



## **Environmental Test Chamber**

### **OPERATION & MAINTENANCE MANUAL**



**Model No. xxxxx, Serial No. 3xxxx**

**Chamber Type: Temperature / Humidity**

**Controller: VersaTenn III**

#### **CHAMBER OPTIONS**

- |   |  |
|---|--|
| <input type="checkbox"/> TempGard IV - Watlow 93    | <input type="checkbox"/> GN2 Purge           |
| <input type="checkbox"/> Watlow LV Limit Controller | <input type="checkbox"/> Data Communications |
| <input type="checkbox"/> LN2 Boost Cooling          | <input type="checkbox"/> LinkTenn32 Software |
| <input type="checkbox"/> CO2 Boost Cooling          | <input type="checkbox"/> Chart Recorder      |
| <input type="checkbox"/> Dry Air Dehumid. / Purge   | <input type="checkbox"/>                     |

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**SUPPLEMENTAL INSTRUCTIONS**

<b>1.0 COMPANY INFORMATION &amp; ASSISTANCE</b>
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Congratulations on purchasing a chamber from one of the fine divisions of TPS - Thermal Product Solutions. You probably already know us as Lunaire Limited. We've changed our name and expanded our vision with the intent to provide you with more diversified solutions to your thermal product process requirements.

We truly hope that every aspect of chamber design and quality will measure up to your strictest standards. Your chamber has been designed to operate with the reliability you expect for the demands you impose on your product and research testing.

Headquartered in Williamsport, Pennsylvania, which is located in the North-central part of the state, TPS includes the following four divisions that manufacture environmental test chambers and industrial ovens.

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Tenney Environmental - - - - - Lunaire Environmental - - - - - Gruenberg Oven - - - - - Blue M

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Parts and service inquiries for equipment within each division should be directed to TPS by any of the following methods.

**Important!** Please have the **Model** and **Serial Numbers** of your unit available when contacting us.



**TPS**  
**2121 Reach Road**  
**Williamsport, PA 17701**

Phone: 570 - 326 - 1770  
Fax - Parts Dept. 570 - 320 - 2160  
Fax - Service Dept. 570 - 326 - 3372  
Fax - Main: 570 - 326 - 7304  
E - Mail Address: [service@lunaire.com](mailto:service@lunaire.com)  
Web site: [www.thermalproductsolutions.com](http://www.thermalproductsolutions.com)

**Parts Replacement**

Your equipment has been designed and manufactured to provide years of reliable service. In the event a component should fail, it is recommended that only OEM approved parts be used as replacements. Please contact the Parts Department for component replacement, or repair.

## 2.0 SAFETY WARNINGS & SYMBOLS



1. Read this entire Operation Manual, as well as the vendor manuals and cut-sheets provided before operating this equipment! Failure to adhere to any Safety Warning, or failure to follow the proper operating procedures listed throughout any of the information provided, could cause damage to your equipment, personal injury, or death.
2. Obey all “CAUTION”, “DANGER”, and “WARNING” signs / labels mounted on the equipment. Do not remove any of these signs / labels.
3. Do not use this equipment in any manner not specified in this manual. Improper use may impair the safety features employed and will void your warranty.
4. Operators and service personnel must be familiar with the location and function of all controls and the inherent dangers of the equipment before operating or maintaining it.
5. Only qualified service personnel should ever be permitted to perform any service-related procedure on this equipment!
6. For chambers that are not rated Explosion Resistant: The air conditioning section contains open wire heating elements, which can attain temperatures sufficiently high to ignite gas vapors. Do not install test articles that may release explosive or flammable vapors in the chamber.
7. Do not place the unit near combustible materials or hazardous fumes or vapors.
8. Do not install unit in a corrosive environment. A corrosive environment may lead to poor performance and deterioration of unit.
9. Make sure the chamber and any remote equipment provided are leveled when installed. The chamber door may swing shut on personnel if unit is tilted.
10. A main power disconnect may not be provided with your unit. If not provided, we recommend that a fused disconnect switch on a separate branch circuit be installed as the power source in accordance with all National and Local Electrical Codes. If your unit is equipped with a power cord and plug, you must utilize a receptacle with the appropriate rating, which is on a branch circuit of its own.
11. Do not position the chamber in a manner that would make it difficult to operate your main power disconnect switch.
12. Your power supply line voltage may be too low or too high to properly and safely operate your equipment. Before making the power supply connection to your equipment, you must follow the specific directions stated under “Power Connection” in the Installation Instructions section. Failing to perform the directions stated may damage your equipment and void your warranty!
13. Control panels, gauge boxes, the conditioning compartment, etc., contain exposed electrical connections. Keep panels in place properly when the unit is in operation. Disconnect and Lock-Out / Tag-Out all electrical power from the unit at its source before servicing or cleaning.
14. Refrigerant under high pressure is used. Only qualified refrigeration mechanic personnel should ever be permitted to perform any service-related procedure on the refrigeration system.
15. Do not adjust any mechanical components such as refrigeration valves or any electrical components except as directed in this manual.

- 16. Human exposure to temperature extremes can cause injury. Do not open the chamber door until chamber temperature drops below 200° F (93° C), when applicable. Take appropriate precautions before opening oven doors and upon handling any chamber contents.
- 17. Do not modify any component on this unit. Use only original equipment manufactured (OEM) parts as replacement parts. Modifications to any component, or the use of a non-OEM replacement part could cause damage to your equipment, personal injury, or death.
- 18. Do not overload the floor of the chamber workspace or load the unit unevenly.

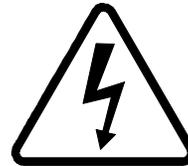
### INTERNATIONAL WARNING / SAFETY SYMBOL DEFINITIONS

Obey all “DANGER”, “WARNING”, and “CAUTION” labels shown in the manual and mounted on the equipment. Do not remove any labels mounted on the equipment.

“WARNING OF HAZARDOUS AREA”



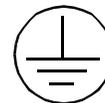
“WARNING OF DANGEROUS ELECTRIC VOLTAGE”



“WARNING OF HOT SURFACE”



“EARTH (GROUND) PROTECTIVE CONDUCTOR TERMINAL”



### 3.0 PRODUCT SPECIFICATIONS & OVERVIEW

#### Application:

This manual applies to the following reach-in temperature / humidity test chambers, which employ a capillary tube type refrigeration system.

- Benchmaster Models BTRS, BTRC
- “T” Series Models T6RS, T6RC, T10RS, T10RC, T20RS, T20RC, T30RS, T30RC, T40RS, T40RC
- “T” Series Models TH27, TH65

Note: This manual may also apply to special chambers with alternate model numbers (listed below).

**For Model XXXX, S/N xxxxx**, the following custom specifications apply:

Temperature Range:            - xx° to + xxx° C, +/- xx deg. after stabilization

Humidity Range:                xx% to xx% RH in the dry bulb range from + 20° to + 85° C, limited by a dewpoint of + 3° C

#### Environmental Conditioning Functions:

- Heating of the chamber is achieved by recirculating chamber air through open-air nichrome wire heater elements. The elements are supported by ceramic insulators.
- Cooling of the chamber is achieved by recirculating chamber air through refrigerated cooling coils in the chamber conditioning section. Non-CFC refrigerants are used.
- Humidification of chamber air is achieved by water vapor injection, which is generated by a Vapor-Flo Humidity Generator. Vapor pressure alone is used for injection.
- Dehumidification is achieved by moisture migration to a refrigerated Dehumidify Coil.
- Air circulation is generated by one or more conditioner motors with propeller type fans. Conditioner motors are mounted external to the chamber.

#### Temperature / Humidity Controller:

Temperature and humidity conditions are controlled by a two channel VersaTenn III Program / Control / Logic System. The VersaTenn control was developed specifically for environmental test chambers. Logic circuits automatically select cooling, heating, and humidity modes as required, with total programming capabilities of temperature and humidity versus time. Up to 99 steps may be programmed into 10 individual programs. Channel 1 controls temperature using an RTD sensor for temperature measurement. Channel 2 controls humidity using a dry capacitance type humidity sensor for humidity measurement. As options, you may have auxiliary event outputs and RS232/RS423, RS422, EIA-485, or IEEE data communications with the VersaTenn III Controller.

### Reach - In Type Model Number Designations and Specifications:

For Model No's. TxxRS and TxxRC, the xx designation indicates chamber workspace capacity in cubic feet. Standard workspace capacities for the T series range from 6 to 40 cubic feet. Custom chambers may be larger. The Benchmaster series have a workspace capacity of 4.89 cubic feet (size not shown in model no.).

The following descriptions explain the remaining model number designations. All specifications are based on operation at 24° C ambient temperature, altitude at sea level, and a 60 Hz power supply.

#### Humidity Specification:

- The letter 'R' in the suffix or letter 'H' in the prefix of the model number indicates that the chamber has humidification capabilities.

The humidity controlled range is from **20% to 98% RH** in the dry bulb range from + 20° to + 85° C, as limited by a 3° dewpoint. As an option, the addition of an external dryer would allow humidification levels as low as 5% RH to be reached, at temperatures to + 20° C.

#### Temperature Specifications:

- The suffix 'S' in the chamber model number indicates that the chamber is equipped with a single stage refrigeration system, which incorporates one compressor. Either an air-cooled, or water-cooled condenser is used to cool hot high-pressure refrigerant gas from the compressor, and change it to its liquid state.

The temperature controlled range is from **- 40° to +200° C, ± 0.3° C**. The exception to this standard range are the Models BTRS and T6RS, which have a low range of - 34° C.

- The Models TH27 and TH65 also incorporate a single stage refrigeration system, but have a smaller temperature operating range than those mentioned above. Either an air-cooled, or water-cooled condenser is used to cool hot high-pressure refrigerant gas from the compressor, and change it to its liquid state.

The temperature controlled range is from **- 20° C to + 100° C, ± 0.2/ ± 0.3°**, respectively.

- The suffix 'C' in the chamber model number indicates that the chamber is equipped with a cascade refrigeration system, which incorporates two compressors. This is a multiple system, consisting of a low stage and a high stage system. Both are integrated in a highly efficient design to permit extreme low temperatures to be attained. This is achieved by utilizing a cascade condenser in the low stage, where low stage refrigerant is cooled and condensed by high stage refrigerant. Either an air-cooled, or water-cooled condenser is used to cool hot high-pressure refrigerant gas from the high stage compressor, and change it to its liquid state.

The temperature controlled range is from **- 73° to + 200° C, ± 0.3° C**. Larger chambers will typically employ a cascade system. The exception to this standard range is the Model T6RC, which has a low range of - 70° C.

**Note:** Some model numbers are supplied with an additional suffix number, e.g., TxxRC - 1.5. This number indicates the Horsepower rating of the compressor(s). The Benchmaster and the Model T6 series employ 1.0 H.P. compressors, which are hermetically sealed type units. Models T10 and larger employ compressors rated from 1.5 to 3.0 H.P., which are semi-hermetic type units.

**Vapor-Flo Humidity Generator:**

Humidification of chamber air is accomplished as water is heated and vaporized by an electric immersion heater in a glass bell jar assembly. The build-up of vapor pressure in the bell jar causes a natural migration of vapor through a copper tube to the chamber conditioning section. The vapor mixes smoothly into the circulating air stream.

**Chamber & Product Over/Under Temperature Protection:**

Chamber overtemperature protection is provided with either a thermal cutoff, or the optional Watlow LV Limit Controller. Product over/under temperature protection may be provided with an optional alarm output from the main controller. The optional TempGard IV feature with the Watlow 93 Controller may be used for redundant product over/under temperature protection. These devices are configured in a comprehensive alarm and shutdown circuit.

**Additional Options:**

Your Tenney chamber may include many other options such as boost heating, boost cooling using LN<sub>2</sub> or CO<sub>2</sub>, a dry air system for dehumidification, a purge air system using compressed air or GN<sub>2</sub>, a chart recorder, and LinkTenn32 software. LinkTenn32 is an enhanced software program that provides centralized remote monitoring, and the control of multiple process controllers / chambers simultaneously.

As you can see, Tenney Environmental Test Chambers are diversified tools designed to encompass a wide range of operating conditions and functions. If you come upon any questions as you continue on through the manual, please contact our Service Department.

**Operating Parameters and Requirements:**

This equipment is designed to operate safely when the following environmental conditions are met:

- Indoor use only.
- Within a temperature range of 5°C to 30°C (max).
- Maximum relative humidity 90%.

The listed chamber specifications are based on operation at 24° C ambient temperature, altitude at sea level, and a 60 Hz power supply. Chamber operation utilizing a 50 Hz power supply may derate the listed performance specifications.

Equipment damage, personal injury, or death may result if this equipment is operated or maintained by untrained personnel. Operators and service personnel must be familiar with the location and function of all controls and the inherent dangers of the equipment before operating or maintaining it. TPS shall not be liable for any damages, including incidental and/or consequential damages, regardless of the legal theory asserted, including negligence and/or strict liability. Observe all safety warnings and operating parameters listed in this manual, as well as all Caution, Danger, and Warning signs or labels mounted on the equipment to reduce the risk of equipment damage and personal injury.

4.0 DRAWINGS, INFORMATION, and VENDOR INSTRUCTION LISTINGS

The following drawings are provided:

Electrical Single Phase Systems:

Electrical Schematic E - xxxx - 4

Electrical Three Phase Systems:

Instrumentation & Control Schematic E - xxxx - 4

Power Schematic E - xxxx - 4

Refrigeration Schematic R - xxxx - 4

**Note:** Additional drawings may be provided when various options are employed.

The following vendor manuals and information are provided:

VersaTenn III Controller Manual - 2 Channel Temp. / Humidity  
Humidity Sensor: Vaisala  
Test Report

**Optional Equipment – Vendor manuals will be supplied when the option is included.**

VersaTenn III Data Communications Manual - 2 Channel  
LinkTenn32 Software  
Watlow 93 Controller Manual (TempGard IV Feature)  
Watlow LV Limit Controller Manual  
Chart Recorder Manual  
Heatless Dryer Manual (with dry air dehumidification, or dry air purge option)

**Note:** Various other vendor product information sheets / manuals are also provided that contain important operation and maintenance instructions. Their inclusion is subject to vendor availability.

## 5.0 INSTALLATION INSTRUCTIONS

Read this section **completely** before attempting to install, or operate the equipment.

### 5.1 Delivery and Uncrating of Unit

Inspect equipment and shipping crate immediately upon receipt. If any damage is apparent, you should discuss it with the trucking delivery person and contact the transportation company immediately. Make notes of any damage on the Bill Of Lading. Retain all shipping materials for inspection. Any claims for damage must start at the receiving point. Check packing slip carefully and make sure all materials have been received as indicated on the packing ticket. Unless otherwise noted, YOUR ORDER HAS BEEN SHIPPED COMPLETE.



Chambers and any remote machinery skids or control cabinets should be handled and transported in an upright position. They must never be carried on their back, front, or any side.



For all models except Model BTRS, BTRC, T6RS, and T6RC:

To safely secure the refrigeration system compressors and piping during shipping, wooden blocks have been installed underneath the compressors. These blocks must be removed before operation! Serious damage may result if not removed!

- ◆ **On compressors with rubber mounts only, just simply slide the wooden block out. Do not loosen any nuts.**
- ◆ **On compressors with spring mounts only, you must loosen the compressor hold down nuts just enough to remove the blocks. Leave nuts in that position. Never loosen nuts beyond top of bolt.**

**Important!** Do to the vibration incurred during shipping and handling, it is possible that mechanical connections could become loose. Check all connections to make sure they are secure.

### 5.2 Location and Installation of Unit

Your equipment has been fully operated, tested, and balanced in our plant prior to shipment, unless notified otherwise. Follow the installation requirements below.

- Do not place the unit near combustible materials or hazardous fumes or vapors.
- Ventilation: The chamber should be installed in an area where there is good air ventilation, especially if an air-cooled condenser is used. Allow a minimum of 18 inches between any wall and chamber side, or to any equipment mounted to the chamber side.
- Do not locate unit in areas of wide ambient temperature variation such as near vents or outdoor entrances.
- Do not install unit in a corrosive environment. A corrosive environment may lead to poor performance and deterioration of unit.
- **Do not position the chamber in a manner that would make it difficult to operate your main power disconnect switch.** See "Power Connection" below.
- Make sure the chamber is leveled when set up.

