



**Model 123H**  
**Temperature/Humidity Chamber**  
Serial Number 230232 and above

**Operation and Service Manual**



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## Chapter 1 – Safety Instructions

### ***Introduction***

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Follow all CAUTION notices to prevent damage to the chamber or your test sample. Failure to follow all CAUTION notices may void your warranty. CAUTION may also indicate a potentially hazardous situation which, if not avoided, may result in minor or moderate personal injury.

WARNING indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

The safety alert symbol  precedes a general CAUTION or WARNING statement.

The electrical hazard symbol  precedes an electric shock hazard CAUTION or WARNING statement.

### ***Installation Safety Notices***

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 **WARNING:** The power cord is equipped with a NEMA 5-20P grounded/polarized plug. To prevent a shock hazard, DO NOT defeat the ground or polarization feature. This device MUST be plugged DIRECTLY into a properly grounded and polarized NEMA 5-20R receptacle. Due to high current demand on start-up, use of an extension cord is NOT recommended.

 **CAUTION:** The minimum clearance you should allow for proper ventilation around the chamber must be at least 6" from both the left and right side, and 12" from the rear.

 **CAUTION:** This chamber is designed for operation in a conditioned laboratory environment. Operation above 30°C (85°F) or below 16°C (60°F) ambient room temperature is NOT recommended.

### ***Operation Safety Notices***

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- △ **CAUTION:** The F4/F4T Controller alarms are configured for internal protection of the humidity system. Do NOT change this configuration under any circumstances. The independent EZ-Zone Limit Controller functions as the main system and product protection device.
- △ **CAUTION:** The EZ-Zone Limit Controller has been properly configured by TestEquity to match the chamber’s system requirements. Improper modifications to these setup values can result in unreliable and unsafe operation. Do not attempt to modify the setup values, unless you thoroughly understand what you are doing. The correct values are documented in the “EZ-Zone Limit Controller Setup Parameters” section of this manual.
- △ **CAUTION:** Always verify that the Limit Controller’s high and low limits are set to temperatures that are appropriate for your test sample.
- △ **CAUTION:** If your test sample is energized, it may be capable of raising the workspace temperature beyond safe limits. This could occur if your test sample exceeds the live load rating of the chamber or if the chamber’s refrigeration system fails. This chamber has a set of contacts that can be used to remove power to your test sample if the Limit Controller’s temperature limits are exceeded.
- △ **CAUTION:** To prevent damage to your test sample and the chamber’s compressors, do not exceed the live load rating of the chamber.
- △ **WARNING:** Do NOT put items in the chamber that could burn or explode at high temperatures. This chamber uses open wire heating elements which generate surface temperatures over 1000°F. This is NOT an explosion-proof chamber.
- △ **WARNING:** Do NOT put items in the chamber which can emit corrosive vapors or substances.
- △ **WARNING:** This chamber is NOT a curing oven. There are NO provisions for venting fumes.
- △ **WARNING:** The chamber door must remain closed while the chamber is operating. If you need to open the door while the chamber is operating, wear safety goggles to prevent the high velocity airflow from blowing particles or objects into your eyes.
- △ **WARNING:** This chamber operates at extreme temperatures. Avoid contact with air, objects, and surfaces that are hot or cold to prevent severe burns or frostbite. Protective gloves are recommended.

## Chapter 2 – Installation

### ***Uncrating***

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Inspect the shipping container for any signs of visible damage. Notify the carrier and TestEquity immediately if there are signs of shipping damage.

The pallet is designed with ramps so the chamber can be rolled off without the need for a forklift or pallet jack.

1. Cut the two metal bands that hold the packaging to the pallet.
2. Remove the top cover.
3. Remove the plastic fasteners that hold the outer box together and remove the outer box.
4. Locate the retainer in the front of the pallet. Remove the two screws, then remove the retainer. Keep in mind that there is also Velcro that holds the retainer in place. Place the retainer in the front of the pallet on the floor.
5. Locate the two ramps under the chamber and remove them.
6. Attach the ramps to the front of the pallet using the Velcro straps. The retainer will be under the ramps and act as a support.
7. Carefully roll the chamber off the pallet, onto the ramps. This should be done with at least two people.

### ***Preparation For Use***

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1. Inspect the chamber for signs of shipping damage.
2. Read this entire manual.
3. Select a suitable location to install the chamber.
4. Connect to the power source.
5. Perform following the procedures as described in the Preventive Maintenance section:
  - a. Inspect the electrical compartment.
  - b. Inspect the refrigeration machinery compartment.
  - e. Verify the chamber performance.

