C-EVO Environmental Test Chamber

OPERATION & MAINTENANCE MANUAL

Model No. C30S2.0-A-S1.1-B

Order No. 128082

Chamber Type: Temperature Only

Controller: Smart 1.0 HMI / PLC

CHAMBER OPTIONS

☐ Dry Air Dehumid / Purge	☐ LN2 Boost Cooling	☐ TempGard IV
☐ GN2 Purge	☐ Chart Recorder	☐

TPS Thermal Product Solutions
Blue M Gruenberg Lindberg/MPH Tenney

2821 Old Route 15
New Columbia, PA 17856
570-538-7200 Fax: 570-538-7380
www.thermalproductsolutions.com

Rev. 08/20/14

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Revisions:

Initial Release: 08/20/14

1.0 COMPANY INFORMATION & ASSISTANCE

Congratulations on purchasing a chamber from one of the fine divisions of TPS™ Thermal Product Solutions. Your chamber has been designed to operate with the reliability you expect for the demands you impose on your product and research testing. We truly hope that every aspect of chamber design and quality will measure up to your strictest standards.

Headquartered in New Columbia, Pennsylvania, Thermal Product Solutions includes the following five divisions that manufacture environmental test chambers, industrial ovens, and furnaces. The Blue M, Gruenberg, Tenney, and Lindberg divisions are located in New Columbia, Pennsylvania, which is in the North-Central part of the state. MPH is located in Riverside, Michigan.

Blue M Gruenberg Lindberg/MPH Tenney

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

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

Model No. _____ **Order No.** _____

TPS Thermal Product Solutions
Blue M Gruenberg Lindberg/MPH Tenney

Thermal Product Solutions
PO Box 150
White Deer, PA 17887
Mailing Address

MADE IN U.S.A.

Thermal Product Solutions
2821 Old Route 15
New Columbia, PA 17856
Physical Address

Phone:	570 - 538 - 7200
Phone:	1 - 800 - 586 - 2473
Fax - Parts Dept.	570 - 538 - 7385
Fax - Service Dept.	570 - 538 - 7391
Fax - Main:	570 - 538 - 7380
Web site:	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

You must follow these and all Warning statements listed <u>throughout</u> the manual!

<u>Definitions of warning statements</u>:

"Caution" – Indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

"Warning" – Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

"Danger" – Indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

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. **Warning!** This chamber is **<u>NOT designed for use with volatile or explosive materials</u>** unless specifically stated in your purchase order. The air conditioning section contains <u>open wire heating elements</u>, 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. Loading of such materials **<u>may result in explosion or fire</u>**.

7. <u>Chamber Classification is NFPA 86 Class B</u>: NFPA 86 Class B chambers / ovens are heat utilization equipment operating at approximately atmospheric pressure wherein there are no flammable volatiles or combustible material being heated in the oven.

8. Do not place the unit near combustible materials or hazardous fumes or vapors.

9. Do not install unit in a corrosive environment. A corrosive environment may lead to poor performance and deterioration of unit.

10. 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.

11. **A main power disconnect switch may not be provided with your unit.** <u>If not provided</u>, we recommend that a **<u>fused</u> 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.

12. Do not position the chamber in a manner that would make it difficult to operate your main power disconnect switch.

13. 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!

14. 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.

15. 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.

16. Do not adjust any mechanical components such as refrigeration valves or any electrical components except as directed in this manual.

17. 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.

18. 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.

19. Do not overload the floor of the chamber workspace or load the unit unevenly.

20. Do not stand on the roof of the chamber. The roof is not designed to withstand additional weight.

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”

“WARNING OF ELECTRIC HAZARD INSIDE”

3.0 PRODUCT OVERVIEW & SPECIFICATIONS

3.1 Application

Tenney is proud to announce our new C-EVO series of environmental cycling reach-in test chambers with the just released **Smart 1.0™ HMI / PLC Color Touchscreen Controller**. These include both **Temperature-only** chambers and **Temperature / Humidity** chambers.

The evolution of the **Classic Tenney series** has produced the most advanced and diversified test chambers in the industry. Since 1932, Tenney engineering continues to incorporate the latest technologies in heating, cooling, and humidification to meet the most stringent demands in a cycling environmental test chamber. This is achieved with performance and pride in the following models.

- **Temperature Only: Models C10S, C10C, C20S, C20C, C30S, C30C**
- **Temperature / Humidity: Models C10RS, C10RC, C20RS, C20RC, C30RS, C30RC**

  (The letter “R” indicates humidity conditioning is employed.)

C-EVO test chambers feature a high volume horizontal-down type air circulation system with an electric heating system, a mechanical refrigeration system, and a vapor injection type humidification system to condition the product. A diversity of optional equipment can be employed to enhance conditioning.

The Smart 1.0 HMI / PLC Control System is another new exciting HMI controller introduced by Tenney. This controller is designed after the long proven line of VersaTenn Environmental Chamber Controllers, which include the VersaTenn I, II, and III Control Systems with LED displays, the VersaTenn IV and VersaTenn V Touch Interface (HMI) Control Systems, and the most recent VersaTouch HMI Controller.

The Smart 1.0™ Control System applies Tenney’s proven environmental control technology with the ultimate in simplicity and versatility. This one / two channel controller employs a 7” color touchscreen terminal that incorporates powerful graphics capabilities using the Eaton Corporation Model XV100 PLC / HMI.

Programs are in the form of **CSV** files. These can be created on the controller via a program editor wizard, moved from another unit or library with a USB stick, or by a network connection. Data communications is provided in Ethernet / IP or Modbus / TCP. Remote Client and VNC application software can be used with Ethernet to provide a real time interactive display on a PC.

The control system is outfitted with Eaton’s SmartWire-DT™ technology. SmartWire connects devices to the PLC DIN-rail mounted modules. SmartWire-DT™ is a control panel wiring replacement system. It uses an eight conductor flat cable to connect common control components together instead of using traditional point to point wiring connections. This flat cable carries the control power for devices and also handles the high level communication and control of the devices. It is a neat, fast, efficient, and safe panel wiring system.

3.2 Model Number Designations (“C” simply stands for the C-EVO series in the sample below.)

Model C**10**RC2.0 - A - S1 - B

- **“xx”** 2-digit number indicates workspace capacity in cubic feet

Model C10**R**C2.0 - A - S1 - B

- **“R”** indicates a humidification system is employed

Model C10R**C2.0** - A - S1 - B

- **“S”** indicates a single stage type refrigeration system is employed using one **2.0 HP** compressor
- **“C”** indicates a cascade type refrigeration system is employed using two **2.0 HP** compressors

Model C10RC2.0 - **A** - S1 - B

- **“A”** indicates an air-cooled refrigeration condenser is employed
- **“W”** indicates a water-cooled refrigeration condenser is employed

Model C10RC2.0 - A - **S1** - B

- **“S1”** indicates the use of the Smart 1.0™ HMI / PLC Controller

Model C10RC2.0 - A - S1 - **B**

- **“B”** indicates the power supply voltage rating: 208 V, 1 PH, 60 HZ
- **“C”** indicates the power supply voltage rating: 230 / 240 V, 1 PH, 60 HZ

3.3 Conditioning Specifications (Custom Chambers - see below)

Temperature Range: With Single Stage Refrigeration System ("S" designation = One Compressor)

- 35° C to + 200° C (- 31° F to + 392° F), +/- 0.3° C after stabilization, measured at air inlet to workspace

Temperature Range: With Cascade Refrigeration System ("C" designation = Two Compressors)

- 73° C to + 200° C (- 99.4° F to + 392° F), +/- 0.3° C after stabilization, measured at air inlet to workspace

Humidity Range: (When Included) 10% to 95% RH, +/- 2% after stabilization, in the dry bulb range from + 20° C to + 85° C (+ 68° F to + 185° F), limited by a dewpoint of + 3° C, measured at air inlet to workspace

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For Special MODEL xxxxx, O/N xxxxxx, the following custom specifications apply:

Note: The suffix **"- SPL**" added to the model number indicates a specially designed unit.

Temperature Range: - xx° C to + xxx° C (- xxx° F to + xxx° F), +/- x.x° C after stabilization, measured at air inlet to workspace

Humidity Range: xx% to xx% RH, +/- x% after stabilization, in the dry bulb range from + xx° to + xx° C, limited by a dewpoint of + x° C, measured at air inlet to workspace

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3.4 General Specifications

Workspace Dimensions:

Model C10xx: 24" x 26" x 28" = 10 Cubic Feet Capacity

Model C20xx: 30" x 32" x 36" = 20 Cubic Feet Capacity

Model C30xx: 36" x 40" x 36" = 30 Cubic Feet Capacity

Chamber Heating Capacity: 3 KW – All Models, Optional Boost Heat – 3KW

Humidifier Heater Capacity: 1.5 KW – All Models

3.5 Conditioning Functions

- Heating of the chamber is achieved by recirculating chamber air through open-air nichrome wire heater elements in the chamber conditioning plenum. The elements are supported by ceramic insulators.
- Cooling of the chamber is achieved by recirculating chamber air through a refrigerated finned cooling coil in the chamber conditioning plenum. With a cascade system, separate coils are used for cooling during temperature-only and temperature with humidity conditioning.
- **Humidity Chambers:** Humidification of chamber air is achieved by water vapor injection, which is generated by a Vapor-Flo IV Humidity Generator. Vapor pressure alone is used for injection.
- **Humidity Chambers:** Dehumidification of chamber air is achieved by moisture migration to a refrigerated dehumidify coil placed at the very bottom of the conditioning plenum. Warm moist air migrates to the cold coil and condenses on the finned surfaces.
- Air circulation is generated by a centrifugal type blower wheel that is directly driven by an externally mounted motor.

3.6 Equipment and Control Features

Smart 1.0™ Temperature / Humidity Controller:

Temperature and humidity conditions are controlled by the Smart 1.0™ Controller. This one / two channel controller employs a 7" color touchscreen terminal that incorporates powerful graphics capabilities using Eaton Corporation Model XV100 PLC / HMI. The control system is outfitted with Eaton's SmartWire-DT™ technology. SmartWire connects devices to the PLC DIN-rail mounted modules.

Programs are in the form of **CSV** files. These can be created on the controller via a program editor wizard, moved from another unit or library with a USB stick, or by a network connection. Data communications is provided in Ethernet or Modbus RTU RS-485. RS-232 and IEEE are optional. Remote Client and VNC application software can be used with Ethernet to provide a real time interactive display on a PC.

Channel One controls temperature using an RTD sensor for temperature measurement. Channel Two controls humidity using a dry capacitance type humidity sensor for humidity measurement. Logic circuits automatically select cooling and heating modes as required, with total programming capabilities of temperature versus time.

Chamber & Product Over / Under Temperature Protection:

The following features are employed for over / under temperature protection. These devices are configured in a comprehensive alarm and shutdown circuit.

- Heat Limiter – Chamber Overtemperature Protection (Standard)
- Smart 1.0 Controller – Chamber Low / High Limit Alarm Output for product / chamber protection (Standard), Deviation Alarms are also included.
- TempGard IV – Watlow EZ Zone Limit Controller - Chamber or Product Over / Under Temp. Protection (Optional)

Refrigeration System:

Refrigeration systems employ thermostatic expansion valve (TEV) type refrigerant control with semi-hermetic reciprocating compressors. Compressors are rated 2.0 horsepower for all chamber models in both single stage and cascade designs. These systems may employ either an air-cooled or a water-cooled condenser where hot compressed refrigerant gas from the compressor is changed to a liquid state to achieve specific heat transfer functions.

Cooling coils placed in the conditioning plenum consist of copper tubing with extended aluminum heat transfer fins. A **main evaporator cooling coil** is used during temperature-only conditioning. For chambers with a single stage refrigeration system, **the main cooling coil is also used as the ambient cooling coil** during temperature / humidity conditioning. With cascade systems, a separate **ambient cooling coil** is used during temperature / humidity conditioning.

- Single Stage Refrigeration System: This type employs one compressor and is normally used for chambers that do not require extreme low temperatures to be attained.

- Cascade Refrigeration System: This type employs two compressors in a low stage / high stage design. A cascade condenser is utilized where low stage refrigerant is cooled and condensed by high stage refrigerant. With the highly efficient heat transfer functions inherent in this design, extreme low chamber temperatures can be attained.

Dehumidification – Humidity Chambers: The **refrigeration system is also used for dehumidification** of chamber air by using a dehumidify coil placed in the base of the plenum away from the main circulating air stream. The coil consists of copper tubing with extended aluminum heat transfer fins. Warm moist air migrates to the cold coil and condenses on the finned surfaces.

Vapor-Flo IV Humidification System – Humidity Chambers:

Humidification of chamber air is achieved with a Tenney Vapor-Flo IV Humidity Generator. Water is heated and vaporized by an electric immersion heater in a compact stainless steel water tank. The build-up of water vapor pressure in the tank causes a natural migration of vapor through a copper tube to the chamber conditioning plenum. Humidified air mixes in smoothly with the circulating airstream. Humidification capacity ranges from 10% to 95% RH, +/- 3% after stabilization.

Optional Extended Dehumidification System – Humidity Chambers:

For extended dehumidification levels below that which a refrigerated dehumid coil can provide, a dry air injection system is available. Humidity levels as low as 5% RH can be attained at temperatures down to + 20° C.

This system uses a twin tower heatless dryer that operates with a compressed air supply. The compressed air is first dried in a pair of desiccant chambers. Dry air is then injected into the chamber conditioning plenum where it mixes with circulating chamber air. Existing moist chamber air is purged out of the chamber through a vent port.

Additional Options:

Your Tenney chamber may include many other options such as:

- Boost Heating
- Boost Cooling with LN2 or CO2
- Purge Air System using Compressed Air or GN2
- Chart Recorder

As you can see, Tenney 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.

3.7 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 maximum (41° F to 86° F maximum).
- 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

Drawings – The following drawings are provided:

Temp. Only – Single Stage Refrig. Chambers C10S, C20S, C30S

Power Schematic	1C807S1
Instrumentation & Control Schematic (Sheets 1 & 2)	1C803S1
Refrigeration Schematic	R - CEVO - XX

Temp. Only – Cascade Refrig. Chambers C10C, C20C, C30C

Power Schematic	1C806S1
Instrumentation & Control Schematic (Sheets 1 & 2)	1C802S1
Refrigeration Schematic	R - CEVO - XX

Temp. / Humidity – Single Stage Refrig. Chambers C10RS, C20RS, C30RS

Power Schematic	1C805S1
Instrumentation & Control Schematic (Sheets 1 & 2)	1C801S1
Refrigeration Schematic	R - CEVO - XX

Temp. / Humidity – Cascade Refrig. Chambers C10RC, C20RC, C30RC

Power Schematic	1C804S1
Instrumentation & Control Schematic (Sheets 1 & 2)	1C800S1
Refrigeration Schematic	R - CEVO - XX

General Arrangement Drawings:

General Arrangement – Model C10	D001
General Arrangement – Model C20	D001
General Arrangement – Model C30	D001

<u>Vendor Manuals</u> – The following vendor manuals and information are provided:

TPS Smart 1.0™ HMI / PLC Controller Manual
Humidity Sensor – Vaisala HMM100 (Humidity Chambers)
Bitzer Compressor Operating Instructions #KB-100-6
Test Report

<u>Optional Equipment</u> – Vendor manuals will be supplied when the option is included.

Heatless Dryer (with dry air dehumidification, or dry air purge option)
Chart Recorder

Note: Various other vendor product information sheets may also be provided, which contain important operation and maintenance instructions. Their inclusion is subject to vendor availability.

Note: Due to page volume or vendor availability, some manuals may only be included as an electronic copy on a CD.

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.

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.

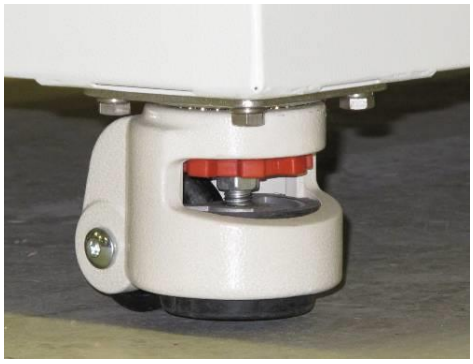
Important! Do to the vibration incurred during shipping and handling, it is possible that mechanical connections could become loose. Check all connections to make sure they are secure. For chambers with a water-cooled refrigeration system, check all water fittings to make sure they are tight.

Very Important! Upon completion of the initial installation of the chamber and upon completion of any maintenance procedure, make sure that all access panels that have been removed are reinstalled securely before operating the unit.

5.3 Equipment Access and Features

FRONT LEFT – C20RC

FRONT RIGHT – C20RC



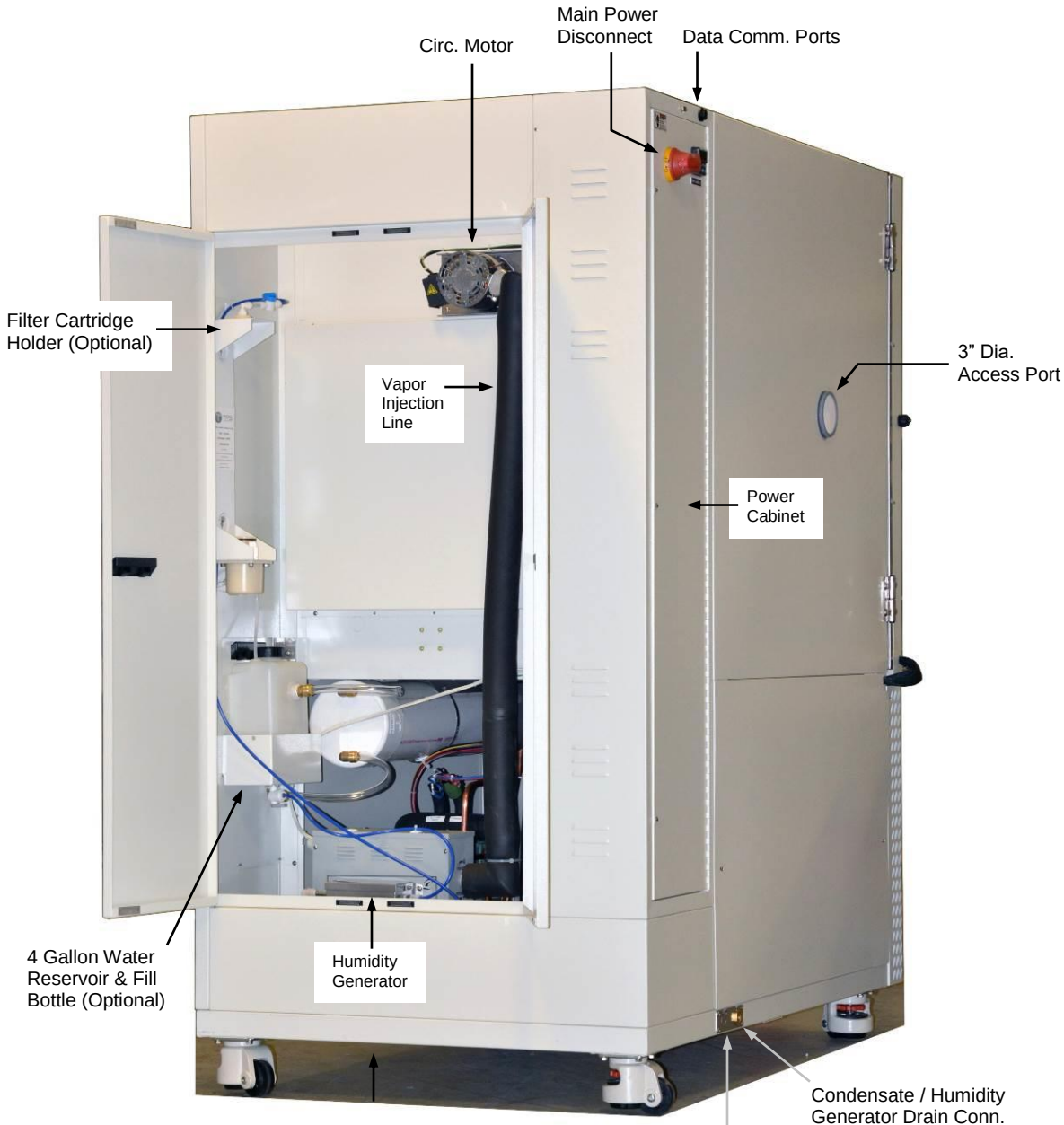
ADJUSTABLE CASTERS

Caster Adjustment

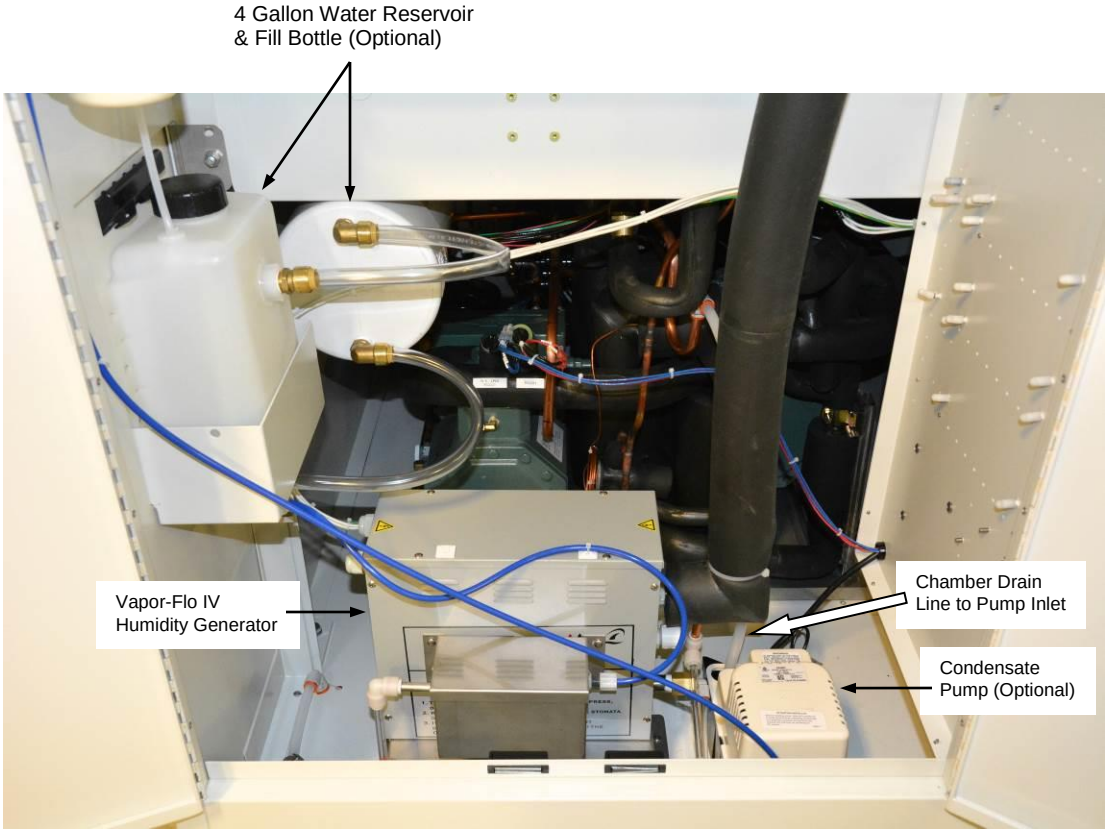
Total Adjustment Height is approximately 3/4 inch.

- To raise chamber, turn adjustment wheel **Counterclockwise** (looking downward).