**5.3 Chamber Drain Connection**

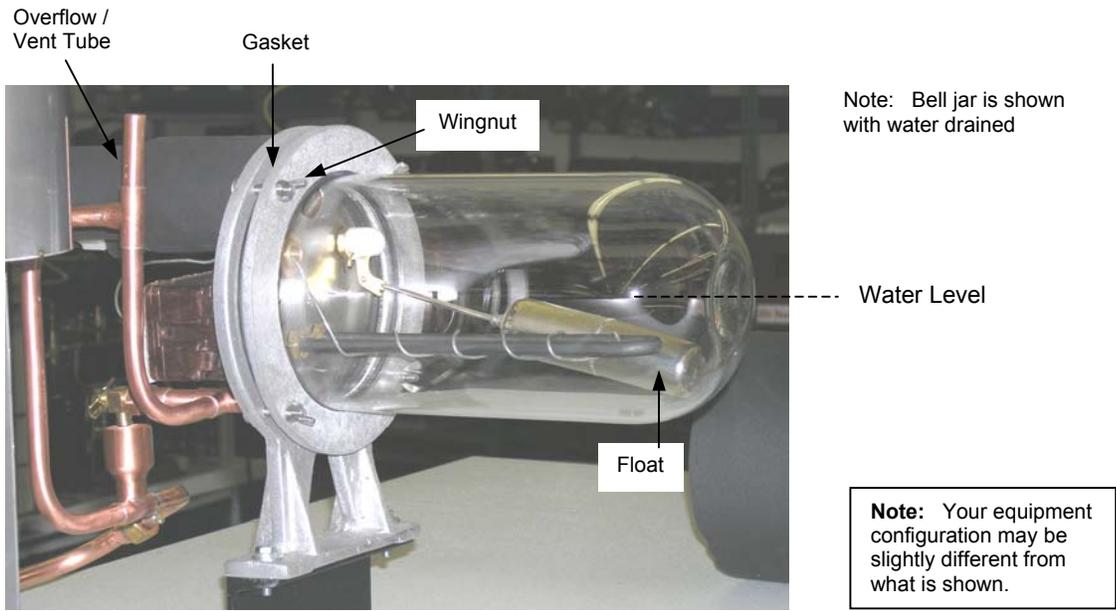
A chamber drain connection is provided for the removal of workspace condensate. The drain port is normally located at the rear of the chamber. The connection is Type 1/2" FPT. Check your General Layout Drawing (when provided) for further details.

**5.4 Water Supply Connection (Water-cooled Refrigeration Condensers Only)**

For chambers with a water-cooled refrigeration condenser, the water supply must be capable of providing a differential of 40 PSIG minimum between the inlet and outlet connections to the chamber. Connect the supply to the Water-In connection. Connect the Water-Out connection to an open drain, or to the return of a tower supply. Make sure both connections are secure. Reference the Refrigeration Schematic or the General Layout Drawing (when provided) for further details.

**5.5 Vapor-Flo Humidity Generator Checks**

The humidity generator is installed inside the machinery section and consists mainly of a glass bell jar assembly. A thick black insulating cover is wrapped around the bell jar. Remove the cover by sliding it off. Make sure the gasket sealing the bell jar is positioned properly around its perimeter, and that the wingnuts securing the bell jar are tight. Do not replace the cover until you follow all of the instructions that follow!



VAPOR-FLO HUMIDITY GENERATOR

## 5.6 Vapor-Flo Water Supply Quality & Connection

### Water Quality

Please read and adhere to the important statements below before utilizing your water supply.



We strongly suggest that you have your water supply tested for resistivity, organic content, and inorganic content before using the humidifier.



The water supply to the generator **must** be demineralized or single distilled, and have a resistance measurement between 50,000 and 100,000 Ohm/cm (20 to 10 Microsiemens/cm). It is important that the water is very low in minerals. Otherwise, the generator's immersion heater, housing, and float assembly will become encrusted with minerals and cause system failure. If your water supply can not meet the resistivity specifications, a cartridge ion exchanger (deionizer) should be obtained from TPS.

Note: Ion exchangers are discussed in detail in the Optional Equipment section.



Do not use double or triple distilled (ultra-pure) water. Pure water (greater than 1.0 Megohm/cm) will attack metals such as copper, brass, etc., and will drastically reduce the life of the humidifier.



Never supply demineralized, or single distilled water to a cartridge ion exchanger. (The result is double distilled water.)



If your water supply tests show that appreciable amounts of suspended particles are present (as determined by a Certified Test Lab), either a 5 micron or 25 micron polypropylene pre-filter should be used. This filter may be needed in addition to an ion exchanger. All filter types can be obtained through TPS.



If your water supply test shows that appreciable amount of organics, free chlorine and chloramines, phosphate complexes and turbidity are present (as determined by a Certified Test Lab), a roughing filter (US Filter Model - Absorber) should be used. This filter may be needed in addition to an ion exchanger. All filter types can be obtained through TPS.



Due to periodic changes that could occur in the quality of city or well water supplies, you should check your water for resistivity and organic / inorganic content every 1 to 2 months. These changes could be attributed to droughts, floods, seasonal changes, or land-use changes, e.g., farming, mining, etc..

### Supply Connection

The water supply should be 30-40 PSIG maximum. The connection is normally made directly to the Water Pressure Regulator WPR (1/4" MPT). The regulator is adjusted at the factory for optimal performance, which is normally between 10 and 20 PSIG at the input gauge.

Water Reservoir: When the optional 5 Gallon Water Reservoir is used, fill the reservoir to just below the top hose inlet port (when provided). Water is fed by gravity to the humidifier. When operating with high humidity conditions, you may have to fill the reservoir daily.

Condensate Pump: The optional condensate pump may be used to reduce the frequency of refilling the reservoir, or to conserve water. Water is pumped back to the reservoir in response to an integral float switch.

Important! Refer to the Humidity System Section in this manual when a water reservoir, a condensate pump, or a cartridge ion exchanger is used.



Water Supply Regulator



After turning on the water supply and adjusting the pressure, make sure the water level in the belljar is approximately 1" above the immersion heater. Replace the insulating cover.

5.7 Before Running Humidity Tests - Important!



**Reach-In Chambers:** Before running humidity tests you must remove the humidity vent port plug from the side of the chamber, which normally consists of a 1” to 4” diameter rubber stopper. If the vent plug is not removed, the heated vapor from the humidity generator will increase chamber temperature and may cause unnecessary cycling with the refrigeration system.

**Exception:** Your chamber will not include a standard humidity vent port if the chamber employs the Boost Cooling, Dry Air Dehumidification, Dry Air Purge, or GN2 Purge options. See Warning below.



**Reach-In Chambers:** If your chamber includes the Boost Cooling, Dry Air Purge, Dry Air Dehumidification, or GN2 Purge options, the vent port on the side of the chamber will consist of a 1½” I.D. checkvalve (with no plug), mounted vertically on an elbow fitting. The checkvalve is screwed onto the elbow fitting and is only hand-tightened.

**Whenever running humidity tests only, YOU MUST REMOVE the checkvalve by simply unscrewing it.** When finished, reinstall the checkvalve and only hand tighten. If the checkvalve is left in place during humidity testing, the resulting increase in chamber temperature / pressure may not be enough to completely open the checkvalve. Unnecessary cycling with the refrigeration system may then occur.



Strato-Flo Check Valve

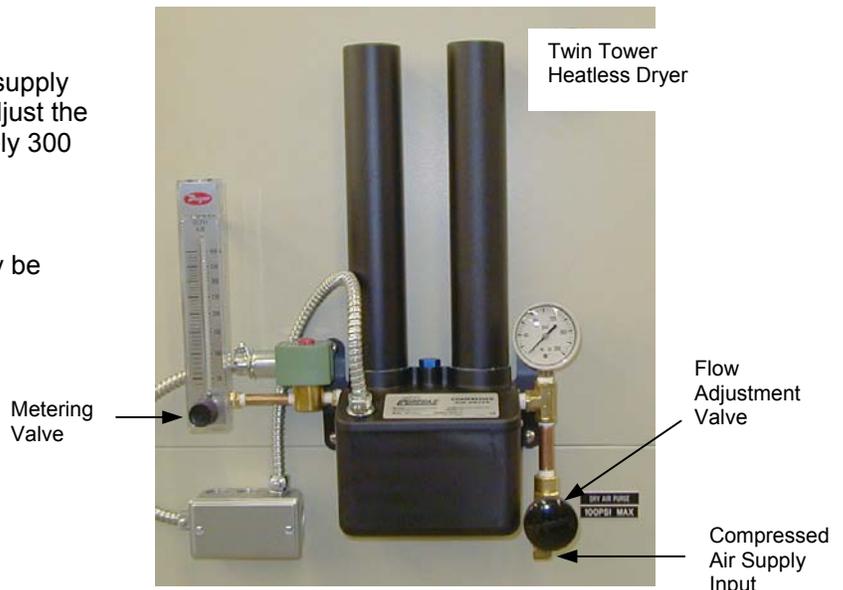
5.8 Air Supply Connection (For Optional Equipment)

Your chamber will require a compressed air supply for the Dry Air Dehumidification / Dry Air Purge System option. The supply should be clean and dry, and range from 80 PSIG min. to 100 PSIG max. The connection type is ¼” FPT. Make sure the connection is secure. Reference the corresponding “Options” section in this manual and your chamber specifications for more details.

**Flow Adjustments:**

Adjust the **flow adjustment valve** at the supply connection to maintain 100 PSIG max. Adjust the flowmeter **metering valve** to approximately 300 cubic feet per hour.

**Note:** Your equipment configuration may be slightly different from what is shown.



Dry Air Purge System

**5.9 GN2 Connection (For Optional Equipment)**

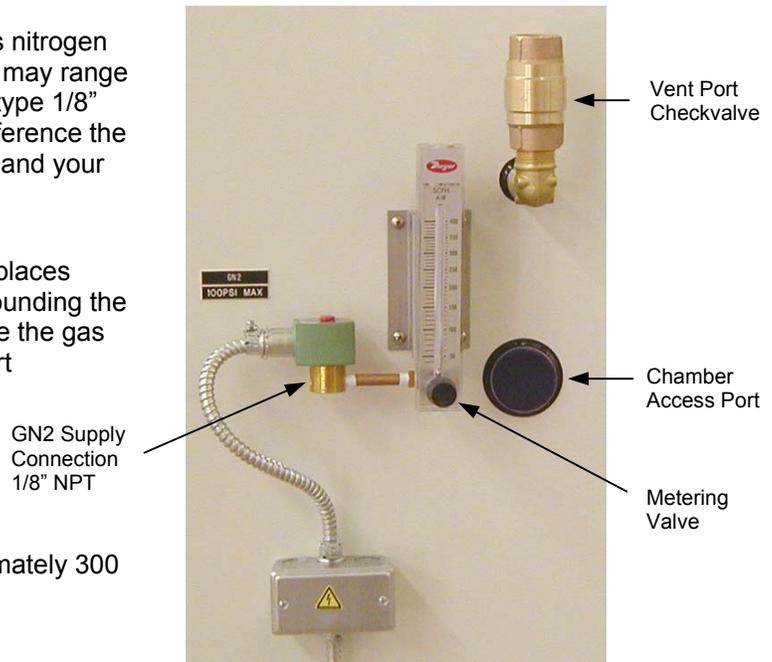
Your chamber will require a supply of gaseous nitrogen for the GN2 Purge System option. The supply may range up to 100 PSIG maximum. The connection is type 1/8" NPT. Make sure the connection is secure. Reference the corresponding "Option" section in this manual and your chamber specifications for more details.



**Warning!** Gaseous nitrogen displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve.

**Flow Adjustment:**

Adjust the metering valve to maintain approximately 300 cubic feet per hour.



GN2 Purge System

**5.10 LN2 Connection (For Optional Equipment)**

Your chamber will require a supply of liquid nitrogen for the LN2 Boost Cooling option. The supply may range up to 40 PSIG maximum. The connection is type 1/8" NPT. Make sure the connection is secure. Reference the corresponding "Option" section in this manual and your chamber specifications for more details.



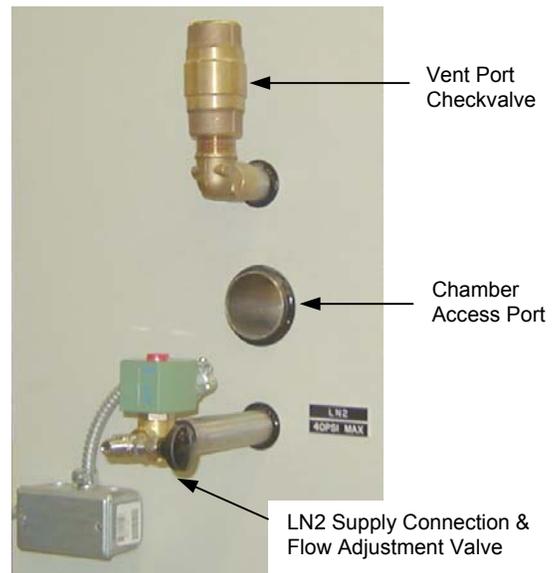
**Warning!** Gaseous nitrogen resulting from vaporized LN2 displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

**LN2 Flow Adjustment:**

LN2 systems are provided with a manually set flow adjusting valve, which permits the adjustment of nitrogen flow to avoid incomplete evaporation at varying LN2 supply pressures. As the chamber cools to the extreme cold temperature limit, complete evaporation of liquid nitrogen may not occur if the supply pressure is allowed to drop. Incomplete evaporation will cause droplets of liquid to fall to the chamber floor and cause puddling.



Do not allow liquid nitrogen to contact the door gasket. Exposure to LN2 will damage the gasket and violate the seal.



LN2 Boost Cooling

A setting of 4 turns open of the valve generally provides good performance at a supply pressure of 20 to 25 PSIG. This valve may be readjusted as necessary to accommodate the supply pressure at the end use point.

**Note:** Your equipment configuration may be slightly different from what is shown.

**5.11 CO2 Connection (For Optional Equipment)**

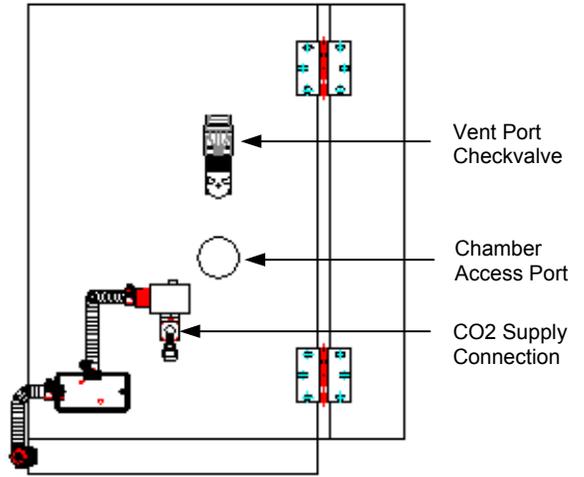
Your chamber will require a supply of liquid carbon dioxide for the CO2 Boost Cooling option. The supply may range up to 1000 PSIG. The connection is type 1/8" NPT. Make sure the connection is secure. Reference the corresponding "Option" section in this manual and your chamber specifications for more details.



**Warning!** Carbon Dioxide gas displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

**Note:** There is no flow adjustment for the CO2 supply. A fixed orifice on the injection port inside the chamber regulates the supply.

**Note:** Your equipment configuration may be slightly different from what is shown.



CO2 Boost Cooling

5.12 Power Connection



**Warning!** Before making the power supply connection to your unit, you must perform the following procedure:

1. Verify the power supply voltage rating established for your chamber (listed above). The voltage rating is also found on the serial tag on the side of the oven. Note the rated value here: \_\_\_\_\_
2. Measure and record the intended voltage source. Note the measured value here: \_\_\_\_\_
3. Reference the “Line Voltage Min/Max Tables” below. Verify that the power supply voltage source you measured and recorded is within the minimum and maximum allowable operating voltages for your chamber rating. If it is not within this operating range, **do not make the power connection!** Otherwise, erratic operation and damage may occur to your equipment, which may void your warranty. If you have any questions, please call the TPS Service Department.

**Important!** One of the most common causes of equipment malfunction is low line voltage as the power source to the unit. Ordinarily in this condition, the heat output would be reduced and the system's motors would operate erratically, eventually overheat, and shut down. You must be certain that your equipment is connected to a circuit with an adequate voltage and current source. An oversupply voltage would also cause erratic operation and eventual shutdown, or damage to your equipment.

- 60 HERTZ SUPPLIES - LINE VOLTAGE MIN. / MAX. TABLE		
Nominal Voltage	Minimum Voltage	Maximum Voltage
208	188	228
230	207	253
460	414	506
480	432	528
<b>60 Hz Supply</b>	<b>Operation outside these limits can result in damage to the system's motors.</b>	

- 50 HERTZ SUPPLIES - LINE VOLTAGE MIN. / MAX. TABLE		
Nominal Voltage	Minimum Voltage	Maximum Voltage
200	180	220
220	198	242
380	342	418
400	360	440
415	374	456
<b>50 Hz Supply</b>	<b>Operation outside these limits can result in damage to the system's motors.</b>	

Making the Power Supply Connection to the Chamber:

A main power disconnect switch is normally not provided with your chamber. We recommend that a fused disconnect switch on a separate branch circuit be installed as the power source to your chamber, in accordance with all national and local electrical codes. Reference your Electrical, or Power Schematic for all electrical requirements.

