec. 4.3, p. 17). This reduces the amount of liquid nitrogen lost during higher temperature operation.

The XF-LN2 system compares the liquid level of each tank, measured by the level sensor gauges **(10)** and **(11)**. The system typically makes the supply tank the one with the higher liquid level (see Chap. 5, p. 18, Single Sensor Systems-Including Large Tanks). If the secondary (receiving) tank becomes nearly full, or the level in the supply tank becomes nearly empty (≤ 5%) the tank roles and flow direction are reversed. This allows both tanks to start full for longer continuous operation.

The manifold solenoid exhaust valve **(5)** is opened and closed (pulsed) rapidly. This keeps the secondary tank's vapor pressure above atmosphere, slows the flow of liquid nitrogen through the system, and slows the release of gaseous nitrogen out of the exhaust.

After the manifold exhaust valve, a pressure regulator **(12)**, set to 40 psig, is connected. This further slows liquid flow through the system and the release of gaseous nitrogen. The combination of pulsing the solenoid exhaust valve and regulating the exhaust gas pressure allows the system to use the available liquid nitrogen most efficiently.

# 4. OPERATIONAL STATES

## 4.1 NO FLOW - EQUILIBRIUM

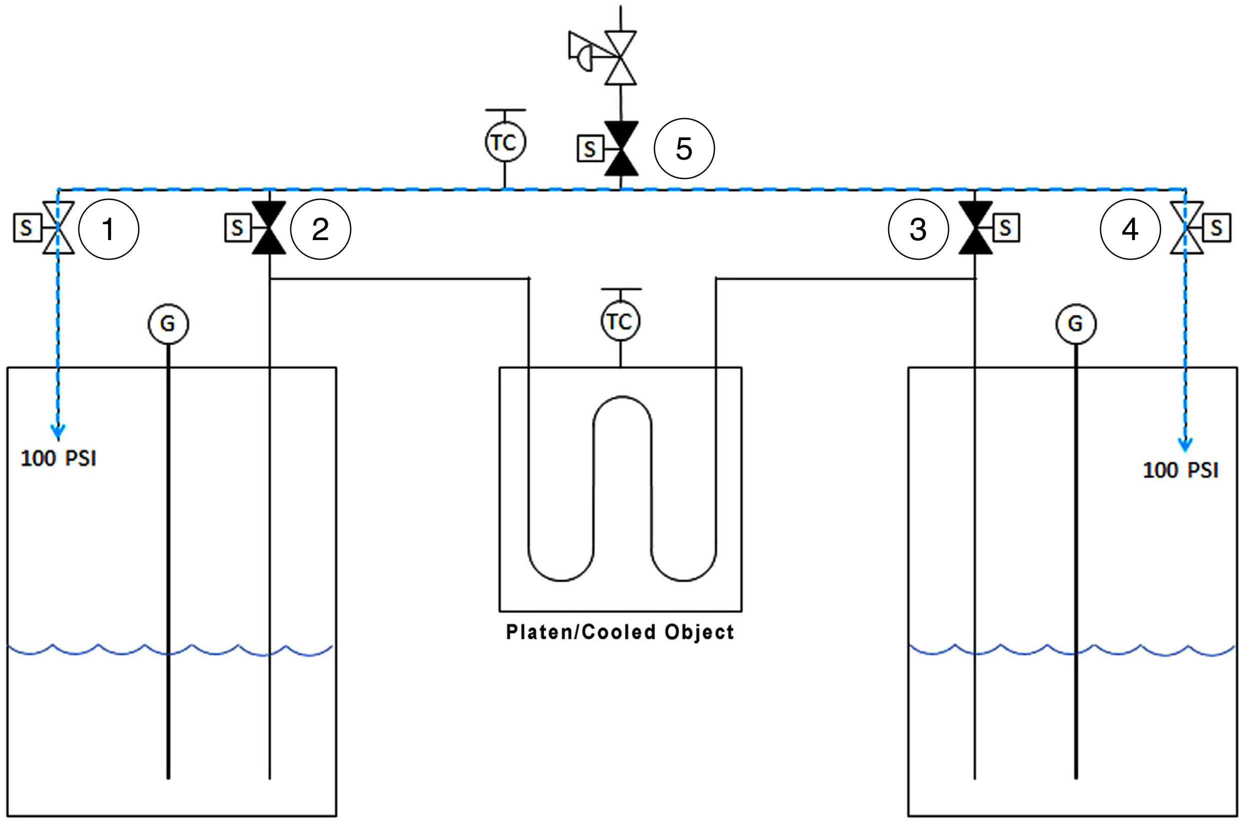



*Figure 10 - System at equilibrium - no flow*

When the system is powered off, or on standby (powered but not running), the manifold solenoid valves are each in their normal states:

- The normally open manifold vent valves on both tanks remain open **(1)** and **(4)**.
- The normally closed manifold bypass valves on both tanks remain closed **(2)** and **(3)**.
- The exhaust valve remains closed **(5)**.

Both tanks build pressure in their respective headspaces up to 100 psi. Because their vent lines are open to each other, head vapor pressure is equalized between the tanks, and liquid nitrogen does not flow in either direction. The tanks vent normally through their pressure relief valves.