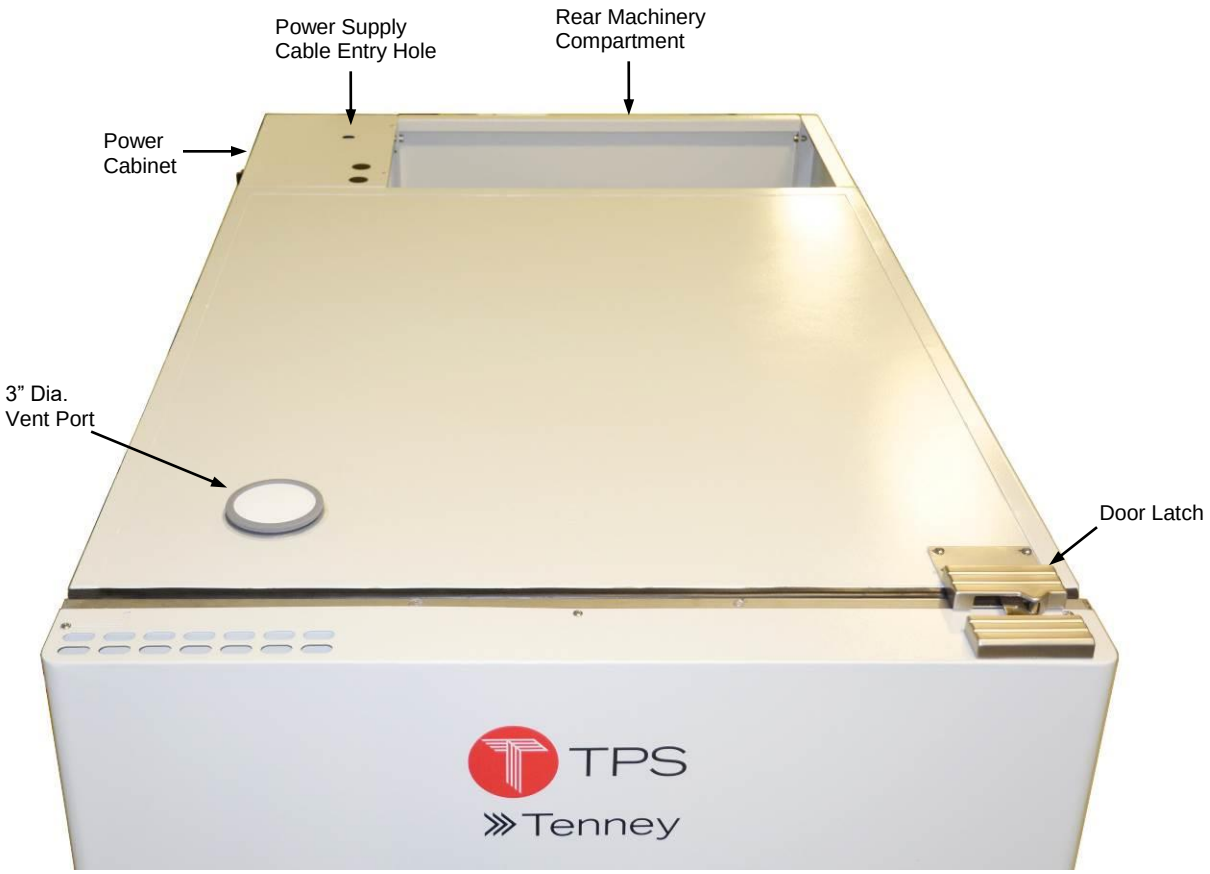
- To lower chamber, turn adjustment wheel **Clockwise** (looking downward).



REAR RIGHT – C20RC



HUMIDITY SYSTEM – REAR OF CHAMBER – C20RC



TOP FRONT – MODEL C20RC

Chamber Overpressure Relief:

When any of the options listed below are employed, a **Strato-flo check valve** will be installed on top of the chamber. The valve spring is removed so that very little pressure is required to open the valve. This insures that the chamber does not become pressurized with the injection of any gas or vapor.

- Boost Cooling (with CO2 or LN2)
- Dry Air Purge
- GN2 Purge
- Dry Air Dehumidification

CHECK VALVE

5.4 Chamber / Humidity Generator Drain Connection

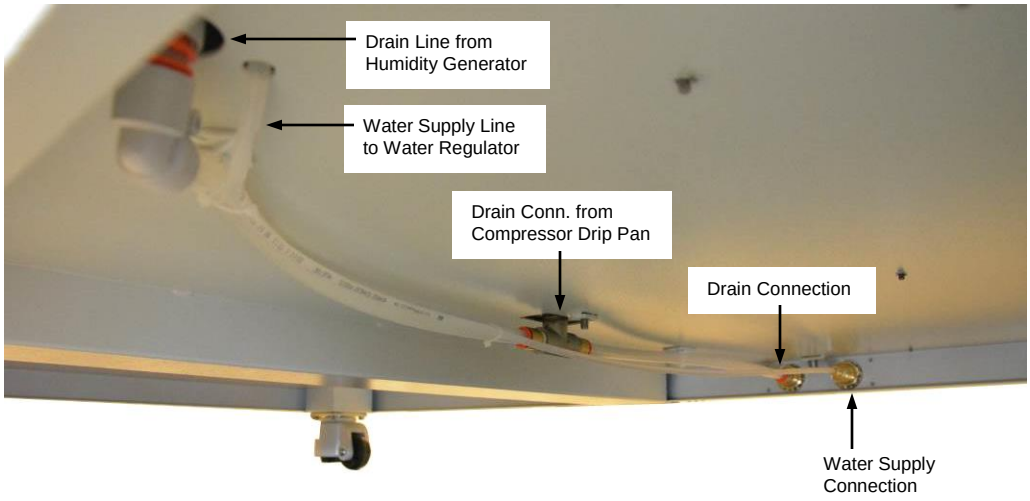
A single drain connection is provided on the left side of the chamber to drain condensate from multiple sources, **along with water from the humidity generator drain line (humidity chambers)**. The connection is Type 3/8" FPT. Your drain line should run to an open drain. Make sure the connection is secure.

The following drain lines are tied into this connection.

- Condensate from chamber floor and conditioning plenum
- Condensate from chamber door drip pan
- Condensate from refrigeration machinery base: This stainless steel base collects condensate from the compressor(s) and the suction line accumulator.
- **Humidity Generator drain line**: **<u>This line is fed to the refrigeration machinery base</u>**.

Note: When the optional 4 gallon humidity water reservoir is employed, the chamber drain line is fed to the water reservoir recirculation system. This would include condensate from the chamber floor, the chamber conditioning plenum, and the chamber door drip pan.

<u>HUMIDITY WATER SUPPLY AND CHAMBER DRAIN CONNECTIONS</u>



<u>DRAIN PIPING UNDERNEATH CHAMBER</u>

5.5 Water Supply Connection (For Water-cooled Refrigeration Condensers)

For chambers with a water-cooled refrigeration condenser, the following water supply sources may be used.

- City Water
- Cooling Tower Water
- Chilled Water

Each water supply system must be capable of providing a differential of 40 PSIG minimum between the inlet and outlet connections. Compressors are rated 2.0 horsepower for all chamber models in both single stage and cascade designs. Follow the chart below for all specifications. **Reference your Refrigeration Schematic for complete details.**

Important! When referring to the chart below, make sure you follow the requirements listed for your type of refrigeration system, i.e., single stage / cascade.

The supply connections are provided at the side of the chamber. Make sure the connections are secure.

2.0 HP REFRIGERATION WATER COOLING REQUIREMENTS					
Water Service	**Nominal Temp. ° F**	**Single Stage System Flow - GPM Max.**	**Cascade System Flow - GPM Max.**	**ΔP (PSID) Minimum**	**Connection Size**
City Water	70°	2.0	1.5	40	3/8" F.P.T.
Tower Water	85°	4.0	3.0		
Chilled Water	40°	1.5	1.0		

Note: This is a reference photo shown with a Vapor-Flo III Humidity Generator Installed

WATER-COOLED CONDENSER SUPPLY CONNECTIONS – C30RC

5.6 Humidity System Vapor-Flo Water Supply Quality

Water Quality Specifications

The composition and quality of your water supply is critical to the operation of environmental test chambers. 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 / conductivity, suspended particles, inorganic content, and organic content before using the humidifier by a Certified Test Lab. Water samples should be taken at **a location immediately upstream** of your proposed chamber location.

The water supply to the generator **must** be demineralized or single distilled, and have a resistance measurement between 50,000 and 100,000 Ohms/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 stainless steel, 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. (Note: A 5 micron filter will require more frequent changes.) 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 (activated carbon filter) 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.

5.7 Humidity Chambers - System Water Supply Methods, Devices, & Connection Types

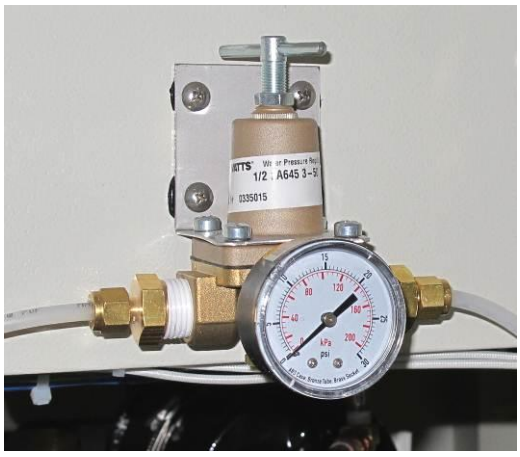
The Vapor-Flo IV Humidity Generator employs a 1.5 KW immersion heater and supplies approximately 4.65 lbs. of water vapor per hour with the required 1.0 GPH water supply. Several methods can be used to supply and treat your water supply to feed the humidity generator. Please read through the following methods carefully.

5.7.1 Standard Systems without Any Options

The water supply connection for the humidity generator is located on the left side of the chamber and is Type 3/8" FPT. Your water supply quality must match the requirements listed in Section 5.6. The supply pressure should be 20 - 50 PSIG, at 1.0 GPH. Make sure the connection is secure.

The supply line runs to a Water Pressure Regulator **WPR** that is installed at the rear middle of the chamber and then to a small stainless steel water level control reservoir mounted on the side of the generator housing. **WPR** is pre-adjusted in the range 10 - 20 PSIG and **should not be changed**.

HUMIDITY WATER SUPPLY AND CHAMBER DRAIN CONNECTIONS



WATER PRESSURE REGULATOR

5.7.2 Ion Exchange Cartridge - Optional

Note: Please also reference Section 5.7.1 as the connection location and type are identical.

When an Ion Exchange Cartridge is used, the water supply connection for the humidity system is located on the left side of the chamber and is Type 3/8" FPT. The supply pressure should be 20 - 50 PSIG at 1.0 GPH. Make sure the connection is secure.

The supply line runs to a Water Pressure Regulator **WPR** that is installed at the rear middle of the chamber and then to the Ion Exchange Cartridge. **WPR** is pre-adjusted in the range 10 - 20 PSIG and **should not be changed**.

Warning! Water supply pressure to the Ion Exchange Cartridge must not exceed **30 PSIG**! Please leave the adjustment of WPR as it is from the factory.

When Ion Exchangers Should Be Used:

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.

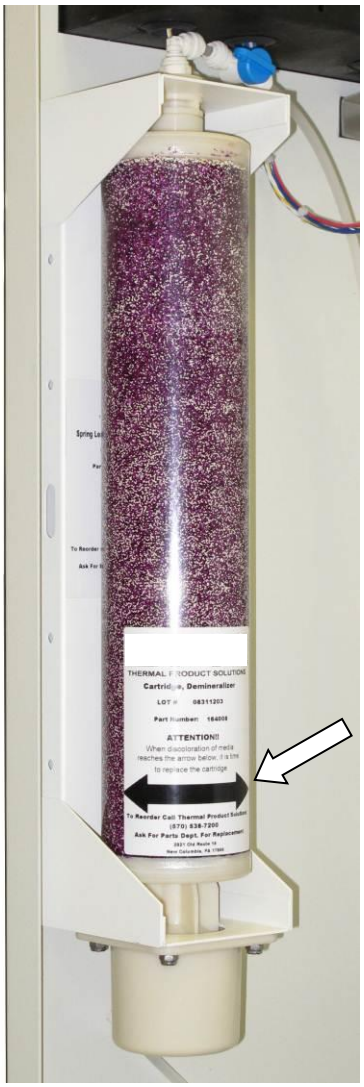
Note: A **pre-filter** may be necessary to remove an excess of suspended particles, which an Ion Exchanger is not designed to do. Please refer to the water supply quality specifications in the previous section.

Aries Model VP - 17 - 4040 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 1,590 grains as $CaCO_3$, 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 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.

Time for Replacement - Important!

When discoloration of the cartridge media reaches the **cartridge replacement line** indicated on the cartridge label (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.



ION EXCHANGER

5.7.3 Activated Carbon Filter - Optional

Note: Please also reference Section 5.7.1 as the connection location and type are identical.

When an Activated Carbon Filter Cartridge is used, the water supply connection for the humidity system is located on the left side of the chamber and is Type 3/8" FPT. The supply pressure should be 20 - 50 PSIG at 1.0 GPH. Make sure the connection is secure.

The supply line runs to a Water Pressure Regulator **WPR** that is installed at the rear middle of the chamber and then to the Activated Carbon Cartridge. **WPR** is pre-adjusted in the range 10 - 20 PSIG and **should not be changed**.

Warning! Water supply pressure to the Activated Carbon Cartridge must not exceed **30 PSIG**! Please leave the adjustment of WPR as it is from the factory.

When Activate Carbon Filters Should Be Used:

If your water supply test shows that appreciable amounts of organics, free chlorine and chloramines, phosphate complexes and turbidity are present (as determined by a Certified Test Lab), an Activated Carbon Filter (roughing filter) should be used. This filter may be needed in addition to an ion exchanger.

Both filters are shown in the photo in a dual cartridge configuration. All filter types can be obtained through TPS™ .

Time for Replacement - Important!

The activated carbon filter should be replaced every 6 months. Never leave the same cartridge in for more than 12 months. Bacteria could grow in the cartridge when left installed for an extended period. Replacement cartridges can be obtained from the TPS Parts Department.

DUAL FILTRATION

5.7.4 Cartridge Replacement Procedure

Both the **ion exchange cartridge** and the **activated carbon (charcoal)** filter cartridge utilize the same quick-connect type cartridge holder. No tools are required to replace either filter. The cartridge holder utilizes a **spring loaded bottom plunger**. O-rings are installed on both the top and bottom ports.

To install a new cartridge, place the bottom of the cartridge overtop the bottom spring loaded plunger, making sure the o-ring seats firmly into the inside diameter of the cartridge. Push downward. Position the top of the cartridge under the top port and allow the cartridge to spring upward and seal with the top port o-ring. Rotate the cartridge back and forth 1/2 turn to insure a good seal with the o-rings. Open the blue inlet valve.

To remove a used cartridge first make sure the blue inlet valve is closed. Open the humidity generator drain valve to allow the system to drain. Grasp the cartridge and push down until the top end releases from the top port. Pull the cartridge slightly away from the holder and then upward.

CARTRIDGE HOLDERS

HOLDER REPLACEMENT LABEL

ION EXCHANGER LABEL

5.7.5 Polypropylene Pre-Filter (Particulate Filter) - Optional

Note: Please also reference Section 5.7.1 as the connection location and type are identical.

When a Polypropylene Pre-Filter (Particulate Filter) is used, the water supply connection for the humidity system is located on the left side of the chamber and is Type 3/8" FPT. The supply pressure should be 20 - 50 PSIG at 1.0 GPH. Make sure the connection is secure.

The supply line runs to a Water Pressure Regulator **WPR** that is installed at the rear middle of the chamber and then to the Pre-Filter. **WPR** is pre-adjusted in the range 10 - 20 PSIG and **should not be changed**.

When Polypropylene Pre-Filters Should Be Used:

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 (particulate filter) should be used. (Note: A 5 micron filter will require more frequent changes.)

This filter may be needed in addition to an ion exchanger and an activated carbon filter. All filter types can be obtained through TPS™.

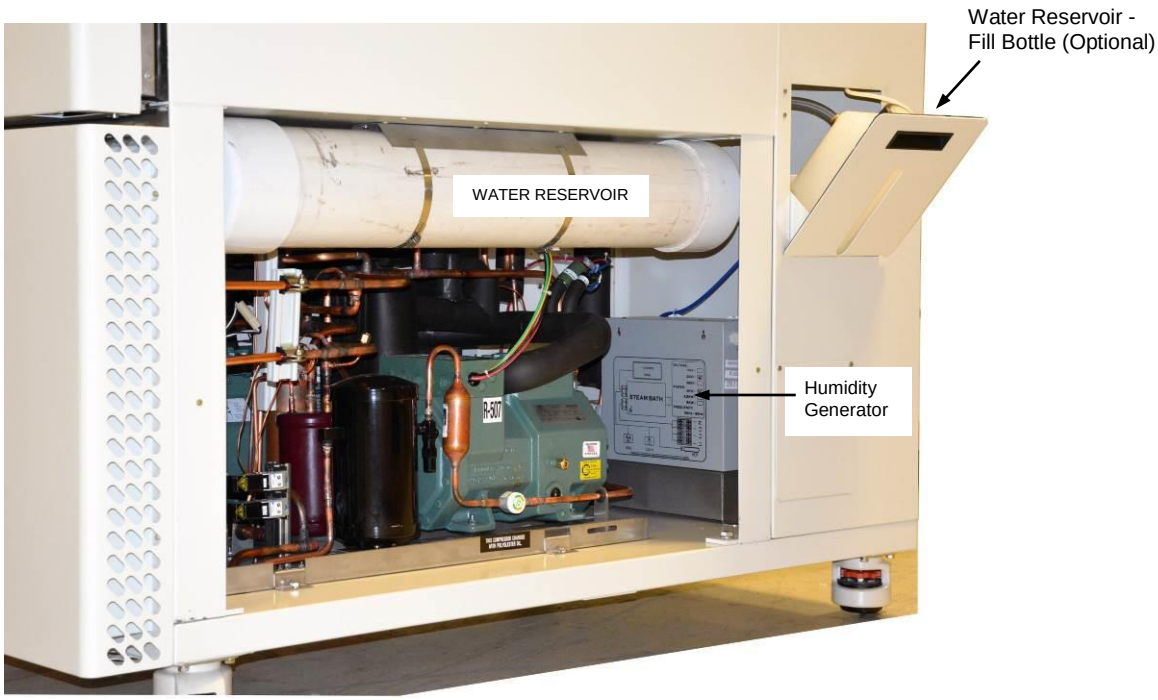
Time for Replacement - Important!

The Polypropylene Pre-Fitler should be replaced every 6 to 12 months, depending on your water quality and usage. Discoloration of the filter will continue with time, typically becoming brown and / or orange. Replacement filters can be obtained from the TPS Parts Department.

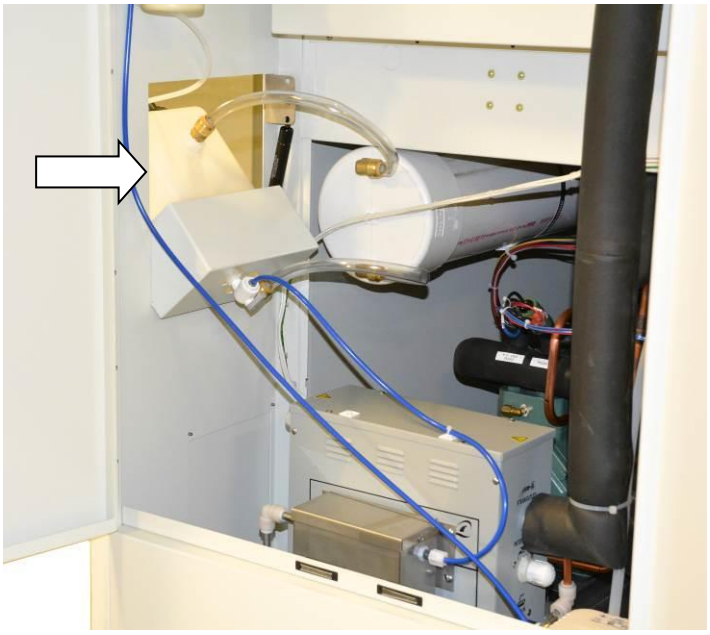
POLYPROPYLENE PRE-FILTER

5.7.6 Humidity System Water Supply Reservoir - Optional

The optional water reservoir for the humidity system consists of a 4 gallon white cylindrical tank, which is mounted on the right side of the machinery base. A **reservoir fill bottle** mounted slightly above the tank is used to supply water to it by **gravity feed**. This bottle is accessed by pulling out the access panel to which it is attached.



OPTIONAL 4 GALLON WATER RESERVOIR – SIDE VIEW (C20RC)

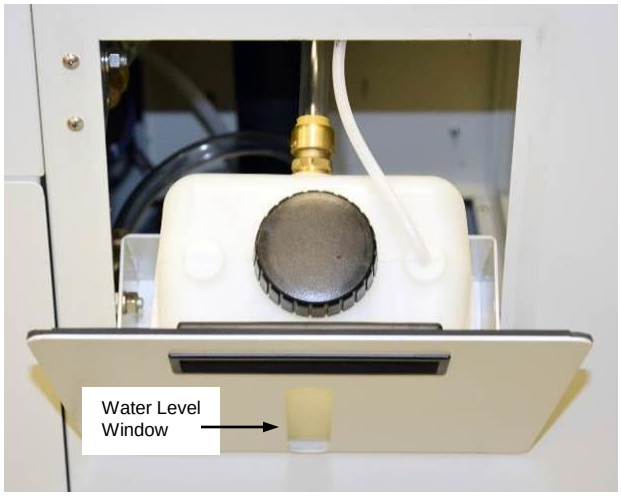


WATER FILL BOTTLE OPENED

Filling the Reservoir Fill Bottle:

Unscrew the bottle cap and fill the system with water that complies with the water quality requirements in Section 5.6. A water level window is located on the access door.

RESERVOIR FILL BOTTLE



TOP VIEW – RESERVOIR FILL BOTTLE

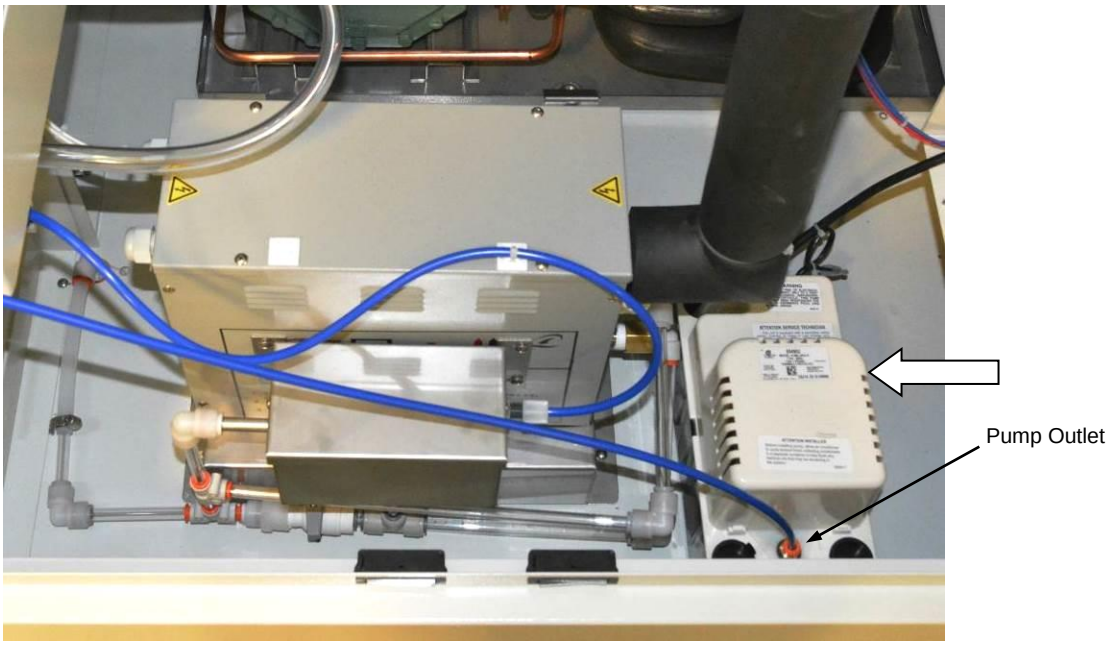
Important! When operating with high humidity conditions, you may have to fill the reservoir daily. You must not allow the humidity generator to operate without a supply of water.