The power connection is made via a cord and plug for small standard units. Connect the plug to a receptacle that has the appropriate power supply on a branch circuit of its own.

For larger or special units that have the power supply hard-wired to the chamber, connect incoming lines to the main input connections provided in the control section.



**Warning!** High Accessible Current – An Earth connection is essential before connecting the power supply. Make sure equipment is properly grounded in accordance with all codes.

### 5.13 Application of Power

- ◆ Before energizing any equipment, make a visual inspection for loose components, electrical connections, fittings, etc. Shut all operating switches to the “OFF” position before energizing.
- ◆ Have trained personnel start and check out the equipment before its first cycle.

**Motor Rotation Check:** Units with three phase motors must be checked to insure proper motor rotation. A red arrow is located on the motor housing to show proper rotation. If it is opposite, shut down the oven and disconnect the main power supply source. Perform **Lock-Out / Tag-Out Procedures** established by your company. Reverse two of the line feeds to obtain proper operation. Failure to check motor rotation may result in **DAMAGE TO THE EQUIPMENT** due to opposite airflow, or no airflow.

### 5.14 Operating With an Active Heat Load

When operating with an active heat load, such as introduced by a powered test unit, this heat must be removed or the chamber temperature will rise. The internal logic of the controller will automatically turn on the refrigeration system to maintain a set temperature. Although a cooling system failure is not likely to occur, it is always a possibility when mechanical systems are used. In the event of a cooling system failure that results in an out of limit over temperature condition, one or more of the system safeties will remove power from the system. However, heating will continue if power remains applied to the active load. To guard against this continued heating, the product should be powered through the spare contact of the Master Contactor 1CON (when provided), which is described in the Alarm and Shutdown Circuit section.

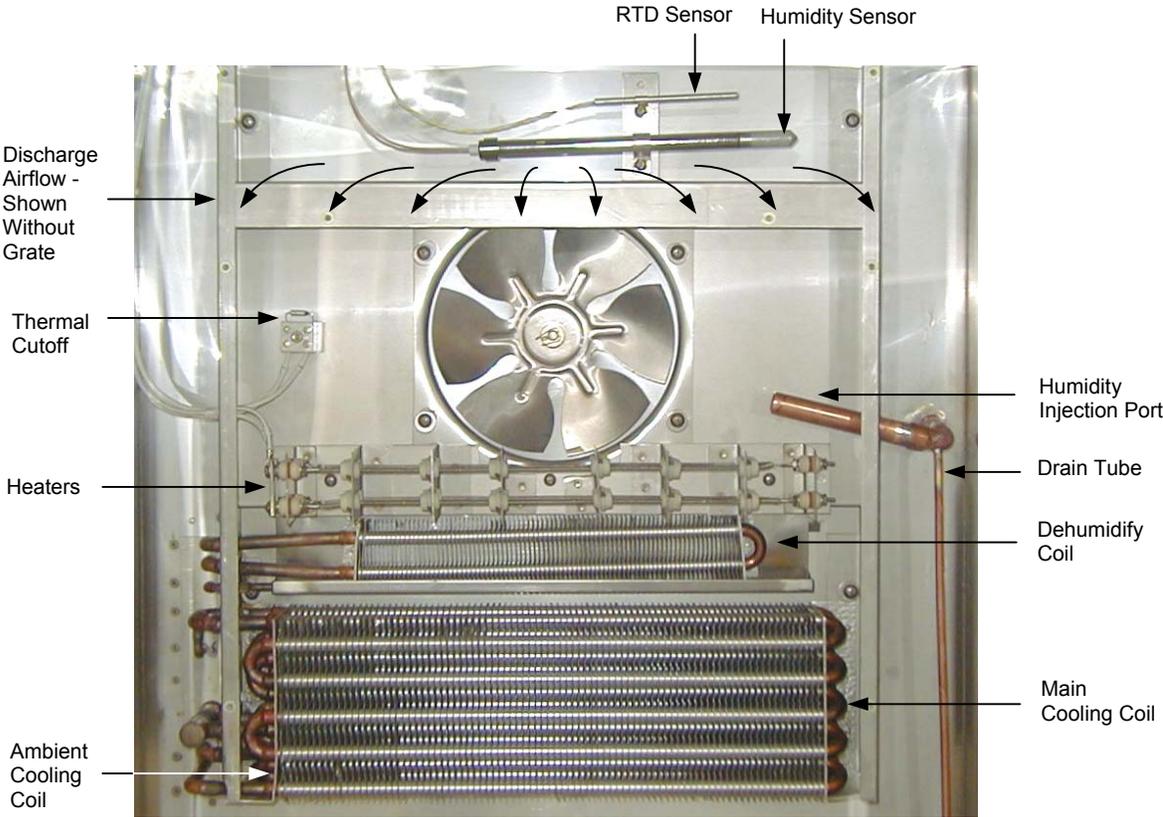
6.0 AIR CIRCULATION SYSTEM

Tenney Environmental Test Chambers are provided with an efficient airflow management system that maintains maximum temperature uniformity. Chamber air is conditioned in the conditioning plenum where the fans, heater elements, refrigeration coil, and humidity injection port are located. The plenum is isolated from the workspace.

**Airflow Description:**

The plenum is installed in the rear wall. Airflow is generated by either propeller type fans or blower wheels, which are mounted near the top of the plenum. Fans and blower wheels are directly driven by externally mounted motors. Due to the size of reach-in chambers, a maximum number of two circulation fans or blowers can be employed.

Process air is drawn from along the bottom of the chamber and up into the plenum. It flows up through the refrigerated coils and heater elements, mixes with injected water vapor, and is discharged into the workspace through either a grate at the top of the plenum, or through a separate ceiling plenum. Ceiling plenums have perforations that disperse the conditioned air downward into the workspace. A vent port is provided either near the top of a side-wall, or in the ceiling.



Plenum Conditioning Section

**Note:** Your equipment configuration may be slightly different from what is shown.

## 7.0 VERSATENN III TEMPERATURE / HUMIDITY CONTROLLER

### 7.1 Controller Features

Temperature and humidity conditions are controlled with the profiling type VersaTenn III Controller. The VersaTenn III is a microprocessor based proprietary instrument, which was developed specifically for environmental test chambers. It is precisely designed to take complete command of the chamber's conditioning systems. Two channel VersaTenn Controllers incorporate logic circuitry that automatically selects heating, cooling, and humidity modes as required, with total programming capabilities of temperature / humidity versus time.

The following main features are employed. Note: Not all inputs / outputs listed are used.

- ◆ Two Channel
- ◆ Profiling: 10 Profiles, 99 Steps Max.
- ◆ Automatic & Manual Control
- ◆ 2 Process Inputs: RTD (Std), and Dry Capacitance Type Humidity Sensor
- ◆ 1 Event Input
- ◆ 10 Temp. Control Outputs: Time Proportioned and On / Off Control
- ◆ 5 Humidity Control Outputs: Time Proportioned and On / Off Control
- ◆ 6 Event Outputs - Optional
- ◆ 1 Alarm Output - Standard
- ◆ Guaranteed Soak - Standard
- ◆ Communications: Serial - Optional



VERSATENN III CONTROLLER

**Note:** Temperature values are shown in the upper VersaTenn III display. Relative humidity values are shown in the lower VersaTenn III display, preceded by "RH". To display humidity go to SYSTEM with the MODE key and press ENTER.

**Controller Configuration:**

The pre-programmed controller configuration for your chamber is documented in the Test Report, which is located in the Supplemental Instructions Section. Refer to the controller's user manual for more information.

**Important!** The configuration set-up is mainly provided for your reference. Not all of the parameters shown apply to your chamber. Changes to some of the set-up parameters may drastically affect your chamber performance and void your warranty. Contact the TPS Service Dept. before attempting any changes.

**Data Communications:**

As an option, your chamber may include data communications with the main controller's serial port. When employed, a Data Communications manual will be included in the Supplemental Instructions Section. As a reference, the available data types are listed and briefly described below.

**RS232C / RS423A:** Both interfaces are compatible and use 3 wires: a single transmit wire; a single receive wire; and a common line. The maximum wire length is 50 feet. Only a single chamber may be connected to your computer. Data signals are measured as plus and minus 12 Volts to common with RS232C, and plus and minus 5 Volts to common with RS423A.

**RS422A:** This interface uses 5 wires: a transmit pair; a receive pair; and a common line. Up to ten chambers may be connected to your computer on a multi-drop network up to 4,000 feet long. Data signals in each pair are measured as a plus or minus 5 Volt differential.

**EIA-485:** This interface uses only 2 wires. Both wires are used for transmitting and receiving data, and therefore, only one device may talk at a time. Up to 10 chambers may be connected to your computer on a multi-drop network up to 4,000 feet long. Data signals are measured as a plus or minus 5 Volt differential. An EIA-485 card must be installed for signal conversion.

**IEEE-488:** This is a parallel multi-drop interface with several control and data lines. Each device connected must be set to a unique address. Data from other test devices may also be collected. An IEEE-488 to serial converter card must be installed. Maximum cable length is approx. 33 ft.



DATA COMMUNICATION PORTS



DATA COMMUNICATION PORTS

## 7.2 Conditioning Control Functions:

Temperature control related functions are affected by solid state outputs on remote switching module 1SM, and are designated 1SM-01 thru 1SM-10. Humidity with temperature control related functions are effected by solid state relay outputs mounted on the VersaTenn III, and are designated SSR1 thru SSR5.

Event outputs (user entered) that can alter the standard VersaTenn logic for special, or optional applications, are solid state devices mounted on remote switching module 3SM. 3SM has six outputs designated 3SM-01 thru 3SM-06. Event outputs that operate a standard optional feature, are normally described in the Options section.

The System ON button must be pressed to start control of the chamber. The following descriptions detail the functions of the various outputs. Event outputs (user entered) are provided mainly for special applications.

### - AIR CIRCULATION -

**1SM-01** -- This output immediately turns on the conditioner fan motor when the VersaTenn "System ON" button is pressed.

### - HEAT CONTROL -

**1SM-03** -- **Control Method #1:** This method is used with chambers that have a 3.0 KW or less heat load and a 240 VAC control circuit. The time proportioned 1SM-03 output will trigger triac 1TRC to conduct and energize the electric heaters.

**Control Method #2:** This method is used with chambers that have a heat load greater than 3.0 KW, or with those that have a 120 VAC control circuit. The time proportioned 1SM-03 output will energize xSCR. xSCR is a Watlow DIN-A-MITE power controller, which incorporates a burst firing technique to supply power to the electric heaters. Contacts of the Heat Arm Contactor xCON must also close.

### - COOLING CONTROL - SINGLE STAGE REFRIGERATION SYSTEM

**1SM-06** -- For chambers with a compressor rated below 3 HP, this output triggers triac 2TRC to conduct, which energizes the entire refrigeration system. The compressor will start, along with either the air-cooled condenser, or the compressor top mounted cooling fan. Only moderate cooling will occur.

For chambers with a compressor rated 3 HP and above, this output energizes contactor xCON (through triac 2TRC), which energizes the entire refrigeration system. The compressor will start, along with either the air-cooled condenser, or the compressor top mounted cooling fan. Only moderate cooling will occur.

**1SM-05** -- This On/Off output will energize the Full Suction solenoid valve 10SOL (when employed) during temperature control only, to permit maximum refrigerant flow from the evaporator coil back to the compressor. 10SOL bypasses a restrictive hand valve. When energized, 1SM-05 will also arm outputs 1SM-07 and 1SM-08.

- 1SM-07** -- This is a time proportioned output that energizes the Full Ambient Coil solenoid valve 1SOL, which permits full refrigerant flow to the Evaporator Coil. 1SOL bypasses the capillary device that precedes 1ASOL and restricts flow to the evaporator cooling coil. This output functions only after being armed by outputs 1SM-05 and 1SM-08.
- 1SM-08** -- This output will turn on when the chamber setpoint is below +20° C, allowing full cooling to be modulated by output 1SM-07.
- 1SM-09** -- This is a time proportioned output that is the compliment of output 1SM-07 (i.e. it is off when 1SM-07 is on and vice versa). It energizes the Suction Line Cooling bypass solenoid valve 11SOL, to inject cool liquid refrigerant into the suction side of the compressor. This occurs with reduced cooling requirements to prevent overheating of the compressor.
- 1SM-10** -- This output will always turn on when cooling is required. 1SM-10 energizes the Ambient Feed Coil solenoid valve 1ASOL, which feeds liquid refrigerant to the Evaporator Coil. Only moderate cooling occurs because refrigerant flow is restricted by the capillary tube that precedes 1ASOL. It also energizes the Ambient Coil Suction solenoid valve 1BSOL. This output may be bypassed and the function locked-on with Event Output 3SM-02.
- SSR1** -- With humidity control, SSR1 turns on to provide time proportioned moderate cooling. SSR1 energizes the Ambient Coil Feed solenoid valve 1ASOL, which feeds liquid refrigerant to the Evaporator Coil. It also energizes the Ambient Coil Suction solenoid valve 1BSOL. **This output may be bypassed and the function locked-on with Event Output 3SM-03.**
- SSR5** -- With humidity control, SSR5 turns on to energize the Suction Line Cooling bypass solenoid valve 11SOL. With a reduced cooling requirement during humidity control, 11SOL injects cool liquid refrigerant into the suction side of the compressor. This prevents the compressor from overheating.
- 3SM-03** -- **Event No. 3 - Ambient Coil Lock-On:** With humidity control, this event must be turned ON to lock-on cooling with the Ambient Cooling Coil. This control is primarily intended for use at ambient temperatures to provide improved temperature control. It will bypass the time proportioned control of SSR1 and keep the Ambient Feed and Ambient Suction solenoid valves opened.

**Important Note:** This event output is provided to give better temperature control near ambient temperatures. Its affect will vary with the chamber size, process load, and ambient conditions. We suggest you experiment with your process. A typical condition where you may want to lock Event No. 3 ON is near ambient conditions, e.g., 25 deg. C, and 50% RH. At higher temperature / humidity conditions such as 50 deg. C and 95% RH, turn Event No. 3 OFF. With these conditions, the cold Ambient Coil would sap out the humidity and cause the chamber to cycle.

#### - COOLING CONTROL - CASCADE REFRIGERATION SYSTEM

- 1SM-06** -- For chambers with compressors rated below 3 HP, this output triggers triac 2TRC to conduct, which enables the entire refrigeration system. The high stage compressor will start (in order to cool the cascade condenser), along with either the air-cooled condenser, or the compressor top mounted cooling fan.

For chambers with compressors rated 3 HP and above, this output energizes contactor xCON through 2TRC, which enables the entire refrigeration system. The high stage compressor will start (in order to cool the cascade condenser), along with either the air-cooled condenser, or the compressor top mounted cooling fan.

For all chambers, 1SM-06 also turns ON when a humidity set point has been entered, and a need for either cooling, or dehumidification is detected.

**1SM-05** -- For chambers with compressors rated below 3 HP, this output triggers triac 3TRC to conduct, which energizes the low stage compressor, and enables outputs 1SM-07,-08,-09.

For chambers with compressors rated 3 HP and above, this output energizes contactor xCON, which energizes the low stage compressor and enables outputs 1SM-08 & -09.

For all chambers, 1SM-05 is disabled when a humidity control set point is entered, since only the high stage compressor is used when cooling is required with humidity.

**1SM-07** -- This is a time proportioned output that energizes the Full Main Coil solenoid valve 8SOL, permitting maximum refrigerant flow to the Low Temperature Evaporator Coil. 8SOL bypasses the capillary device that restricts flow to the cooling coil. This output functions only after being armed by output 1SM-08.

**1SM-08** -- This output will turn on when the chamber setpoint is below +20° C, allowing full cooling to be modulated by output 1SM-07. When this output is off, only reduced cooling is available, resulting in finer control at higher temperatures.

**1SM-09** -- This is a time proportioned output that is the compliment of output 1SM-07 (i.e. it is off when 1SM-07 is on and vice versa). It energizes the Artificial Loading bypass solenoid valve 14SOL, to inject cool liquid refrigerant into the suction side of the compressor. This occurs with reduced cooling requirements to prevent overheating of the compressor.

**1SM-10** -- For units with compressors 1.5 H.P. and larger, this output energizes the Cascade Condenser solenoid valve 9SOL, allowing liquid refrigerant flow to the Cascade Condenser.