### ***Installation Location***

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The chamber will produce a significant amount of heat during normal operation. Locate the chamber in a room with adequate ventilation to prevent excessive heat build-up. The chamber generates a heat load of up to 5,000 btuh during a continuous cool down from a high temperature.

The chamber must be on a solid and level floor. Allow enough space around the chamber to permit serviceability and the removal of the service access panels, which are located on each side and the rear.

**△ CAUTION:** The minimum clearance you should allow for proper ventilation around the chamber must be at least 6" from both the left and right side, and 12" from the rear.

**△ CAUTION:** This chamber is designed for operation in a conditioned laboratory environment. Operation above 30°C (85°F) or below 16°C (60°F) ambient room temperature is NOT recommended.

### ***Humidity Water Connection***

---

**⚠ CAUTION:** The humidity system must be supplied with demineralized water having a specific resistance of 50,000 to 200,000 ohms/centimeter. The use of unfiltered tap water or triple-distilled water will damage the humidity system and chamber interior, and will void the warranty.

### **Plumbed Demineralized Water Installation**

Follow these instructions if your chamber is NOT being used with the optional water recirculation system, and you are connecting to a plumbed source of demineralized water.

1. Attach a supply of demineralized water to the Water Supply fitting on the chamber. Water pressure must not exceed 50 psi.
2. The chamber drain water is not under pressure, and is fed by gravity. Therefore, it must empty into an open floor drain, condensate pump, or bucket.

### **Water Recirculation System Installation, Model W100**

The optional Model W100 Water Recirculation System provides a source of demineralized water for the humidity system, using ordinary tap water. Condensate from the chamber is returned back to the water tank. The water pump runs continuously when the humidity system is enabled, keeping the supply line pressurized at all times. Detailed assembly pictures are shown on the next page.

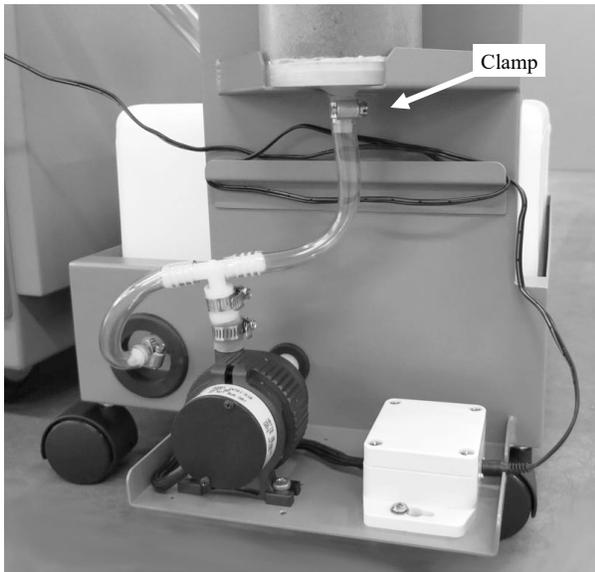
1. Attach filter cartridge. Use clamp provided on each end of filter to prevent leaking. Do not overtighten.
2. Position the recirculation system on the back left side of the chamber.
3. Attach the chamber Water Supply hose from the chamber to the top fitting of the filter. Use clamp provided to secure the hose to the Water Supply fitting.
4. Attach the chamber Drain hose to the chamber and position it so it goes into the water tank. The drain hose must not be submerged in the water.
5. Fill the water tank with clean water.
6. Place the cover on the water tank.
7. Plug the pump power supply into the receptacle labeled Pump on the rear of the chamber.

### **Water Recirculation System Filter Cartridge Replacement**

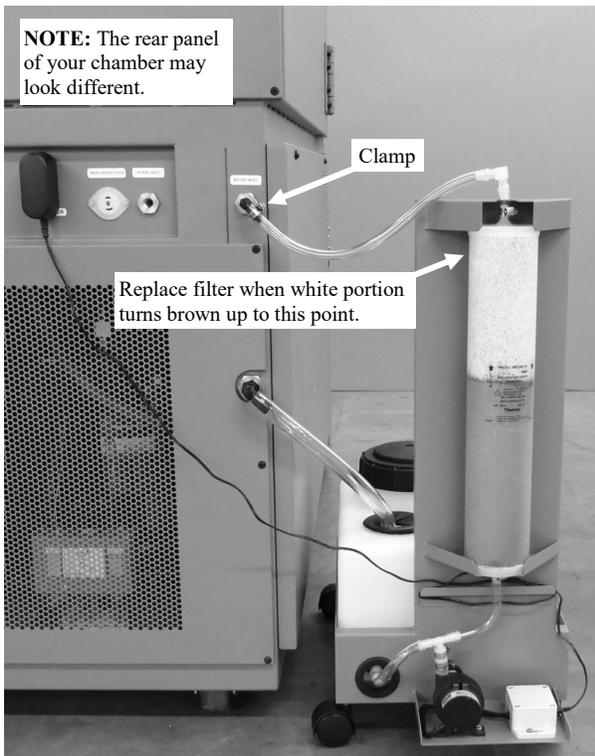
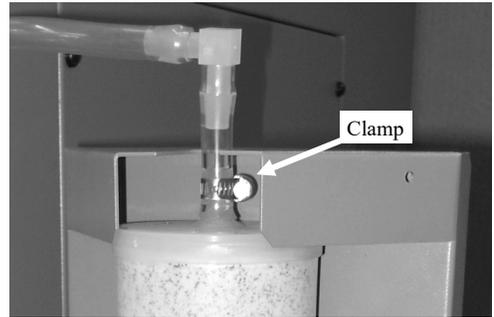
The demineralizer filter cartridge must be replaced when it is used up. The color of the top half of the cartridge changes gradually through continued use. Replacement cartridges are available from TestEquity (part number TE-0014 for a carton of 6 cartridges).