5.7.7 Humidity System Condensate Pump - Optional

The optional condensate pump may be used to pump water condensation from the chamber drain port and the chamber door drip pan to either a drain located away from your chamber, or back to the optional water reservoir to reduce the frequency of refilling the reservoir.

Pump to Remote Drain Method: When the system is designed to pump condensate to a drain located away from the chamber, a **20' long piece of 1/4" diameter plastic tubing** with a "push-to-connect" type fitting will be supplied. Simply push the fitting into the outlet port of the condensate pump. Make sure the connection is secure.

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.



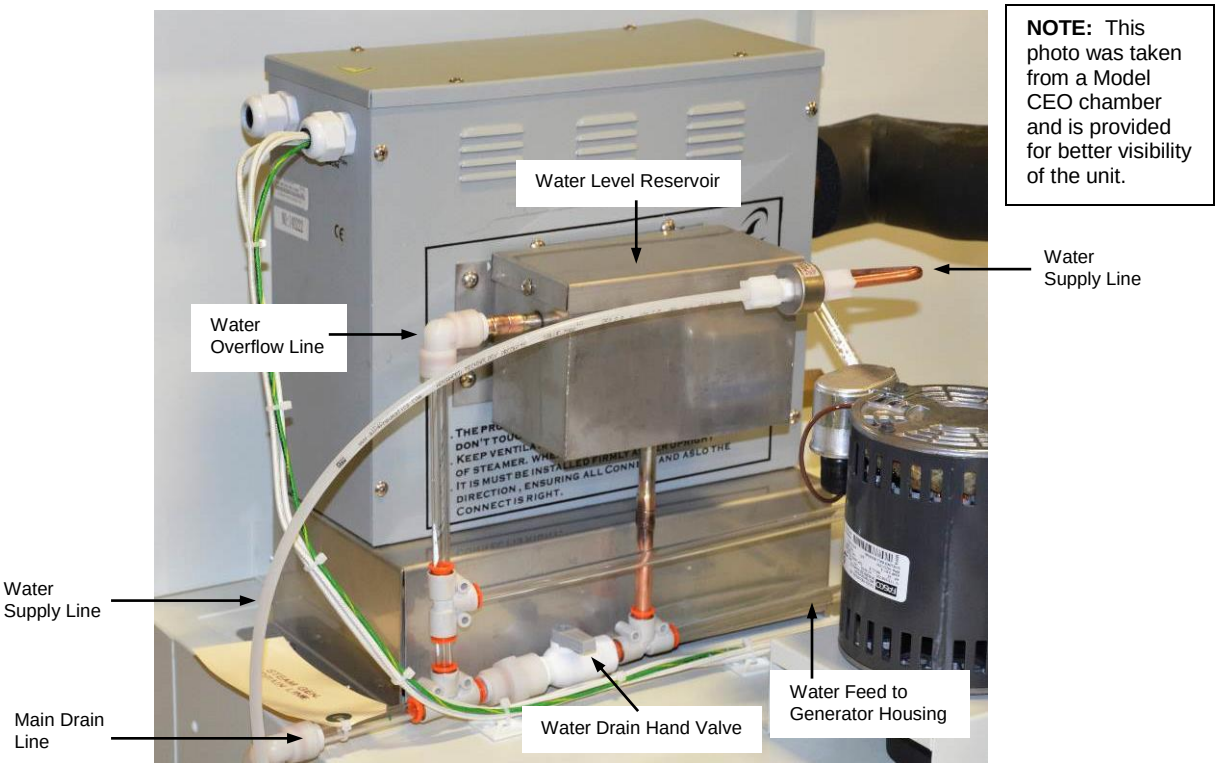
CONDENSATE WATER PUMP

Note: In the photo above, the outlet of the condensate pump is fed to an ion exchanger.

5.8 Before Running Humidity: Water Level - Important!

A small stainless steel water level control reservoir is installed on the side of the humidity generator. Inside is a float switch assembly and a water level indicator consisting of an L bracket welded to the side. This reservoir supplies and maintains a predetermined water level in the main generator housing water tank so that the immersion heater is always submersed.

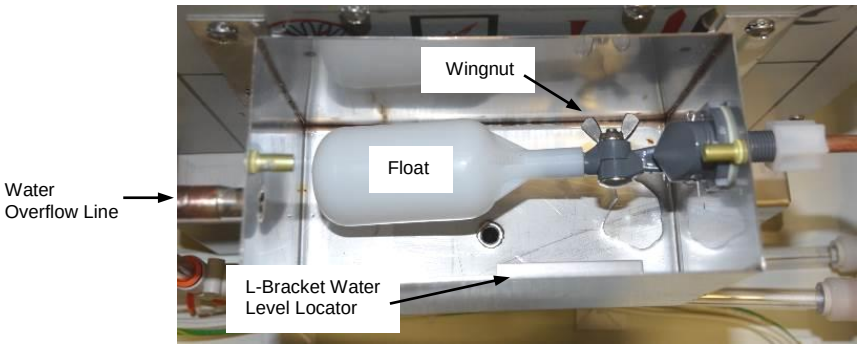
You must check the water level in the reservoir before each start-up, especially after not running the system for several days. It is critical that the water level be maintained no lower than the level locator on the inside of the reservoir. Otherwise, little or no vapor will be produced and the immersion heater will be subject to burn-out from being exposed to air.



VAPOR-FLO IV HUMIDITY GENERATOR – MOUNTED ON MODEL CEO UNIT

Check Water Level Procedure - - See next page.

To check the water level, remove the cover from the water level control reservoir by removing the screw on both ends. Turn on the main water supply and make sure the water level reaches the level indicator, and then shuts off the supply. If the water level is maintained above or below the level locator, you must adjust the float switch assembly by loosening the **wingnut** on the inlet shaft and rotating the float assembly up or down. **Make sure the float assembly doesn't slip at the correctly set position when you tighten the wingnut.** Replace the cover.

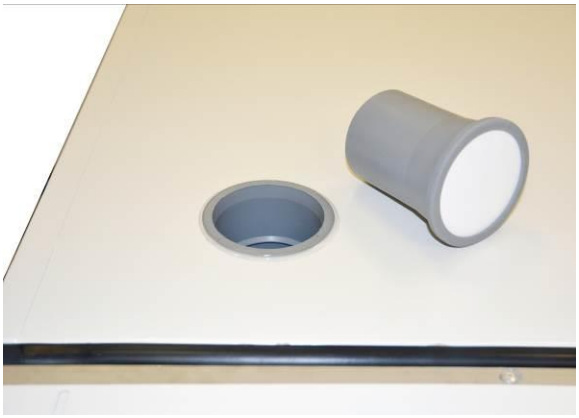


WATER LEVEL ADJUSTMENT

5.9 Before Running Humidity: Venting - Important! (Humidity Chambers)

Important! Before running humidity tests you must remove the humidity vent port plug from the top of the chamber. 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.

VENT PORT INSTALLED



VENT PORT REMOVED

Important! If your chamber employs the Strato-flo check valve with the Boost Cooling, Dry Air Purge, Dry Air Dehumidification, or GN2 Purge option, you **still must remove** the 3" diameter vent port plug on top of the chamber. If the vent port plug 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.

5.10 Air Supply Connection (For Optional Equipment)

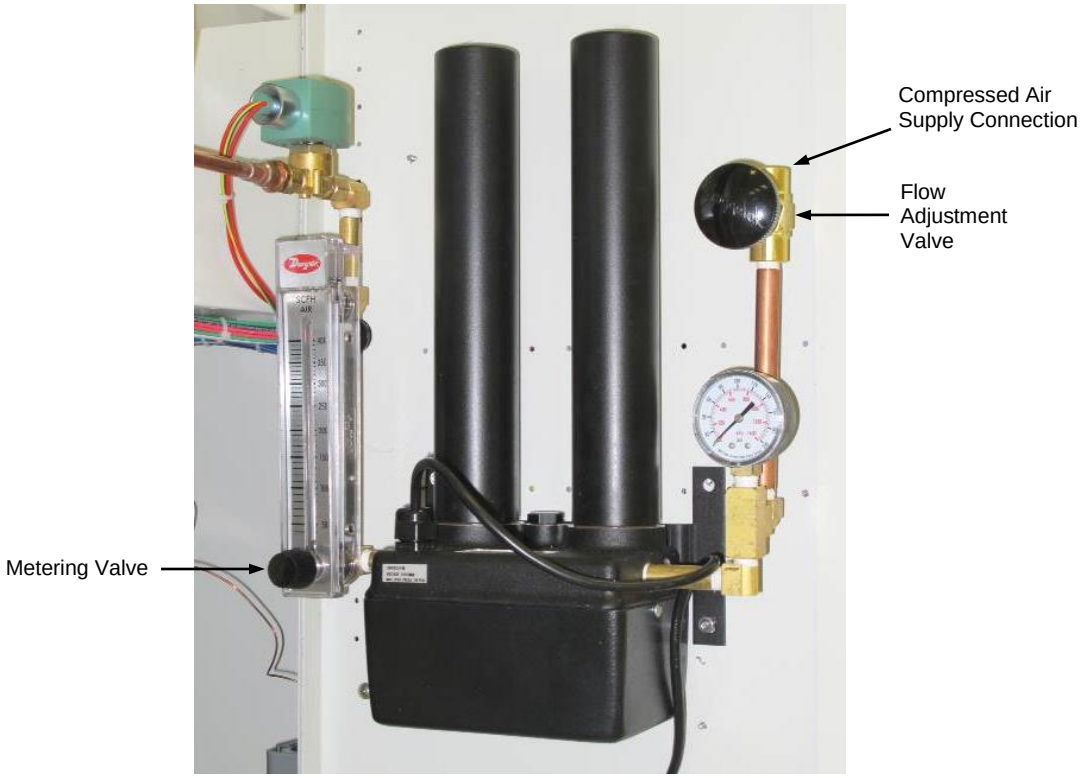
Your chamber will require a compressed air supply for the Dry Air Purge / Dry Air Dehumidification System option. The supply should be clean and dry, and range from 80 PSIG min. to 100 PSIG max. The connection type is 1/4" FPT. Make sure the connection is secure. Reference the corresponding "Options" section in this manual and your chamber specifications for more details.

Note: A **Strato-flo check valve** is mounted on top of the chamber to insure that the chamber does not become pressurized.

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 / DEHUMID SYSTEM

5.11 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.

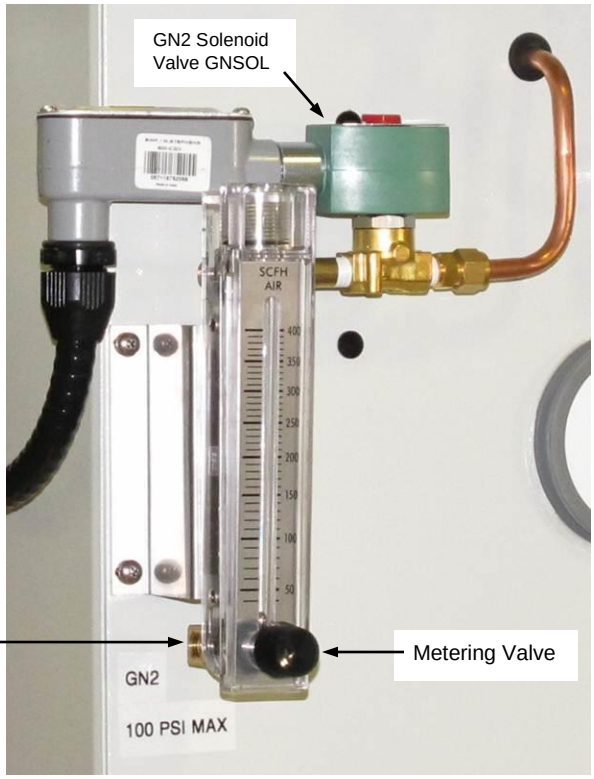
Note: A **Strato-flo check valve** is mounted on top of the chamber to insure that the chamber does not become pressurized.

Warning! Gaseous nitrogen displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the Strato-flo check valve.

Warning! Burn Hazard. Avoid contact with cryogenic materials. Serious burns from immediate frostbite will result. Insulated gloves, eye goggles, and protective clothing MUST be worn when working with or around these materials. Gloves should be loose fitting so they can be quickly discarded in case liquefied gas spills or sprays into them.

Flow Adjustment:

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



GN2 PURGE SYSTEM

5.12 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.

Note: A **Strato-flo check valve** is mounted on top of the chamber to insure that the chamber does not become pressurized.

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 Strato-flo check valve!

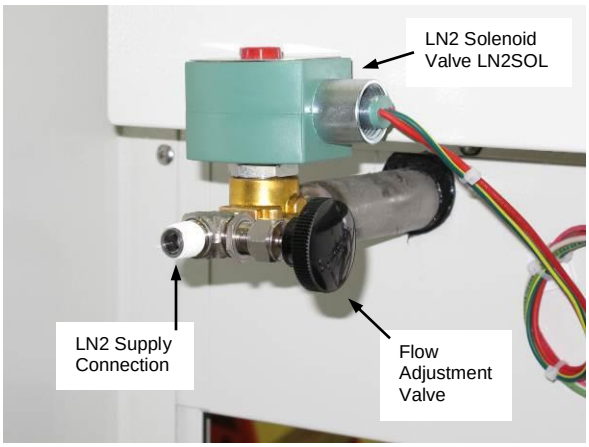
Warning! Burn Hazard. Avoid contact with cryogenic materials. Serious burns from immediate frostbite will result. Insulated gloves, eye goggles, and protective clothing MUST be worn when working with or around these materials. Gloves should be loose fitting so they can be quickly discarded in case liquefied gas spills or sprays into them.

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

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.

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.



LN2 SUPPLY CONNECTION

Note: Black Armaflex insulation is removed in the photo.

5.13 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.

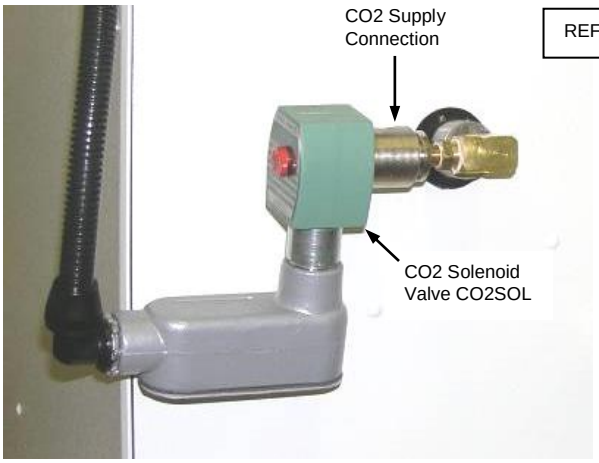
Note: A **Strato-flo check valve** is mounted on top of the chamber to insure that the chamber does not become pressurized.

Warning! Carbon Dioxide gas displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the Strato-flo check valve!

Warning! Burn Hazard. Avoid contact with cryogenic materials. Serious burns from immediate frostbite will result. Insulated gloves, eye goggles, and protective clothing MUST be worn when working with or around these materials. Gloves should be loose fitting so they can be quickly discarded in case liquefied gas spills or sprays into them.

CO2 Flow Adjustment:

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



CO2 BOOST COOLING

5.14 Power Supply Specifications and Connection

C-EVO chambers are configured to operate with the following voltages per the “Voltage Code” in your model number. Reference your Power Schematic for full load amperage and fused amperage ratings.

Code “B”: 208 V, 1 P, 60 Hz

Code “C”: 230 V / 240 V, 1 P, 60 Hz

For Special Chamber O/N xxxxx, the following specifications apply.

xxx VAC, xx A, x PH, xx HZ Your main power fused disconnect switch is rated xx Amps.

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 voltage 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		
Chamber Voltage Rating	**Minimum Voltage**	**Maximum Voltage**
208	188	228
230	207	253
460	414	506
480	432	528
60 Hz Supply	**Operation outside these limits can result in damage to chamber equipment.**	

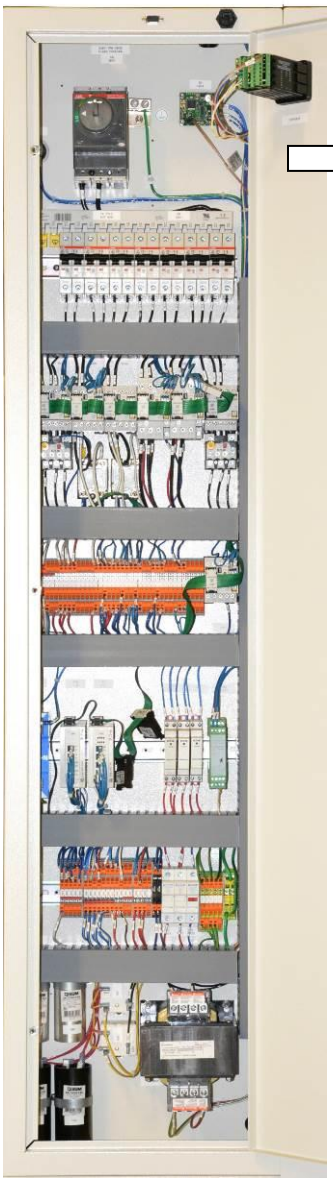
- 50 HERTZ SUPPLIES - LINE VOLTAGE MIN. / MAX. TABLE		
Chamber Voltage Rating	**Minimum Voltage**	**Maximum Voltage**
200	180	220
220	198	242
380	342	418
400	360	440
415	374	456
50 Hz Supply	**Operation outside these limits can result in damage to chamber equipment.**	

Making the Power Supply Connection to the Chamber:

The power supply connection is made to the main power disconnect switch, which is installed in the control cabinet. We highly recommend that the power source for this oven be supplied by a separate branch circuit in accordance with all national and local electrical codes. Reference your Electrical Schematic for all electrical requirements. A power supply cable entry hole is provided at the top of the control cabinet.

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.

Warning! Make sure that all electrical wiring is properly installed in accordance with all National and Local Electric Codes. Make sure all connections are secure.



CONTROL CABINET

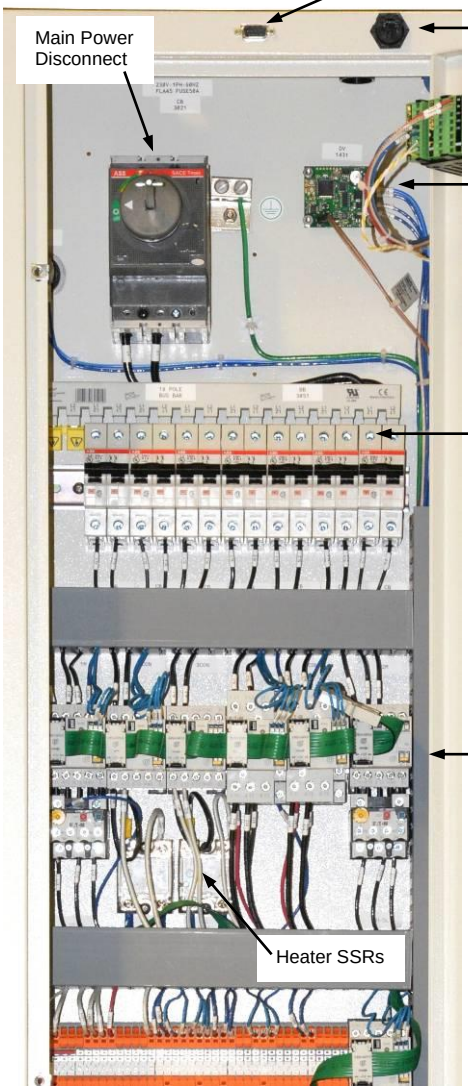
REFERENCE PHOTO

POWER CONNECTION

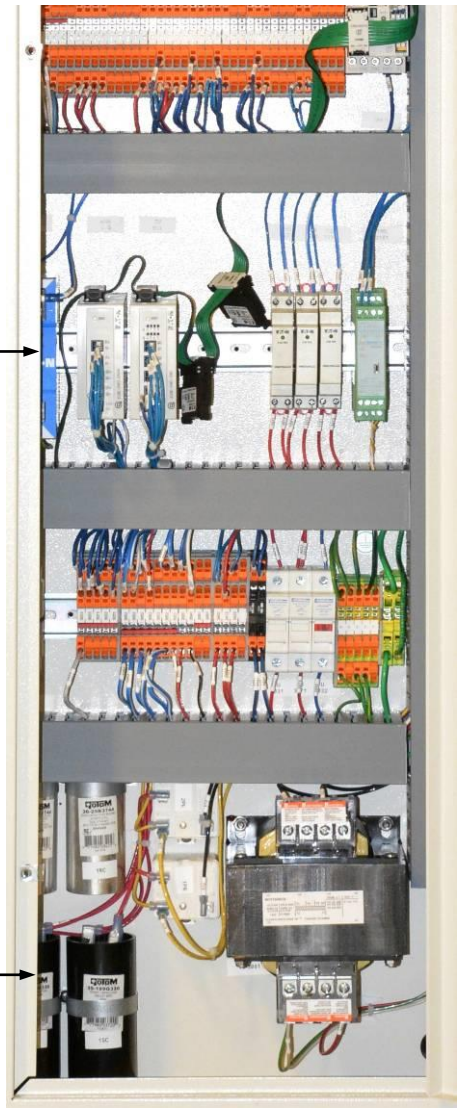
Note: See next page for photo enlargements of the control cabinet.

Control Cabinet Photo Enlargements:

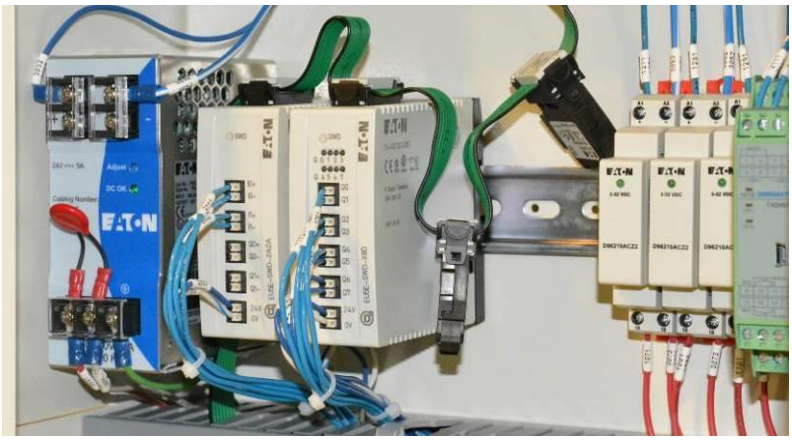
TOP HALF



BOTTOM HALF



SmartWire™ Control System



5.15 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.

5.16 Power Outage Effect on Smart 1.0™ Controller & Profile

In an event of a power outage, once power is reapplied to the chamber the controller will automatically resume operation from where it left off. This includes both manual and program operations.

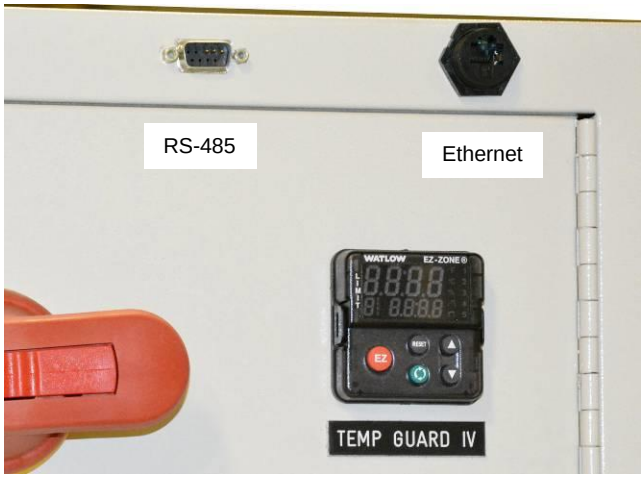
5.17 Data Communications

The following data communication protocols may be provided with the Smart 1.0 Controller HMI / PLC. Go to the Settings / **Communications Screen** in **Section 4.3.5** in the Smart 1.0 Controller Manual for a complete description of the standard and optional protocols listed below.