**SSR1** -- With humidity control, SSR1 turns on to provide time proportioned moderate cooling. Output 1SM-06 is simultaneously turned on to energize the high stage compressor. SSR1 energizes the Ambient Coil Feed solenoid valve 1ASOL, which feeds liquid refrigerant to the Ambient Coil. It also energizes the Ambient Coil Suction solenoid valve 1BSOL. **This output may be bypassed and the function locked-on with Event Output 3SM-03.**

**3SM-03** -- **Event No. 3 - Ambient Coil Lock-On:** With humidity control, this event must be turned ON to lock-on cooling with the Ambient Cooling Coil. This control is primarily intended for use at ambient temperatures to provide improved temperature control. It will bypass the time proportioned control of SSR1 and keep the Ambient Feed and Ambient Suction solenoid valves opened. Event No. 3 will be disabled by the Ambient Coil Disable relay ACR whenever the low stage compressor turns on.

**Important Note:** This event output is provided to give better temperature control near ambient temperatures. Its affect will vary with the chamber size, process load, and ambient conditions. We suggest you experiment with your process. A typical condition where you may want to lock Event No. 3 ON is near ambient conditions, e.g., 25 deg. C, and 50% RH. At higher temperature / humidity conditions such as 50 deg. C and 95% RH, turn Event No. 3 OFF. With these conditions, the cold Ambient Coil would sap out the humidity and cause the chamber to cycle.

- HUMIDITY CONTROL - HUMIDIFICATION -

**SSR2** -- This time proportioned output triggers triac 4TRC to conduct, which energizes the Vapor-Flo Humidity Generator to produce water vapor.

**Important Note:** To completely turn off the humidification system, you must create a separate step and enter a value of -0.1 as the humidity setpoint into the VersaTenn III.

- HUMIDITY CONTROL - DEHUMIDIFICATION -

**SSR3** -- This time proportioned output energizes the Dehumidify Coil solenoid valve 4SOL, which permits refrigerant to flow to the Dehumidify Coil in the chamber conditioning compartment. Output 1SM-06 is energized simultaneously to turn on the entire refrigeration system in a single stage system, or just the high stage compressor in a cascade system.

**SSR4** -- This time proportioned output operates the **Optional** air dryer system for extended dehumidification. To activate SSR4, the VersaTenn internal logic event LEV1 must first be turned ON.

SSR4 will energize the air dryer through a one minute delay-off timer TD. SSR4 also energizes the Dry Air solenoid valve ASOL, which permits the injection of dry air into the chamber. The timer will deenergize the air dryer if output SSR4 remains off for more than one minute.

- EVENT OUTPUTS - For Special Applications - S/N xxxxx ONLY

**3SM-01** -- **Event Output No. 1:** This event must be turned ON to .....

**3SM-02** -- **Event Output No. 2:** This event must be turned ON to .....

**3SM-03** -- **Event Output No. 3:** This output must be turned ON to ..... (Also see Cooling Control Outputs previously described.

**3SM-04** -- **Event Output No. 4:** This output must be turned ON to .....

**3SM-05** -- **Event Output No. 5:** This output must be turned ON to .....

**3SM-06** -- **Event Output No. 6:** This output must be turned ON to .....

## 8.0 TEMPERATURE ALARM & SHUTDOWN CIRCUIT

A comprehensive alarm and shutdown circuit may be provided for multiple protection against chamber overtemperature, product over/under temperature, and Master Contactor 1CON failure. The sensors utilized for temperature measurement / sensing are normally placed in the plenum in the downstream airflow. This is the most responsive area of the chamber.

**Chamber Over Temperature Protection:** The following devices may be used.

1. **Heat Limiter (HL)** - - Temperature Actuated Thermal Cutoff (Standard)

This is an axial leaded one-shot protection device that is mounted in a small white ceramic terminal block. For chambers with a top temperature limit of 200 degrees C, the Heat Limiter is designed to open when the surrounding temperature reaches 240 degrees C. For chambers with a lower temperature limit, either an alternate thermal cutoff will be used, or the Watlow LV Limit Controller will be used.



Thermal Cutoff

2. **Watlow LV Limit Controller (1TS)** - - High Heat Cut-Out (Optional)

This controller is a 1/8 DIN type with a push to set adjustable dial and a four character red LED display. The push to set operation reduces accidental limit set point adjustments. A red LED on the Watlow LV will illuminate in an alarm condition.

The controller is installed inside the main control cabinet. A Type T thermocouple is used for temperature measurement. The high limit setpoint is shown in the LED display, and is factory preset 10-15 degrees above the maximum chamber operating temperature. **This limit should never be changed!**

Note: This model replaces the Watlow 147 open board type limit controller. The operation is identical.



Watlow LV Limit Controller

**Product Over/Under Temperature Protection:**

These controllers utilize a 100 ohm Platinum RTD for temperature measurement.

1. **VersaTenn III Controller** - - VST Alarm Output - High/Low Limits **(Standard)**
2. **Watlow 93 Controller** - - TempGard IV Feature – High / Low Limits (Optional)

**CIRCUIT OPERATIONS**



When Master Contactor 1CON is deenergized due to ANY alarm condition described below, power is only removed from the temperature conditioning control circuitry. The instrumentation and alarm circuitry will still be energized!

**Normal Conditions:**

- ◆ When the monitored temperature is within the selected setpoints, the green NORMAL light 2LT is illuminated and Master Contactor 1CON is energized. The contacts of 1CON provide power to the temperature control circuitry.
- ◆ With the optional alarm buzzer / silence switch, a NORMAL light is also provided, and it will illuminate.

**Note:** A spare set of 1CON contacts is provided for the customer's closure. It is recommended that these contacts, wired to terminal blocks #14 & #15, be used to energize an active heat load if utilized.

**Opened Heat Limiter (Thermal Cutoff):**

When a predetermined high temperature limit is reached and the Thermal Cutoff opens, Master Contactor 1CON will deenergize and remove power from the conditioning control circuitry. The Chamber OVERTEMP light will illuminate and the Chamber Control switch light will extinguish.

With the optional alarm buzzer / silence switch feature, both the red Chamber OVERTEMP light and red ALARM light will immediately illuminate, the alarm buzzer will sound, and the NORMAL light will extinguish.)

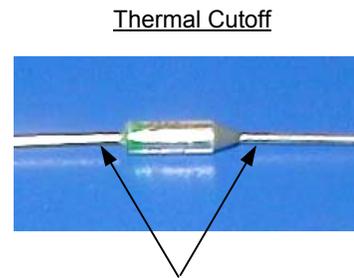
**When the Thermal Cutoff opens, it must be replaced.**

Thermal Cutoff Replacement:



When replacing the Thermal Cutoff, make sure all power is completely disconnected from the chamber. Open the closest main power disconnect and pull the plug (if provided) from the outlet. Lock Out / Tag Out all power to the chamber.

1. Loosen the 2 appropriate screws on the side of the white ceramic mounting block as shown in the photo above. Use a flat blade screwdriver. Pull out Thermal Cutoff with needle nose pliers.
2. Bend the leads of a new Thermal Cutoff as indicated, insert into ceramic block, and tighten the 2 screws.



**You must place needle nose pliers as shown before bending each lead. Otherwise, you may damage the device.**

**Watlow LV Controller High Limit Alarm (1TS) - Optional:**

When a predetermined high temperature limit is reached and the Watlow LV 1TS contacts open, 1CON will deenergize along with the temperature control circuitry. The NORMAL light will extinguish, both the red Chamber OVERTEMP light 3LT and the red ALARM light 4LT will immediately illuminate, and the buzzer (if provided) will sound. 1TS contacts will automatically reset (normal configuration) when the temperature falls below the cut-out limit.

**VersaTenn, or optional TempGard IV Alarm:**

When a preset temperature limit is reached within the VersaTenn or the Watlow 93 TempGard IV, the corresponding alarm contacts open to deenergize Master Contactor 1CON, which removes power from the conditioning control circuitry. The NORMAL light is now extinguished, the red ALARM light illuminates, and the alarm buzzer (if provided) sounds.

The red Chamber OVERTEMP light will illuminate when the alarm condition clears **and** the VersaTenn Alarm Message is cleared as is explained below. You must then reset the chamber. **The TGIV alarm will clear automatically.**



TEMPGARD IV CONTROL PANEL

To clear the flashing VersaTenn Alarm Message:

- ◆ Press the Mode button to arrive at System and press Enter.
- ◆ Press the Mode button to arrive at CLR ALARM and press Enter.

**Note:** The alarm buzzer / silence switch is standard with the TempGard IV feature only. The TGIV configuration is shown in the "TempGard IV Alarm Setpoint Entry" section.

**SYSTEM RESET - - Important!**

After an out of limit condition has been corrected, the conditioning control circuit must be restarted by pressing the RESET button 1PB. A 1.5 second timer 1TC, is included in the reset circuit to provide for automatic start when power is applied to the chamber. This avoids the need to press the reset button each time the power is cycled.

**Alarm Buzzer & Silence Switch (Optional):**

With this option the silence switch disables the alarm buzzer while corrective action is taken. When 1SS is activated, the white Silence light will be illuminated. If the alarm buzzer was disabled and the system was successfully reset with 1PB, the alarm buzzer will now sound to alert the operator to place the silence switch 1SS in it's normal (down) position.

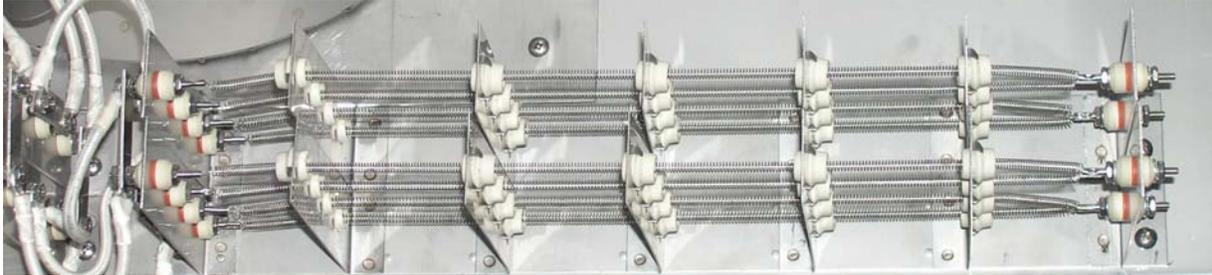
**Shunt Trip Pole - Circuit Breaker 1CB (Optional):**

In addition to the protection afforded when the Master Contactor 1CON is deenergized, the chamber is equipped with a five pole circuit breaker 1CB, which incorporates a shunt trip pole. This circuit breaker also protects the conditioning control circuitry. 1CB is located on the side of the chamber.

Pole #1 serves as a means of tripping open the breaker if an alarm or over temperature condition exists and the **Master Contactor 1CON has failed to open**. A time delay resistor 2R is included to prohibit this breaker from tripping when 1CON opens as intended. If the breaker has tripped, it must be manually reset before the chamber can be started. Poles #2 through #5 function as a normal circuit breaker for over current protection.

## 9.0 HEATING DESCRIPTION

Heating of the chamber is accomplished with the use of open-air low mass nichrome wire heating elements. These elements have low thermal lag and provide rapid response to the controller's demands. The elements are mounted in the plenum conditioning section. This isolates them from the workspace and prevents direct radiation to the product. Electric power ratings for your chamber's heater bank are listed on the Electrical or Power Schematic.



OPEN-AIR NICHROME WIRE HEATER ELEMENTS

### Heater Control:

State of the art power control is used for the electric heating system. Two different heat control methods can be used. A Heat Enable contactor xCON may be employed with larger chambers.

**Control Method #1:** This method is used with chambers that have a 3.0 KW or less heat load and a 240 VAC control circuit. The controller's time proportioned output will trigger triac 1TRC to conduct and energize the electric heaters.

**Control Method #2:** This method is used with chambers that have a heat load greater than 3.0 KW, or with those that have a 120 VAC control circuit. The controller's time proportioned output will energize xSCR. xSCR is a Watlow DIN-A-MITE power controller, which incorporates a back-to-back SCR design with a fixed time base burst firing technique. Burst firing provides short bursts of alternating current to the heaters. This results in very short temperature swings of the heater elements, which greatly extends their life. The load current is very smooth and temperature control is precise. Electrical noise is practically eliminated by the zero-cross switching of the SCRs. DIN-A-MITE power controllers are used in both single phase and three phase-two leg designs.

**Note:** Reference the Electrical, or Power Schematic for the type of heater control employed.

### Boost Heat - Optional:

As an option, your chamber may be equipped with the boost heat feature, which includes extra heaters to provide rapid increases in temperature. As the main controller's heat output energizes the main heater bank, it will also energize a timer. If the timer times out before the controller's heat output turns off, the relay will energize the boost heaters through a set of relay contacts.

## 10.0 SINGLE STAGE REFRIGERATION SYSTEM

### **Basic System Description:**

The main design features of this refrigeration system include capillary tube type refrigerant control and the use of either a hermetic (1 H.P. and smaller), or semi-hermetic (1.5 H.P. and larger) compressor.

The basic single stage system consists of a compressor, an oil separator for units with a compressor 1.5 HP or greater (except for models TH27 & TH65), either an air cooled or water cooled condenser, an Evaporator (Ambient) Coil and a Dehumidify Coil, a bypass solenoid to allow for full refrigerant flow, and a suction line accumulator to guard against liquid refrigerant return to the compressor.

### **Capillary Tube Control Description:**

This system employs capillary tube type refrigerant control. A long length of seamless copper tubing with a small internal diameter is used to feed the Evaporator Coil. The tube acts as an automatic throttle in controlling refrigerant pressure and flow to the Evaporator Coil. With the compressor running, a high pressure is maintained on the inlet to the capillary tube, and a low pressure is maintained in the Evaporator Coil. The pressures will balance when the compressor is turned off. This places a low starting load on the compressor motor when turned back on. A fine filter, or filter-drier is provided at each capillary tube inlet to remove moisture and dirt from the refrigerant.

### **Temperature Control Without Humidity:**

Two levels of cooling are provided when operating without humidity control. One level of cooling utilizes a second capillary tube in series with a primary one. This restricts the flow of refrigerant to the evaporator coil, allowing very fine (moderate) temperature control. The Ambient Coil Feed and Ambient Coil Suction solenoid valves are both energized.

When full cooling is required, the Full Ambient solenoid valve 1SOL is energized, which allows refrigerant flow to bypass the second capillary tube. The Full Suction solenoid valve 10SOL is also energized in this mode.

Refrigerant flow is from the compressor as a hot compressed gas, through the oil separator, and then to the air or water cooled condenser. Here the refrigerant cools and condenses to liquid form. It then flows through various capillary tubes to the evaporator cooling coil in the chamber conditioning section. Warm chamber air circulates through the cooling coil, and heat exchange occurs as the liquid refrigerant boils, vaporizes, and absorbs heat. The vaporized refrigerant returns to the compressor through the suction line accumulator SLA. The cycle is repeated. A Suction Line Cooling solenoid valve 11SOL is included to inject liquid refrigerant into the suction side of the system, in order to maintain a positive cool refrigerant flow when operating at reduced capacities.

### **Temperature Control With Humidity:**

When operating with humidity control, only moderate cooling is used. The Ambient Coil Feed and Ambient Coil Suction solenoid valves are both energized. Refrigerant flow is restricted by the second capillary tube described above.

**Refrigerant Flow During Dehumidification:**

A Dehumidify Coil is provided in the chamber conditioning section, however it is mounted slightly away from the main circulating air stream. The reason is to minimize sensible heat loss. Refrigerant flow is from the compressor as a hot compressed gas, to the air or water cooled condenser where the gas cools and condenses to liquid form. It is directed through solenoid valve 4SOL to the Dehumidify Coil. Water vapor condenses on this coil due to the reaction of warm moist chamber air coming in contact with a cold coil surface. Heat exchange occurs as the refrigerant boils and vaporizes. It then returns to the compressor through the suction line accumulator SLA. The cycle is repeated.

**Thermostat (TS) - (except for Model BTRS):**

A thermostat is mounted on the suction return line near the low stage compressor to monitor the temperature of the return gas flow. When a predetermined temperature is reached (typically set for +70° F), the thermostat will energize and open the Suction Line Cooling bypass solenoid valve 11SOL. This will inject cool liquid refrigerant through a capillary tube to the compressor. This action prevents overheating of the compressor.

## 11.0 CASCADE REFRIGERATION SYSTEM

### **Basic System Description:**

The main design features of this cascade refrigeration system include capillary tube type refrigerant control and the use of hermetic (1 H.P. and smaller), or semi-hermetic (1.5 H.P. and larger) compressors.

This is a multiple refrigeration system consisting of a low stage and a high stage system. These systems are integrated to efficiently provide very low temperature levels. This is achieved by utilizing a cascade condenser in the low stage, where low stage refrigerant is cooled and condensed by high stage refrigerant. The cooled low stage refrigerant now has greater cooling capacity in the chamber cooling coil. Three different evaporator coils are provided in the chamber conditioning plenum. These include a Low Temperature (Main Cooling) Coil, an Ambient Coil for moderate cooling during humidity, and a Dehumidify Coil.