# 4.2 BYPASS FLOW - COMPLETE VAPORIZATION

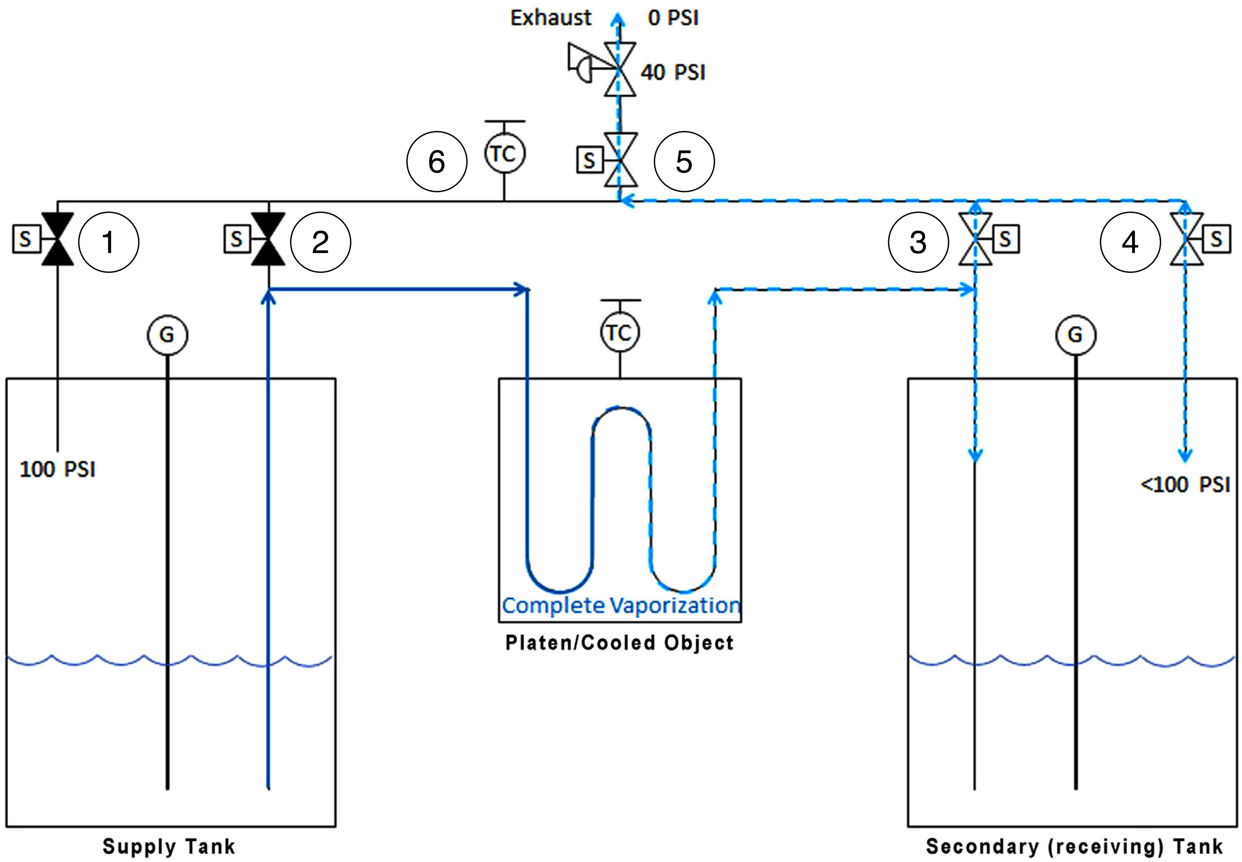



*Figure 11 - Complete vaporization of liquid nitrogen - bypass flow*

When the system begins running to cool the platen or a test item, the manifold supply tank vent valve **(1)** is closed, allowing pressure to build in its headspace. The supply tank liquid bypass valve remains in its normally closed state **(2)**. The liquid nitrogen bypass valve to the secondary tank is opened **(3)**. This equalizes the pressure between the secondary tank's headspace and its liquid nitrogen outlet.

The manifold exhaust valve **(5)** is opened, venting pressure in the secondary tank's headspace.

When the platen or test item is very warm or hot, the liquid nitrogen flowing from the supply tank vaporizes as it goes through the platen or test item. The exiting vapor travels through the secondary tank's liquid bypass valve **(3)** and out of the exhaust valve **(5)**, bypassing the secondary tank entirely. This reduces the amount of liquid nitrogen lost during higher temperature operation.

The manifold thermocouple **(6)** measures the temperature of the exiting gas stream. If the exit vapor temperature exceeds 190°C, the system reverts to the equilibrium/no flow state to prevent damage to its valves (Sec 4.1, p. 15).

If the liquid nitrogen is not completely vaporized (there is a combination of both gas and liquid exiting the platen or test item), the system switches to the recovery state (Sec. 4.3, p. 17).

## 4.3 RECOVERY FLOW - INCOMPLETE VAPORIZATION

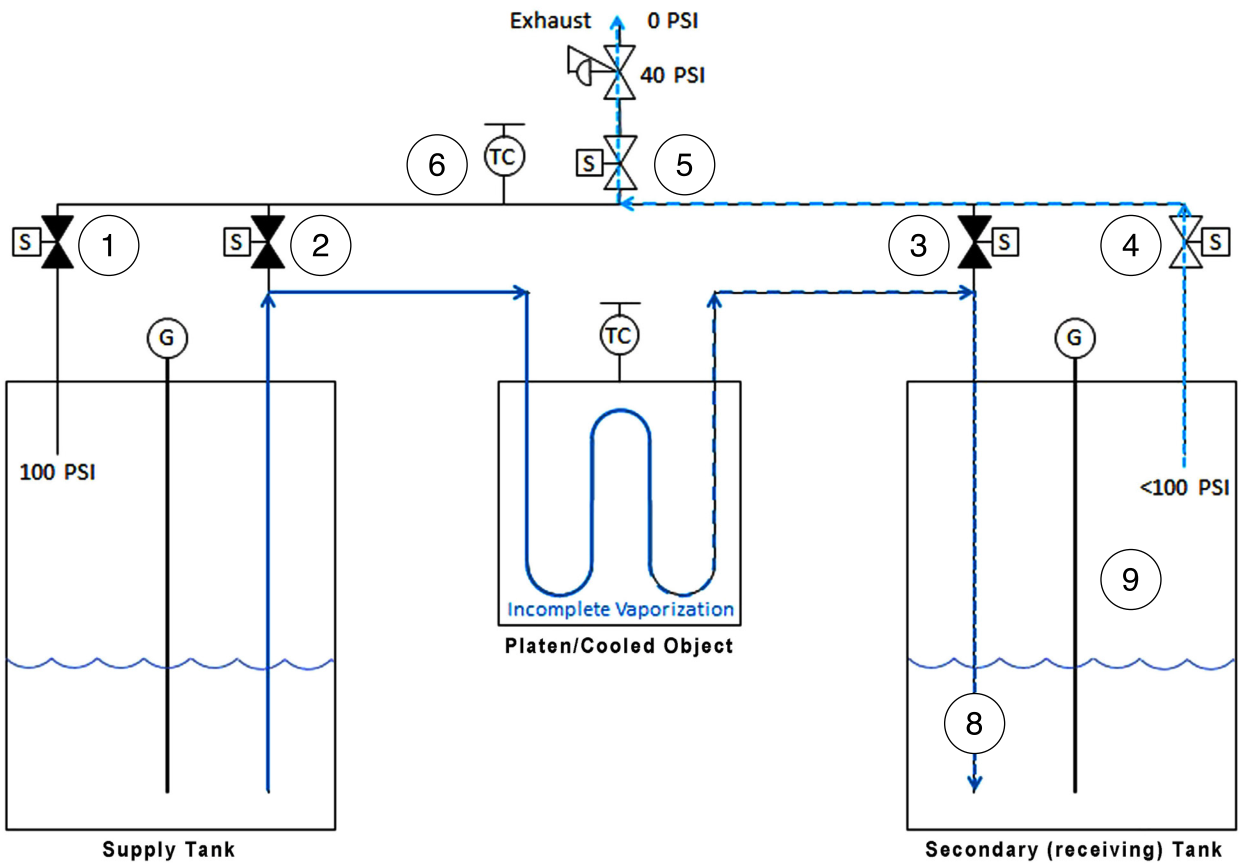



*Figure 12 - Incomplete vaporization of liquid nitrogen - recovery flow*

When the platen or test item temperature becomes insufficiently warm to fully vaporize the flowing liquid nitrogen, the exiting stream is incompletely vaporized. It is a combination of both liquid and gaseous nitrogen.

When incomplete vaporization occurs, the liquid is recovered and the gas is expelled.

The system closes the secondary tank bypass valve **(3)**, which forces the exiting liquid/gas mix into the liquid nitrogen reservoir in the secondary (receiving) tank (**8**). Nitrogen that is liquid is added to the existing liquid. The gaseous nitrogen portion rises into the tank's headspace (**9**), where it passes through the vent valve **(4)**, and out the exhaust **(5)**.