- Ethernet TCP / IP - - **Standard**
- Remote Access - - Remote Client and VNC Software Applications **using Ethernet**. Remote Client and VNC provide a real time interactive display of the Smart 1.0 Controller HMI on the customer's PC, with the same basic functionality using the PC mouse or track pad.
- Serial RTU - - RS-RS485 - - **Standard** (RS-232 is available with optional converter plug installed.)
- IEEE - 488 GPIB - - **Optional** with ICS IEEE board installed

Ethernet Port:

An Ethernet Port is installed at the top of the control /power cabinet for data communication with a PC.



RS-485 & ETHERNET PORT

RS-485 Data Communications Port:

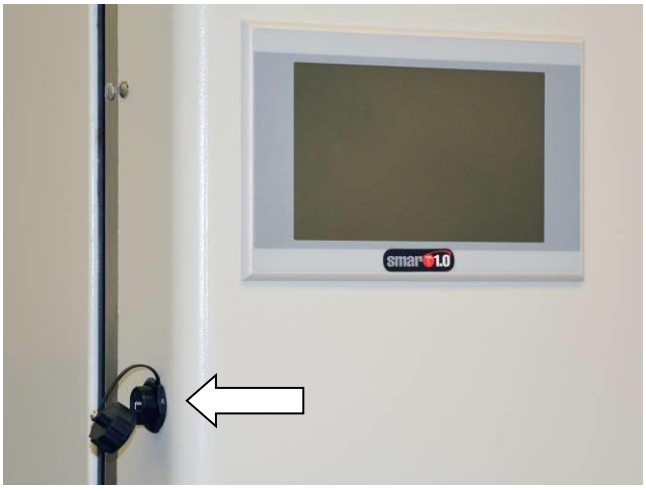
An RS-485 port is installed at the top of the control / power cabinet for data communication with a PC.

RS-232 communication is available with the optional converter plug installed.

Smart 1.0 Controller USB Port:

A USB port is installed on the left side of the chamber door so that you can download data logging files from the Smart 1.0 Controller. Thte USB port is also used for uploading new software to controller. Unscrew the black plastic cap to access the connection.

Make sure you reattach the cap when the port is not in use.



USB PORT

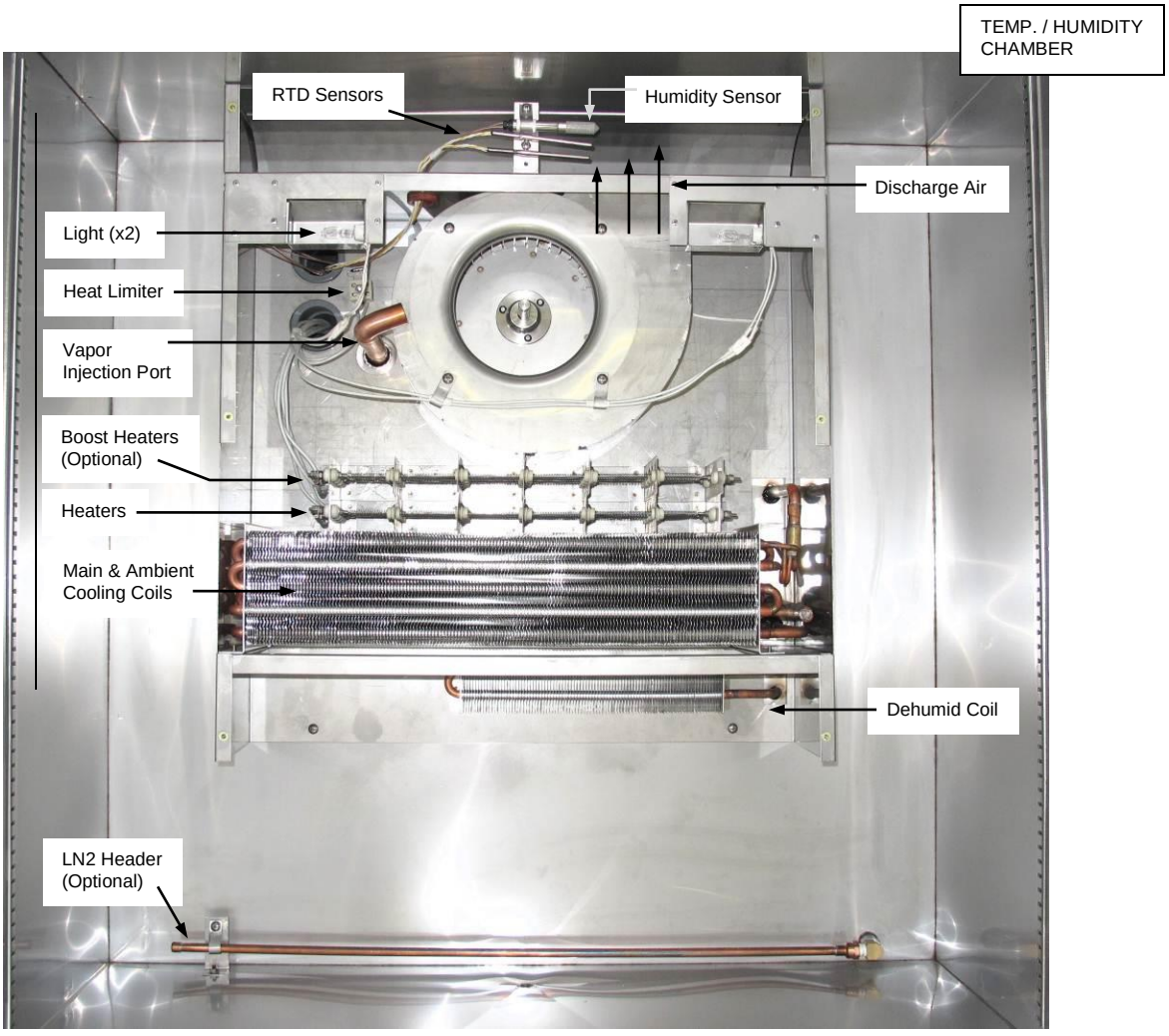
6.0 AIR CIRCULATION SYSTEM

6.1 System Overview

This chamber features a high volume horizontal-down type airflow system with an electric heating system, a mechanical refrigeration system, and a vapor injection type humidification system (humidity chambers) to condition the product. The generation of airflow and conditioning of circulating air occurs in the conditioning plenum mounted along the rear wall of the workspace. The plenum is isolated from the workspace to prevent direct heat radiation.

6.2 Conditioning Equipment

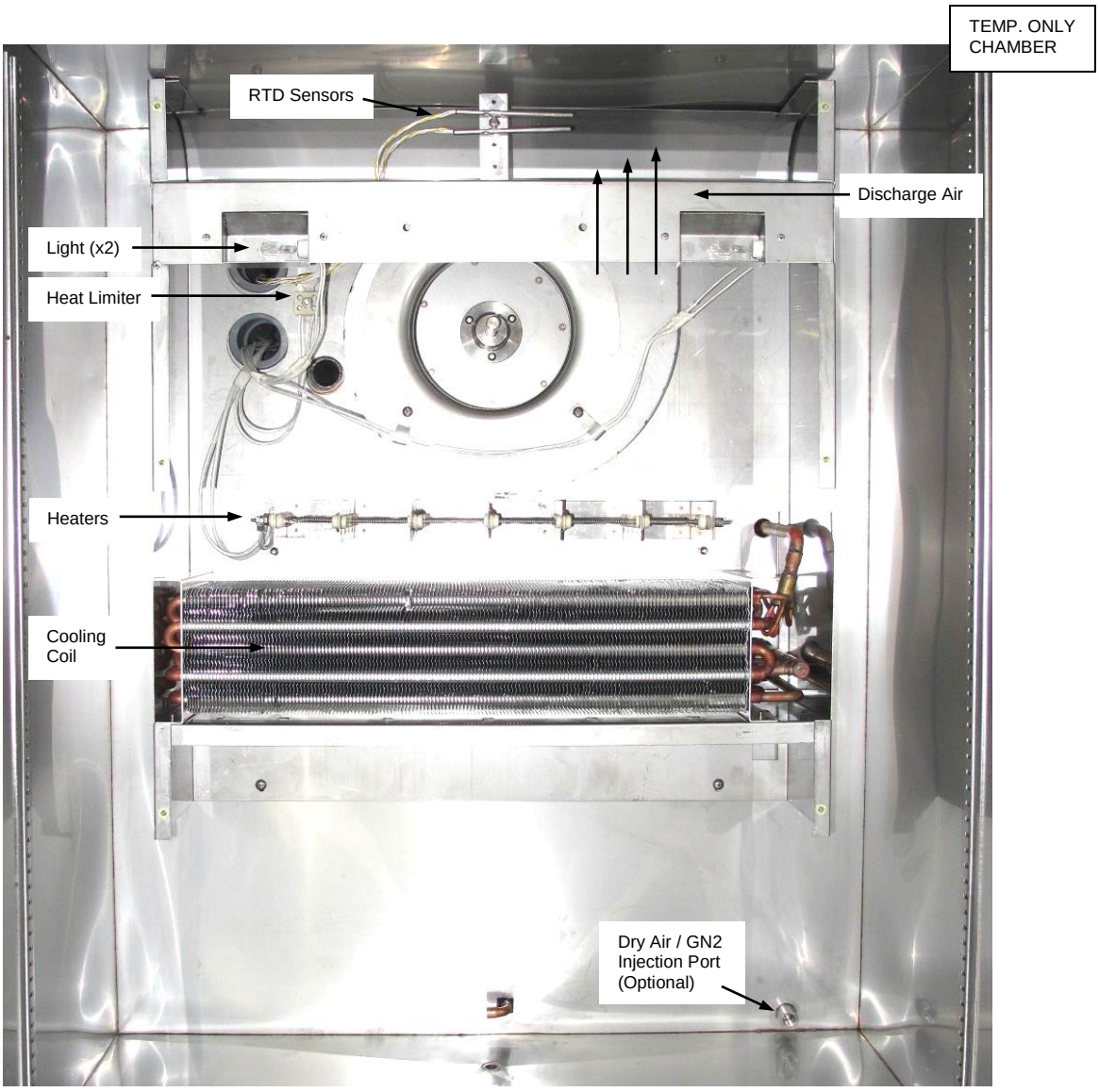
Conditioning equipment mounted in the plenum includes open-air nichrome wire type heaters, a refrigerated cooling coil consisting of a copper coil with expanded aluminum heat transfer fins, a vapor injection port (humidity chambers) and a centrifugal type blower wheel to generate airflow. The blower wheel is mounted at the top of the plenum and is directly driven by an externally mounted motor. A vent port is installed in the chamber ceiling. The optional dry air purge / dehumid injection port, GN2 injection port, CO2 injection port, and LN2 header would be installed at the base of the conditioning plenum.



CONDITIONING PLENUM – MODEL C30RC

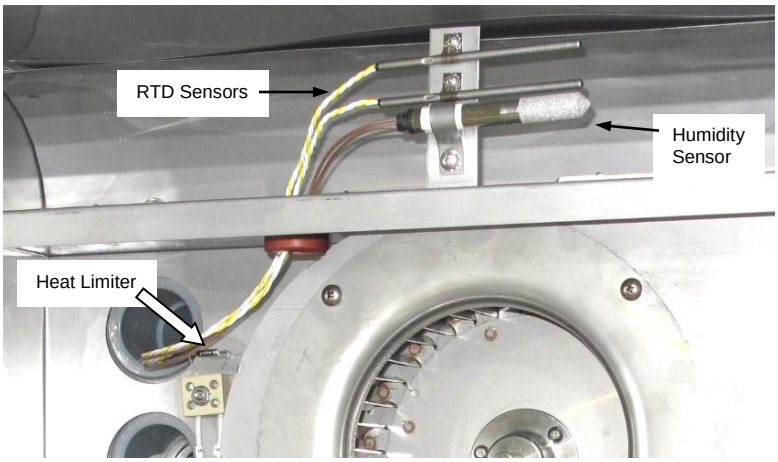
Either a single stage or a cascade type refrigeration system is used with thermostatic expansion valve (TEV) type refrigerant control. Single stage units utilize one reciprocating type compressor while cascade units utilize two. The system is mounted in the base of the unit.

A refrigerated dehumidify coil (humidity chambers) is mounted vertically in the plenum base away from the main circulating air stream to avoid heat transfer directly to the airstream.



CONDITIONING PLENUM – MODEL C10S

100 Ohm Platinum RTD sensors are used for temperature measurement by the main controller and the chart recorder (when provided). A dry capacitance type humidity sensor is used for humidity measurement by the main controller and chart recorder (humidity chambers). A retransmit humidity level signal from the main controller to the chart recorder is normally used. Sensors are placed in the discharge air at the top middle of the discharge air grate.



TEMPERATURE & HUMIDITY SENSORS

Chamber Vent Port:

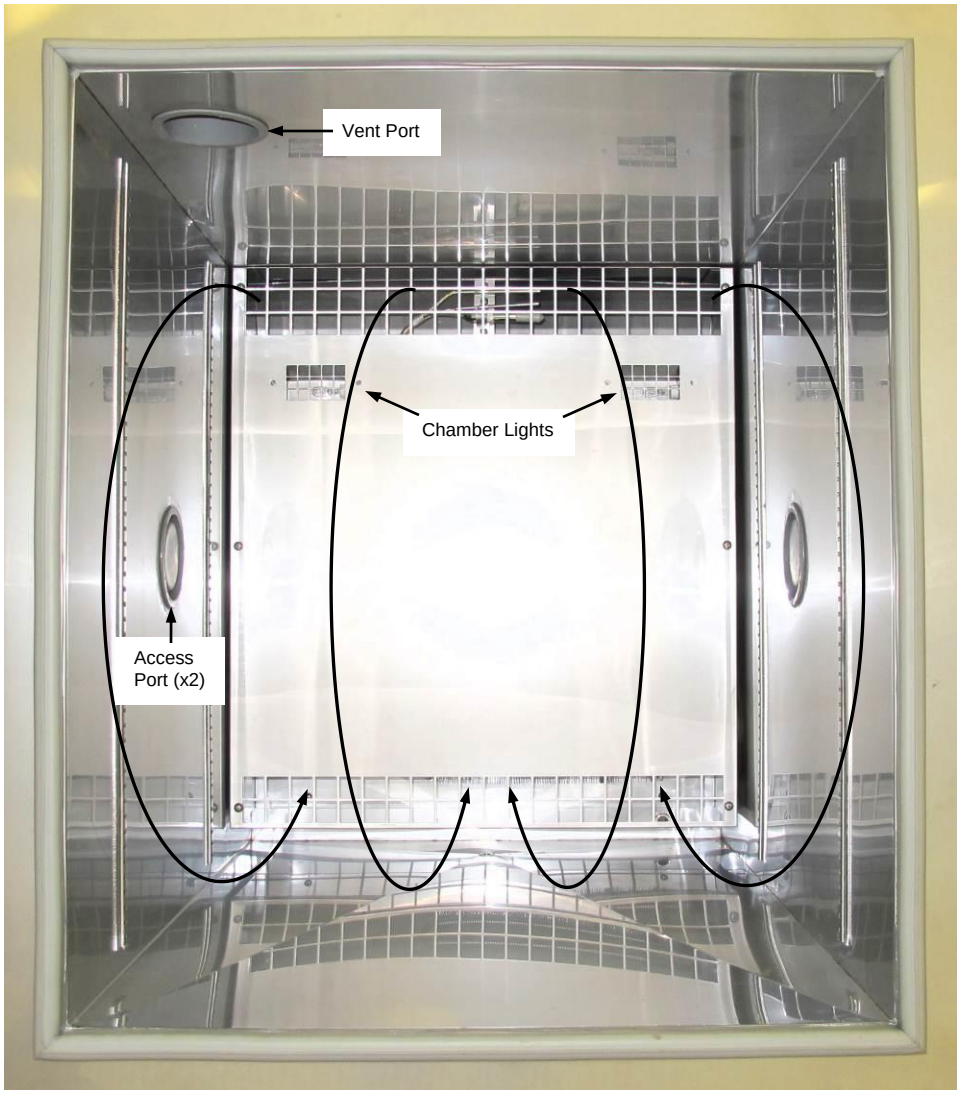
A 3” diameter vent port is installed at the top left corner of the chamber with a special rubber plug. This port plug is the same type used to seal access ports.

Important – For Humidity Chambers! Before running humidity tests you must remove the humidity vent port plug from the top of the chamber. 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.

VENT PORT REMOVED

6.3 Airflow Description

Process air is drawn from along the bottom of the chamber and up into the conditioning plenum by the circulation blower wheel. The air flows up through the cooling coil and the heater elements, mixes with injected vapor (humidity chambers), and is discharged back into the chamber through the grate at the top. The air flows horizontally out and downward to condition the product. Airflow in the workspace is basically in an elliptical type pattern. Processed air returns to the base of the conditioning plenum for reconditioning, and the cycle continues. A small portion of circulating air will exhaust out through the vent port, when remvoed. During dehumidification, moist air will migrate to the dehumidify coil and condense on its cold surfaces.



AIR CIRCULATION – 10 Ft^3 WORKSPACE

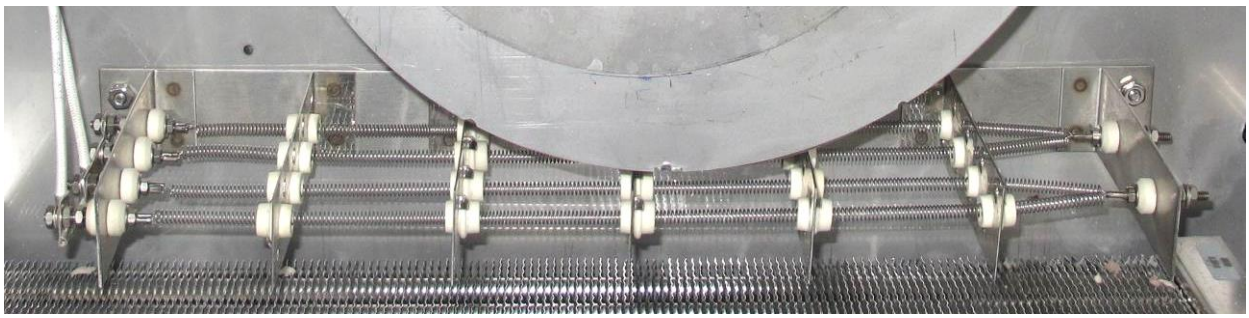
Chamber Light

7.0 HEATING DESCRIPTION

Heating of the chamber is achieved 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 configured in a serpentine pattern within stainless steel racks and are supported with ceramic insulators. Heater racks are installed in the conditioning plenum. 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 Power Schematic.

Heater Control:

State of the art power control is used for the electric heating system along with redundant safety components. A Heat Enable contactor **x**CON is used in the heater power circuit to guard against failure of the heat control output and heat control solid state relay.



OPEN-AIR NICHROME WIRE HEATERS

Power to the electric air heaters is time proportioned by the PLC's Channel 1 Heat Control Output, which will energize the Heat Solid State Relay SSRxxxx to supply the heaters.

REFERENCE PHOTO

SOLID STATE RELAY

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 controller's heat output energizes the main heater bank, it will also energize an On-Delay timer in the PLC logic. If the timer times out before the PLC's Heat Control Output turns off, the timer output will energize the Boost Heat Solid State Relay SSRxxxx to provide power to the boost heaters. Contacts of the Boost Heat Enable Contactor BHCON must also close.

8.0 SINGLE STAGE REFRIGERATION SYSTEM

8.1 System Overview

The main design features of this refrigeration system include thermostatic expansion valve (TEV) type refrigerant control and the use of a semi-hermetic compressor in a **single stage** design.

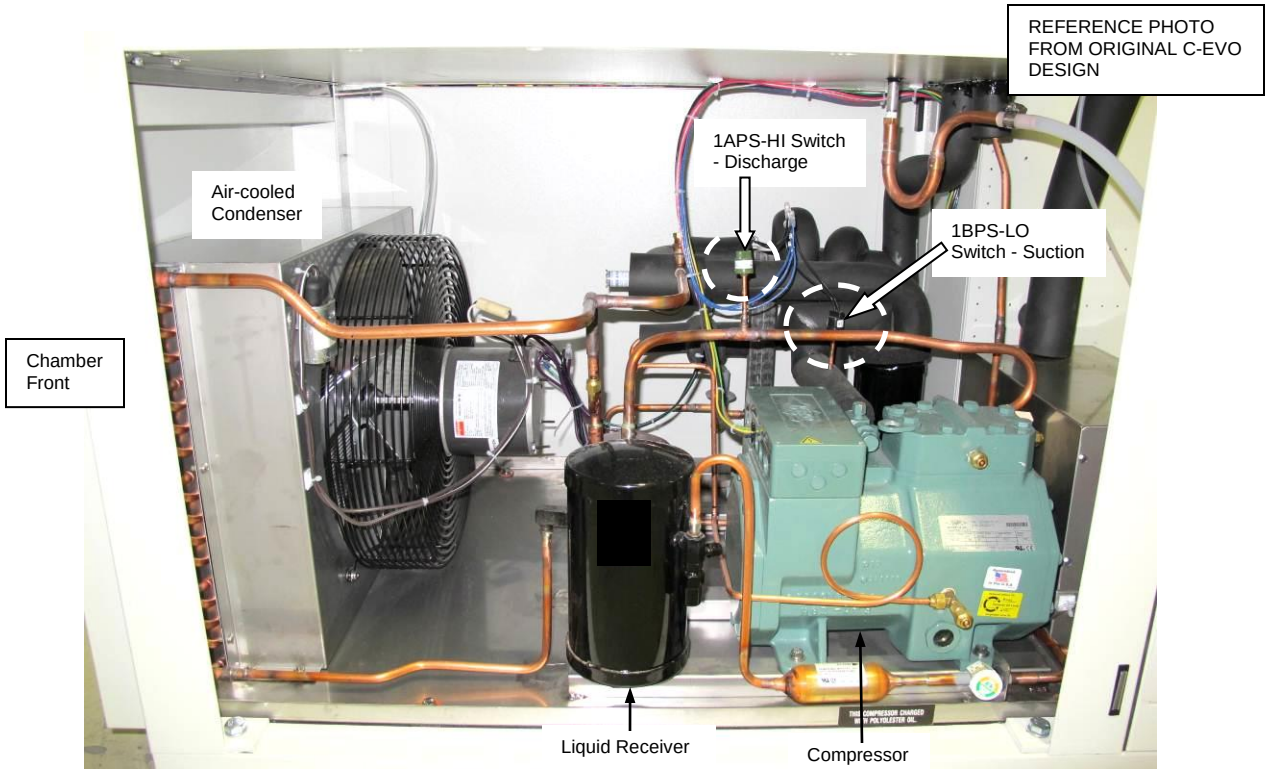
Cooling of the chamber is achieved by regulating refrigerant flow to the main evaporator cooling coil mounted in the conditioning plenum. During humidity conditioning (humidity chambers), cooling may be achieved by using either a separate refrigerant ambient feed line to the main evaporator cooling coil, or by using a separate “ambient” evaporator cooling coil. Cooling during humidity conditioning is at a reduced rate.

The system is also used for dehumidification (humidity chambers) using an evaporator dehumidify coil mounted in the conditioning plenum, but out of the main air circulation path.