### **Capillary Tube Control Description:**

This system employs capillary tube type refrigerant control. A long length of seamless copper tubing with a small internal diameter is used to feed the evaporator coil. The tube acts as an automatic throttle in controlling refrigerant pressure and flow to the evaporator. With the compressor running, a high pressure is maintained on the inlet to the capillary tube, and a low pressure is maintained in the evaporator. The pressures will balance when the compressor is turned off. This places a low starting load on the compressor motor when turned back on. A fine filter or filter-drier is provided at each capillary tube inlet to remove moisture and dirt from the refrigerant.

### **LOW STAGE DESCRIPTION:**

The low stage system is only used when operating without humidity control. It includes a compressor, an oil separator for units with a compressor 1.5 HP or greater, the cascade condenser, an expansion tank, and the Low Temperature Evaporator Coil located in the chamber conditioning section.

Two levels of cooling are provided. One level of cooling utilizes a second capillary tube in series with a primary one. This restricts the flow of refrigerant to the evaporator coil, allowing very fine (moderate) temperature control. When full cooling is required, the Full Main Coil solenoid 8SOL is energized, which allows refrigerant flow to bypass the second capillary tube.

Refrigerant flow in the low stage is from the compressor as a hot compressed gas, through the oil separator, and then to the cascade condenser. Here, low stage refrigerant is cooled by the high stage refrigerant. It condenses to liquid form, and flows through the various capillary tubes to the evaporator coil in the chamber conditioning section. Warm chamber air circulates through the cooling coil, and heat exchange occurs as the liquid refrigerant boils, vaporizes, and absorbs heat. The vaporized refrigerant returns to the compressor through the suction line accumulator SLA. The cycle is repeated.

**Compressor Cut-In Switch (3PS):**

Switch 3PS turns on the low stage compressor only after a preset high stage suction pressure has been reached following start up. This feature allows for the cascade condenser to cool before the low stage compressor is started.



Pressure Switch

**Thermostat (TS):**

A thermostat is mounted on the suction return line near the low stage compressor to monitor the temperature of the return gas flow. When the temperature rises above +70 degrees F, the thermostat will energize the Artificial Loading solenoid 14SOL, which will inject refrigerant into the suction side of the low stage system. It will first enter the expansion tank, where the added volume permits the charging of additional refrigerant, without increasing the standby or charging pressure beyond workable limits. Refrigerant gas is then sucked out of the expansion tank and metered through a capillary tube to the suction side of the low stage compressor. This action will maintain a positive cool refrigerant flow to the compressor, preventing overheating of the compressor and the discharge gas.

**Load Limit Switch (4PS):**

A high pressure cut-in sensor monitors the pressure inside the low stage compressor. It will activate the Load Limit Switch 4PS when the low stage discharge pressure reaches 280 PSIG. This will energize the Artificial Loading solenoid 14SOL, which will inject refrigerant into the suction side of the low stage system as described above. Switch 4PS prevents the compressor from cycling on and off in response to signals from the high pressure cut-out switch HPCO (HPCO only on 1.5 H.P. units or greater).

**HIGH STAGE DESCRIPTION:**

The high stage system includes a compressor, either an air or water cooled condenser, an Ambient Coil, a Dehumid Coil, and a suction line accumulator to guard against liquid refrigerant return to the compressor.

**Temperature Control Without Humidity:**

The high stage works in tandem with the low stage when controlling temperature without humidity control. Refrigerant flow in the high stage is from the compressor as a hot compressed gas, to the air or water cooled condenser where the gas cools and condenses to liquid form. It then flows to the cascade condenser as modulated by solenoid valve 9SOL (when provided). In the cascade condenser, high stage refrigerant absorbs heat from the circulating low stage refrigerant. As it absorbs heat, the high stage refrigerant boils and vaporizes. It then returns to the compressor through the suction line accumulator SLA. The cycle is repeated.

**Temperature Control With Humidity:**

When operating with humidity control, only moderate cooling is used. The low stage compressor remains off. Refrigerant flow in the high stage is from the compressor as a hot compressed gas, to the air or water cooled condenser where the gas cools and condenses to liquid form. It is directed through solenoid valve 1SOL to the Ambient Evaporator Coil in the chamber conditioning section. Warm chamber circulates through this coil, and heat exchange occurs as the liquid refrigerant boils, vaporizes, and absorbs heat. The vaporized refrigerant returns to the compressor through the suction line accumulator SLA. The cycle is repeated.

**Refrigerant Flow During Dehumidification:**

When operating with dehumidification control, the low stage compressor remains off. A Dehumidify Coil is provided as part of the high stage system. It is located in chamber conditioning section, however, slightly away from the main circulating air stream. The reason is to minimize sensible heat loss. Refrigerant flow is from the compressor as a hot compressed gas, to the air or water cooled condenser where the gas cools and condenses to liquid form. It is directed through solenoid valve 4SOL to the Dehumidify Coil. Water vapor condenses on this coil due to the reaction of warm moist chamber air coming in contact with a cold coil surface. Heat exchange occurs as the refrigerant boils and vaporizes. It then returns to the compressor through the suction line accumulator SLA. The cycle is repeated.

For more detailed information on a cascade system, please reference the section entitled "Servicing Cascade Refrigeration Systems".

## 12.0 REFRIGERATION SYSTEM SAFETY DEVICES

The refrigeration system is provided with several safety devices that stop the compressor(s) from running if conditions exceed preset limits.

### Hi-Lo Pressure Switch 1PS / 2PS:

1PS is a two-pole switch that combines a high pressure cutout switch and a low pressure cutout switch in one package. It is normally configured with Open high – Close low contact action. In a cascade refrigeration system, which employs two compressors, two Hi-Lo Pressure Cutout switches are used. The low stage switch would be labeled 1PS, and the high stage switch would be labeled 2PS.

With a low limit condition the HI-LO Pressure Cutout Switch 1PS (and 2PS for cascade) will continue to automatically reset until sufficient pressure develops. With a high limit condition you must manually reset 1PS (or 2PS). If the compressor continues to trip off have the system checked by a qualified refrigeration system mechanic. **Note:** The HI-LO Pressure Cutout Switch does not apply to compressors rated 1.0 HP.)

The possible causes of a high or low limit cutout are as follows:

- ◆ **High Pressure Cutout (1PS, 2PS)** -- Opens if a preset compressor discharge pressure is exceeded. Probable cause for high stage cutout is insufficient cooling water (water cooled systems) or restricted air flow (air cooled systems). Probable cause for low stage cutout is a malfunction of the high stage system. 1PS/2PS is typically set at 300 PSIG.
- ◆ **Low Pressure Cutout (1PS, 2PS)** -- Opens if the compressor suction pressure falls below a preset value. Probable causes are a loss of refrigerant (either stage) or restricted air flow across the evaporator (low stage). 1PS/2PS is typically set at 6 inches of vacuum.



High / Low Pressure Switch

### Oil Pressure Switch OPS:

- ◆ **Low Oil Pressure Cutout (1 OPS, 2 OPS)** -- (For 3 HP or larger compressors only) Opens if the compressor oil pressure falls below a preset value. Probable causes are low oil level or a "foaming" of the oil due to refrigerant flood back.

**Important Alert!** The low oil safety switch has a built in time delay to give the compressor time to establish oil pressure on startup. Following a trip, repeated attempts to reset without correcting the problem can result in significant running time without adequate lubrication, with a high probability of compressor failure. If the switch opens more than a few times following a reset, have the system inspected by a qualified refrigeration mechanic.



Oil Pressure Switch

**Motor Overload:**

This device opens if the motor windings exceed a preset temperature. Probable causes are insufficient flow across the motor due to a refrigerant loss or a failure of the liquid injection valve provided for suction gas cooling. The motor overload is installed directly in the motor windings and will automatically reset and restart the compressor after the motor has cooled.

NOTE: Compressors smaller than 10 HP have the motor overload installed directly in the motor windings. This overload will automatically reset and restart the compressor after the motor has cooled. Compressors 10HP and larger have the overload installed in the control circuit and the reset button must be pressed for a restart after the motor has cooled.

## 13.0 HUMIDITY SYSTEM



Make sure the water supply is turned on to the Vapor-Flo System before operating.

### IMPORTANT!

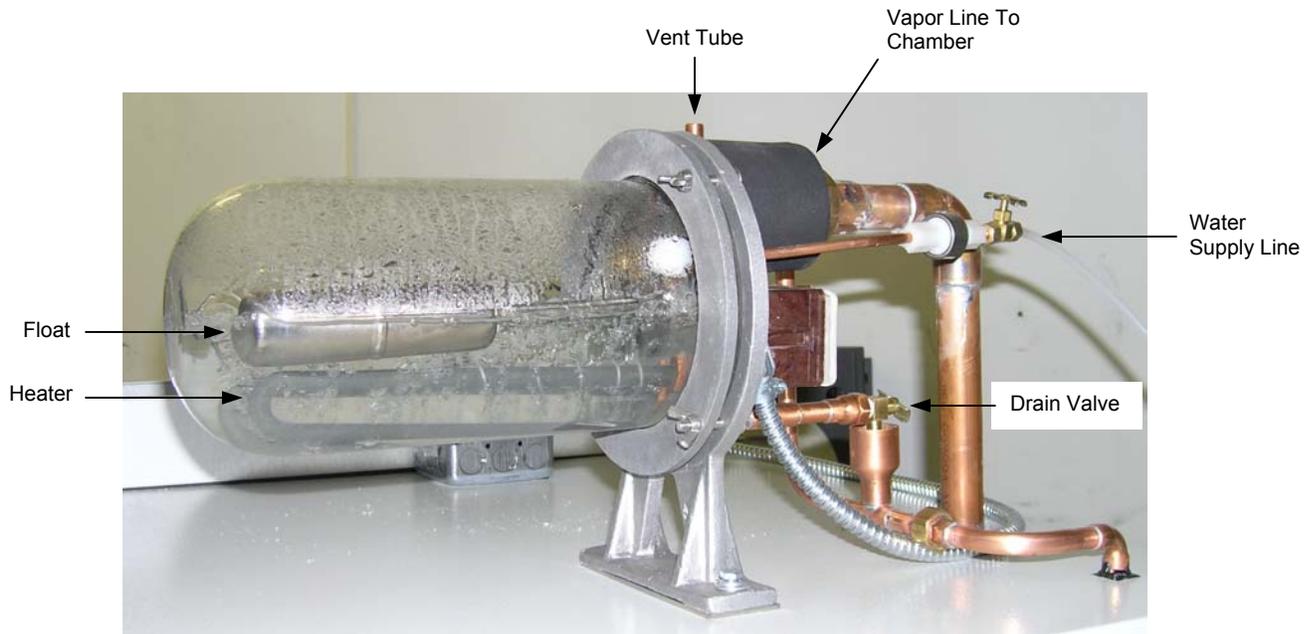
To completely turn off the humidification system, you must create a separate step and enter a value of -0.1 as the humidity setpoint into the VersaTenn III Controller.

### 13.1 System Overview

Vapor-Flo Humidity Generators are used to generate water vapor for the humidification of test chambers. Vapor is produced by heating water with an electric immersion heater in an enclosed glass bell jar assembly. Power to the heater is time proportioned by the controller output. The build-up of vapor pressure in the bell jar causes a natural migration of vapor from the vapor port to the chamber conditioning plenum through copper or stainless steel tubing. Vapor enters the conditioning plenum through a port on the discharge side of the fan blade or blower wheel, and mixes in smoothly with the circulating air stream.

The system is very responsive, but not overpowering as you may have with a steam injection type system. An overpressure condition within the belljar can not occur because the vapor port acts like a vent port. Another important feature of the Vapor-Flo is its ability to increase chamber humidity levels with minimum effect on dry bulb temperature. This is important in small chamber designs with limited cooling capacity. Vapor generating capacities vary from 0.9 lbs./hr. (at 300 W, 115 V), to 9.0 lbs./hr. (at 3,000 W, 220 V), depending on the model used.

**Note:** Your equipment configuration may be slightly different from what is shown in the photo below.



VIEW DURING OPERATION

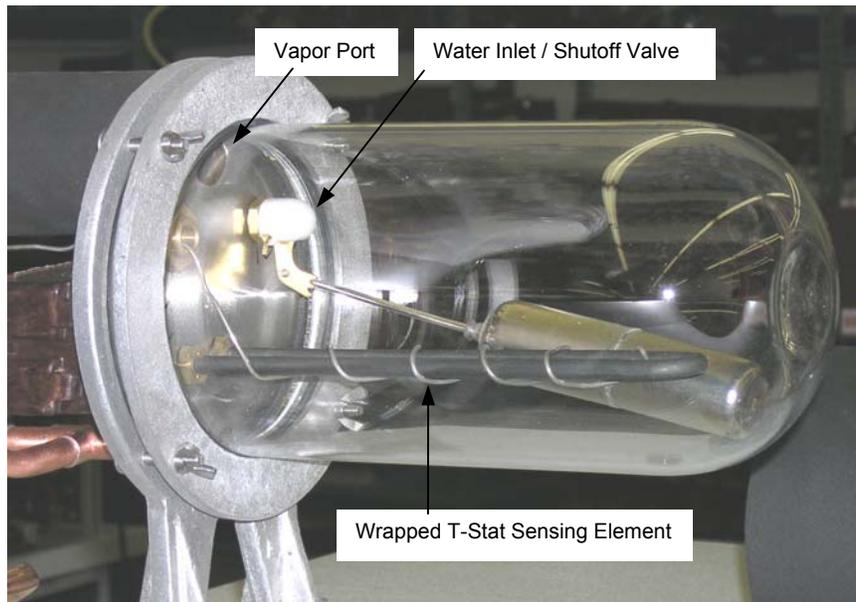
**Water Supply:** The water supply should be 30-40 PSIG maximum. The connection is made to either the Utility Connection Panel (1/4" MPT), or directly to the Water Pressure Regulator WPR (1/4" MPT). The regulator is adjusted at the factory for optimal performance, which is normally between 10 and 20 PSIG at the input gauge.

### 13.2 Design / Operational Features

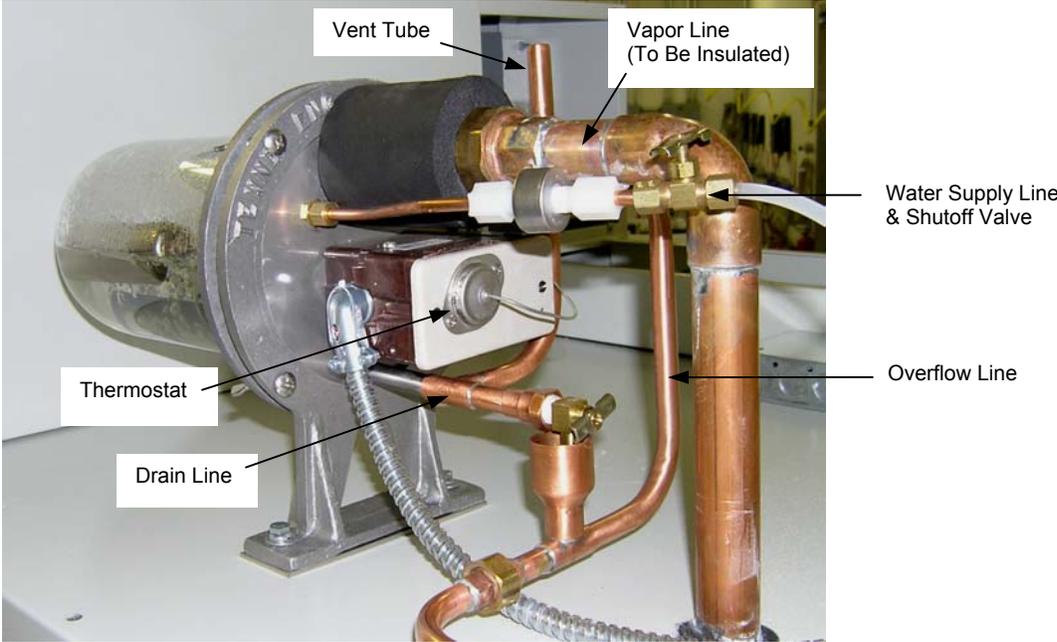
The bell jar is filled with either demineralized or single distilled water through the water inlet port. Water level is accurately controlled by a float that is connected to a shut-off valve at the water inlet port through an extension arm. The water level is kept to a minimum, about one inch above the immersion heater. This permits the water to be rapidly heated or cooled as power is cycled to the heater. There is very little system lag. A thick black insulating sleeve covers the length of the bell jar. The sleeve is removable for inspection and cleaning purposes.