# 5. SINGLE SENSOR SYSTEMS - INCLUDING LARGE TANKS

The user can replace one of the original XF-LN2 tanks with their own tank without a CylTEC level sensor gauge. This would allow the user to use a very large tank, to swap out multiple tanks in a single day, or to continue operating the original system with a broken or poorly calibrated sensor.

The setup and operation of a two tank, one sensor scenario is essentially the same as the two tank, two sensor system previously described, but with several important exceptions:

**DANGER**

**Explosion Hazard. Any sensor-less tank MUST be fitted with a 100 psig pressure relief valve! Excess pressure in the platen or test item could cause a severe failure!**

- The system assumes the sensor-less tank starts out full. The sensor-less tank will always be the supply tank initially.
- Flow is reversed only when the tank with the sensor becomes completely full. Reverse flow only continues until the tank with the sensor returns to its lowest level before flow reversal.
- Even if the sensor-less tank becomes depleted, the system will attempt to draw from the sensor-less tank. This may cause recipe or process failure if left unmonitored.

# 6. OPERATIONAL CONFIGURATIONS AND CONTROL MODES

The XtremeFreez-LN2 cooling system can operate as a stand-alone device, as a RS-232 computer software controlled device using AutoExplor software, or as an auxiliary module for an ExploraVAC instrument, whether it be manually controlled, or controlled by AutoExplor software.

## 6.1 STAND-ALONE CONTROL

The XF-LN2 unit may be used as a stand-alone cooling device to cool any user test item. The user's test item must be setup to accept the standard flared fittings on the ends of the two liquid nitrogen delivery hose ends, and the test item must be able to withstand a minimum of 100 psig internal pressure at cryogenic temperatures.

A Type-K thermocouple is used to measure the temperature of the user's test item. The thermocouple is attached to the test item and connected to the female thermocouple connector on the XF-LN2 control module. The XF-LN2 system automatically recognizes that it is operating as a stand-alone device. The user inputs a desired setpoint temperature and ramp rate via the XGC-820 Setpoint Controller on the control module (Sec. 7.1, p. 20). To run, the TEMP. CONTROL pushbutton switch is pressed. **Note: if the external thermocouple is not attached to the item being cooled, the system will cool at a maximum rate, potentially achieving a lower temperature than desired.**

## 6.2 COMPUTER CONTROL

The XF-LN2 is connected from its DB9 RS-232 serial port to a computer and operated with a licensed version of AutoExplor software. Similar to use as a stand-alone device, a Type-K thermocouple is attached to the user's test item and connected to the XF-LN2 thermocouple connector on the control module.

The XF-LN2 system will appear in the AutoExplor device card section, and can be operated through the AutoExplor PLATEN TEMP controller on the home page (Sec. 7.3, p. 23). The user gains additional control of the XF-LN2 system, including recipe creation and data logging capabilities, in the premium version of AutoExplor.,

## 6.3 EXPLORAVAC AUXILIARY CONTROL

The XF-LN2 control module is connected to the ExploraVAC instrument via the supplied DB9-to-DB15 pin, 10 foot long serial cable. The external thermocouple connection on the XF-LN2 control module is not used.

Once powered on, the XF-LN2 automatically connects with the ExploraVAC. The XGC-820 temperature setpoint controller and single TEMP. CONTROL pushbutton switch on the XF-LN2 control box mirror the XGC-820 setpoint controller and HEAT/COOL PLATEN pushbutton switch on the ExploraVAC manual control panel. When an ExploraVAC system is controlled with AutoExplor software, the XF-LN2 system appears in the AutoExplor device card section, and can be operated through the AutoExplor PLATEN TEMP controller on the home page (Sec. 7.3, p. 23).

Setpoints, ramp rates, and soak times for heating and/or cooling can be input from the ExploraVAC, XF-LN2, or AutoExplor. The XF-LN2 system works in tandem with platen heating to achieve more precise setpoints and obtain smoother cooling rates than possible with cooling only.

# 7. USING SETPOINT CONTROLLERS

In order to run the XF-LN2 system, a temperature setpoint and other parameters (ramp rate and soak time) must be input into either the XF-LN2 or ExploraVAC XGC-820 setpoint controller, or into the PLATEN TEMP Controller in AutoExplor software. The platen, sample, or thermocouple connected the the XF-LN2 control module measures the temperature. Once setpoint parameters are entered into the controller, liquid nitrogen flow is initiated by pressing the TEMP. CONTROL on the XF-LN2 system, or the HEAL/COOL PLATEN switch on the ExploraVAC (Sec 7.2, p. 22).

## 7.1 XGC-820 TEMPERATURE SETPOINT CONTROLLER

The onboard XGC-820 setpoint controller on the XF-LN2 system, or on an ExploraVAC manually operated system, is used to input setpoint parameters.

Setpoint temperature is the temperature for the system to maintain.

Ramp rate is the speed with which the platen heats or cools from its initial state to the setpoint temperature. The maximum ramp rate for the XF-LN2 system is 10°C/min. The ramp rate can also be set to MAX, which forces the platen to get to temperature as quickly as possible. Compared to a numerical ramp rate which is a linear function, the MAX rate is non-linear.

Soak is the amount of time, after the setpoint temperature is reached that the platen temperature is maintained. When the soak time has elapsed, the XF-LN2 and/or platen heaters (if equipped) will turn off. Platen or test item temperature will naturally heat or cool to ambient temperature.

The XGC-820 temperature setpoint controller's home screen show's the current platen temperature, the setpoint temperature, the ramp rate or soak time, and the platen mode. See the ExploraVac User Manual about temperature setpoint controllers and platen modes.

Figure 13 shows the XGC-820 controller's home page. Figure 14, p. 21 shows its menu flowchart.

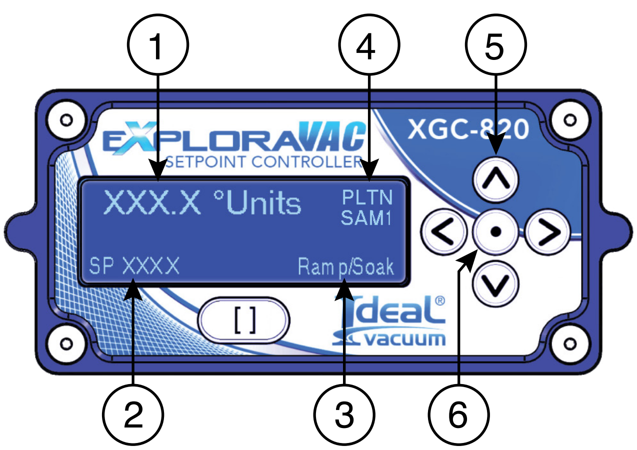



*Figure 13 - XGC-820 controller home page*

| Item | Description |
|---|---|
| 1 | Platen Temperature<br>(user selected units, resolution 0.1 degree |
| 2 | Setpoint Temperature<br>(in same units as platen temperature) |
| 3 | Ramp Rate or Soak Time<br>(if a soak time is saved, ramp rate changes to soak time when setpoint temperature is reached. |
| 4 | Platen Mode<br>(indicates the thermocouple the controller is using. SAM1-SAM4 are the feedthrough thermocouples attached to a test object) |
| 5 | Arrow Buttons<br>(used to negotiate through the menus) |
| 6 | Select/Enter Button<br>(used to make a selection or save a parameter value) |

*Table 6 - XGC-820 controller display items*

To negotiate the menu heirarchy:

- Press the center SELECT/ENTER button to go down (right) one tier.
- Press the LEFT ARROW button to go to the left (up) one tier.
- Press the UP or DOWN ARROW button to move vertically in the same tier.
- Press the UP or DOWN ARROW to increase or decrease a value.
- Press the SELECT/ENTER button to save a value.
- Arrows on the flowchart boxes below indicate which arrow buttons are active for that menu item.