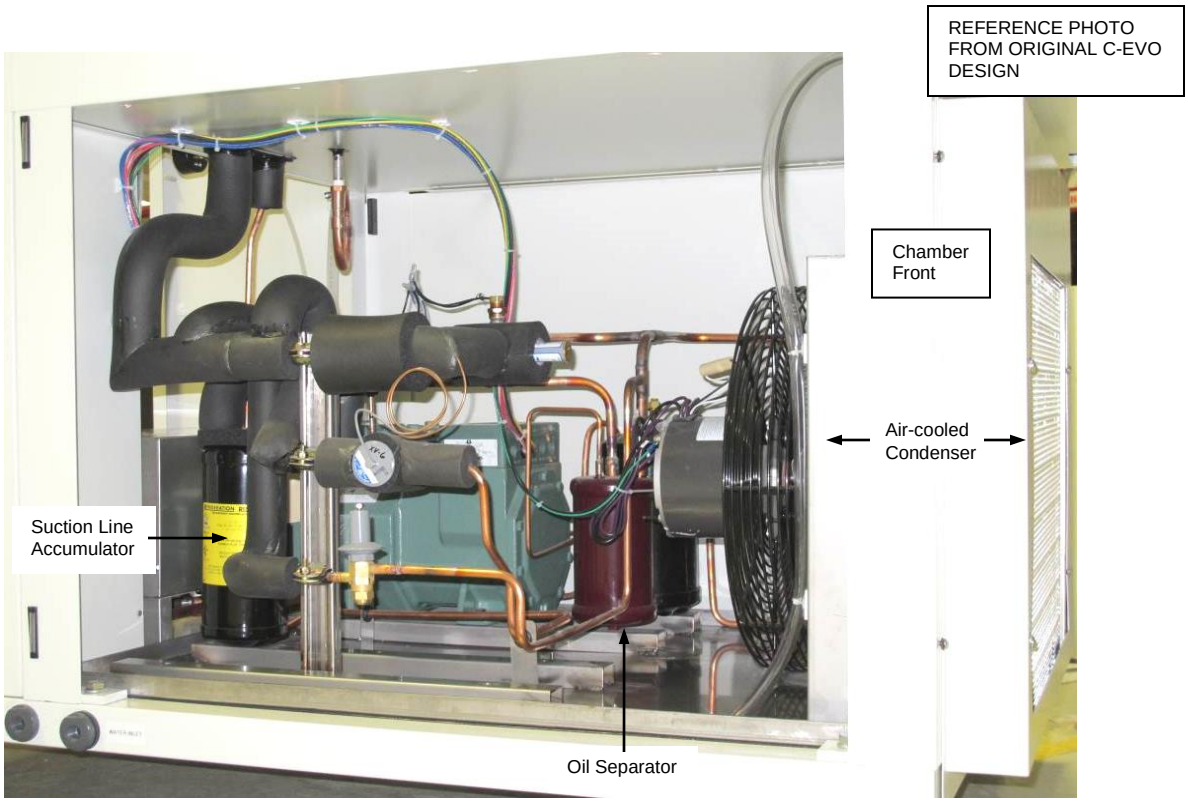
The description below is of a standard **single stage system** that is used in many different Tenney chambers and is **provided as a reference**. System design varies widely with chamber size and cooling capacity.

8.2 Basic System Description

The basic single stage system consists of a semi-hermetic compressor, an oil separator, either an air-cooled or water-cooled condenser, a Main Cooling Coil provided with a TEV, a suction line accumulator to guard against liquid refrigerant return to the compressor, and various flow regulating devices. Remote air-cooled condensers are often used with large systems.



SINGLE STAGE SYSTEM – C10RS (RIGHT SIDE OF CHAMBER)



SINGLE STAGE SYSTEM – C10RS (LEFT SIDE OF CHAMBER)

Thermostatic Expansion Valve (TEV) Description:

This system employs thermostatic expansion valve (TEV) type refrigerant control. A TEV is installed on the inlet to each evaporator coil, with refrigerant flow through the valve. The valve responds to any rate of flow, which is regulated by the temperature controller.

Operation of the thermostatic expansion valve is controlled by two conditions. These are the temperature of the TEV control (sensing) bulb on the outlet of the evaporator, and the low-side pressure / temperature of the evaporator. The temperature of the control bulb must be higher than the refrigerant temperature in the evaporator before the valve will open. This temperature difference produces different pressures within the valve, which causes it to open and close. When the outlet temperature is much warmer than the inlet, the valve will open wide to permit a high flow of refrigerant into the evaporator. As the outlet temperature cools, the valve will close to decrease refrigerant flow. During operation, the sensing bulb temperature is normally about 10° F (5.6° C) warmer than the evaporator temperature. With TEV control, pressures do not balance on the off-cycle. As a result, compressor motors are chosen to start under load.

8.3 Refrigerant Flow - Temperature Control (Standard)

Refrigerant (suction gas) returns to the compressor and is compressed to the system design condensing pressure. Discharge gas from the compressor flows to an oil separator (OS), where entrained oil vapors are removed. Oil vapors return to the compressor crankcase through a float valve integral to the separator.

The oil-free refrigerant gas flows to the air-cooled or water-cooled condenser (COND), where it is condensed into a liquid by heat exchange with circulating ambient air, or cooling water. The liquid refrigerant flows through a drier assembly (D), a solenoid valve (1SOL), and to a thermostatic (superheat type) expansion valve (XV3) where it is metered to the Main Cooling Coil. 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 temperature actuated (remote bulb) valve (TPV), and a liquid injection solenoid valve (11SOL) are provided to insure that the suction gas is cooled to an acceptable level. As the suction gas temperature increases, TPV modulates open to admit some liquid refrigerant into the suction side. The evaporation of this liquid cools the gas admitted through the hot gas bypass valve (CPV).

A downstream pressure actuated hot gas bypass valve (CPV) and a hot gas bypass solenoid valve (12SOL) are provided to prevent the compressor suction pressure from dropping below 0 PSIG. As the suction pressure tends to fall below 0 psig, the CPV modulates open to allow some discharge gas to flow to the suction side of the compressor.

Two levels of cooling are provided with temperature control only. When operating at moderate temperatures, or for just fine temperature control, refrigerant flow is through a restrictive hand valve (or capillary tube) to the **Main Cooling Coil**. When operating at extreme low temperatures, the **Full Main Coil** solenoid valve opens to allow full refrigerant flow to bypass the hand valve.

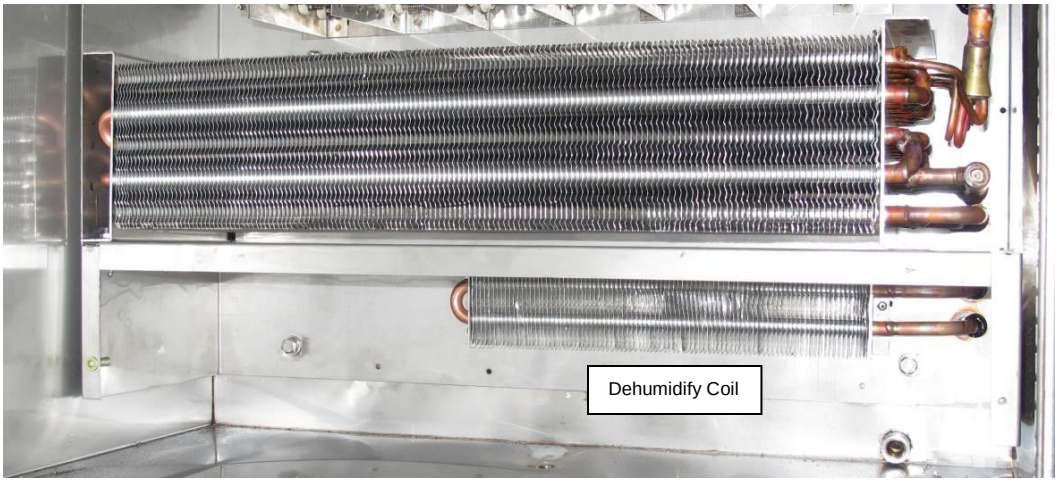
When operating with humidity conditioning, refrigerant flow is through the Ambient Cooling solenoid valve 1SOL.

8.4 Refrigerant Flow - Dehumidification Control

Refrigerant flow during dehumidification continues as a liquid from the condenser, through the Dehumidify Coil solenoid valve 4SOL and to the Dehumidify Coil in the chamber conditioning plenum. The Dehumidify Coil is normally located near the base of the plenum and away from the main circulating air stream to minimize sensible heat loss.

As liquid refrigerant flows through the coil it boils and vaporizes do to heat exchange with the warm coil surfaces. As the refrigerant absorbs this heat, it cools the finned coil. Warm moist air flowing through and past the dehumid coil migrates to the cold coil surfaces and condenses. The air is dehumidified and continues up through the plenum for further conditioning. Warmed refrigerant gas leaves the dehumid coil and returns through the suction line to the compressor.

An evaporator pressure regulator EPR is sometimes used in the suction line. The EPR prevents the Dehumidify Coil from freezing up as it maintains the coil temperature slightly above 0° C. It also maintains a constant coil pressure. As a result, a more constant dehumidification process occurs along with the capability of obtaining very dry conditions. The EPR is fed hot refrigerant gas through the EPR Solenoid Valve 10ASOL (when applicable), which acts as a pilot valve.



COOLING & DEHUMIDIFY COILS – C10RC

9.0 CASCADE REFRIGERATION SYSTEM

9.1 System Overview

The main design features of this refrigeration system include thermostatic expansion valve (TEV) type refrigerant control and the use of semi-hermetic compressors in a **cascade** design.

Cooling of the chamber is achieved by regulating refrigerant flow to the main evaporator cooling coil mounted in the conditioning plenum. During humidity conditioning (humidity chambers), cooling may be achieved by using either a separate refrigerant ambient feed line to the main evaporator cooling coil, or by using a separate “ambient” evaporator cooling coil. Cooling during humidity conditioning is at a reduced rate.

The system is also used for dehumidification (humidity chambers) using an evaporator dehumidify coil mounted in the conditioning plenum, but out of the main air circulation path.

The description below is of a standard **cascade system** that is used in many different Tenney chambers and is **provided as a reference**. System design varies widely with chamber size and cooling capacity.

9.2 Basic System Description

The refrigeration system is of the classical type employed by Tenney since early 1950 for ultra-low temperature refrigeration. The complete system consists of a single stage, low temperature (low stage) system charged with R-23 refrigerant (normal boiling point - 82.1° C), and a single stage moderate temperature (high stage) system charged with R-404A refrigerant (normal boiling point - 47.8° C).

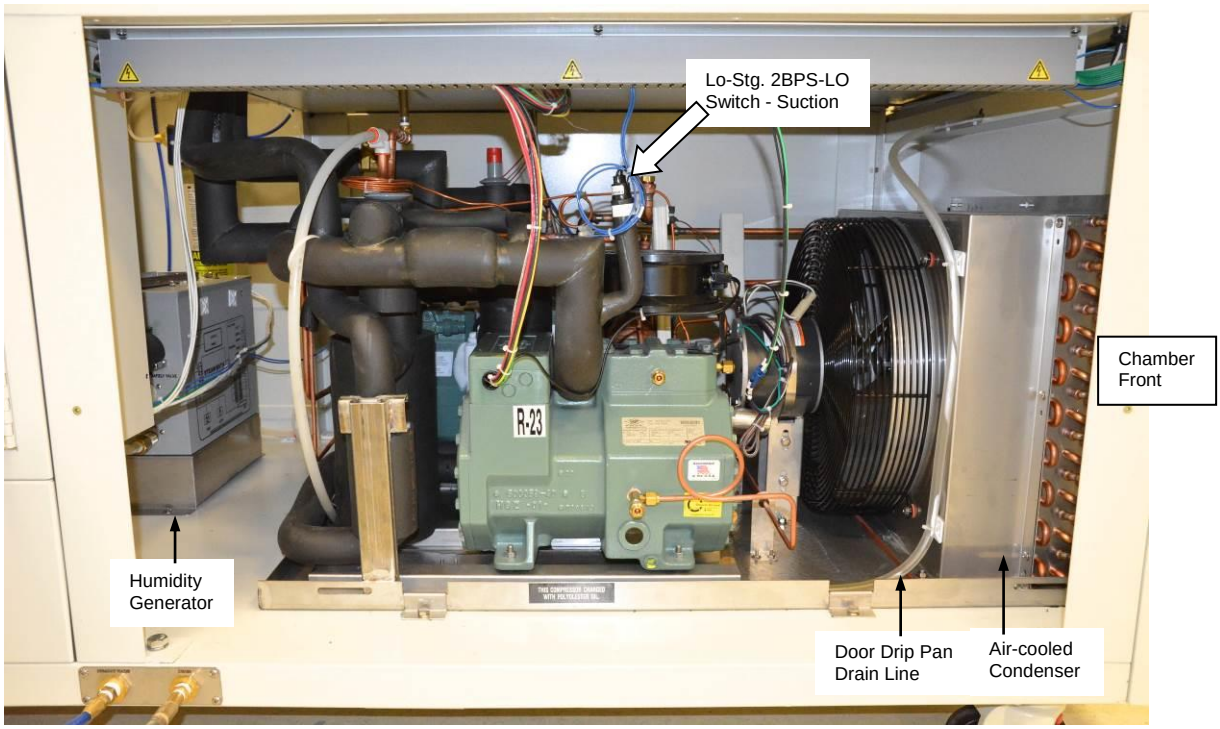
The complete low stage system consists of a motor driven semi-hermetic compressor, a desuperheater, an oil separator, the condensing side of a cascade condenser, various flow control solenoid valves, a thermostatic expansion valve, and an evaporator (air cooling coil) to remove heat from the recirculating chamber air stream. A refrigerant gas storage (expansion) tank is included to maintain a satisfactory system pressure during shutdown and initial startup.

The complete high stage system consists of a motor driven semi-hermetic compressor, an oil separator, an air or water-cooled condenser, a liquid receiver, various flow control solenoid valves, a thermostatic expansion valve, the evaporator side of a cascade condenser, and a suction line accumulator. An Ambient Cooling Coil is provided for moderate cooling during humidity control (humidity chambers). A Dehumidify Coil is provided for dehumidification.

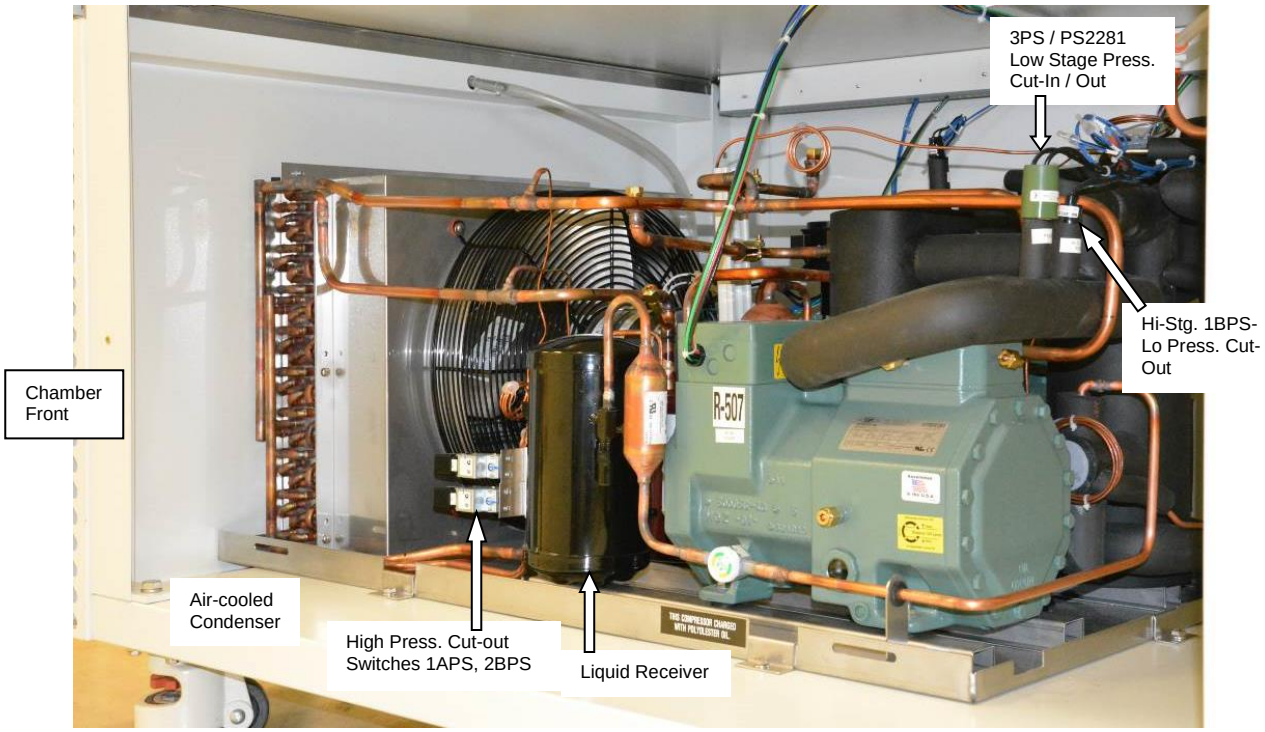
Thermostatic Expansion Valve (TEV) Description:

This system employs thermostatic expansion valve (TEV) type refrigerant control. A TEV is installed on the inlet to each evaporator coil, with refrigerant flow through the valve. The valve responds to any rate of flow, which is regulated by the temperature controller.

Operation of the thermostatic expansion valve is controlled by two conditions. These are the temperature of the TEV control (sensing) bulb on the outlet of the evaporator, and the low-side pressure / temperature of the evaporator. The temperature of the control bulb must be higher than the refrigerant temperature in the evaporator before the valve will open. This temperature difference produces different pressures within the valve, which causes it to open and close. When the outlet temperature is much warmer than the inlet, the valve will open wide to permit a high flow of refrigerant into the evaporator. As the outlet temperature cools, the valve will close to decrease refrigerant flow. During operation, the sensing bulb temperature is normally about 10° F (5.6° C) warmer than the evaporator temperature. With TEV control, pressures do not balance on the off-cycle. As a result, compressor motors are chosen to start under load.



LOW STAGE COMPRESSOR – C20RC (LEFT SIDE OF CHAMBER)



HIGH STAGE COMPRESSOR – C30C (RIGHT SIDE OF CHAMBER)

9.3 System Operation

Low Stage (R-23) System:

Refrigerant (suction gas) returns to the low stage compressor (C2) and is compressed to the system design condensing pressure. Discharge gas from the compressor flows to a desuperheater (DSH), where most of the heat of compression is removed by heat exchange with circulating cooling air, or water. It then flows to an oil separator (OS1), where entrained oil vapors are removed. Oil vapors return to the compressor crankcase through a float valve integral to the separator.

A spring loaded upstream pressure actuated control valve (LL), an expansion tank (XT), and a suction return line with a metering valve (H-5) are provided to limit the system discharge pressure during startup. As the compressor discharge pressure increases to the maximum design level, the control valve (LL) modulates open, and a portion of the refrigerant flows to the expansion tank, thereby limiting the system load.

The cool, oil-free refrigerant gas flows to the cascade condenser (CC), where it is condensed into a liquid by heat exchange with evaporating high stage (R-404A) refrigerant. The liquid refrigerant flows through a drier assembly (D), a solenoid valve (8ASOL), and to a thermostatic (superheat type) expansion valve (XV3), where it is metered to the low temperature air cooling coil. 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 suction side of the compressor.

A downstream pressure actuated hot gas bypass valve (CPV), and a hot gas bypass solenoid valve (14SOL) are provided to prevent the compressor suction pressure from dropping below a preset value (generally about 10 PSIG). This condition occurs when the refrigerant feed solenoid valve (8ASOL) closes, which halts flow to the cooling coil. When 8ASOL closes, 14SOL opens. As the suction pressure tends to fall below the valve (CPV) setting, the CPV modulates open to allow some discharge gas to flow to the suction side of the compressor.

A temperature actuated (remote bulb) valve (XV7) is provided to insure that the suction gas is cooled to an acceptable level. As the suction gas temperature increases, XV7 modulates open to admit some liquid refrigerant into the suction side. The evaporation of this liquid cools the gas admitted through the hot gas bypass valve (CPV).

Two levels of cascade cooling are provided. When operating with moderate temperatures, refrigerant flow is through a restrictive hand valve (HXV), and to the cooling coil. When operating at extreme low temperatures, the Full Main Coil solenoid valve 8SOL opens to allow full refrigerant flow to bypass the hand valve.

Compressor Cut-In Switch (3PS):

Compressor Cut-In Pressure Switch 3PS monitors high stage suction pressure. Following start-up, it is used to turn on the low stage compressor once a ‘cut-in’ suction pressure of at least 20 PSIG is reached. This feature allows for the cascade condenser to cool before the low stage compressor is started. 3PS will open when the ‘cut-out’ suction pressure reaches 40 PSIG.

High Stage (R-404A) System:

Refrigerant (suction gas) returns to the high stage compressor (C1) and is compressed to the system design condensing pressure. Discharge gas from the compressor flows to an oil separator (OS2), where entrained oil vapors are removed. Oil vapors return to the compressor crankcase through a float valve integral to the separator.

The oil-free refrigerant gas flows to the air-cooled or water-cooled condenser (COND), where it is condensed into a liquid by heat exchange with circulating ambient air, or cooling water. The liquid refrigerant flows to a receiver (LR), through a drier assembly (D), through solenoid valve (9SOL), and then to a thermostatic (superheat type) expansion valve (XV2) where it is metered to the cascade condenser.

In the cascade condenser, high stage refrigerant absorbs heat from the circulating low stage refrigerant. This causes the low stage refrigerant to condense. As the high stage refrigerant absorbs heat, it boils and vaporizes. It returns to the compressor through the suction line accumulator SLA. The cycle is repeated.

A downstream pressure actuated hot gas bypass valve (CPV) and a hot gas bypass solenoid valve (12SOL) are provided to prevent the compressor suction pressure from dropping below 0 PSIG. As the suction pressure tends to fall below 0 psig, the CPV modulates open to allow some discharge gas to flow to the suction side of the compressor.

A temperature actuated (remote bulb) valve (XV6) and a liquid injection solenoid valve (11SOL) are provided to insure that the suction gas is cooled to an acceptable level. As the suction gas temperature increases, XV6 modulates open to admit some liquid refrigerant into the suction side. The evaporation of this liquid cools the gas admitted through the hot gas bypass valve (CPV).

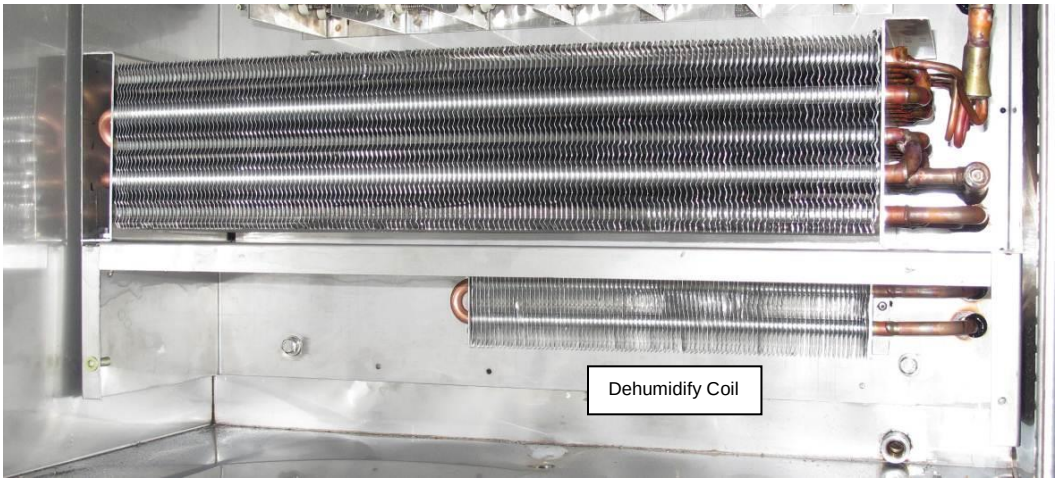
Refrigerant Flow - Temperature with Humidity Control:

Only the high stage system is used when controlling temperature with humidity operation. As a result, the low stage system turns off and the Cascade solenoid valve 9SOL closes. The temperature is controlled by regulating refrigerant flow to the Ambient Evaporator Coil through solenoid valve 1SOL. The flow of refrigerant is basically as described above.