An Overflow Line extends upward from the Drain Line to a point above the normal water operating level, but below the vapor port. This design prevents excess water from draining into the chamber should the float valve fail. A Vent Line extends up from the Overflow Line, which prevents a vapor-lock condition.

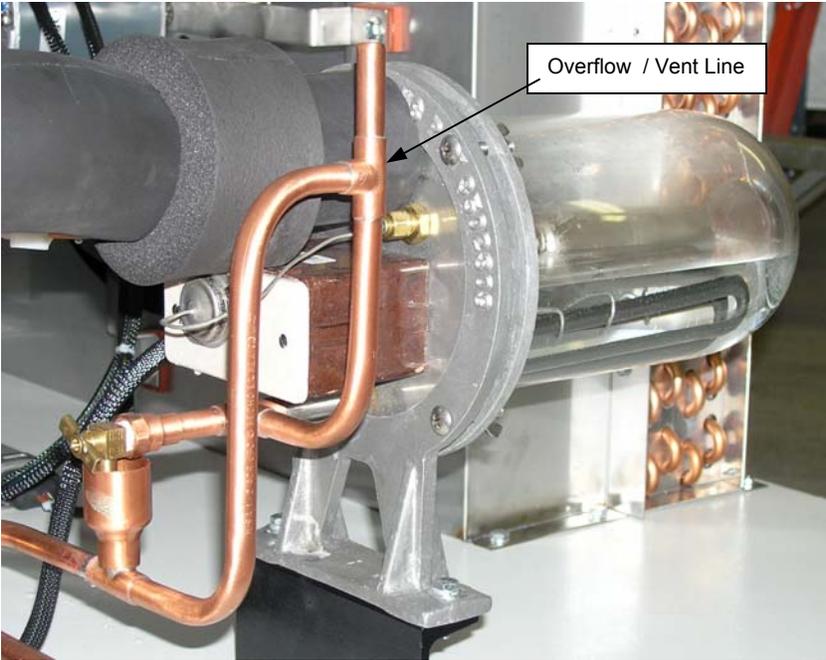
The immersion heater is protected from an overheat condition that could occur from a water supply failure by an automatic reset thermostat TS. The thermostat employs a temperature sensing element that is wrapped around the length of the immersion heater. TS contacts will open to remove power to the heater when the heater temperature rises above 168° C (334° F). The fail-safe design of the thermostat also removes power to the heater should the thermostat itself fail.



VAPOR & WATER PORTS, T-STAT ELEMENT



VAPOR-FLO REAR LEFT VIEW



VAPOR-FLO REAR RIGHT VIEW

Note: Your equipment configuration may be slightly different from what is shown.

### 13.3 Vapor Generating Capacity

Approximate vapor generating capacity of various models is given in the table below. This is a general guide. Please remember that the data is approximate. Variable factors such as line voltage, incoming water temperature, back pressure, and condition of the immersion heater will affect the output.

VAPOR GENERATING CAPACITY		
Heater		Maximum Output
300 Watt	115 Volt	0.9 Lbs. / Hr.
750 Watt	220 Volt	2.2 Lbs. / Hr.
1,000 Watt	220 Volt	3.0 Lbs. / Hr.
1,500 Watt	220 Volt	4.5 Lbs. / Hr.
2,000 Watt	220 Volt	6.0 Lbs. / Hr.
3,000 Watt	220 Volt	9.0 Lbs. / Hr.

### 13.4 Humidity Control

Power to the electric immersion heater is time proportioned by the controller output. This output may be derived directly from a dedicated Humidity Controller, or from Channel 2 of a Temperature / Humidity Controller. (PLCs normally use a 4-20 ma control output signal, which may be converted to time proportioned control.) For chambers with a 3.0 KW or less immersion heater and a 240 VAC control circuit, the controller output will trigger a triac to conduct and supply power to the heater.

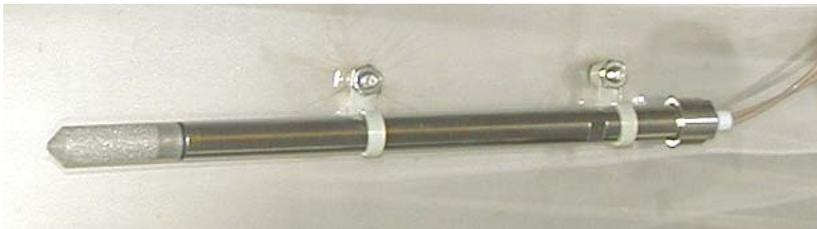
For chambers with an immersion heater greater than 3.0 KW, or a 120 VAC control circuit, the controller output will trigger a Watlow Din-a-mite SCR Power Controller to supply power to the immersion heater. The Din-a-mite incorporates a back-to-back SCR design with a fixed time base burst firing technique. Burst firing provides short bursts of alternating current to the immersion heater. This results in very short temperature swings of the heater element, which greatly extends its life. The load current is very smooth and temperature control is precise. Electrical noise is practically eliminated by the zero-cross switching of the SCRs.

**Important Note!** Always shut down the humidity system when pulling down to a very low chamber temperature.

### 13.5 Humidity Sensor

A dry capacitance type humidity sensor is used to measure chamber relative humidity. The sensor is mounted in the head of a stainless steel probe that is 8.5" long, 0.5" diameter, and is protected by a sintered filter. The probe is mounted in the downstream air of the conditioning section.

In response to humidity levels, the sensor modifies a signal from the humidity transmitter circuit board. This signal is converted by the transmitter to a 0 to 5 Volt DC signal, representing 0 to 100 percent relative humidity, and is sent to the humidity controller / channel. The humidity transmitter is powered by a small 15 Volt AC transformer.

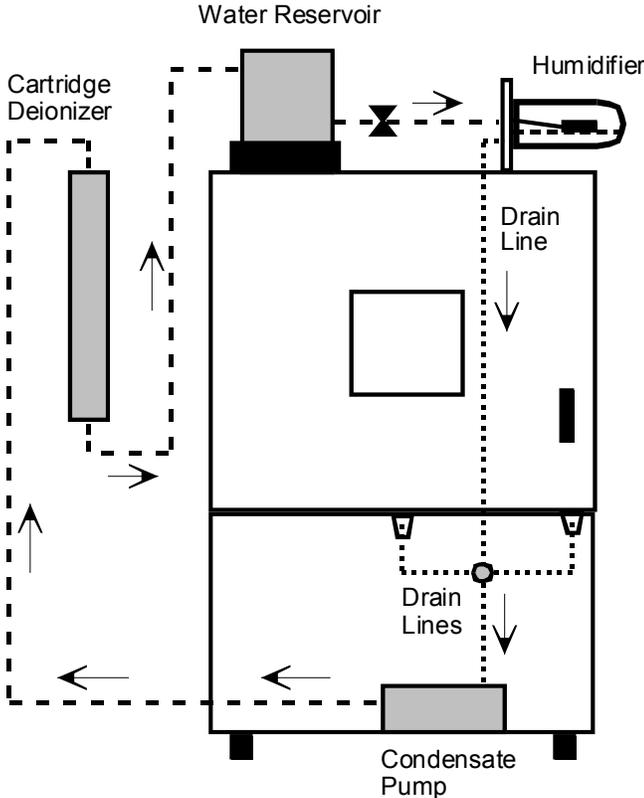


HUMIDITY SENSOR



HUMIDITY TRANSMITTER

13.6 Optional Equipment with Water Flow Diagram



**HUMIDITY SYSTEM**  
**WATER FLOW**  
**DIAGRAM**

NOTE: Optional Cartridge Deionizer, Water Reservoir, and Condensate Pump Are Shown

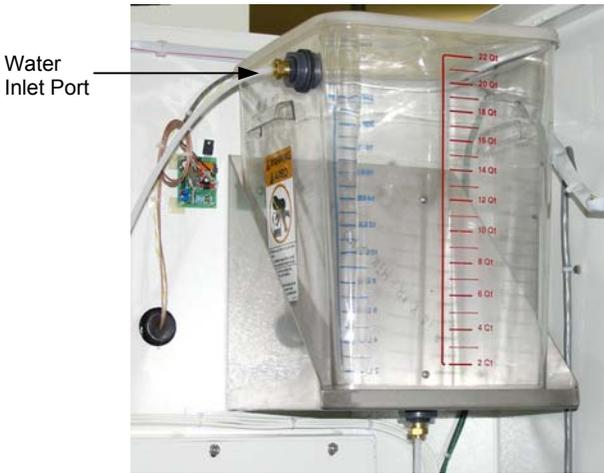
IMPORTANT!  
This drawing is for reference only. Your equipment layout may be different. All components may not be employed.

Water Reservoir:

A five gallon water reservoir may be used in place of a fixed water supply line. The gravity feed reservoir is mounted either on the top or side of the chamber. Water level in the reservoir must be maintained to just below the top hose inlet port (when provided). When operating with high humidity conditions, you may have to fill the reservoir daily. We recommend that the optional condensate pump be used with the reservoir to conserve water. Two different reservoir models are shown below. The inlet port has a 1/4" compression fitting.



5 GALLON WATER RESERVOIR - ROUND



5 GALLON WATER RESERVOIR - SQUARE

Cartridge Ion Exchanger:

Ion exchangers (deionizers) should be installed in the water supply line to the humidity generator when the resistivity of your water supply is less than 50,000 Ohms/cm (20 Microsiemens/cm). Most city water supplies have a resistivity that ranges from 2,000 to 20,000 Ohms/cm (500 to 50 Microsiemens/cm). The use of water with these resistivity levels would result in encrustation of the generator's immersion heater, housing, and float assembly, and cause system failure.

Note: A prefilter may be necessary to remove an excess of suspended particles. Please refer to all water quality warnings in section (5.0).

**Universal Model II Cartridge Ion Exchanger:**

This unit produces an effluent with a resistivity between 50,000 and 100,000 Ohm/cm (20 to 10 Microsiemens/cm), which is equivalent to an ion concentration level obtainable by single distillation. It has a maximum capacity of 1600 grains as CaCO<sub>3</sub>, at a flow of 7.2 gallons per hour. Essentially all ionizable constituents are removed with the exception of silica and free carbon dioxide.

The resin in a newly installed Model Universal II Cartridge consists of white and purple spherical shaped beads. Discoloration of the resin will occur from the top down with the resin changing to an amber color.

**Important!** When discoloration of the cartridge media reaches the line indicated on the cartridge (approx. 2¼" from the bottom), you must replace the cartridge. The amount of time it takes for complete exhaustion of the cartridge depends on your water resistivity and the amount of use. Typically, the cartridge should last between four and eight weeks. **However, check it weekly.** Replacement cartridges can be obtained from the TPS Parts Department.



Cartridge Deionizer

Condensate Pump:

A condensate pump may be used to pump water condensation from the chamber drain port to either a drain located away from the chamber, or back to the optional water reservoir. The pump will automatically turn on and off in response to an integral float switch. A grounded power supply cord is provided with the unit.



Condensate Pump

## 14.0 DRY AIR DEHUMIDIFICATION / DRY AIR PURGE SYSTEM (Optional)

A Dry Air System may be employed as an option for either dehumidification or purging applications. This system incorporates a heatless desiccant dryer for the generation of a controlled flow of dry air into the chamber.

### 14.1 Dry Air Dehumidification System

A Dry Air Dehumidification System may be employed to dehumidify the chamber to dew point levels below those attainable by a refrigeration system, which uses a dehumidification coil.

#### Operation:

The Dry Air Dehumidification System is activated by the VersaTenn internal Logic Event LEV1, which must be turned ON. This is explained in the VersaTenn manual. Event LEV1 will turn on the Dryer Output SSR4.

During operation, the time proportioned output SSR4 will immediately energize the air dryer through a one minute delay-off timer TD. The Dry Air solenoid valve ASOL will also be energized, which permits the injection of dry air into the chamber. The timer will deenergize the air dryer if output SSR4 remains off for more than one minute.

### 14.2 Dry Air Purge System

A Dry Air Purge System may be provided to purge the chamber of moisture or undesirable process vapors.

#### Operation:

The Dry Air Purge System is activated by an Event output from the main controller, which must be turned ON. Reference the Event Label on the side of the chamber or your Test Report for the Event Number assigned to this feature. When activated, the event output will directly energize the dryer and the Dry Air Purge solenoid valve ASOL.

### 14.3 Dry Air Equipment Description

The dryer is a twin tower heatless desiccant type that is self-regenerating. Each desiccant tower (chamber) contains a compression packed molecular sieve. As the compressed air passes through the sieve, moisture is picked up by the desiccant. The dried air is released through an outlet port and injected into the test chamber's conditioning airflow through solenoid valve ASOL. A small portion of the dried air is passed through a sized orifice to the other tower to purge the desiccant of moisture collected during the previous cycle. There are four distinct phases of the heatless dryer where the compressed air is alternately cycled and dried in each of the two desiccant towers. Integral timers and solenoid valves within the dryer control this operation. **Note:** Your equipment configuration may be slightly different from what is shown.



Dry Air Dehumidification / Purge System

## 15.0 GN2 PURGE AIR SYSTEM (Optional)

Note: Refer to the Installation Instructions Section for supply and connection type specifications.



**Warning!** Gaseous nitrogen displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

### General Description:

As an option, your chamber may be equipped with a GN2 Purge System to provide an inert atmosphere inside the chamber. An inert atmosphere minimizes the buildup of moisture and prevents condensation on the product under test. Eliminating oxygen in the chamber air helps prevent corrosion of the product. Gaseous nitrogen is injected into the chamber through a header pipe in the conditioning plenum. It readily mixes in with the circulating process air.

### Operation:

The system is activated by an event output from the main controller (or by a manual switch). To use the system, the Event must be turned ON. Reference the Event Label on the side of the chamber or your Test Report for the Event Number assigned to this feature.

When activated, the event output will energize and open the GNSOL solenoid valve to permit the injection of GN2. A metering valve and flowmeter is supplied as part of the system to establish the design purge flow. The valve should be adjusted until the indicated flow is about 300 cubic feet per hour.

**Note:** Your equipment configuration may be slightly different from what is shown.



GN2 Purge System

## 16.0 LN2 BOOST COOLING SYSTEM (Optional)

Note: Refer to the Installation Instructions Section for supply and connection type specifications.



**Warning!** Gaseous nitrogen resulting from vaporized LN2 displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

### General Description:

The LN2 Boost Cooling System option may be provided to increase the rate or limit of cooling beyond the means of the refrigeration system. Boost cooling is achieved by injecting liquid nitrogen into the chamber through a header pipe in the conditioning section. LN2 has a boiling point of -196 degrees Celsius (-320 deg. F). As the liquid sprays out of the header pipe, it vaporizes and absorbs chamber heat while it mixes with process air.

LN2 systems are provided with a manually set flow adjustment valve, which permits the adjustment of nitrogen flow to avoid incomplete evaporation at varying LN2 supply pressures. As the chamber cools to the extreme cold temperature limit, complete evaporation of liquid nitrogen may not occur if the supply pressure is allowed to drop.



**Important!** Incomplete evaporation will cause droplets of liquid to fall to the floor and may promote puddling. If enough liquid accumulates, it may seep towards the chamber door gasket. Do not allow LN2 to contact the door gasket. Exposure to LN2 will damage the gasket and violate the seal.

### Operation:

The system is activated by an event output from the main controller (or by a manual switch). To use the system, the Event must be turned ON. Reference the Event Label on the side of the chamber or your Test Report for the Event Number assigned to this feature.

Once the system is enabled with the event output, the controller's time proportioned Full Cooling output will energize a solid state On-delay timer. If the Full Cooling output remains on longer than ten seconds, the timer will time out and energize the LN2 Injection solenoid valve SOL. This valve will open to permit the flow of LN2 into the chamber to boost the cooling rate. As soon as the Full Cooling output turns off, the timer output will open to deenergize SOL and shut off the flow of LN2.

**Note:** Your equipment configuration may be slightly different from what is shown.



LN2 Boost Cooling

17.0 CO2 BOOST COOLING SYSTEM (Optional)

Note: Refer to the Installation Instructions Section for supply and connection type specifications.



**Warning!** Carbon Dioxide gas displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the chamber vent port checkvalve!