## Water Recirculation System Assembly, Model W100

Bottom of Filter



Top of Filter



Finger-tighten the Water Supply and Drain connections to chamber. Plug the pump power supply into receptacle on the back of the chamber. The drain tube from the chamber must not be submerged in the water.

### Chapter 3 – Operation

#### ***Introduction***

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The Front Panel Switches control power to the chamber. The Front Panel Lights provide indication of heat and cool functions.

The EZ-Zone Limit Controller is a protection device. It turns the chamber OFF if the workspace temperature exceeds either a high temperature or low temperature limit set point.

The F4/F4T Controller controls the temperature and humidity in the chamber. It can function as either a single set point controller or as a programmable profile controller. The F4/F4T Controller automatically turns the refrigeration system on or off based on the demand for cooling.

**Refer to the separate F4 or F4T Temperature/Humidity Controller manual for details on how to use the Controller.**

#### ***Summary of Chamber Operation***

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1. Turn the Power Switch ON.
2. Enter the appropriate high and low temperature safety limits on the Limit Controller.
3. Enter the desired set points (or program) on the F4/F4T Controller.
4. Load your test sample in the chamber.
5. If you are running a controlled humidity condition between +10°C and +85°C, turn Event 2 on the F4 controller or the Humidity button on the F4T controller ON.
6. If you are running temperature-only conditions or are operating lower than +10°C or higher than +85°C, turn Event 2 on the F4 controller or the Humidity button on the F4T controller OFF. Humidity cannot be controlled in this range of temperature.
7. Turn the CONDITIONING Switch ON. Alternatively, turn the CONDITIONING Switch to the EVENT 1 position and turn EVENT 1 on the F4 controller or the Power button on the F4T controller ON.

### ***Front Panel Switches and Lights***

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#### **POWER Switch**

The POWER Switch controls power to the entire chamber. The POWER Switch illuminates when it is ON.

#### **CONDITIONING Switch – ON Mode**

The CONDITIONING Switch enables all chamber functions. When the CONDITIONING Switch is OFF, only the Temperature Controller and Limit Controller are operational. When the CONDITIONING Switch is ON, the chamber's temperature conditioning system will function to maintain the temperature set point. The CONDITIONING Switch does NOT illuminate in any position.

#### **CONDITIONING Switch – EVENT 1 Mode**

When the CONDITIONING Switch is in the EVENT 1 position, you can enable and disable all chamber functions through Event 1 (Digital Output 1) of the F4 Controller or the Power button on the F4T Controller.

#### **LIGHT Switch**

The LIGHT Switch controls the workspace light. The LIGHT Switch illuminates when it is ON.

#### **HEAT Light**

The HEAT Light will illuminate when the Temperature Controller turns on the heater to maintain the workspace temperature. The HEAT Light will cycle on/off as the workspace temperature approaches and reaches the temperature set point.

#### **COOL Light**

The COOL Light will illuminate when the Temperature Controller turns on the cooling valve to maintain the workspace temperature. The COOL Light will cycle on/off as the workspace temperature approaches and reaches the temperature set point.

#### **HUMIDITY ENABLE Light**

The Humidity mode is enabled through Event 2 on the F4 Controller or the Humidity button on the F4T Controller. This should only be ON if you are performing a controlled humidity test within the humidity range of the chamber (+10°C and +85°C). The HUMIDITY ENABLE light will be illuminated, as long as the chamber temperature is within +7°C and +90°C. The chamber will cool in single-stage refrigeration mode.

If the Humidity mode is disabled, the chamber will cool in cascade refrigeration mode and there will be no humidity control.