Refrigerant Flow - Dehumidification Control:

Refrigerant flow during dehumidification continues as a liquid from the condenser, through the Dehumidify Coil solenoid valve 4SOL to the Dehumidify Coil in the chamber conditioning section. The Dehumidify Coil is located away from the main air stream to minimize sensible heat loss. Warm moist chamber air is circulated through the Dehumidify Coil and heat exchange occurs as the liquid refrigerant boils, vaporizes, and absorbs heat. The outside surface areas of the Dehumidify Coil cool. Water vapor condenses on this coil due to the reaction of warm moist air coming in contact with a cold coil surface. Heat exchange converts the refrigerant to a gas, which returns to the suction side of the compressor through an evaporator pressure regulator EPR (when provided), and through the suction line accumulator.

Note: For servicing and a more detailed description of a cascade system, please reference Servicing Cascade Refrigeration Systems, located in the Supplemental Instructions Section.



COOLING & DEHUMIDIFY COILS – C10RC

10.0 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. High and Low Pressure Cutout Switches are installed in both the discharge and suction lines of each compressor installed to measure refrigerant pressure.

High Pressure Cutout Switches – 1APS / 2APS: Discharge Side of Compressor

- High Stage Switch 1APS-HI (Used with single stage systems)
- Low Stage Switch 2APS-HI

These switches will open 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. 1APS and 2APS are designed to open above 325 PSIG.

Low Pressure Cutout Switches – 1BPS / 2BPS: Suction Side of Compressors

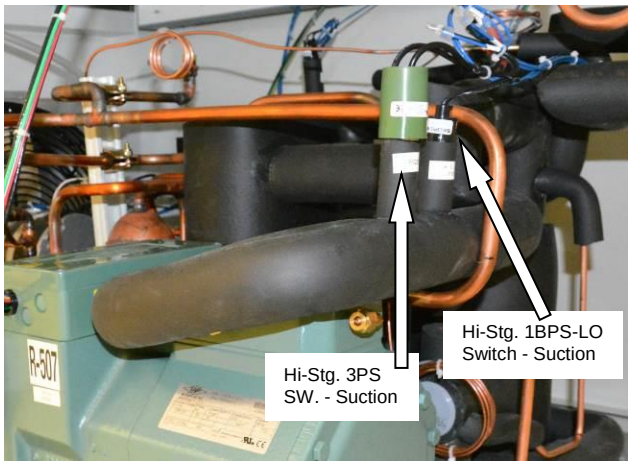
- High Stage Switch 1BPS-LO (Used with single stage systems)
- Low Stage Switch 2BPS-LO

These switches will open 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). 1BPS and 2BPS are designed to open below 15 inches of vacuum.

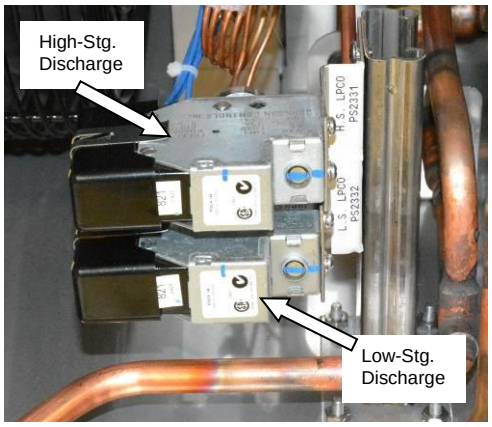
Alarm Condition: (All switches will automatically reset when pressure conditions return to normal.)

When any of the pressure cutout switches open, you must press the ACK All Alarms button on the HMI.

Note: If a compressor continues to trip OFF, have the system checked by a qualified refrigeration system mechanic.



HIGH STAGE COMPRESSOR PRESSURE SWITCHES



HIGH PRESSURE CUT-OUT SWITCHES

Compressor Protection Module (1PM, 2PM):

Contact of 1PM / 2PM will open if a preset motor temperature is exceeded which may result from a locked rotor, a loss of charge, or a motor overload. This relay module also locks the compressor off if a low line voltage condition occurs. The protection module is installed inside the compressor junction box.

System Reset: In order to reset the compressor protection module, you must cycle power with the Main Power Disconnect Switch 1CB only.

11.0 HUMIDITY SYSTEM

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

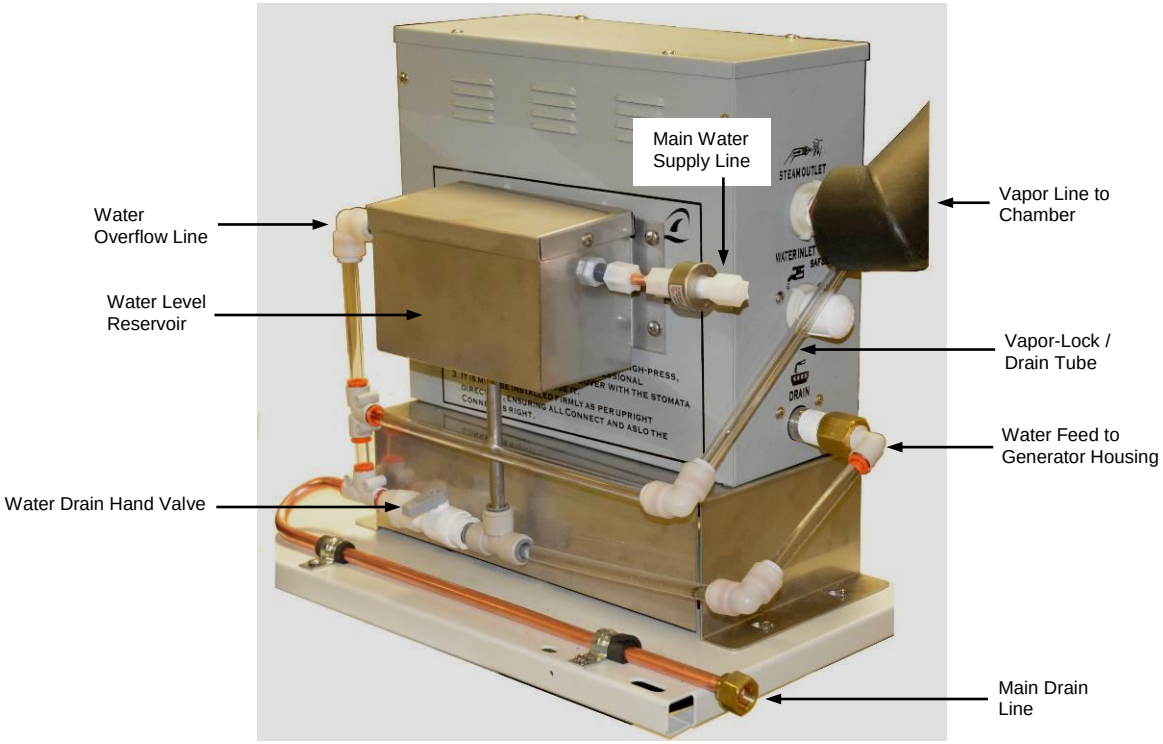
11.1 System Overview

Vapor-Flo IV 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 stainless steel housing. A small stainless steel water reservoir with a float valve is attached to the side of the main housing. Power to the heater is time proportioned by the controller output to produce a supply of vapor that has a quick and smooth response time. The build-up of vapor pressure in the generator housing 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 generator housing cannot 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.

The Vapor-Flo IV comes equipped with a 1.5 KW immersion heater that can generate the following water vapor rate.

- 1.5 KW: Approx. 4.65 lbs. water vapor per hour with 1.0 GPH water supply.



VAPOR-FLO IV HUMIDITY GENERATOR – MOUNTED ON MODEL CEO UNIT

11.2 Design / Operational Features

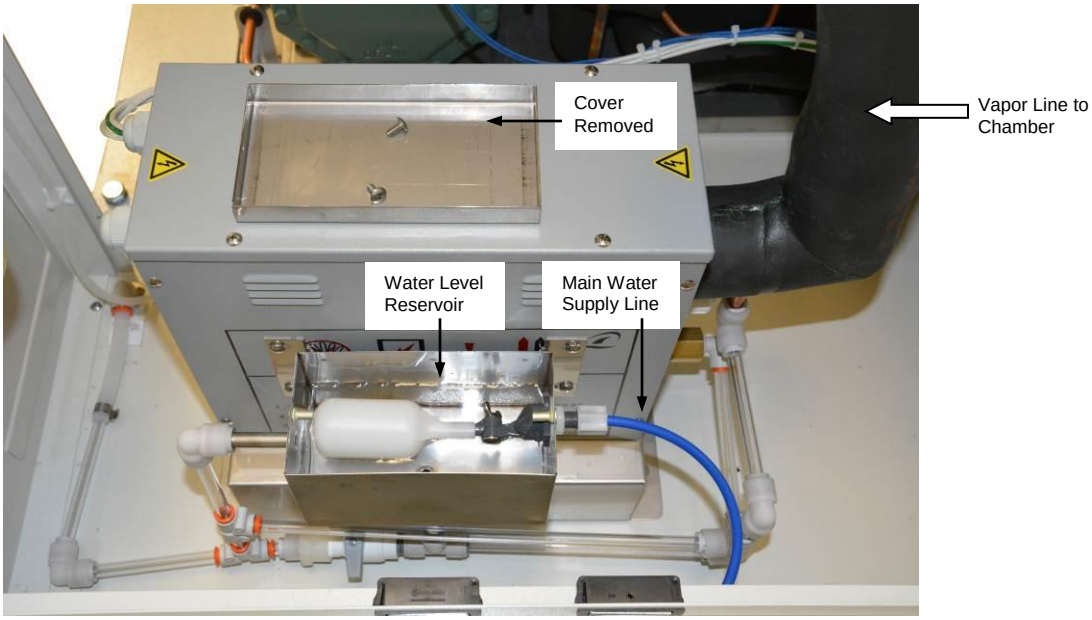
The main generator housing is supplied with water from the attached **water supply level reservoir** by a gravity feed line. This line runs from the base of the reservoir to the base of the generator housing. Either demineralized or single distilled water is supplied to the water level reservoir through an inlet port with an integral shut off float valve. The float valve is positioned to maintain a water level in the main generator housing that is approximately 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. Generated vapor flows out of the vapor port at the top of the housing and through the insulated vapor line to the chamber. A vapor-lock tube connects the vapor line to the generator water feed line.

Important: Make sure the water level in the water level control reservoir is maintained at the water level locator (L bracket) mounted on the inside of the reservoir as described in Section 5.8.

An overflow line is provided to drain excess water from the reservoir should the float valve fail open. This line runs to the machinery base condensate drip pan. When the optional condensate pump is employed, the overflow drain line will be run into the pump. A drain **handvalve** is also provided to drain the reservoir and main housing for maintenance.

Internal Generator Protection Features:

An electric water level sensor is also installed inside the generator housing to insure that the proper water level is maintained within the main reservoir. **High limit thermostats** are attached to the internal main reservoir housing to protect against an overtemperature condition. This may arise if the water level drops to an unsafe level and the water level sensor fails to detect this.



VAPOR-FLO IV HUMIDITY GENERATOR – MOUNTED IN MODEL C20RC

11.3 Humidity Control

Humidification:

Power to the electric immersion heater is time proportioned by the main controller's Channel 2 Humidity Control Output, which will energize the Humidifier Solid State Relay 2SSR to supply power to the heater.

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

REFERENCE PHOTO

SOLID STATE RELAY

Dehumidification:

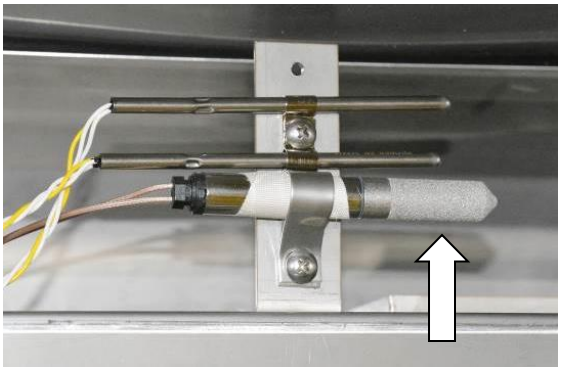
Dehumidification is achieved using the refrigerated dehumid coil mounted at the base of the conditioning plenum, slightly away from the circulating airstream. Warm moist air migrates to the coil and condenses. Refrigerant is fed to the coil with the time proportioned Channel 2 Dehumid Control Output of the main controller.

DEHUMID COIL

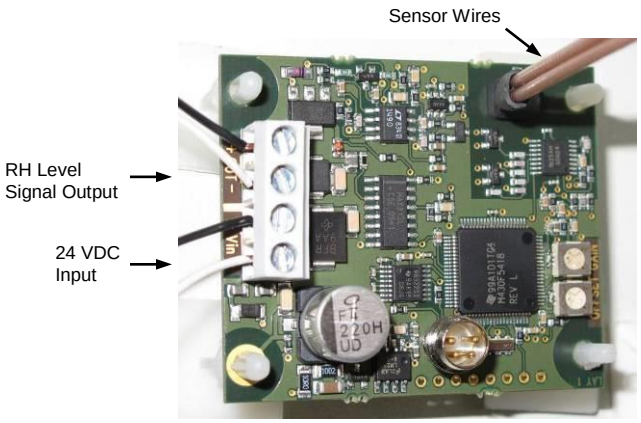
11.4 Humidity Sensor / Module – Vaisala HMM100

A Vaisala Model HMM100 Humidity Module is used to measure chamber humidity using a dry capacitance type humidity sensor. The sensor is mounted in the discharge air of the conditioning plenum and measures approximately 3.3" long, 0.5" diameter. **Temperature compensation for the sensor is included** across the operating temperature range using an integrated PT1000 sensor.

The humidity transmitter module is an open board type, which is mounted in the control cabinet. Output signals from the sensor are fed to the module, which converts them to a 0 - 5 VDC signal, representing 0 to 100% relative humidity. This signal is sent to the Humidity Channel, Channel No. 2 of the main controller. The transmitter is powered by a small 24 VAC transformer.



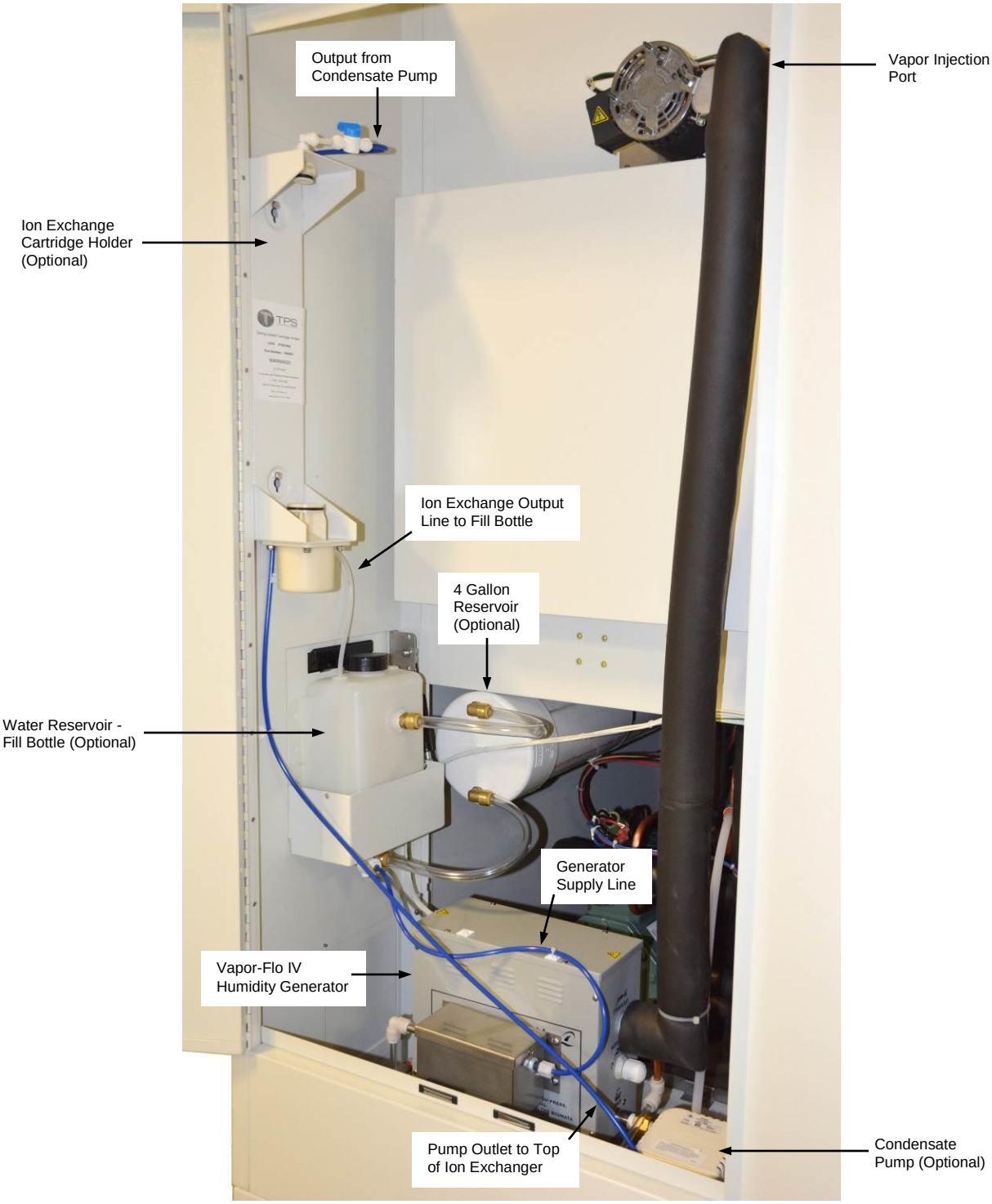
VAISALA HMM100



HMM100 MODULE

11.5 Humidity System Layout with Options

Several available options for the humidity system are installed in the photo below.



HUMIDITY SYSTEM with OPTIONS – C30RC

12.0 SMART 1.0 TEMPERATURE / HUMIDITY CONTROLLER

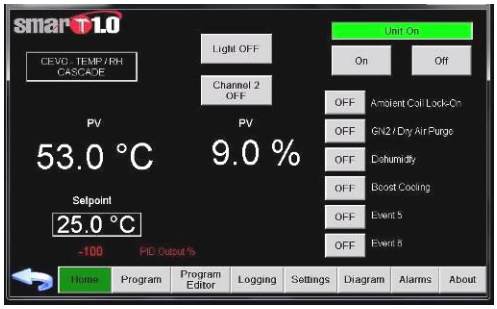
12.1 Controller Features

Temperature and humidity conditions are controlled by the Smart 1.0™ Controller. This one / two channel controller employs a 7" color touchscreen terminal that incorporates powerful graphics capabilities using Eaton Corporation Model XV100 PLC / HMI. The control system is outfitted with Eaton's SmartWire-DT™ technology. SmartWire connects devices to the PLC DIN-rail mounted modules.

Programs are in the form of **CSV** files. These can be created on the controller via a program editor wizard, moved from another unit or library with a USB stick, or by a network connection. Data communications is provided in Ethernet or Modbus RTU RS-485. RS-232 and IEEE are optional. Remote Client and VNC application software can be used with Ethernet to provide a real time interactive display on a PC.

Channel One controls temperature using an RTD sensor for temperature measurement. Channel Two controls humidity using a dry capacitance type humidity sensor for humidity measurement. Logic circuits automatically select cooling and heating modes as required, with total programming capabilities of temperature versus time.

The main features are listed below.



- 2 Channel
- Single Setpoint – Manual Selectable Control
- Programmable Control – Selectable: Programs are created in named CSV files. A list box enables the user to edit or load a CSV program.
- Programs – Up to 100 viewable programs on HMI
- Program Steps – Up to 99 Steps in each program
- 2 Process Inputs: Chan. 1 - 100 Ohm Platinum RTD, Chan. 2 - Dry Capacitance Humidity Sensor
- 4 PID Loops
- Ramp / Soak Programming For All PID Loops
- Temperature Control Outputs - PID / On-Off
- Humidity Control Outputs - PID / On-Off

- 5 Event Outputs
- Alarm Output for Each Channel
- Ethernet / IP, Modbus / TCP Communication
- USB Port: This port is used to download data logging files from the Smart 1.0 Controller. Data logging is stored as a .CSV File.

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 manual for programming details.

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.

Smart 1.0™ HMI Controller Operation Manual:

This manual provides a great wealth of information about the many unique functions of the controller. It is a very comprehensive manual that guides you through operating screens and procedures with an easy to read format. The manual is located in the Supplemental Instructions Section of the 3-ring binder.

12.2 Navigation Button Functions

Button	Functions	HMI Manual Section
Return Arrow	Return to the previous screen from any screen.	N/A
Home	Chamber operation in manual mode – can edit screen.	4.1
About	TPS Contact Info. Software, Address, and Memory Storage Info.	4.2
Settings	**Log In** & **Password Change**, Access to Factory, User, and L Value Settings, Data Communications Settings, Update HMI / PLC Procedure	4.3
Program Editor	View, edit, create, delete, load, and auto-start programs.	4.4
Program	Chamber operation in program mode – can edit screen.	4.5
Logging	View Trending Screen, Select data to log, File transfer.	4.6
Alarms	Current / Historical alarms & messages, Acknowledge alarms, Configuration.	4.7
Diagram	Real-time display diagram of active chamber conditioning system.	4.8

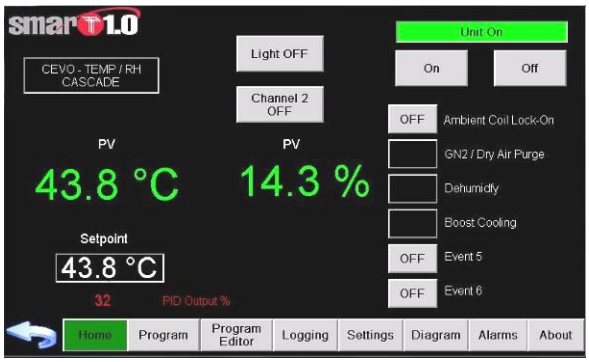
Return to Previous Screen Button

12.2 SCREEN NAVIGATION GUIDE

The following screens appear immediately upon pressing the **main navigation buttons**.

HOME Screen

Home

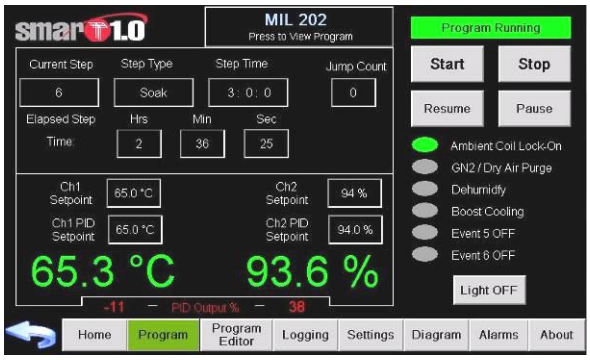


The Home Screen is the first screen that appears after a successful power-up of the chamber. This screen permits single setpoint / manual control of your chamber.

Channel 2 can be turned ON and OFF. Setpoints for both Channel 1 and 2 can be entered. Optional equipment and Event outputs can be turned ON and OFF.