**General Description:**

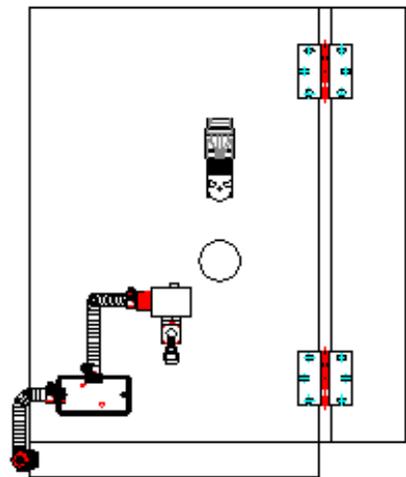
The CO2 Boost Cooling System option may be provided to increase the rate of cooling beyond the means of the refrigeration system. Boost cooling is achieved by injecting liquid carbon dioxide into the chamber through an orifice within an injection port. There is no flow adjustment valve for the supply. CO2 has a boiling point of -78.5 degrees Celsius (-109.3 deg. F). As the liquid sprays out of the orifice, it immediately vaporizes and absorbs chamber heat while it mixes with process air.

**Operation:**

The system is activated by an event output from the main controller (or by a manual switch). To use the system, the Event must be turned ON. Reference the Event Label on the side of the chamber or your Test Report for the Event Number assigned to this feature.

Once the system is enabled with the event output, the controller's time proportioned Full Cooling output will energize a solid state On-delay timer. If the Full Cooling output remains on longer than ten seconds, the timer will time out and energize the CO2 Injection solenoid valve SOL. This valve will open to permit the flow of CO2 into the chamber to boost the cooling rate. As soon as the Full Cooling output turns off, the timer output will open to deenergize SOL and shut off the flow of CO2.

**Note:** Your equipment configuration may be slightly different from what is shown.



CO2 Boost Cooling

18.0 TempGard IV ALARM SETPOINT ENTRY (Optional)

The purpose of this section is to explain how to set your low & high temperature alarm setpoints with the optional TempGard IV. This feature is part of the optional Alarm and Shutdown Circuit described earlier.

**Normal Conditions:** When conditions are within the alarm setpoints, the upper display of the Watlow 93 will indicate the process temperature (normally in degrees Celsius), and the lower display will be blank. Temperature measurements are made with a 100 ohm platinum RTD sensor.

**Alarm Setpoint Entry Procedure:** Disregard parameters not listed. (You will be in the Operation Menu.)

1. Press the Advance Key (key with two curved arrows) to scroll to the Alarm Low (ALO) parameter (lower display). Use the Up / Down arrow keys to set the desired low alarm setpoint (upper display).
2. Press the Advance Key to scroll to the Alarm High (AHI) parameter (lower display). Use the Up / Down arrow keys to set the desired high alarm setpoint (upper display).
3. After setting the low and high limit values, continue scrolling with the Advance Key until the Alarm Low setpoint that you just entered appears in the lower display. It will go blank after a few seconds.

Note: On the old style Watlow 965 Controller, you must press the “M” key to scroll in any menu.

**Alarm Conditions:** When an out of limit condition occurs, the lower display will flash “HI” or “LO”.

**Important:** When the alarm condition has cleared, the **TGIV alarm will automatically reset**. You must then reset the chamber control circuitry by pressing the chamber Reset button.

**Setup Menu:** The Setup Menu is provided for reference only. It has already been configured. **Do not change any values unless circumstances demand it**, such as when you need to change controllers.

To access the Setup Menu, press the Up Arrow and the Down Arrow keys simultaneously. Setup parameters are shown in the lower display. Parameter values appear in the upper display. Press the Advance key to scroll through the menu. Values for the Low Range Limit (rL) and the High Range Limit (rH) are the low and high temperature ratings of your chamber, minus and plus 4 degrees, respectively.

<b>SETUP MENU for WATLOW 93 - TEMPGARD IV</b>			
<b>Parameter</b>	<b>Value</b>	<b>Parameter</b>	<b>Value</b>
LOC	1	Ot2	PrA
In	rtd	HSA	1
dEC	(default)	LA t	Nla
C - F	C	SIL	(default)
rL	Low Limit minus 4 deg.	rtd	Din
rH	High Limit plus 4 deg.	rP	OFF
Ot1	ht	P L	100
HSC	(default)	dSP	Pro

19.0 LinkTenn32 SOFTWARE (Optional)

LinkTenn32 is a Microsoft Visual Basic Software application designed for the Microsoft Windows™ family of PC Operating Systems. LinkTenn32 utilizes a Multi-Document Interface (MDI) familiar to Windows™ software applications so more than one Environmental Chamber Window can be used at a time. LinkTenn32 provides centralized remote monitoring and control of multiple process controllers simultaneously. LinkTenn32 supports the following controllers: **TPS - VersaTenn III, IV, and V, Watlow 942 & F4, and Partlow MIC 1462 Controllers** . The major features provided include:

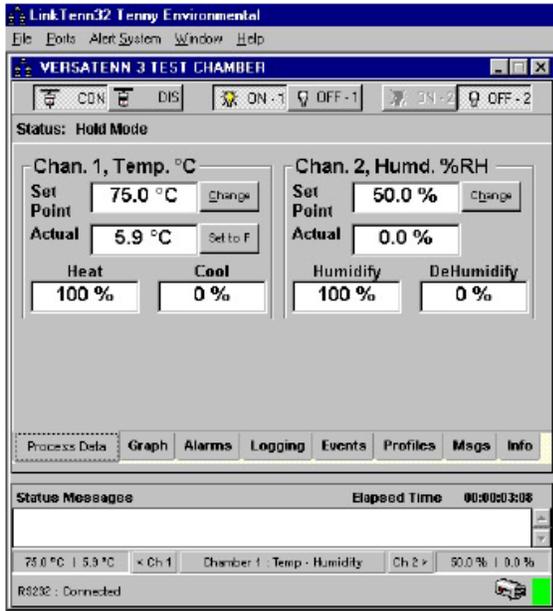
- ◆ Interactive remote control and monitoring.
- ◆ Alarm reporting and notification via Email or Fax.
- ◆ User-friendly profile program editor.
- ◆ Logging, printing and graphing of process data.
- ◆ Exporting of logging history data via an ASCII comma separated values (CSV) file for easy import into Microsoft Excel or any analysis package that accepts comma separated values (CSV) file format.

Go to website: [www.tidaleng.com](http://www.tidaleng.com) for more information on LinkTenn32 Software.

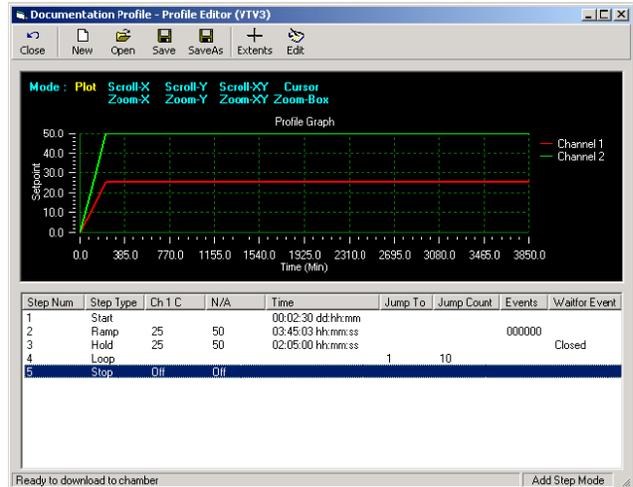
The minimum hardware requirements for LinkTenn32 are as follows:

- ◆ One of these Microsoft Windows™ PC Operating Systems: Windows 95, 98, 98 Special Edition, NT 4.0 Service Pack 6a, 2000 Service Pack 2
- ◆ A Pentium Processor 233 MHz or better
- ◆ 128 MB Ram plus 32 MB for each simultaneous chamber session
- ◆ 40 MB hard disk space
- ◆ One serial port
- ◆ One National Instruments GPIB IEEE Interface (Optional)
- ◆ One 10/100 Ethernet card using TCP/IP (Optional)
- ◆ Printer (Optional)
- ◆ Fax Modem (Optional)

Example Screens:



LinkTenn32 - 2 Channel VersaTenn III Screen



LinkTenn32 Sample Graph Screen - 2 Channel

<b>20.0 CHART RECORDER (Optional)</b>
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As an option, your chamber may be provided with either a circular or strip type chart recorder to record temperature and humidity versus time. This recorder may be either a one pen or a two pen type, which also digitally displays the measured values. Typically, Channel 1 (or Pen 1) records temperature as measured directly with a 100 ohm platinum RTD. Channel 2 (or Pen 2) records humidity utilizing a processed 0-5 volt dc signal from the VersaTenn III Controller. This signal represents 0-100% relative humidity as measured by the humidity sensor.

The recorder configuration is documented in the Test Report, which is located in the Supplemental Instructions Section. Reference the recorder's user manual for a detailed operation of the unit.

## 21.0 SEQUENCE OF OPERATION

**Important!** Make sure the **Installation Instructions have been properly followed before operating the chamber.** All switches should be in the OFF position before starting the sequence below.

**Important!** To completely turn off the humidification system, you must create a separate step and enter a value of - 0.1 (minus 0.1) as the humidity setpoint into the VersaTenn III.

**Important!** You should always shut down the humidity system when pulling down to a very low temperature!

VersaTenn III Controller:

**Channel 1** = Temperature      **Channel 2** = Humidity

**Note:** Temperature values are shown in the upper VersaTenn III display. Relative humidity values are shown in the lower VersaTenn III display, preceded by "RH". To display humidity go to SYSTEM with the MODE key and press ENTER.



VERSATENN III CONTROLLER

Sequence:

1. Turn on the power source to the chamber. Plug in the power supply cord to the chamber, when provided. Close the main chamber circuit breaker 1CB.

The Power ON light, Normal light, and the display of the main controller should be illuminated.

2. Load product and close the chamber door securely.
3. Enter the desired temperature / humidity program, or manual setpoints into the main controller.

Important: Check to see if any features or optional equipment must be turned on with an Event Output from the main controller. If an Event Output were supplied, a **Controller Event Output Label** with the Event Output listing would be installed on the side of the chamber. Event Outputs are described either in one of the various "Option" sections, or in the "Temperature Controller - Conditioning Control Functions" section for unique applications.

**Important Note:** Event No. 3 (Ambient Coil Lock-On) is provided to give better temperature control near ambient temperatures. Its affect will vary with the chamber size, process load, and ambient conditions. We suggest you experiment with your process. A typical condition where you may want to lock Event No. 3 ON is near ambient conditions, e.g., 25 deg. C, and 50% RH. At higher temperature / humidity conditions such as 50 deg. C and 95% RH, turn Event No. 3 OFF. With these conditions, the cold Ambient Coil would sap out the humidity and cause the chamber to cycle.

Reference the corresponding 'Option' section for a description of any optional feature.

Continued.....

4. If your chamber includes the optional Watlow 93 Controller with TempGard IV feature, set this controller's high/low temperature limits at this time. Refer to the "Temperature Alarm and Shutdown Circuit", and the "Watlow 93 - TempGard IV Alarm Setpoint Entry" sections for further details.
5. Press the VersaTenn III System ON button. The conditioner fan(s) will start and chamber conditioning will begin.

**Important Note!** For **complete** programming and/or operating instructions on any of the controllers, electrical / mechanical components, or optional equipment, you must refer to their operating manuals included with your Tenney Environmental manual.

## 22.0 PREVENTATIVE MAINTENANCE



**Only qualified service personnel should ever be permitted to perform any service related procedure on this chamber!**

Frequency of preventive maintenance procedures depends upon how the unit is used and upon other circumstances. Because of this, a hard and fast schedule of maintenance operations is difficult to present. Indeed, an inflexible schedule might be suitable for one user, but completely inadequate for another. Therefore, we have provided periodic figures when to perform maintenance procedures, based on the average chamber use.

We suggest that you maintain a preventive maintenance log. In this log you will record operating notes, pressures, temperatures, and electric readings. The log is valuable because it will help maintenance and service people by documenting long term trends and by showing parameter levels when the chamber is operating properly. A sample Preventative Maintenance Schedule / Log is provided at the end of this section.

Since the refrigeration system is sealed and the instruments are solid state, little maintenance is required on the temperature chamber. However, the following preventive maintenance steps are suggested.

### 22.1 Maintenance Checks / Procedures



**All interlocks and safety features should be tested periodically for proper operation.**

#### **Door Gaskets:**

Inspect the door gaskets for wear (cracks, tears, etc.). Replace gasket if significant wear is evident.

Inspection Period: 30 Days

#### **Door Sealing Quality:**

Check that the door seals evenly around its perimeter to negate thermal loss. Adjust door latch if necessary.

Inspection Period: 30 Days

#### **Air-Cooled Condenser Coil / Fan:**



**Remove All Power From Chamber!**

Inspect the condenser coil for dust or dirt accumulation that would impede the flow of air. A dirty condenser will decrease system efficiency and drive up compressor head pressure, causing it to trip out. If necessary, clean with a brush or vacuum cleaner. Frequency of cleaning depends upon the air quality at the chamber. The condenser fan should also be checked for cleanliness. Make sure the fan spins freely.

Inspection Period: 30 Days

**Water Cooled Refrigeration System – Supply / Drain:**

For water-cooled refrigeration systems, make sure the condenser water supply is according to the specifications listed on the Refrigeration Drawing. If a closed-loop water supply system is not utilized and the water-out port connection is to an open drain, make sure that flow to the open drain is not restricted. Inadequate flow will decrease system efficiency and drive up compressor head pressure, causing it to trip out. The water supply pressure must be 40 PSI Delta.

Inspection Period: 30 Days

**Conditioner Fan (Blower Wheel - when employed):**

Remove All Power From Chamber!

Inspect and clean the conditioner fan in the conditioning plenum. Make sure the fan spins freely and that it is tight on its shaft.

Inspection Period: 6 Months

**Evaporator Cooling Coil:**

Remove All Power From Chamber!

Clean the evaporator cooling coil in the conditioning plenum.

Inspection Period: 6 Months

**General Electrical Connections:**

Remove All Power From Chamber!

Inspect inside the control panel and the machinery compartment for loose electrical connections, frayed wires, loose components, or other potential problems.

Inspection Period: 6 Months

**Electric Heaters:**

Remove All Power From Chamber!

Inspect the electric heaters inside the chamber conditioning plenum and look for sagging elements, broken insulators, or other defects.

Inspection Period: 6 Months

**Electrical Supply Voltage:**

Measure the power supply voltage to your oven and verify that it is within the  $\pm 10\%$  tolerance established for the nameplate rating of your oven.

Inspection Period: 6 Months

**Controller Calibration:**

The main temperature and high limit controllers should be checked for temperature indicating accuracy, and for the proper activation of limit or alarm outputs. Please reference the controller user manual for more information.

Inspection Period: 1 Year

**Optional TempGard IV Alarm Circuit Test:**

If your chamber has the optional TempGard IV, perform the following alarm circuit test.

Test Period: 6 Months

- a) **High Setpoint:** Enter a temperature setpoint into the Watlow 93 that is well below the actual workspace temperature. The Watlow 93 must transfer to an alarm state and disable the protected circuit(s).
- b) **Low Setpoint:** Enter a temperature setpoint into the Watlow 93 that is well above the actual workspace temperature. The Watlow 93 must transfer to an alarm state and disable the protected circuit(s).
- c) Test the alarm buzzer, making sure it is operable.
- d) If customer's contact closure is used to energize an externally powered heat source, make sure that the contact closure removes power when TempGard IV is in the alarm state.

**Notes:**

- ◆ The refrigeration system is permanently sealed and a periodic oil change is NOT required.
- ◆ If a loss of cooling performance is noted, immediately check the condenser for restricted air flow.
- ◆ All motors are permanently lubricated; therefore, greasing or oiling is not required.

## 22.2 Vapor-Flo Humidifier Maintenance & Troubleshooting



Only qualified service personnel should ever be permitted to perform any service related procedure on this chamber!

### Maintenance:

- ◆ Pull back the bell jar insulation and inspect the float, heater and jar. When they appear encrusted with salts and scale, clean the assembly (described below). **Inspection Period: Every 2 weeks**
- ◆ Drain the bell jar assembly completely to remove any concentrated impurities. This is achieved by opening the drain valve at the rear of the Vapo-Flo. **Inspection Period: Every 2 to 4 weeks**

### Cleaning:

**Disconnect all power** from the chamber. Shut off the water supply. Drain the bell jar. Remove the bell jar as described below and gently wipe the inside of the glass with a mild cleaner. Carefully clean any water deposits from the heater assembly. Rinse the glass thoroughly and replace as described below.

### Removing the Bell Jar:

Remove the Armaflex insulating sleeve by sliding it over the end of the bell jar. Spin off the four wing nuts - **top one last**. Slip off the outer ring flange and then remove the glass jar. The immersion heater, thermostat element, float, and float valve are now exposed. Usually, the bell jar flange will adhere to the humidifier bracket. **LOOSEN IT GENTLY**. Prying with a screwdriver may chip or break the glass.

### Reassembling the Bell Jar:

When reassembling, smear a thin coat of silicone grease on the bell jar's ground flange to prevent its sticking to the gasket. Tighten the four wing nuts finger tight only: Do not use pliers.