### **HUMIDITY Light**

The HUMIDITY Light will illuminate when the F4/F4T Controller turns on the humidifier heater to maintain the workspace humidity. The HUMIDITY Light will cycle on/off as the workspace humidity approaches and reaches the humidity set point.

Note that the HUMIDITY ENABLE must be ON, the chamber workspace must be between +7°C and +90°C, and the humidifier water level must be correct for the HUMIDITY Light to correspond to the humidity output on the F4/F4T controller.

There is no corresponding light on the front panel for the dehumidification function.

### ***Loading the Chamber***

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- △ **WARNING:** Do NOT put items in the chamber that could burn or explode at high temperatures. This chamber uses open wire heating elements which generate surface temperatures over 1000°F. This is NOT an explosion-proof chamber.
  
- △ **WARNING:** Do NOT put items in the chamber which can emit corrosive vapors or substances.
  
- △ **WARNING:** This chamber is NOT a curing oven. There are NO provisions for venting fumes.
  
- △ **WARNING:** The chamber door must remain closed while the chamber is operating. If you need to open the door while the chamber is operating, wear safety goggles to prevent the high velocity airflow from blowing particles or objects into your eyes.
  
- △ **WARNING:** This chamber operates at extreme temperatures. Avoid contact with air, objects, and surfaces that are hot or cold to prevent severe burns or frostbite. Protective gloves are recommended.
  
- △ **CAUTION:** If your test sample is energized, it may be capable of raising the workspace temperature beyond safe limits. This could occur if your test sample exceeds the live load rating of the chamber or if the chamber's refrigeration system fails. This chamber has a set of contacts that can be used to remove power to your test sample if the Limit Controller's temperature limits are exceeded.
  
- △ **CAUTION:** To prevent damage to your test sample and the chamber's compressors, do not exceed the live load rating of the chamber.

**Live Load Capacity for Model 123H (uncontrolled humidity mode only)**

<b>Temp</b>	<b>+23°C</b>	<b>0°C</b>	<b>-40°C</b>	<b>-55°C</b>	<b>-65°C</b>
<b>Watts</b>	500 W	400 W	225 W	175 W	100 W

### **Performance Considerations**

The performance of all chambers is significantly affected by the characteristics of your test sample. Factors include size, weight, material, shape, and power dissipation if energized. The test sample should be placed in the chamber in a manner that allows for air circulation. The air plenum is located on the back wall of the chamber, where air is sucked in from the bottom and exits from the top. You should not place the test sample directly on the chamber floor. It should be placed on the shelf. Multiple test samples should be distributed throughout the chamber to ensure even airflow and minimize temperature gradients. If necessary, additional shelves should be used to evenly distribute the load. Verify that the temperature gradients are within acceptable limits, by measuring the chamber temperature at strategic points using a multipoint thermocouple meter or data logger.

You may find that the temperature throughout the chamber is even, but always different from what the F4/F4T Controller indicates. The correct way to adjust what the F4/F4T Controller “displays” compared to what is measured at some point other than the controller’s sensor is with the “Calibration Offset” parameter, NOT by recalibrating the controller.

### Port Plugs

Foam port plugs are provided with a gray silicone surface on one side. The port plug must be inserted with the gray silicone surface facing the inside of the chamber. Port plugs should be considered expendable and be replaced when they no longer provide a good seal.

### Avoiding Moisture (non-humidity mode)

Any time the ambient air is subjected to temperatures below the dew point, moisture will condense out of the air. The effect is ice or frost during low temperature operation, or water when maintaining over 0°C and cooling is required.

To avoid moisture condensation, make sure the port plugs are inserted at all times. Also, avoid opening the chamber door while the chamber is operating at temperatures below room ambient. When a low temperature test is completed, warm the chamber to at least room ambient before opening the chamber door and before removing your test sample.

You CANNOT use the humidity system to control moisture at low temperatures. The humidity system is disabled below +7°C. However, if you have a source of GN<sub>2</sub> (gaseous nitrogen) or Dry Air, you can use the Purge system to eliminate moisture condensation at low temperatures.

### Internal Test Fixtures

Some applications require internal fixtures to support test samples and provide a convenient method of connecting wires and sensors. Fixtures must be designed to minimize their impact on chamber functionality and performance.

Fixtures should be designed for easy removal to permit maintenance and cleaning of the chamber. The chamber liner should never be drilled or screwed into. This will compromise the integrity of the liner and permit moisture migration due to condensation into the insulation, which will eventually impact performance and lead to premature rusting of the outer cabinet.