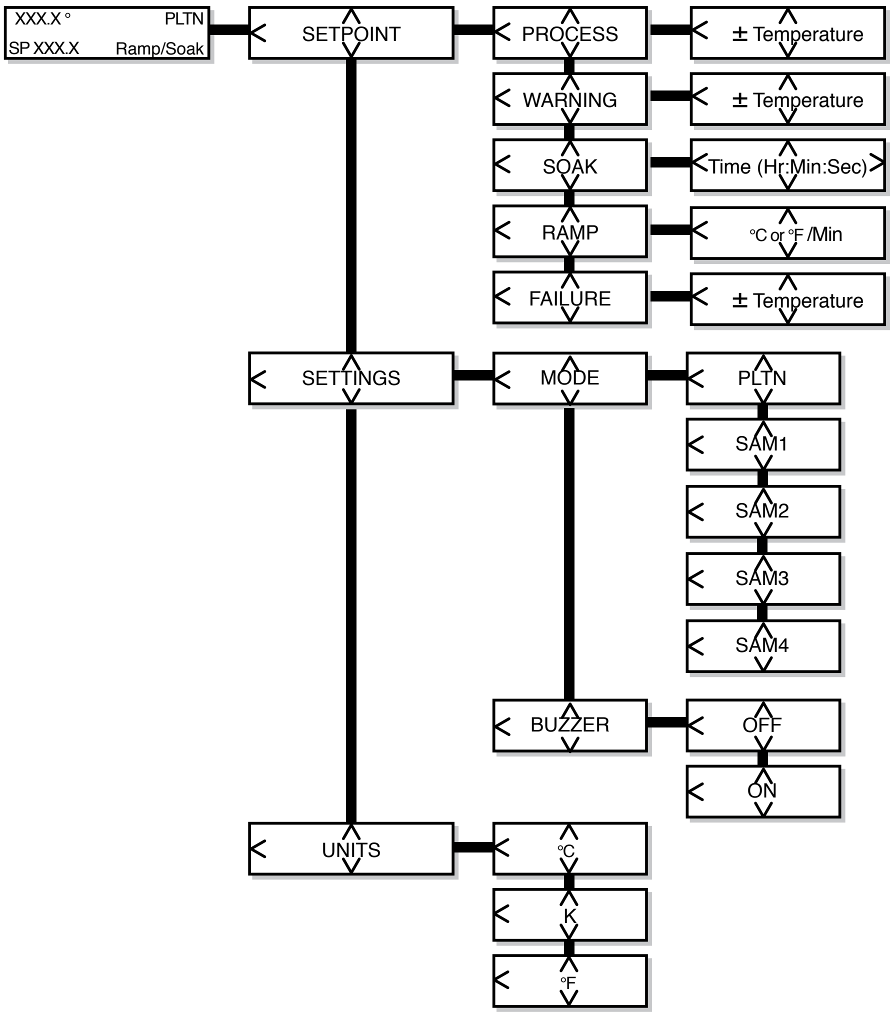



*Figure 14 - Temperature controller menu flowchart*

- PROCESS is the temperature for the system to maintain (the setpoint).
- WARNING is the temperature above the setpoint that the HEAT/COOL PLATEN switch will begin to blink green/yellow to indicate a potential problem. The platen will continue to operate.
- SOAK is the amount of time after reaching the setpoint that the temperature will be maintained.
- RAMP is the rate at which the temperature increases or decreases towards the setpoint (process).
- FAILURE is the temperature above the setpoint when the system will automatically shut off and alarm. This setting ensures that your sample or the system will not be damaged.
- MODE is the thermocouple that the setpoint controller uses.

## 7.2 TEMP. CONTROL AND HEAT/COOL PLATEN SWITCHES


The TEMP. CONTROL switch on the XF-LN2 system turns on and off the flow of liquid nitrogen and/or the platen heaters once a setpoint temperature is input and saved in the XGC-820 setpoint controller.

When pressed, the system will immediately begin to heat or cool the platen to achieve the temperature saved in the setpoint controller. Desired temperatures can be maintained to ± 0.3°C on an ExploraVAC equipped with a heated platen and the XF-LN2 system.


When attached to an ExploraVAC instrument, the HEAT/COOL PLATEN switch controls the XF-LN2 system and platen heaters exactly the same way as the TEMP. CONTROL switch. The setpoint controller can be turned on by pressing either switch. When running, both switches will illuminate green. When on standby, both switches will be red.

| NOTE | **If the chamber is vented with air when the platen is below 0°C, ice will form on the platen. Bring the platen up to room temperature and let dry naturally. Alternatively, to avoid roughing pump or gauge damage, turn on the gas ballast valve on the roughing pump and pump the chamber. See the nXDSi pump manual for instructions.** |
|---|---|

## 7.3 AUTOEXPLOR PLATEN TEMP CONTROLLER

When used with an ExploraVAC system running AutoExplor software or when AutoExplor is used to control the XF-LN2 system as a stand-alone device, the XF-LN2 system is automatically recognized by AutoExplor. The software adds the LN2 SYSTEM into the devices section of the home page. When selected, an LN2 SYSTEM information window is displayed.

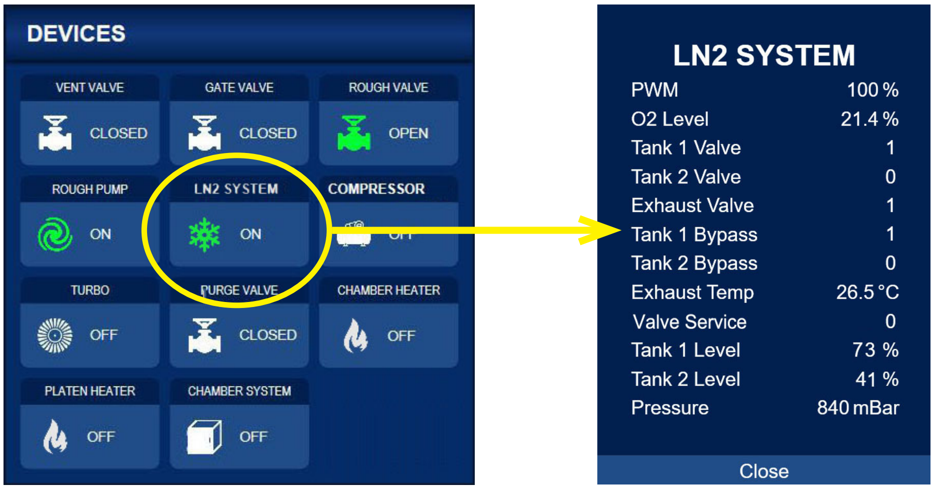



*Figure 15 - XF-LN2 device card and information window*

Setpoint parameters are entered from the AutoExplor home page in the PLATEN TEMP controller box. Any of the control parameters can be adjusted at any time. Select the PLATEN TEMP icon on the left side to turn on the controller and start heating or cooling.