### Trouble Shooting:

Generator will not deliver vapor: Make sure the water level in the bell jar is approximately 1" above the immersion heater. Measure voltage on immersion heater. Heater terminals can be accessed in the electrical box on the rear of the Vapor-Flo.

Immersion heater cycles on and off: This is usually an indication of low water level. Be sure water supply is adequate. Clean the water inlet valve and washer of contamination. Flush and clean the bell jar. Finally, adjust the float so that water level is about 1" above the immersion heater. You may have to bend the float arm slightly. Careful! Do not damage the float. If the element still cycles, replace the thermostat assembly. Wind the sensing element on the immersion heater approximately as the original was wound.

Water continually runs or dribbles from over-flow: The float valve is leaking. Shut off water. Remove the bell jar insulating sleeve and bell jar. Remove and disassemble the float valve. Shake the float. If it is water-logged, replace it. Clean the valve and reassemble. If the valve still leaks after cleaning, replace the Viton seal.

Humidifier operates but vapor volume is low: Examine the humidity feed line and remove any obstruction. Thoroughly clean the immersion heater. Be sure the water level is approximately 1" above the immersion heater.

Check the optional reservoir water level, which should be just below the top inlet port. The Viton seal may need replaced if the water level is too far above this level.

Measure the immersion heater's resistance. Unusually high resistance would indicate lack of heating power. With the Vapor-Flo unit operating, measure voltage at the immersion heater terminals. The voltage should be no lower than 10% below nominal. (Chief cause of low immersion heater voltage is an inadequate power cord.)

**Immersion Heater Resistance:**

The Heater Resistance Table is provided to identify shorted or open elements and to identify heater size. Resistance values are those at 75 degrees Fahrenheit and may vary by 15% or more without falling out of tolerance. Heater terminals can be accessed in the electrical box on the rear of the Vapor-Flo.

**Important!** The Vapor-Flo Generator should be drained before checking heater resistance. This prevents erroneous readings that may occur from a shorted element.

HEATER RESISTANCE		
Heater		NOMINAL RESISTANCE
300 Watt	115 Volt	43 Ohm
750 Watt	220 Volt	63 Ohm
1,000 Watt	220 Volt	47 Ohm
1,500 Watt	220 Volt	31 Ohm
2,000 Watt	220 Volt	24 Ohm
3,000 Watt	220 Volt	16 Ohm

**Spare Parts:**

Complete spare parts are available from the TPS Service Department. When you order, please specify the model and serial number of the equipment served by your Vapor-Flo Humidity Generator.

**22.3 Preventative Maintenance Schedule / Log**

**Important:** For each of the items to be inspected, refer to item description sections for details on maintenance and service.

<b>PREVENTATIVE MAINTENANCE SCHEDULE / LOG</b>					
<b>ITEM TO BE INSPECTED</b>	<b>Inspection Period</b>	<b>Actual Date Inspected / Serviced</b>			
Door Gaskets	30 Days				
Door Sealing Quality	30 Days				
Condenser Coil / Fan	30 Days				
Water-cooled Condenser Water Supply / Drain	30 Days				
Conditioner Fan	6 Months				
Evaporator Cooling Coil	6 Months				
General Electrical Connections	6 Months				
Electric Heaters	6 Months				
Electrical Supply Voltage	6 Months				
Main Temperature Controller Calibration	1 Year				
TempGard IV Alarm	6 Months				
Vapor-Flo Bell Jar	2 Weeks				
Drain Vapor-Flo Bell Jar	2 to 4 Weeks				

## 23.0 SERVICING CASCADE REFRIGERATION SYSTEMS

### INTRODUCTION

**Note: Only qualified service personnel should ever be permitted to perform any service related procedure on this chamber!**

This information is written to help the refrigeration serviceman trouble-shoot and repair low temperature cascade systems. It is assumed that the reader is familiar with standard refrigeration practice and is interested in the special techniques applicable to cascade systems.

**Important! Please remember that the following description may differ in some respects to the refrigeration system equipped with your particular chamber.**

#### **History:**

Prior to the development of low boiling point refrigerants such as R13 (-114 deg. F) and R503 (-127 deg. F), reaching ultra low temperatures with mechanical refrigeration was difficult. R22 was used down to -80 deg. F, but its system had serious drawbacks. Large and cumbersome, the machinery was subject to the many troubles that afflict a compound system operating at suction pressures as low as 23 inches of vacuum. The modern cascade system can reach as low as -120 deg. F with suction pressures of 0 PSIG or higher. Compact, serviceable, and reliable, today's cascade system is found on thousands of environmental test chambers.

#### **How It Works:**

Two types of popular cascade systems are expansion valve and capillary tube. The system described in this manual is the capillary tube type.

Refrigerants with low boiling points have correspondingly high condensing pressures at normal ambients. They cannot be liquefied by conventional air or water-cooled condensing units. Therefore, low temperature refrigerants are condensed by a separate refrigeration system called "the high stage". The main job of the high stage in most cascade systems is to condense low stage refrigerant.

#### **High Stage:**

The high stage is a conventional single-stage system having a compressor, air or water cooled condenser, expansion valve, and evaporator. The evaporator is the cascade condenser, serving the low stage. Modern systems use R404a in the high stage, making -50 deg. F refrigerant temperature possible at 0 PSIG suction pressure.

#### **Low Stage:**

The low stage is charged with refrigerant in vapor phase only to a specified gauge pressure. When the low-stage is idle with all components stabilized at 70 deg. F, it will contain no liquid refrigerant. When the system is activated, the low stage compressor will pump hot gas through the discharge line to the de-superheater (on 1HP units only). The de-superheater (air or water-cooled) removes some heat from the refrigerant gas, lightening the heat load on the cascade condenser. Leaving the de-superheater, the gas passes through an oil separator and flows to the cascade condenser. Here it is liquefied by heat exchange with high stage refrigerant and flows to the expansion valve.

**Cascade Condenser:**

The cascade condenser is the high stage system's evaporator and low stage system's condenser. It can be either tube-in-tube with the low-stage refrigerant in the outside tube, or tube-in-shell with the low-stage refrigerant in the shell.

**De - Superheater (only on 1HP units):**

The de-superheater consists of coils as part of the high stage condenser with low stage discharge gas running through them. Its purpose is to remove some heat from the low stage discharge gas and thereby lighten the load on the high-stage system.

**Evaporator Coil:**

The evaporator coil is part of the low stage system in which the liquid refrigerant boils or evaporates, absorbing heat as it changes into a vapor. Refrigerant flow to the evaporator is metered by a capillary tube type valve.

**Capillary Tube:**

A capillary tube is a length of tubing of small diameter with the internal diameter held to extremely close tolerances. It is used as a fixed orifice to meter the proper feed of liquid refrigerant.

**Thermostat:**

A thermostat TS is mounted on the suction return line near the low stage compressor to monitor the temperature of the return gas flow. When a predetermined high temperature is reached, the thermostat will energize the Artificial Loading solenoid 14SOL. The setting is normally 70 degrees Fahrenheit.

**Load Limit Switch:**

A high pressure cut-in sensor monitors the pressure inside the low stage compressor and will activate the Load Limit Switch 4PS when the low stage discharge pressure reaches 280 PSIG. This will energize the Artificial Loading solenoid 14SOL. 4PS will be deactivated when the pressure falls to 240 PSIG.

**Artificial Loading:**

In response to the Thermostat switch TS or the Load Limit switch 4PS, the Artificial Loading solenoid will inject liquid refrigerant into the suction side of the low stage. It will first enter the expansion tank where the added volume permits the charging of additional refrigerant without increasing the standby or charging pressure beyond workable limits. Refrigerant gas is then sucked out of the expansion tank and metered through a capillary tube to the suction side of the low stage compressor. This action will maintain a positive cool refrigerant flow to the compressor, preventing overheating of the compressor and the discharge gas.

**Expansion Tank:**

An expansion tank is provided to add volume to the low stage. Added volume permits the charging of additional refrigerant without increasing the standby or charging pressure beyond workable limits. Refrigerant gas is sucked out of the expansion tank during system operation. It is metered through a capillary tube, regulating the rate of gas entry into the system.

**Frosted Lines Are Typical:**

A low-stage characteristic is frosted liquid and suction lines. In a normal cascade system, the liquid line is always below +32 deg. F. The suction line, returning from a -100 deg. F evaporator, assuming 15 degree superheat, will also be far below freezing.

**Leak Testing:**

Loss of refrigerant is the most common cause of refrigeration failure. Because of temperature extremes experienced by its metal parts, the cascade system is particularly susceptible to leaks.

Check the entire system with an electronic leak detector. If the system is empty or at low pressure, boost pressure to 200 PSIG with inert gas (not oxygen) diluted with a percentage of high stage refrigerant. Test again.

A leak check while the system is at low temperature, -80 deg. F or colder, is a necessity. Expansion valve flanges, superheat adjustment caps, and other mechanical joints should be tightened and checked for leaks while at low temperature.

You may use a Halide torch to locate large leaks, but make your final test with the more sensitive electronic leak detector. This is especially important on the low stage. The low stage is gas charged with a relatively small quantity of refrigerant. Because of this, small leaks can quickly incapacitate the system.

**Testing by Static Charge:**

One advantage of a gas charged system is that its tightness can be checked by periodic observation of static or standby pressure. You must read the pressure with all parts of the system at ambient temperature. This is important. The unit must be shut down at least 24 hours before a static pressure reading is taken. To eliminate the possibility of cooling the cascade condenser with the high-stage, pump-down cycle, all power to the unit must be off during the shut down period.

When reading static pressure, consider ambient temperature. Most static charge data are for a 10 deg. F decrease in temperature. Due to a large system's considerable thermal mass, several days may be required for all components to completely stabilize at a particular ambient.

**Evacuation:**

Granted, refrigerants R23 and R404a are expensive, but there are times when charges must be recovered. A contaminated system must be cleaned and evacuated regardless of refrigerant expense.

If there is a possibility that moisture, non-condensibles, or the wrong refrigerant contaminated a system, recover the charge and evacuate.

Select a two-stage pump capable of pumping the system down below 200 microns, and connect an appropriate gauge to ready system pressure. The ordinary compound refrigeration gauge is inadequate, however a thermocouple gauge is ideal. Evacuating a leaky system is an exercise in futility. Therefore, make sure the system is absolutely tight before beginning evacuation.

**Charging a Low Stage:**

1. Do not charge liquid into the low stage.
2. Do not charge the system when it is below room temperature.
3. Do not use charging hoses on very high pressure refrigerants or low stage refrigerants. Cylinder pressure exceeds 500 PSIG.
4. Never charge the unit when it is running.

As you will note from the above, low stage charging procedure differs from the conventional method. Correct charging pressure will be noted on the equipment nameplate or in the instructions. Remember that it is important that you charge by pressure, not by volume of refrigerant.

Use 1/4 inch copper tube between refrigerant cylinder and system. Open the cylinder valve very slowly. Charge into the suction side while closely watching the discharge gauge. When correct pressure is reached, shut off the refrigerant cylinder valve, allowing the system to equalize from 10 to 15 minutes. If the pressure drops, crack open the cylinder valve, and slowly raise the pressure. Always take enough time. Systems with expansion tanks connected by a capillary tube or restrictor valve may need several minutes for gas pressure to equalize.

Keep the refrigerant cylinder upright when charging. Above all, be careful. Do not over-pressurize. Disconnect the cylinder immediately when charging is complete. A leaky cylinder valve could continue to bleed high pressure refrigerant into the system, possibly causing it to rupture. Do not take chances. The saturation pressures of low temperature refrigerants are extremely high.

**24.0 CHAMBER TROUBLESHOOTING GUIDE**

This section does not propose to be a complete and comprehensive troubleshooting guide for the serviceman. However, it attempts to help you locate the causes of possible troubles so that you can make simple repairs or adjustments yourself. The information here should also help you in localizing trouble so that you can better describe the malfunction when contacting the Tenney Service Department. Refer to the appropriate electrical and refrigeration drawings when using these troubleshooting suggestions.

<b>TROUBLESHOOTING GUIDE</b>		
<b>PROBLEM</b>	<b>POSSIBLE CAUSE</b>	<b>CORRECTIVE ACTION</b>
<b>1. Chamber Control is Dead</b>	Plug connection not secure	Secure connection
	Circuit Breaker 1CB open	Close 1CB
	Contactors 1CON failing to close	Press Reset 1PB, Check Heat Limiter & controller alarm outputs
<b>2. Red OVERTEMP Light ON &amp; Chamber Dead, Doesn't Reset</b>	Thermal Cutout has opened	Replace
<b>3. Conditioner Fan Dead</b>	Any cause from Problem #1	Do as stated
	Motor shaft frozen	Verify - rotate by hand carefully!
	Defective motor	Verify - feel for heat & measure current
	Open conductor at term. #32 or #37	Secure termination
	Output 1SM-01 failing to close	Verify - Call Tenney Service
<b>4. Insufficient Heat</b>	Chamber door is ajar	Close securely
	One heater element is burned out	Verify - measure current
	Controller Failure	Carefully check programming
<b>5. No Heat</b>	Heater elements burned out / open	Replace
	Output 1SM-03 failing to close	Verify - Call Tenney Service
	Triac 1TRC failed open	Replace
	Open connection between triac & heater, or heater & neutral	Secure Connection
	Open temperature sensor	Replace
<b>6. Excessive Heat</b>	Short circuited temperature sensor	Replace
	Triac 1TRC failed in conducting state	Replace
	Output 1SM-03 failing to open	Verify - Contact Tenney Service
<b>7. Refrigeration System Dead</b>	Output 1SM-06 failing to close	Verify - Contact Tenney Service
	Triac 2TRC failing to conduct	Replace
	Compressor motor overload protector has tripped	Wait 5 minutes, if overload does not close - replace it
	Press. Switch 1PS, 2PS, 3PS not closing	Verify - Contact Tenney Service
<b>8. Compressor hums - will not start</b>	Low line voltage	Get proper electrical service
	Starting Capacitor is defective	Replace
	Compressor relay defective	Replace
	Internal compressor problem	Measure winding resistance, test for grounds, contact Tenney Service

<b>TROUBLESHOOTING GUIDE - continued</b>		
<b>PROBLEM</b>	<b>POSSIBLE CAUSE</b>	<b>CORRECTIVE ACTION</b>
<b>9. Repeated shorting or blowing of start capacitors</b>	Excessive start time, voltage too low	Correct low line voltage problem
<b>10. Compressor starts, hums, runs slowly, staying on start winding</b>	Low line voltage	Get proper electrical service
	Compressor relay is stuck	Replace
	Shorted winding	Test resistances, test for grounds, contact Tenney Service
<b>11. High stage compressor will not run (Cascade System)</b>	Any cause in Problem #1 or #7	Do as stated
<b>12. Low stage compressor will not run</b>	Any cause in Problem #1 or #7	Do as stated
	Output 1SM-05 not closing	Verify - contact Tenney Service
	Triac 3TRC failing to conduct	Replace
	Pressure switch 2PS not closing	Contact Tenney Service
<b>13. Low stage compressor runs, but little or no cooling</b>	Pressure switch 3PS not closing	Verify that high stage is running
	Low stage is low on refrigerant	Have system leak tested
	Full main solenoid valve 8SOL failing to open	Replace
	Artificial Loading solenoid valve 14SOL stuck open full time	Replace
<b>14. Compressors run but cool inefficiently</b>	Main cooling coil badly frosted	Raise temperature to defrost
	Restricted ventilation, dirty condenser fins	Move unit away from wall, clean condenser fins
	<b>15. Refrigeration works long or continuously</b>	Excessive heat load
Ice on evaporator coil		Defrost
Low refrigerant charge		Have charge checked by refig. mechanic - charges are on ID label
<b>16. Compressor repeatedly trips out overload protector</b>	Pressure switch failure	Have refrigeration mechanic check switches. Contact Tenney Service
<b>17. Noisy Compressors</b>	Compressor loose on mounts	Tighten hold down nuts
<b>18. Noisy compressors, even with secure hold-downs</b>	Broken springs within compressor housing	Replace compressor - Call Tenney Service

NOTE: At site ambient temperature, if the chamber does not pull down substantially in temperature within 15 minutes, something is wrong. Turn the chamber off. Let it normalize and defrost. Then, try it again. If it still does not pull down to low temperature, shut it off and get technical help. A refrigeration system that does not cool properly should not be run for prolonged periods. It may have a leak and be low on refrigerant. Since the compressor depends upon cool returning refrigerant for cooling, it can be overheated when operated in an undercharged system.

Remember that the compressors have internal overloads with automatic reset; these are in addition to circuit breakers. Therefore, when a compressor cuts out, it must be given time to cool so that its internal protector has time to reset.

**SUPPLEMENTAL INSTRUCTIONS**