Fixtures should be constructed of stainless steel. This also applies to all screws and fasteners. All welds should be passivated. To prevent rust and corrosion, never use iron or mild steel even if it is painted or plated. Aluminum may be used. However, since the specific heat of aluminum is double that of steel, it represents a greater load and will have more impact on the chamber performance.

Make sure that all connectors, wiring, pc boards, and auxiliary components can withstand the temperature extremes that they will be subjected to. In some cases, these components may not be able to last after repeated tests and should be considered expendable.

## Humidity Operation

### Humidity Mode Enable

The Humidity mode is enabled through Event 2 on the F4 Controller or the Humidity button on the F4T Controller. This mode should only be ON if you are performing a controlled humidity test within the temperature humidity range of the chamber as shown in the chart below.

### Standard Humidity Range

This chamber is capable of controlling humidity from 10% RH to 95% RH over the temperature range of +10°C to +85°C. The lowest possible humidity in the Standard Range varies depending on the temperature, and is limited to a 6°C dew point. For example, +45°C is the lowest temperature that 10% RH can be achieved. Below is a chart that shows the achievable range of humidity as compared to temperature. Achieving low humidity levels require you to start with a clean, dry chamber. For extended low humidity range below 6°C a dew point condition, see “Purge Option” which follows.

The F4/F4T will automatically disable the humidity system below +7°C and above +90°C to protect the chamber.

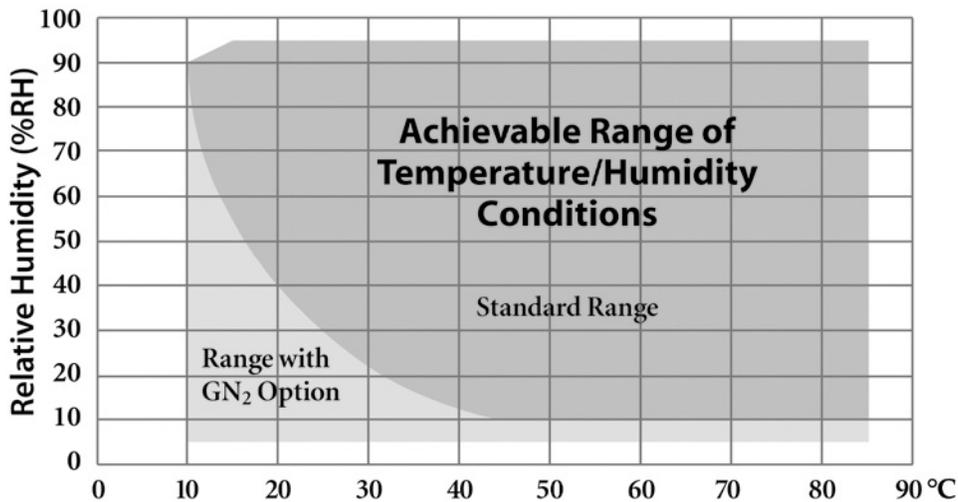


Figure 3-1 – Achievable Range of Temperature/Humidity Conditions

### Humidity Mode Considerations

The chamber workspace must be between +7°C and +90°C. If the chamber is outside this temperature range, the chamber will operate as though the Humidity Enable was OFF.

It takes several minutes for the humidifier to fill to the correct level after the water supply is initially connected to an empty system. The humidifier function is disabled until the water level is correct.

If you are running a high humidity condition, it can take approximately 5 minutes until the humidifier heats up from an initial “cold start”. During most of that time, it might appear that “nothing is happening” because there is little increase in the humidity reading. Be patient – if the Humidity Light is ON, the humidity will eventually begin to rise after this initial heat-up period.

### **Purge**

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GN<sub>2</sub> (gaseous nitrogen) Purge or Dry Air Purge can be used to reduce to possibility of condensation in the chamber at low temperatures, or to achieve humidity control below a 6°C dew point condition.