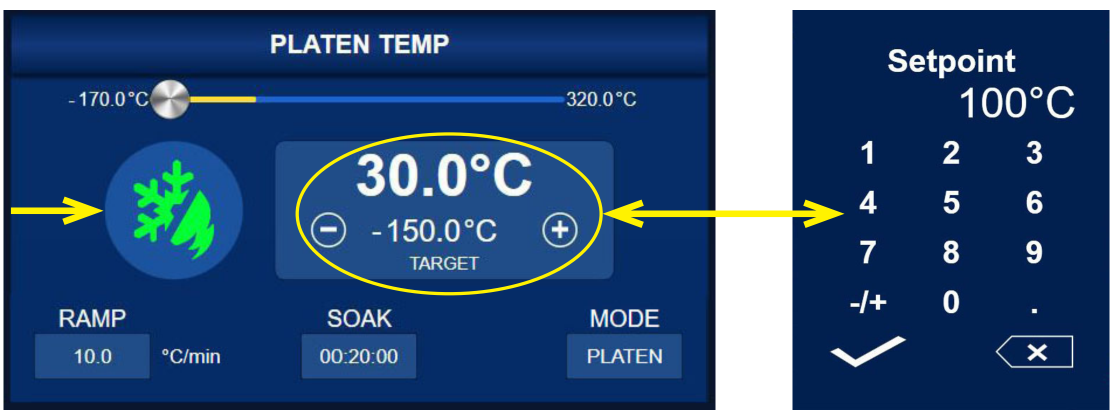



*Figure 16 - Platen Temp. controller - input setpoint value*

The largest white text displays the current temperature. In Figure 16, above, the current temperature is 30°C. Select it to open a window that allows the measurement units to be changed.

**Changing the Setpoint Value:**

The setpoint (target) temperature is shown just below the current temperature. In Figure 16, the setpoint target temperature is -150°C. Select it to open a window where a numerical value is entered. Select the (+) or (-) button to change the setpoint temperature incrementally. If a temperature input is outside the system limit, the pressure reverts to the closest allowable value.

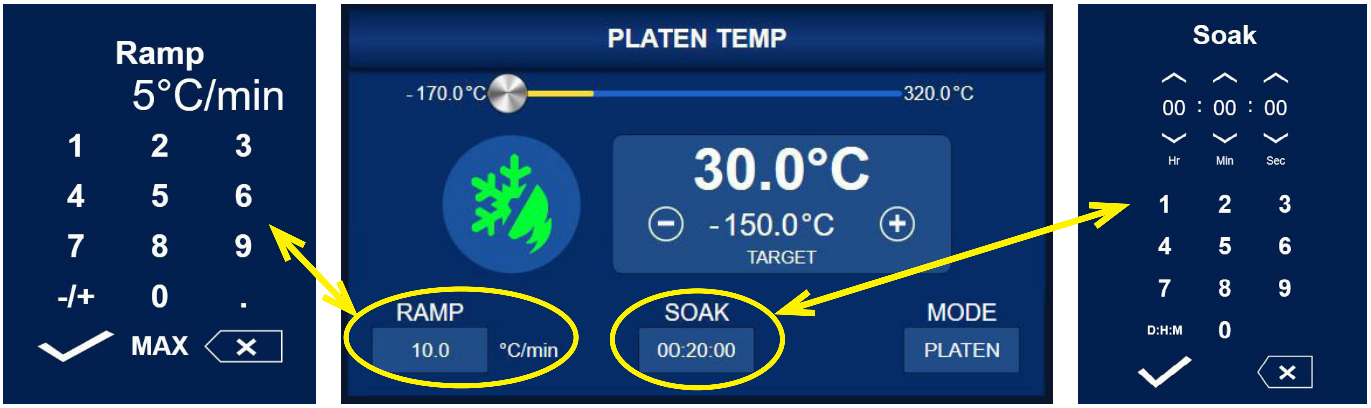



*Figure 17 - Platen Temp. controller - input ramp rate and soak time*

**Changing the Ramp Rate:**

Ramp rate is the speed at which the platen goes from its current temperature to the target (setpoint) temperature. The rate is dependent on the speed with which the heating elements and/or liquid nitrogen can tranfer heat to or from the platen, as well as the chamber pressure. When the chamber is under vacuum, the platen heats and cools faster than when at ambient atmosphere. Under vacuum, the ramp rate limit for cooling is approximately 10°C/min (Sec. 1.3, p. 7).

To change the ramp rate, select the RAMP tile at the bottom left of the controller (above). A window appears where a value can be entered. The ramp rate is expressed in the current temperature units per minute. Above, a ramp rate of 5°C/min. is entered. The ramp rate can also be set to MAX, which forces the system to get to the setpoint temperature as quickly as possible. Compared to a numerical ramp rate which is a linear function, the MAX rate is non-linear.

**Changing the Soak Duration:**

Soak is the amount of time after the setpoint temperature is reached that the platen temperature is maintained. When the soak time has elapsed, heating and/or cooling is discontinued and the platen will naturally heat or cool towards ambient temperature.

Select the SOAK tile at the bottom right of the controller to enter a soak time. Select the time in hours, minutes, and seconds, or select D:H:M to change to days, hours, and minutes. The maximum soak duration is 99 days. If no soak time is specified, the system continues at the setpoint until it is turned off manually.

**Changing the Platen Mode:**

Please see the AutoExplor Manual, Sec. 3.3.2, Platen Temperature Controller.

## 7.3 MORE INFORMATION AND ASSISTANCE

**For more information about using AutoExplor and the ExploraVAC system, please see the user manuals provided with the system or download them here:**

AutoExplor Software: idealvac.com/files/manuals/AutoExplor_Software_User_Manual.pdf

ExploraVAC Manual: idealvac.com/files/manuals/ExploraVAC_System_User_Manual.pdf

ExploraVAC MAX Manual: idealvac.com/files/manuals/ExploraVAC_MAX_System_User_Manual.pdf

# 8. REFILLING TANKS

**CAUTION**

**Do not use a tank exchange program. Always use the original XF-LN2 tanks. Non-system tanks have pressure relief valves set to greater than 100 psig, and do not have a CylTEC level sensor gauge installed. See Chap. 5, p. 17 about using non-system tanks.**