PROGRAM Screen

Program



The Program Screen permits operation of your chamber in the program mode. After loading the program to run through the Program Editor Screen, you can start, stop, pause, and resume the program with the Program Screen.

The entire program step listing can be viewed from the “Press to View” program window at the top.

Optional equipment and Event outputs ON / OFF statuses are displayed.

PROGRAM EDITOR Screen

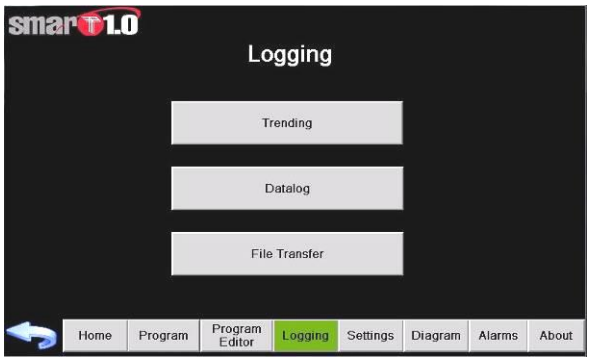
Program Editor

The Program Editor Screen permits you to advance to the following functions and screens.

- Load Program To Run
- View / Edit Program – Create up to 99 steps in each program
- Create New Program - Up to 100 Programs
- Delete Program
- Auto Start Setup

LOGGING Screen

Logging

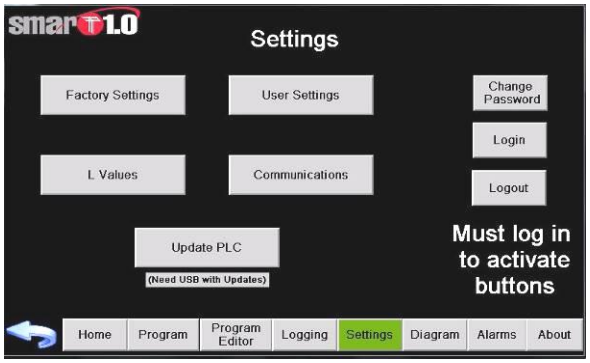


Provides access to the following screens that can be edited.

- Trending Screen – Temp. & Humidity Graphs
- Datalog Screen – Select information to log and logging interval. Start / Stop logging.
- File Transfer – Transfer program files between controller SD card and USB Drive.

SETTINGS Screen

Settings

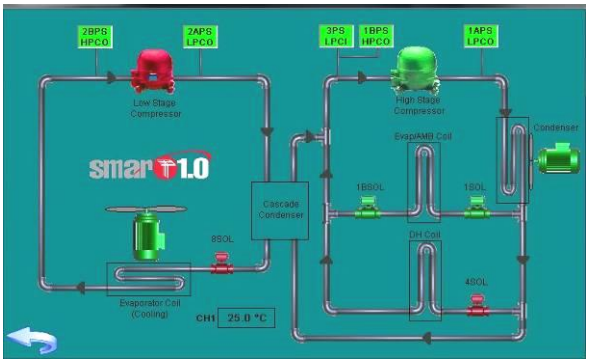


Provides access to the following screens and settings that can be edited.

- Log In & Password Change
- Factory Settings Screen – Select Model, Chan. 1 & 2 Setup, and Options
- User Settings Screen – Set PIDs, ° C / ° F, and Output Retransmit Configuration
- L Values Screen – Set parameters for the programmable logic that controls processes.
- Data Communication Settings
- Update HMI / PLC Software

DIAGRAM Screen

Diagram

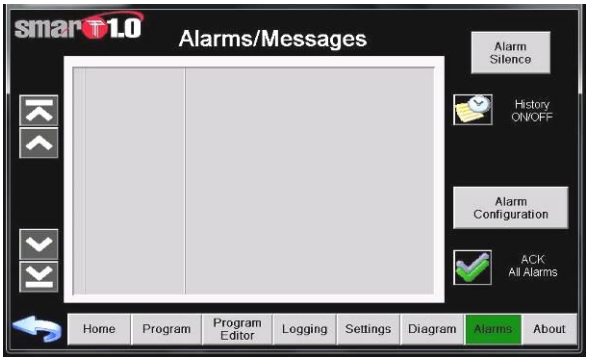


Displays your chamber conditioning system operation in real-time. Equipment and controls that are turned ON are displayed in green. (Red is OFF or not activated.) A conditioning system diagram will be viewable with the following CEVO chamber types.

- Temperature Only – Single Stage
- Temperature Only – Cascade
- Temperature / Humidity – Single Stage
- Temperature / Humidity – Cascade

Alarms

ALARMS Screen

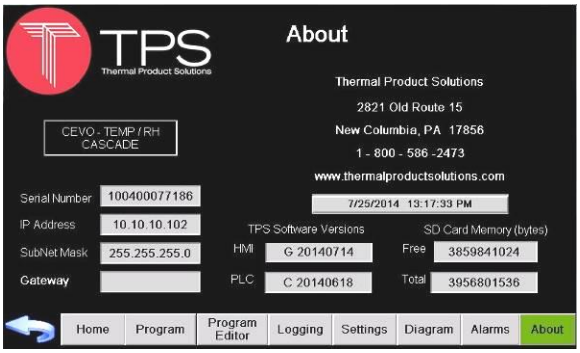


The Alarms Screen permits you to set up your high, low, and deviation alarm setpoints for Channel 1 and 2, and will display the active alarm condition with the date and time it occurred. The following functions and screens are accessible.

- Alarm Acknowledge Button
- Alarm Silence Button
- **Alarm Configuration** Button permits the setup of **low, high, and deviation alarm setpoints** for Channel 1 & 2.
- Access to Alarm History Screen

About

ABOUT Screen



The About Screen displays the following software versions, addresses, memory storage, and other information pertinent to your Smart1.0 Controller.

- TPS Company Contact Information
- Controller Serial Number & IP Address
- SubNet Mask Address
- Gateway Address
- TPS Software Versions for HMI & PLC
- SD Card Memory (bytes) - Free & Total

12.3 Conditioning Control Functions

The following are the functions of the various outputs of the Smart 1.0 HMI / PLC. The Cooling Control outputs of single stage refrigeration systems and cascade refrigeration systems are separately described.

- AIR CIRCULATION -

When the chamber is started in either the single setpoint mode or the program mode, Contactor 1M will close to energize the conditioner motor.

- HEAT CONTROL -

The time proportioned Heating PID Output will energize the Heat Control Relay to provide power to the electric heaters mounted in the conditioning plenum. Heat Enable Contactor 2CON must first be enabled by PLC logic.

- COOLING CONTROL - SINGLE STAGE REFRIGERATION SYSTEM -

The Compressor Output will energize Contactor 4CON to start the compressor. Contactor 2M will be energized to start the air-cooled condenser motor (air-cooled systems). Only moderate cooling occurs as refrigerant flows through a restrictive capillary tube to the evaporator cooling coil mounted in the conditioning plenum. 4CON will also energize the window heater.

Temperature Only Conditioning

Full cooling occurs when the time proportioned Cooling Output energizes the Cooling solenoid valve 8SOL. Refrigerant flow now bypasses the capillary tube through 8SOL, and is regulated by a Thermostatic Expansion Valve as it flows to the evaporator cooling coil mounted in the conditioning plenum.

The door frame heater will be energized by the Full Cooling Output whenever chamber setpoint is +20° C or below.

Temperature with Humidity Conditioning (Temp. / Humidity Chambers)

In single stage systems, the main evaporator cooling coil is also used during temperature conditioning with humidity control.

In addition to 8SOL being energized as described with the temperature only conditioning, the time proportioned Ambient Cooling Output will energize the Ambient Coil solenoid valve 1BSOL on the suction side of the evaporator cooling coil. An EPR valve is used in the suction line to permit only moderate cooling. When humidity conditioning is turned OFF, the L.S. Compressor 5CR Relay Output will energize and open the Full Cooling Suction solenoid valve 8BSOL. Normally closed 5CR contacts will open and cause 1BSOL to deenergize and close.

Ambient Coil Lock-ON: Cooling with the ambient cooling coil during humidity conditioning may be locked ON. This control is primarily intended for use at ambient temperatures to provide improved temperature control. This is achieved by turning the Ambient Coil Lock-On Event ON, in either the HOME Screen (single setpoint) or in the Program Editor Step Wizard Screen.

- COOLING CONTROL - CASCADE REFRIGERATION SYSTEM -

The High Stage Compressor Output will energize Contactor 4CON to start the high stage compressor, which cools the cascade condenser. The Low Stage Compressor Output will then energize Contactor 5CON to start the low stage compressor. Contactor 2M will be energized to start the air-cooled condenser motor (air-cooled systems). Only moderate cooling occurs as refrigerant flows through a restrictive capillary tube to the evaporator cooling coil mounted in the conditioning plenum. 4CON will also energize the window heater.

Temperature Only Conditioning

Full cooling occurs when the time proportioned Cooling Output energizes the Cooling solenoid valve 8SOL. Refrigerant flow now bypasses the capillary tube through 8SOL, and is regulated by a Thermostatic Expansion Valve as it flows to the evaporator cooling coil mounted in the conditioning plenum.

The door frame heater will be energized by the Full Cooling Output whenever chamber setpoint is +20° C or below.

Temperature with Humidity Conditioning (Temp. / Humidity Chambers)

In cascade systems, a separate ambient evaporator cooling coil is employed in the chamber conditioning plenum for cooling during humidity conditioning. Only the high stage compressor is turned on. The time proportioned Ambient Cooling Output will energize and open the Ambient Coil Feed solenoid valve 1SOL and the Ambient Coil Suction solenoid valve 1BSOL. Refrigerant flow through 1SOL is regulated by a Thermostatic Expansion Valve to the ambient cooling coil.

Ambient Coil Lock-ON: Cooling with the ambient cooling coil during humidity conditioning may be locked ON. This control is primarily intended for use at ambient temperatures to provide improved temperature control. This is achieved by turning the Ambient Coil Lock-On Event ON, in either the HOME Screen (single setpoint) or in the Program Editor Step Wizard Screen.

- HUMIDITY CONTROL - HUMIDIFICATION -

The time proportioned Humidity PID Output will energize the Humidity Control Relay to provide power to the electric immersion heater Vapor-Flo Humidity Generator to produce water vapor. Humidity Enable Contactor 3CON must first be enabled by PLC logic.

- HUMIDITY CONTROL – DEHUMIDIFICATION -

The time proportioned Refrigeration Dehumidify Output will energize and open the Dehumidify Coil solenoid valve 4SOL, which permits refrigerant flow to the Dehumidify Coil in the chamber conditioning plenum.

In single stage systems, the Compressor Output will energize Contactor 4CON to start the compressor. In cascade systems, the High Stage Compressor Output will energize Contactor 4CON to start the high stage compressor.

Dehumidification with Optional Air Dryer:

Dehumidification of chamber air may be achieved utilizing the optional heatless desiccant air dryer. The Dry Air Dehumid Event must be turned ON in in either the HOME Screen (single setpoint) or in the Program Editor Step Wizard Screen. The PLC will energize the air dryer through the Dehumid Dryer Output. Time proportioned dehumidification control is achieved with the Dehumid Dry Air Output, which will energize and

open the Dry Air Dehumid solenoid valve SOL1111. Dry air will be injected into the chamber conditioning plenum and mix in smoothly with the circulating process air.

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

Event Output No. 1: This output must be turned ON to .....

Event Output No. 2: This output must be turned ON to .....

Event Output No. 3: This output must be turned ON to .....

Event Output No. 4: This output must be turned ON to .....

Event Output No. 5: This output must be turned ON to .....

Event Output No. 6: This output must be turned ON to .....

13.0 TEMPERATURE ALARM & SHUTDOWN CIRCUITS

13.1 System Overview

A comprehensive alarm and shutdown circuit may be provided for multiple protection against chamber overtemperature and product over/under temperature. The sensors utilized for temperature measurement / sensing are normally placed in the discharge airflow at the top of the conditioning plenum. This is the most responsive area of the chamber. The heat limiter is placed next to the blower housing.

Chamber Over Temperature Protection:

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 (464° F). 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

.

Chamber and / or Product Over / Under Temperature Protection:

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

1. **Smart 1.0 Controller** - - Process and Deviation Alarms (Standard)

2. **Watlow EZ Zone Limit Controller** - - TempGard IV Feature - High / Low Limits (Optional)

   The Watlow EZ Zone Limit is a 1/16 DIN single channel non-profiling type controller that is installed on the TempGard IV control panel.

Watlow EZ Zone Limit

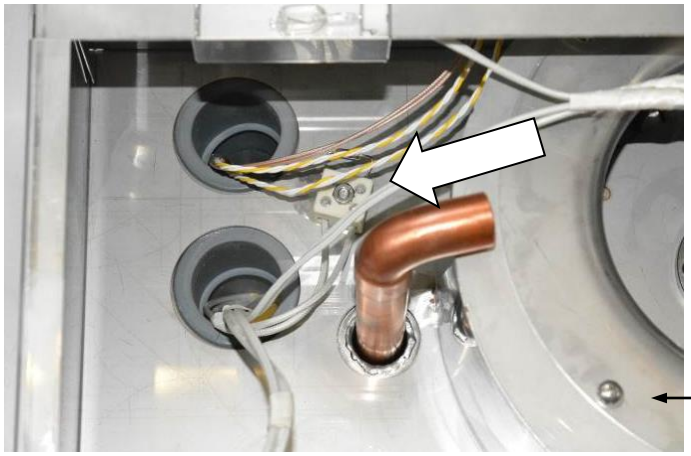
13.2 Opened Heat Limiter (Thermal Cutoff)

The heat limiter is a temperature actuated, axial leaded, one-shot protection device that is mounted in a small white ceramic terminal block. This device is mounted on the left side of the blower housing above the electric heaters.

Heat limiters conduct electrical current but only react to excessive temperature. They utilize a meltable pellet that holds down a spring. Once the pellet melts, the spring is permanently released and the circuit is broken, so it behaves like an electrical fuse. The type of pellet and spring assembly used determines the temperature rating.

For C-EVO Chambers, the heat limiter is designed to open when the surrounding air temperature reaches 240° C (464° F). When a predetermined high temperature limit is reached and the Thermal Cutoff opens, power will be removed from the conditioning control circuitry. The alarm buzzer will sound.

When the Thermal Cutoff opens, it must be replaced.



HEAT LIMITER LOCATION

Heat Limiter (Thermal Cutoff) Replacement:

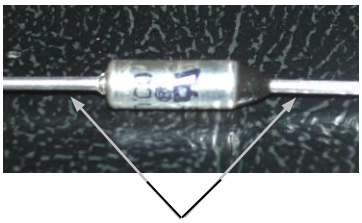
Before replacing the Thermal Cutoff, make sure all power is completely disconnected from the chamber. Pull the power supply plug from the power supply receptacle (when provided) and perform your company Lock Out / Tag Out procedure.

1. Remove plenum cover.

2. Loosen the 2 appropriate screws on the bottom side of the white ceramic mounting block using a flat blade screwdriver. Pull out the Thermal Cutoff with needle nose pliers.

3. Bend the leads of a new Thermal Cutoff as indicated below. Insert it into the ceramic block, and tighten the 2 screws.

Thermal Cutoff

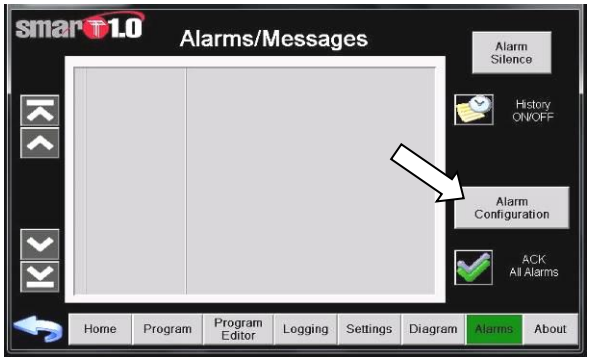


You must place needle nose pliers as shown before bending each lead. Otherwise, you may damage the device.

13.3 Smart 1.0 Controller Over / Under Temperature Protection Setup

To set up your over and under temperature and humidity alarm setpoints, go to the Alarms Screen and press the **Alarm Configuration** button.

Note: See Section 4.7 of the Smart 1.0 HMI / PLC Controller Manual for a full description of the Alarms Screen.

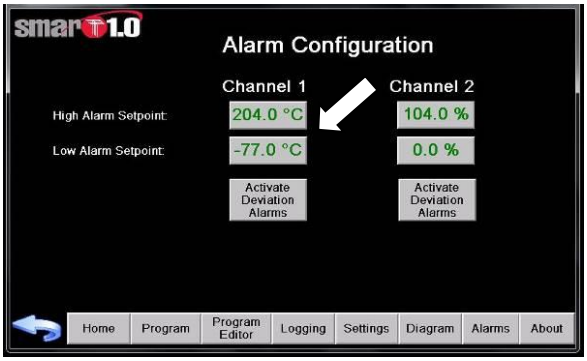


ALARMS SCREEN

Press the **High / Low Alarm Setpoint** buttons for Channel 1 and 2 to enter your setpoints. The keypad will appear for each.

Note: The high / low temperature and humidity alarm setpoints are preset at the factory and should normally not be changed.

Press the **Activate Deviation Alarms** buttons for Channel 1 and 2 to enter your setpoints. The keypad will appear for each.



ALARM CONFIGURATION SCREEN

13.4 Main Controller, or Optional TempGard IV Alarm Condition

When a preset temperature limit is reached within the main controller or the TempGard IV, the corresponding alarm contacts will open to remove power from the conditioning control circuitry. The alarm buzzer will sound.

- Smart 1.0 Controller alarm: You must press the **ACK All Alarms** button to clear the alarm.
- Watlow EZ Zone Limit TempGard IV alarm:

  THE TEMPGARD IV MUST BE RESET BY PRESSING THE RESET KEY ON THE EZ ZONE CONTROLLER FACEPLATE.

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.

14.0 TempGard IV ALARM SETPOINT ENTRY – WATLOW EZ (Optional)

The purpose of this section is to explain how to set your low & high temperature alarm setpoints with the optional **Watlow EZ Zone TempGard IV**. This feature is normally used for product over / under temperature protection and can be changed for each process cycle desired. However, it can also be used for chamber temperature protection, which is the factory preset default. It is part of the Alarm and Shutdown Circuit described earlier.

Watlow EZ Zone Limit

Normal Conditions: When conditions are within the alarm setpoints, the upper display of the EZ Zone 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, which is placed in the discharge air of the conditioning plenum.

Alarm Setpoint Entry Procedure:

This controller incorporates preconfigured software that is designed for this particular type of test chamber. Operations and Setup type parameters have been set at the factory and cannot be changed. Only the high and low limit setpoints can be changed with the procedure below.

1. Press the Advance key one time. The High Limit Setpoint “Lh.S1” parameter will appear in the green lower display, while the current setpoint for that parameter will be displayed in the upper display.

2. Press the Up or Down arrow key to adjust the High Limit Setpoint. Please note that the preprogrammed software already has the maximum High Limit Setpoint permitted for this particular chamber. As a result, as factory received, you can only adjust the High Limit downward.

3. Press the Advance key one time. This will register the new High Limit Setpoint value.

   The Low Limit Setpoint “LL.S1” parameter will appear in the green lower display, while the current setpoint for that parameter will be displayed in the upper display.

4. Press the Up or Down arrow key to adjust the Low Limit Setpoint. Please note that the preprogrammed software already has the maximum Low Limit Setpoint permitted for this particular chamber. As a result, as factory received, you can only adjust the Low Limit upward.

5. Press the Advance key one time. This will register the new Low Limit Setpoint value. The upper display will now show the current process temperature.

Alarm Conditions: When an out of limit condition occurs the green lower display will flash “Attn”, while the red upper display will flash “LıH1” for a high limit alarm and “LıL1” for a low limit alarm. This will alternate with the actual process temperature in the upper display. The alarm buzzer will sound.

Important: When the alarm condition has cleared, you must first press the Reset key on the EZ Zone faceplate to reset the EZ Zone TGIV alarm contacts.

You must then press the red lighted RESET pushbutton on the TGIV panel. This will reset the chamber main control circuitry.

Saving and Restoring User Settings (Copied from the Watlow Limit Controller Manual):

Recording setup and operations parameter settings for future reference is very important. If you unintentionally change these, you will need to program the correct settings back into the controller to return the equipment to operational condition.

After you program the controller and verify proper operation, use User Save Set - "**USr.S**" (Setup Page, Global Menu) to save the settings into either of two files in a special section of memory. If the settings in the controller are altered and you want to return the controller to the saved values, use the User Restore Set - "**USr.r**" (Setup Page, Global Menu) to recall one of the saved settings.

A digital input or the Function Key can also be configured to restore user settings.

Note: Only perform the above procedure when you are sure that all the correct settings are programmed into the controller. Saving the settings overwrites any previously saved collection of settings. Be sure to document all the controller settings.

15.0 DRY AIR PURGE / DEHUMIDIFICATION SYSTEM (Optional)

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

A Dry Air System may be employed as an option for either purging or dehumidification applications. This system incorporates a heatless desiccant dryer for the generation of a controlled flow of dry air into the chamber. A **Strato-flo check valve** is mounted on top of the chamber to insure that the chamber does not become pressurized.

15.1 Dry Air Purge System

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

Operation:

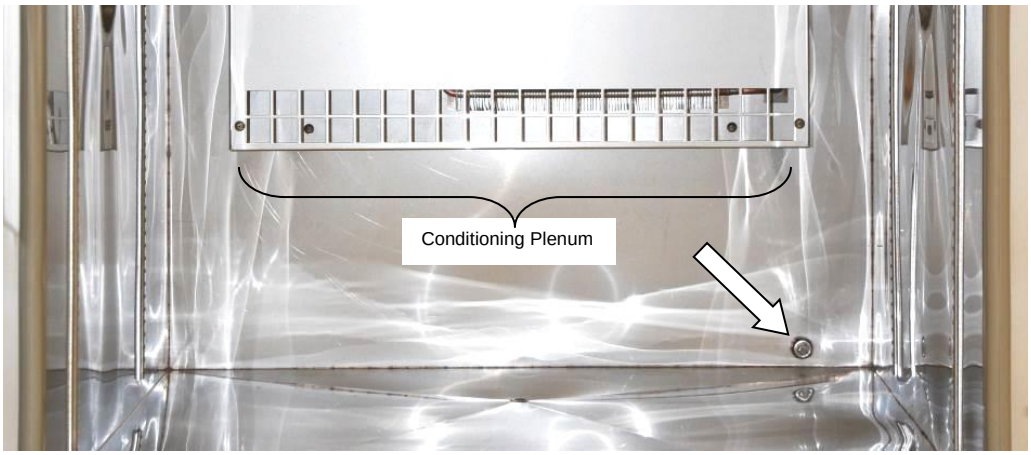
The Dry Air Purge System is activated by an Event Output of the main controller. When activated, this event output will energize the twin tower heatless dryer. It will also energize and open the Dry Air Purge solenoid valve ASOL to permit the injection of dry air into the chamber conditioning plenum.

15.2 Dry Air Dehumidification System

A Dry Air Dehumidification System may be employed to dehumidify chamber air 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 an Event Output of the main controller. When activated, this event output will energize the twin tower heatless dryer. It will also energize and open the Dry Air Dehumid solenoid valve ASOL to permit the injection of dry air into the chamber conditioning plenum.