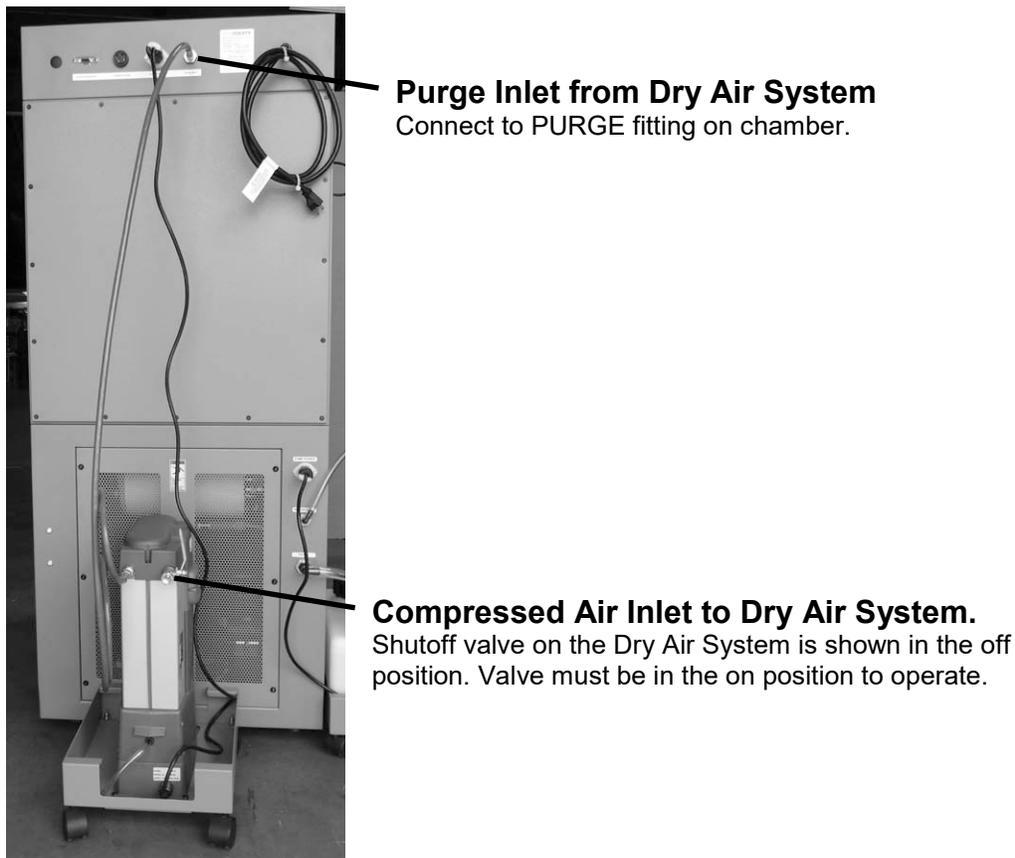
**⚠ CAUTION:** Nitrogen cannot be detected by human senses. Nitrogen is non-toxic. However, if adequate ventilation is not provided, nitrogen will displace air. This can cause dizziness, unconsciousness or death without warning. The chamber must be located in a well-ventilated area. Do not open the chamber door with the GN<sub>2</sub> flowing.

### **GN<sub>2</sub> (Gaseous Nitrogen) Installation**

Connect a supply of GN<sub>2</sub> with a maximum pressure of 100 psig to the 1/4-inch FPT fitting which is designated PURGE on the rear panel.

### **Dry Air Installation (Option TE-0017)**

Connect the hose from the Dry Air system to the fitting which is designated PURGE on the rear panel. Connect a supply of compressed air to the 3/8-inch FPT shutoff valve of Dry Air system. This system requires a 5 cfm supply air flow rate at 100 psig (175 psig max).



**Figure 3-2 – Dry Air Purge System Installation**

### Purge Operation

The Purge mode is enabled through Event 3 (Digital Output 3) on the F4 Controller or the Purge button on the F4T Controller.

#### For low humidity control

- Turn Event 2 (HUMIDITY) ON and Event 3 (PURGE)ON.
- Purge gas will feed when the F4/F4T Controller cycles the dehumidification system. It will cycle on/off as the workspace humidity approaches and reaches the low humidity set point, or whenever dehumidification is necessary.

#### For low humidity control below +10°C

- Turn Event 2 (HUMIDITY) OFF and Event 3 (PURGE)ON. The Purge System will continue to provide controlled dehumidification even though the humidity system is disabled.

### Adjusting the Purge Flow

A flowmeter is located on the front panel to adjust the flow of purge gas into the chamber. The flowmeter has a scale, calibrated in SCFM. The flow of purge gas should be adjusted to the minimum amount required to obtain the desired drying in the chamber for your particular conditions. A suggested starting setting is 2 SCFM.

### Relief Vent

Excess pressure in the chamber workspace is vented through a pressure-relief check-valve, which is located on the top of the chamber behind the fan shroud. There is no need to vent this externally.

## Event Outputs

The F4/F4T Controller has digital outputs which can be configured as Event Outputs to turn remote devices on and off. There are four Event Outputs which are available for customer use. Event Output 1 is dedicated for System Enable. Event Output 2 is dedicated for Humidity Enable. Event Output 3 is dedicated for Purge. The Event Outputs 4 through 7 are available for customer use.

## Event Assembly

The Event Assembly contains four solid state relays to control AC operated devices, such as power to a test sample. The solid state relays are rated for 24 to 240 VAC, 5.0 Amps. The event relays are just switches. You must provide power from an external source.