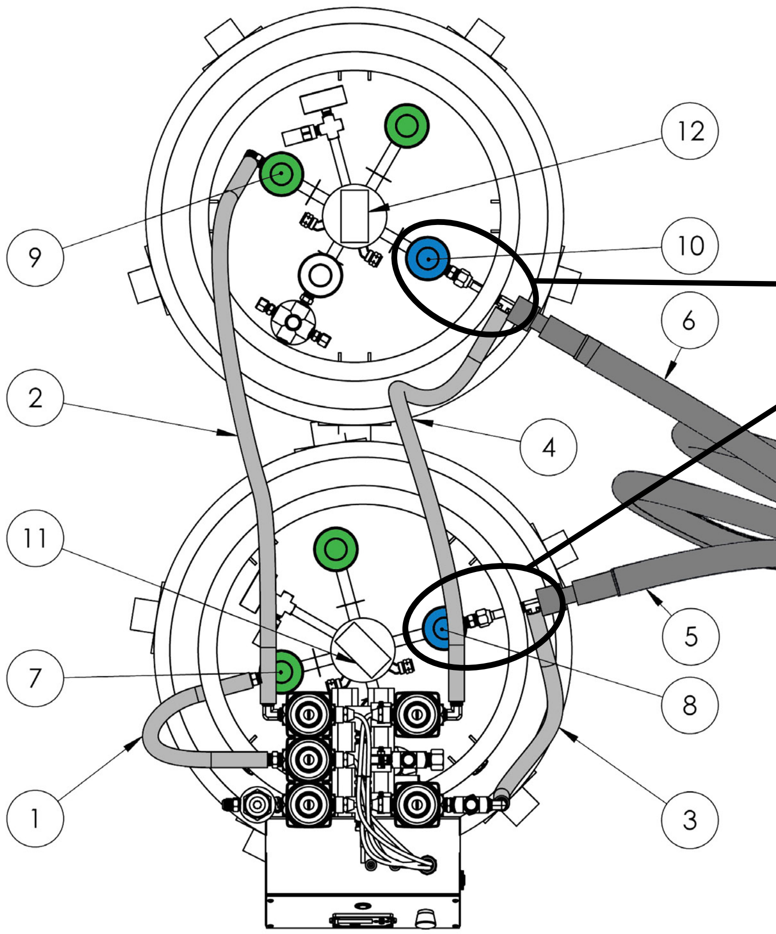



*Figure 18 - Tank valves and transfer line connections*

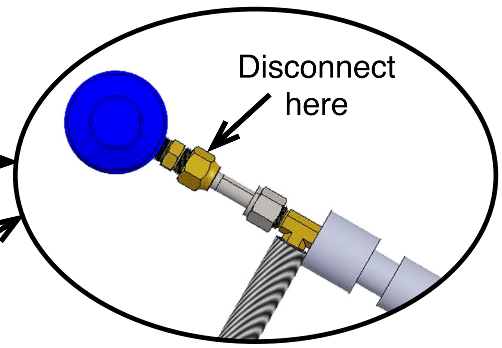



*Figure 19 - Enlarged view of liquid valve disconnect*

Use a 7/8" (22mm) or adjustable wrench to disconnect all nitrogen transfer lines on the tanks and valve manifiold. Do not remove brass fittings from valves. The lines should be at room temperature before they are disconnected. If there is still any liquid nitrogen in the tank, valves may be very cold. Wear gloves when disconnecting lines.

Close the manual vent and liquid valves on the tanks: **(7)**, **(8)**, **(9)**, and **(10)**.

Disconnect the vent and liquid lines from both tanks and from the valve manifold. Transfer lines **(4)** and **(6)**, and **(3)** and **(5)**, are attached to tees coming off the manual liquid valves. Disconect as shown above in the enlargement image above. It is not necessary to remove each line from the tee.

If the tanks are to be refilled outside of the facility, cap all valve manifold flare connectors with plastic covers.

# 9. TROUBLESHOOTING

If the platen is not cooling, perform these diagnostics. Refer to Figure 20.

1. Verify that all liquid transfer lines are plumbed correctly.
2. Verify that both Level-eye gauges are turned on and have working batteries.
3. Verify that at least one of the nitrogen tanks is above 12% capacity.
4. Ensure that the system is plugged in.
5. Turn off the system and close the AutoExplor software (if applicable).
6. Turn the system back on.
7. Turn the controller or software back on.
8. Set and turn on the PLATEN TEMP controller.

If the system still does not cool the platen, continue with these procedures:

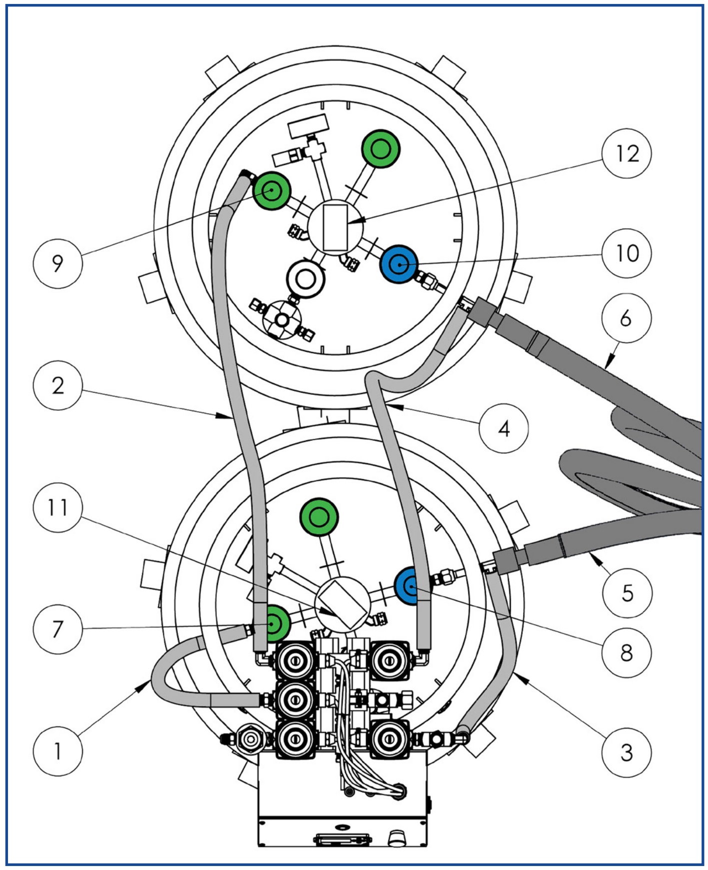



*Figure 20 - Tank valves and lines*

9. Use the software or ExploraVAC control panel to turn off the PLATEN TEMP controller.
10. Close the four manual valves on the tanks (Figure 20, items 7, 8, 9, and 10).
11. Wait until all 5 manifold solenoid valves become cool to the touch. This can take some time.
12. With all four manual valves closed on the tanks, turn on platen cooling using the control panel or software. There should be a click or a clunk from the valve manifold as the valves energize. Nitrogen will not flow because the tanks are closed.
13. Select the LN2 device card in AutoExplor (if applicable) and verify that PWM is 100%.