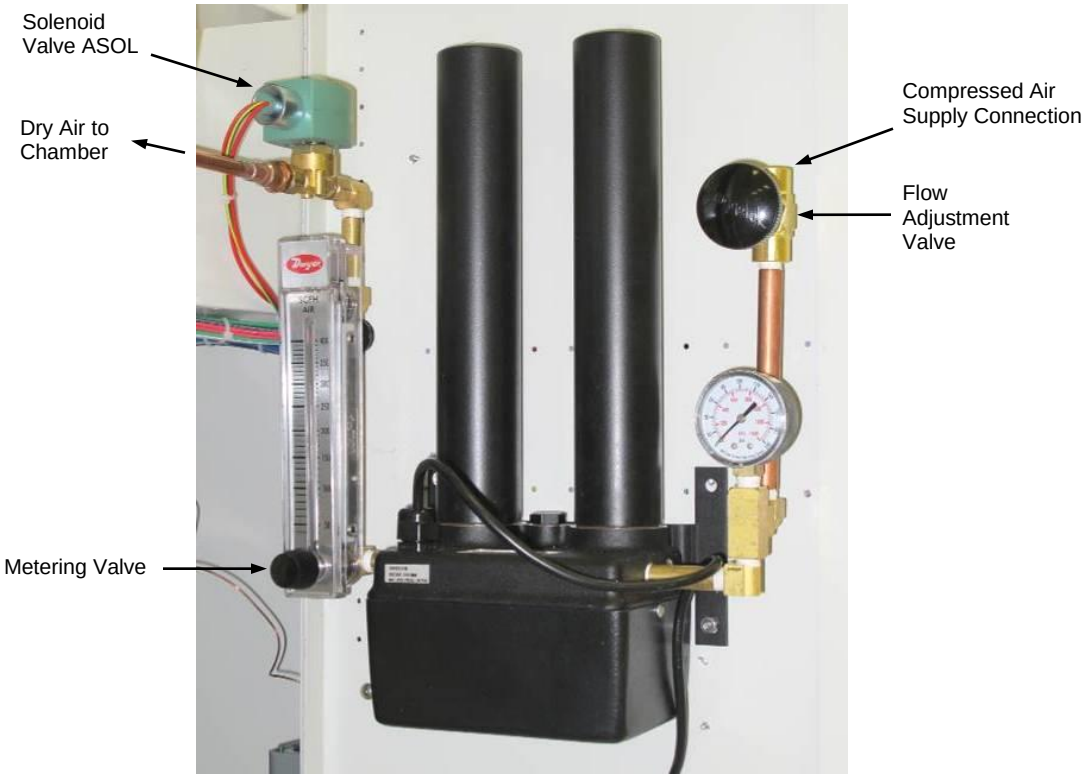


DRY AIR, GN2, or CO2 INJECTION PORT – MODEL C20RC

15.3 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.

A metering valve and flowmeter is supplied as part of the system to establish the designed air flow. The valve should be adjusted until the indicated flow is about 300 cubic feet per hour.



DRY AIR PURGE / DEHUMID SYSTEM

16.0 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 Strato-flo check valve.

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.

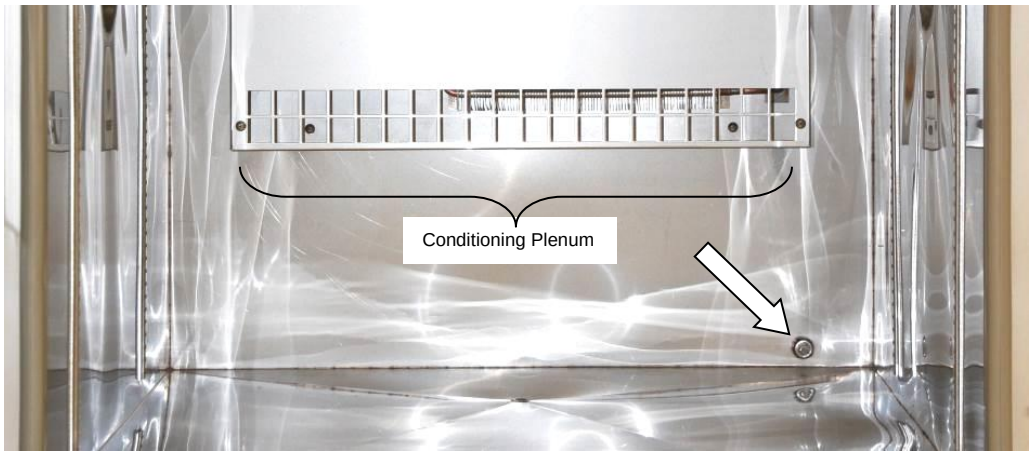
Gaseous nitrogen is injected into the chamber through a header pipe in the conditioning plenum and readily mixes in with circulating process air. A **Strato-flo check valve** is mounted on top of the chamber to insure that the chamber does not become pressurized.

Operation:

The GN2 Purge Air System is activated by an Event Output of the main controller. When activated, this event output will energize and open the GN2 Purge solenoid valve GN2SOL to permit the injection of GN2 into the chamber conditioning plenum.

A metering valve and flowmeter is supplied as part of the system to establish the design purge air 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.



DRY AIR, GN2, or CO2 INJECTION PORT – MODEL C20RC

17.0 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 Strato-flo check valve.

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 at the base of the conditioning plenum. 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. A **Strato-flo check valve** is mounted on top of the chamber to insure that the chamber does not become pressurized.

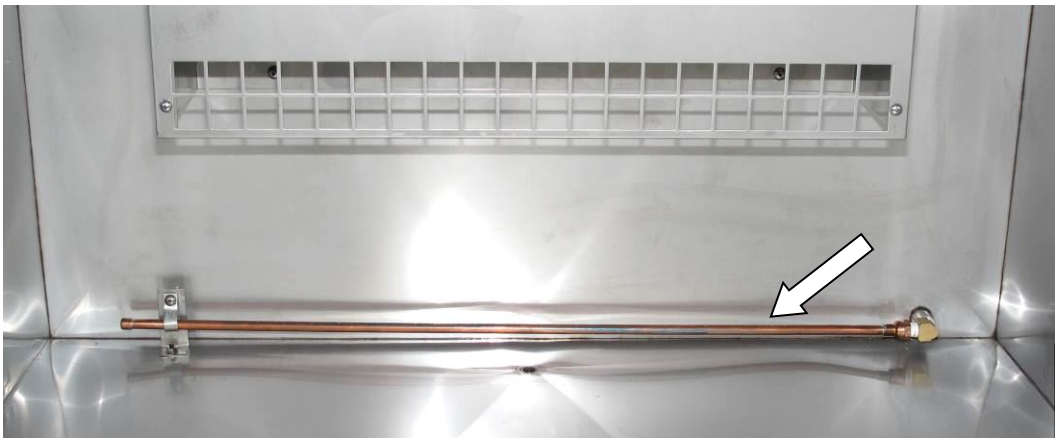
LN2 systems are provided with a manually set flow adjustment valve, which permits the adjustment of nitrogen flow to avoid incomplete evaporation at varying LN2 supply pressures. As the chamber cools to the extreme cold temperature limit, complete evaporation of liquid nitrogen may not occur if the supply 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 Boost Cooling System is activated by an Event Output of the main controller. When activated, this event output will energize and open the LN2 Boost Cooling solenoid valve SOL to permit the injection of LN2 into the LN2 header located in the base of the conditioning plenum.

There is a 10 second delay in the controller logic before the Boost Cooling solenoid valve SOL will be energized, as long as the Full Cooling output remains ON.



LN2 BOOST COOLING HEADER – MODEL C30

18.0 CO2 BOOST COOLING SYSTEM (Optional)

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

Warning! Carbon dioxide displaces oxygen. Make sure the area surrounding the chamber is well ventilated to dilute the gas vented from the Strato-flo check valve.

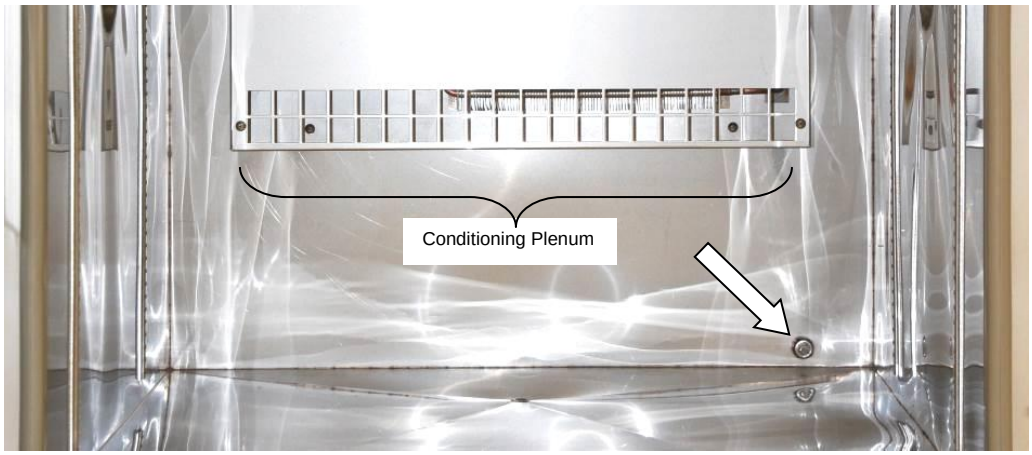
General Description:

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. A **Strato-flo check valve** is mounted on top of the chamber to insure that the chamber does not become pressurized.

Operation:

The Boost Cooling System is activated by an Event Output of the main controller. When activated, this event output will energize and open the CO2 Boost Cooling solenoid valve SOL to permit the injection of CO2 through the orifice located at the base of the conditioning plenum.

There is a 10 second delay in the controller logic before the Boost Cooling solenoid valve SOL will be energized, as long as the Full Cooling output remains ON.



DRY AIR, GN2, or CO2 INJECTION PORT – MODEL C20RC

19.0 CHART RECORDER (Optional)

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 by a dedicated 100 ohm platinum RTD. Channel 2 (or Pen 2) records humidity as measured by the 0-5 VDC output signal from the humidity transmitter. This same signal is fed to Channel 2 of the main controller.

Note: Some configurations may incorporate a humidity level retransmit signal from the main controller to the chart recorder.

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.

HONEYWELL DR4300

HONEYWELL DR4500 TRULINE

Note: The DR4500 Truline recorder draws its own chart (in real time) as it plots temperature / humidity / pressure (as applicable) for each channel. Up to four channels may be employed.

Note: Other models may be provided.

20.0 SEQUENCE OF OPERATION

WARNING! This equipment is not designed for use with volatile or explosive materials unless it is equipped with a solvent venting package or intrinsically safe interior design, and specifically stated in your chamber specifications. Loading of such materials may result in explosion or fire.

Important! Make sure you have read (and understand) this entire manual before beginning operation.

Important! **Make sure the Installation Instructions have been properly followed before operating the chamber.**

Important! Always shut down the humidity system when pulling down to a very low temperature!

Important! Do not open the chamber door immediately after running at extreme low temperatures. Warm the chamber temperature to ambient conditions before opening the chamber door.

Note: Smart 1.0 Controller: **Channel 1** = Temperature **Channel 2** = Humidity

1. Turn on the main power source to the chamber and close the main power disconnect switch.

   The Smart 1.0 Controller will go through a boot-up routine and display the Home Screen when completed. If any errors occur during the boot-up, a red error banner will be displayed across the screen.

2. Load product and close the chamber door securely.

3. Make sure your alarm setpoints on the Alarm Configuration Screen are properly set. The high / low alarm setpoints have been factory set to ± 4° C for the high / low ratings of your chamber and should not be changed.

4. If you wish to use the optional **TempGard IV feature** of the Watlow EZ Zone Controller for product over / under temperature protection, set the Watlow EZ Zone's high / low temperature limits at this time. Refer to the "Temperature Alarm and Shutdown Circuit", and the "Watlow EZ Zone - TempGard IV Alarm Setpoint Entry" sections for further details.

   If you wish to use the optional **TempGard IV feature** for chamber over / under temperature protection, **do not change the factory preset values**. **These have been set to ± 4° C for the high/low ratings of your chamber**.

5. Enter the desired temperature or temperature / humidity program or manual setpoints into the Smart 1.0 Controller. Follow the Smart 1.0™ HMI Controller Operation Manual for complete details on how to set up and operate your chamber.

6. Make sure the proper Event Outputs are turned ON in the appropriate HMI screens, when and where applicable. The following Event Outputs that control standard and optional equipment are listed below.

   - Ambient Coil Lock-On (Standard with Humidity Chambers Only)
   - GN2 Purge / Dry Air Purge
   - Dry Air Dehumid
   - Boost Cooling
   - Event No. 5 (For Custom Feature)
   - Event No. 6 (For Custom Feature)

   Check for the proper operation of any optional equipment used in the corresponding Options Section.

7. Upon completion of your process cycle, take appropriate precautions when removing product from the chamber. Do not open the chamber door until chamber temperature drops below 200° F (93° C). Human exposure to temperature extremes can cause injury.

Warning! **D**o not open the chamber door immediately after running at extreme low temperatures. Warm the chamber temperature to ambient conditions before opening the chamber door.

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 this manual.

21.0 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.

21.1 Chamber 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

Conditioner Fans / Blower Wheels:

 Remove All Power From Chamber!

Inspect and clean the conditioner fans / blower wheels in the conditioning plenum. Make sure the fans / blower wheels spin freely and that they are tight on their shafts.
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 ±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 Controller, perform the following alarm circuit test.
Test Period: 6 Months

a) **High Setpoint:** Enter a temperature setpoint into the TGIV Controller that is well below the actual workspace temperature. The Limit Controller must transfer to an alarm state and disable the protected circuit(s).

b) **Low Setpoint:** Enter a temperature setpoint into the TGIV Controller that is well above the actual workspace temperature. The Limit Controller 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.

21.2 Vapor-Flo IV Humidifier Maintenance

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

Maintenance:

Float Switch Operation & Water Level Check:

Remove the cover of the water level reservoir, which is located on the side of the humidity generator. Turn on the water supply. Make sure the water level in the reservoir reaches the water level locator (**L bracket**) mounted on the inside of the reservoir. Verify that the float switch shuts off the supply. Replace the cover.

The small reservoir supplies and maintains a predetermined water level in the main generator water tank so that the immersion heater is always submersed. This is achieved by the float switch assembly in the reservoir. If the water level is maintained above or below the level locator (L bracket), you must adjust the float switch assembly by loosening the **wingnut** on the inlet shaft and rotating the float assembly up or down. Make sure the float assembly doesn't slip at the newly set position when you tighten the wingnut.

Periodically check the water level in the reservoir. It is critical that the water level be maintained no lower than the level locator on the inside of the reservoir. Otherwise, little or no vapor will be produced and the immersion heater will be subject to burn-out from being exposed to air.

Inspect the float and the float switch mechanism for proper operation. If the float assembly or the inside of the reservoir shows a buildup of water deposits, drain and clean the generator as described below.
Inspection Period: 2 to 4 Weeks

Draining the Generator:

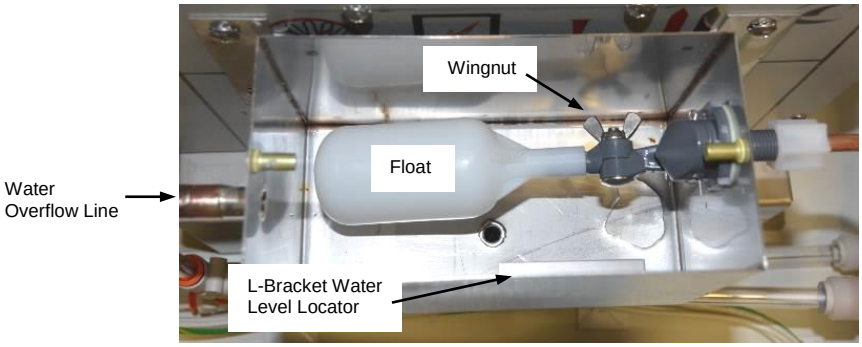
 Remove All Power From Chamber!

Drain the generator by first shutting off the water supply and then by opening the drain valve at the bottom of the generator. The drain line runs to the drain port at the left side of the chamber.
Inspection Period: 2 to 4 Weeks

Cleaning the Water Supply Level Reservoir:

 Remove All Power From Chamber!

Shut off the water supply. Drain the generator by opening the drain valve at the bottom of the generator. Remove the cover from the water supply reservoir. Wipe the inside of the reservoir with a mild cleaner. Be careful not to damage the float switch mechanism. Carefully clean and remove any water deposits from the float switch mechanism. Rinse the reservoir thoroughly.
Inspection Period: 2 to 4 Weeks



WATER LEVEL ADJUSTMENT

Spare Parts:

Spare parts are available for the small water supply level reservoir from the TPS Service Department. However, there are no internal spare parts available for the main generator housing. The entire generator housing would need to be replaced if it is found to be defective.

When you order any spare parts for the small water supply level reservoir or if the generator housing needs replaced, please specify the model and order number of the equipment served by your Vapor-Flo IV Humidity Generator.

21.3 Preventative Maintenance Schedule / Log

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

PREVENTATIVE MAINTENANCE SCHEDULE / LOG					
ITEM TO BE INSPECTED	**Inspection Period**	**Actual Date Inspected / Serviced**	**Actual Date Inspected / Serviced**	**Actual Date Inspected / Serviced**	**Actual Date Inspected / Serviced**
Door Gaskets	30 Days				
Door Sealing Quality	30 Days				
Air-cooled Condenser Coil / Fan	30 Days				
Conditioner Fan / Blower Wheel	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 Float Switch Operation & Water Level	2 to 4 Weeks				
Vapor-Flo – Drain System	2 to 4 Weeks				
Vapor-Flo – Clean Water Supply Reservoir	2 to 4 Weeks				

21.4 Chamber Troubleshooting Guide

Troubleshooting procedures in this section must only be performed by qualified personnel that possess the knowledge and skill required to successfully maintain or repair this equipment. Anyone who performs such work is responsible for his or her own safety and should use proper safe guards at all times.

This troubleshooting guide will assist in determining possible component failures. When troubleshooting, clearly define the problem before performing the recommended solution. It may be necessary to attempt to run the equipment to clearly identify the probable cause. If further troubleshooting assistance is required, please contact the TPS Service Department.

Warning! Electric shock and severe burn hazard. Never perform troubleshooting while the unit is in operation unless directed in this manual. Perform **Lock-Out / Tag-Out Procedures** established by your company.

1. When troubleshooting the unit, ensure that the unit is in the correct mode for the requested action.
2. If further troubleshooting assistance is required, please contact the TPS Service Department.
3. If you need to call, to provide better service and expedite your call, please have the following ready:
   A. Unit Order Number
   B. Operation and Maintenance Manual
   C. Electrical Schematics, Refrigeration Schematic, General Layout Drawing

Refrigeration System Troubleshooting Tips:

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.

C-EVO (S1) SERIES CHAMBER TROUBLESHOOTING GUIDE		
PROBLEM	**POSSIBLE CAUSE**	**SOLUTION**
1. Chamber Dead / HMI (when employed) Doesn't Boot Up	Chamber Main Disconnect (when employed) not turned ON or defective	Turn disconnect ON. Replace if defective.
	Instrumentation Fuse FU3071 Blown Control Circuit Fuse FU3032 Blown	Replace fuse and verify power connections.
2. Chamber Control Non-Operational	Control Circuit Fuse FU3032, 2031, or 2041 Blown	Replace fuse and verify power connections
	Unit in Alarm Condition	Press HMI ACK All Alarms button, Check Heat Limiter, & Controller Alarm Output
3. Circulation Motor Non-Operational	Motor Contactor not closing	Verify and replace
	Any cause from Problem #2	Do as stated
	Motor shaft frozen / defective motor	Verify. Feel for heat on motor housing and check motor current. Contact TPS Service.
4. Refrigeration Condenser Motor Non-Operational	Any cause from Problem #3	Do as stated
	Refrig. condenser coil dirty	Clean coil
5. Chamber Does Not Heat	Controller parameters not configured correctly, High limit alarm setpoint improperly set. TempGard IV alarm improperly set	Verify that the controllers are configured correctly. Check alarm operation.
	Controller heat output not closing	Verify – Contact TPS Service
	Heat Solid State Relay not closing	Verify and replace faulty 1SSR.
	Heat Enable Contactor not closing	Verify and replace faulty 2CON
	Heating element failure – coil may be open, shorted, or shorted to ground	Check element resistance and replace if necessary.
	Open RTD temperature sensor	Check and replace
6. Heat-Up Rate Too Slow	Low line voltage	Install specified power supply source to oven on a branch circuit of its own
	Heater circuit not functioning properly	Check SSRs and heater resistance.
	Heavy load in chamber	Reduce load in chamber to allow sufficient circulation.

C-EVO (S1) SERIES TROUBLESHOOTING GUIDE – CONT'D		
PROBLEM	**POSSIBLE CAUSE**	**SOLUTION**
7. Temperature Overshoots Setpoint	Controller improperly set	Verify controller configuration.
	Shorted Heat Solid State Relay	Replace faulty 1SSR.
	Grounded heater element	Check element resistance and replace if necessary.
	Shorted RTD temperature sensor	Check and replace
8. Temperature Fluctuates	Improper loading	Test the unit empty. If results are satisfactory, the chamber was improperly loaded. Redistribute load.
9. Refrig. System Non-Operational	Controller improperly set	Verify controller configuration.
	Controller compressor turn-on output(s) failing to close	Verify – Contact TPS Service
	Compressor contactors failing to close	Verify and replace
	Compressor motor overload protector has tripped	Wait until compressor cools. If overload does not close – replace it.
	Refrig. pressure switches not closing	Verify – Contatct TPS Service
10. Compressor hums – will not start	Low line voltage	Verify – Get proper electrical service
	Starting capacitor defective	Replace
	Compressor potential relay defective	Replace
	Internal compressor problem	Measure winding resistance, test for grounds. Contact TPS Service
11. Repeated shorting or blowing of start capacitors	Excessive start time, line voltage low	Correct low line voltage problem
12. Compressor starts, hums, runs slowly, staying on start winding	Low line voltage	Get proper electrical service
	Compressor potential relay is stuck	Replace
	Shorted winding	Test resistances, test for grounds, contact TPS Service

C-EVO (S1) SERIES TROUBLESHOOTING GUIDE – CONT'D

PROBLEM	POSSIBLE CAUSE	SOLUTION
13. High stage compressor will not run (Cascade System)	Any cause in Problem #2 or #8	Do as stated
14. Low stage compressor will not run	Any cause in Problem #2 or #8	Do as stated
	Humidity Enable - Chan. 2 turned ON	Turn OFF Humidity Channel 2
	Pressure Switch 3PS not closing	Verify that high stage is running
15. Low stage compressor runs, but little or no cooling	Low stage is low on refrigerant	Have system leak tested
	Full main solenoid valve 8SOL failing to open	Replace
	Main cooling coil badly frosted	Raise temperature to defrost
	Heaters either shorted or inadvertently turned ON	Verify – Contact TPS Service
16. Compressors run but cool inefficiently	Restricted ventilation of condenser air outlet, dirty condenser fins	Make sure top of machinery compartment at rear of unit is not restricted, clean condenser fins
	Heaters either shorted or inadvertently turned ON	Verify – Contact TPS Service
17. Refrig. works long or continuously	Excessive heat load	Reduce load if possible
	Ice on evaporator cooling coil	Defrost
	Low refrigerant charge	Have charge checked by refrig. mechanic - charges are on ID label
18. Compressor repeatedly trips	Not enough airflow through evaporator cooling coil, cooling coil frosted	Check coil, defrost coil, product loading issue - may have to redistribute load, contact TPS Serv.
19. Noisy Compressor(s)	Compressor loose on mounts	Tighten hold down nuts

22.0 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 suctions 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:

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 sole 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° F, it will contain no liquid refrigerant. When the system is activated, the low stage compressor will pump hot gas through the discharge line through an oil separator, and then to the cascade condenser where it is liquefied by heat exchange with high stage refrigerant. It then flows to the expansion valve which feeds the evaporator coil.

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:

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. The refrigerant flow to the evaporator is metered by an expansion valve.

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 xxxx refrigerant. (Consult EPA regulations for leak testing.) 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-condensables, 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, 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.

SUPPLEMENTAL INSTRUCTIONS