### Connecting to the Event Assembly

1. Unplug the chamber from the power source.
2. Remove the top cover.
3. Locate the Event Assembly and connect your wires to the desired solid state relay terminals.
4. A 1/2-inch conduit hole is provided on the back panel to route your wires through. Use the appropriate wire/cable management fittings.

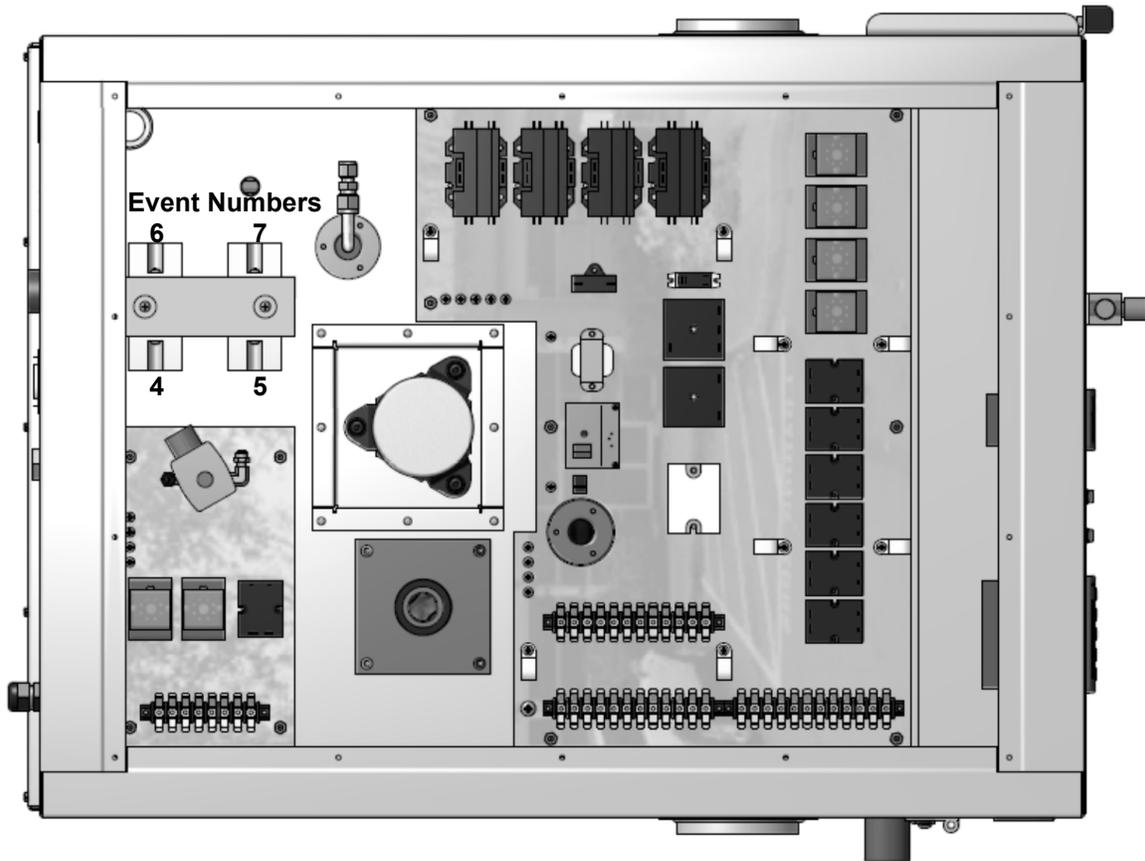


Figure 3-3 – Event Relay Location



## Chapter 4 - Limit Controller

### *Introduction*

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The EZ-Zone Limit Controller is a protection device. It turns the chamber OFF if the workspace temperature exceeds either a high temperature or low temperature limit. You can set these limits to correspond to the maximum and minimum temperature that your test sample can safely withstand. This provides protection against someone setting the F4 Controller to a temperature that is unsafe for the test sample. It also provides protection in the unlikely event of a chamber system component failure. The Limit Controller has its own temperature sensor (thermocouple) and functions completely independent of the F4 Controller.

This section provides a brief overview on how to operate the Limit Controller. For more detailed instructions, see the “EZ-Zone User’s Manual”.

**⚠ CAUTION:** The “EZ-Zone User’s Manual” is a general manual and is written by the manufacturer, Watlow, for a wide variety of applications and configurations. Not all features or functions are applicable. Only the capabilities of a model PM6L1AJ-AAAABAA are applicable.