*Figure 21 - LN2 device card, PWM at 100%*

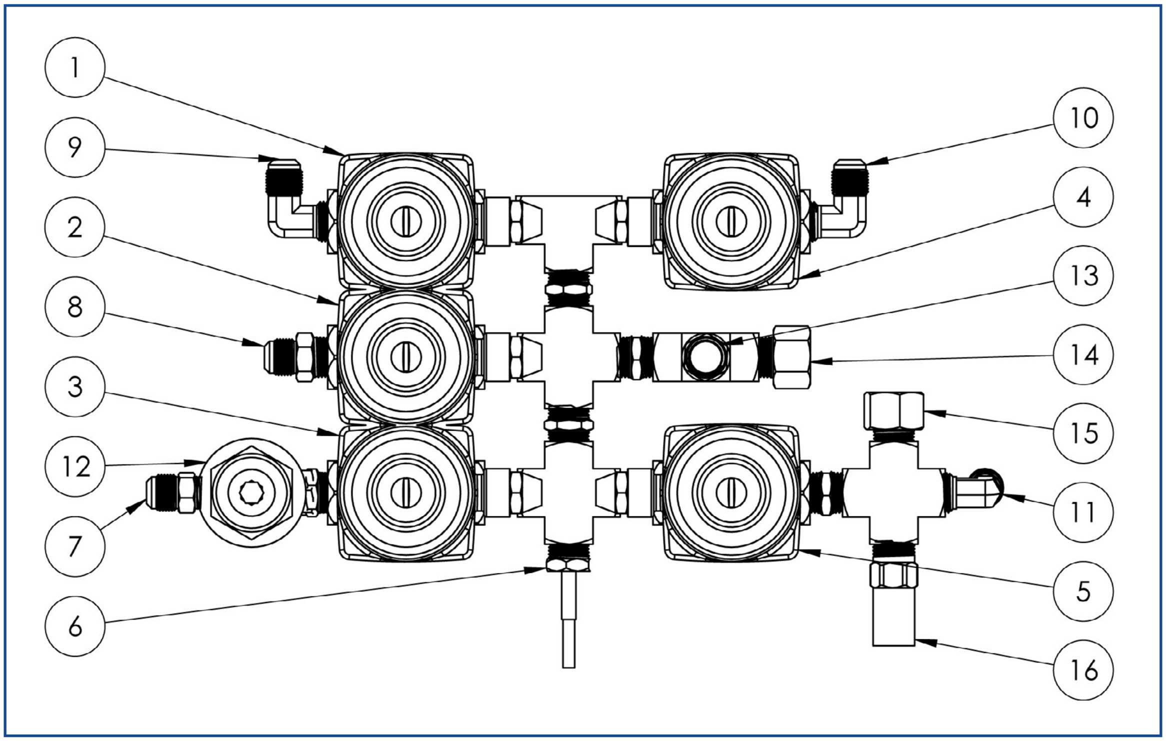



*Figure 22 - Valve manifold components*

Refer to Figure 22:

14. Wait at least 10 minutes, but not longer than 1 hour, and carefully touch the exhaust solenoid valve (item 3). The valve should be warm or hot. If it is cold, the exhaust valve may be electrically disconnected.
15. Carefully touch the four other solenoid valves. Mark which ones are hot.
16. The Tank 1 Vent and Tank 2 Bypass valves should be warm (Figure 22, items 2 and 4), and the Tank 2 Vent and Tank 1 Bypass Valves (Figure 22, items 1 and 5) should be cold.
17. Also acceptable are if Tank 1 Vent and Tank 2 Bypass valves are cold (Figure 22, items 2 and 4 ), and Tank 2 Vent and Tank 1 Bypass Valves are warm (Figure 22, items 1 and 5).
18. If only one or none of the valves are warm, then a valve may be electrically disconnected.
19. If two valves are warm, but they do not match the descriptions above, some of the valves may have become electrically switched.

If the valves are operating normally per steps 16 and 17, continue.

20. Use the control panel or the software to turn off platen cooling.
21. Open all four manual valves on the tanks (Figure 20, previous page, items 7, 8, 9, and 10).
22. Use the control panel or software to turn on platen cooling.
23. The platen should begin cooling.
24. If the platen does not begin to cool, one of the valves may have failed (become stuck). See Chapter 10 beginning on the following page for instructions.

# 10. REBUILDING VALVES

In AutoExplor, check for a system status notification at the bottom of the screen (Status: SERVICE Rebuild LN2 Control System Valves). Also check the Valve Service entry on the LN2 device card in the DEVICES section of the home page. Valve Service is normally “0”. If Valve Service equals “1”, then the valves have reached 500,000 cycles and should be rebuilt. Normal valve life is approximately 1 year. If the system is used continuously, valve life will be shorter.

If the platen still does not cool after performing the troubleshooting steps described in Chapter 9, then it is likely that at least one of the control valves has failed and the valves needs to be rebuilt. All the valves should be rebuilt at the same time.

The valve rebuilding steps are the same for both the normally open (NO) and the normally closed (NC) valves. There are three NC valves and two NO valves.

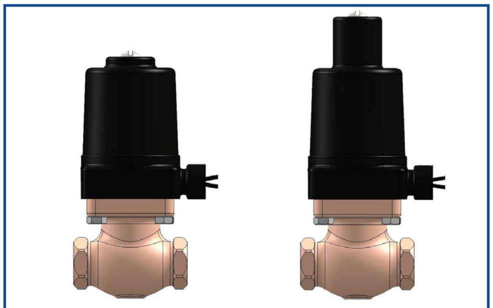



*Figure 23 - Normally closed (NC) and normally open (NO) control valves.*

The valve rebuild kit (part number: P1013270) includes replacement piston assemblies for all five cryogenic valves and also includes five round gaskets.

*Figure 23 - Valve rebuild kit for cryo valves (P1013270)*

| Tools Required | |
|---|---|
| Gloves and safety glasses | Ratchet |
| 1/2” wrench, stubby suggested | 3 or 6” extension |
| 1/2” short socket | Dental pick |
| Universal joint | Torque Wrench |

*Table 7 - Tools for rebuilding valves*

## STEP 1

Disconnect and remove the control system from the tank and place it on a bench.

Note: The control system is heavy. Use 2 people.

Note: The NO valve is rebuilt the same way as the NC valve (shown here).

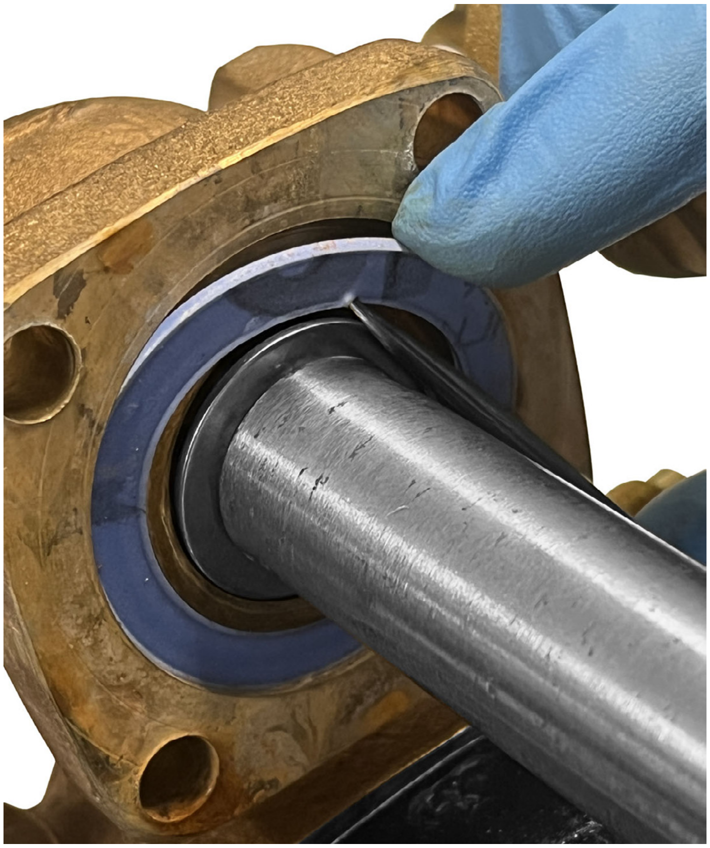
Rebuild one valve at a time.

Remove the four 5/16-18 x 1” head retaining bolts. Use a 1/2” wrench.

Note: Some of the valve bolts are easier to remove with a wrench. Others are easier with a ratchet when the system is turned upside down. Use a short socket, an extension and a universal joint as needed.

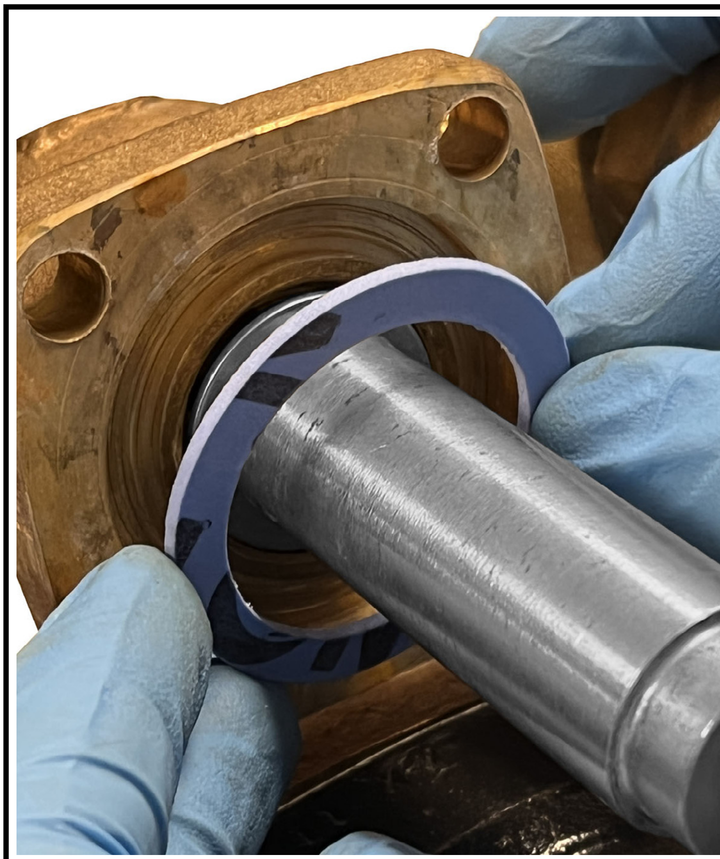
## STEP 2

Once the bolts are removed, gently lift the head off the piston.



## STEP 3

Use a dental pick to pry out the blue gasket. Discard the used gasket.



## STEP 4

Get a new gasket.

Slide it over the piston and press it into the recess with your fingers.

## STEP 5

Carefully pull the piston assembly straight out of the valve body.

## STEP 6

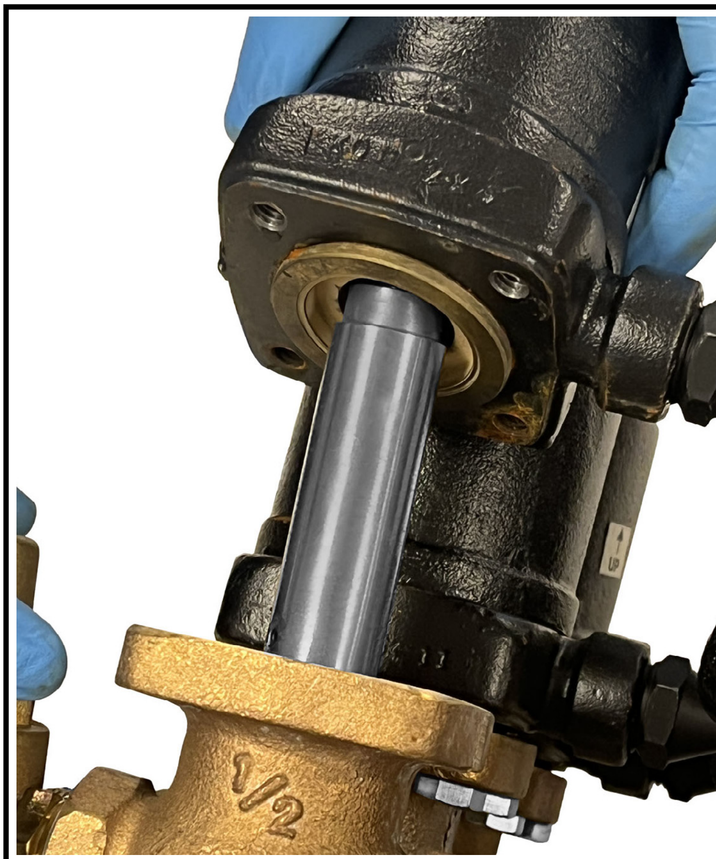
Get the new piston assembly.

Make sure the brass split ring is on the last groove (sometimes it moves or gets separated from the piston assembly).

While compressing the split ring with your fingers, carefully slide the piston into the valve body. Do not force it.

## STEP 7

Slide the piston assembly all the way into the valve body.



## STEP 8

Carefully slide the head over the new piston.

## STEP 9

Start all 4 head retaining bolts and hand tighten.

## STEP 10

Tighten bolts to snug with a wrench or ratchet.

Using a cross pattern, torque all bolts to 10 lb-ft.

Repeat Steps 1-10 for each of the other valves.

# 11. ADDITIONAL SAFETY PRECAUTIONS

Follow all warnings and instructions in this manual.

Follow all general guidelines for cryogenic liquid use.

This system is designed for use with tanks that have pressure relief valves set at 100 PSIG. If a third party tank is used, it must have a 100 PSIG pressure relief valve installed on the tank's headspace valve (vent valve) to ensure proper operation.

Do not use a tank exchange system for liquid nitrogen refills. Always use the originally supplied tanks with the XF-LN2 system, or a tank that has been verified as having a headspace regulated to 100 PSIG.

All test items must be rated for pressures >100 PSIG at cryogenic temperatures. Test items which are not rated for a minimum of 100 PSIG may rupture or explode.

If the XF-LN2 is connected to a thermocouple that is not attached to an item that is being cooled, the system will cool at a maximum rate, potentially achieving a lower temperature than desired.

Never operate the XtremeFreez-LN2 system with any gas or liquid other than nitrogen.

Do not install additional valves between the test item and the XF-LN2 system. This could result in liquid nitrogen being trapped inside the test article without a pressure relief pathway, resulting in extreme internal pressures, article failure, and possible explosion.

Do not touch lines or valves during operation. They may be very cold and could cause frostbite. Lack of condensation may not indicate lack of cold in dry environments. During cooling of hot test articles, outlet valves and lines may reach temperatures up to 200°C. Touching the valves or lines at this temperature may cause burns.

This system has an exhaust line which must be plumbed to an outside exhaust. Large amounts of inert nitrogen gas are generated during system operation and pose an asphyxiation hazard in a closed room. The pressure relief valves generate small amounts of nitrogen gas and do not need to be plumbed to an outside exhaust.

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