**⚠ CAUTION:** The EZ-Zone Limit Controller has been properly configured by TestEquity to match the chamber’s system requirements. Improper modifications to these setup values can result in unreliable and unsafe operation. Do not attempt to modify the setup values, unless you thoroughly understand what you are doing. The correct values are documented in the “EZ-Zone Limit Controller Setup Parameters” section of this manual.

**⚠ CAUTION:** Always verify that the Limit Controller’s high and low limits are set to temperatures that are appropriate for your test sample.

**⚠ CAUTION:** If your test sample is energized, it may be capable of raising the workspace temperature beyond safe limits. This could occur if your test sample exceeds the live load rating of the chamber or if the chamber’s refrigeration system fails. This chamber has a set of contacts that can be used to remove power to your test sample if the Limit Controller’s temperature limits are exceeded.

## Limit Controller Keys and Displays

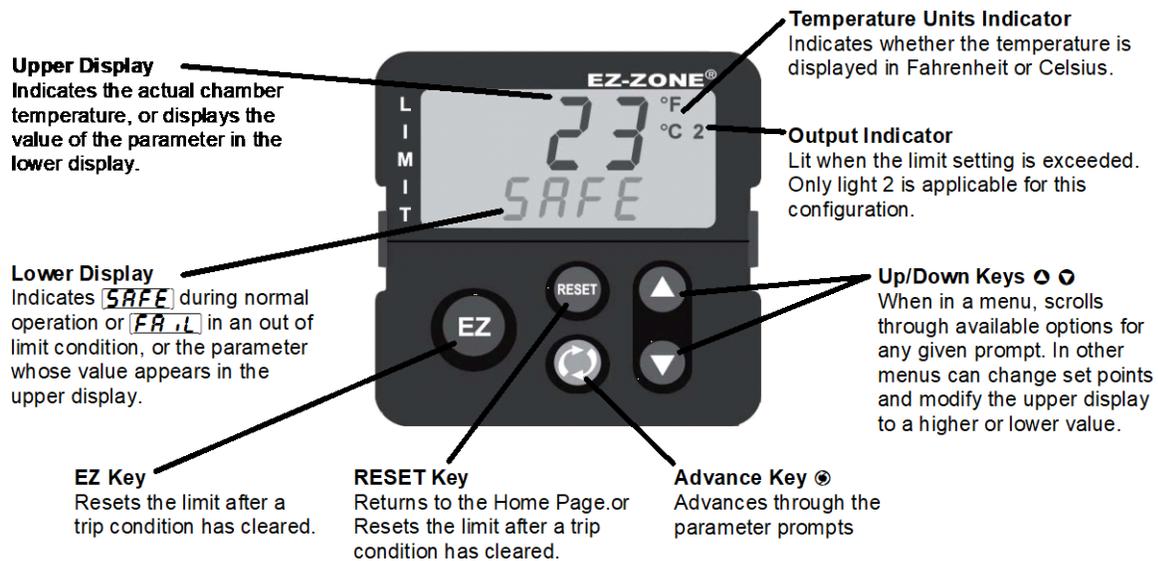


Figure 4-1 – Limit Controller Keys and Displays

## How to Set the High and Low Temperature Safety Limits

1. Press the **⊙** key once to get the **LLS** prompt in the lower display. This is the Low Limit Set Point prompt.
2. Press the **▲** or **▼** key to enter the desired Low Limit Set Point in the upper display. Make sure it is lower than your actual chamber temperature set point, and at least below room temperature to prevent nuisance tripping.
3. Press the **⊙** key once again to get the **LhS** prompt in the lower display. This is the High Limit Set Point prompt.
4. Press the **▲** or **▼** key to enter the desired High Limit Set Point in the upper display. Make sure it is higher than your actual chamber temperature set point to prevent nuisance tripping.
5. Press the RESET Key to return to the Home Page.
6. The upper display will show the actual chamber temperature while the lower display will show **SAFE** as long as the limits are not exceeded.

## Resetting an Out of Limit Condition

If the limit is exceeded, the Limit Controller will flash **L h I** (high limit) or **L l I** (low limit) in the upper display and **ALLO** in the lower display, alternating with the actual chamber temperature in the upper display and **FAIL** in the lower display. It will also shut down all chamber functions. The Limit Controller cannot be reset until the temperature returns to within the limit set points. Then, you must press the RESET or EZ Key to resume normal operation.

## Silencing the Audible Alarm

Turning off the CONDITIONING switch on the chamber front panel lets you temporarily turn off the Audible Alarm, even though the High or Low Limit condition may still exist.

## Protecting an Energized Test Sample

If your test sample is energized, it may be capable of raising the workspace temperature beyond safe limits. This could occur if your test sample exceeds the live load rating of the chamber or if the chamber’s refrigeration system fails.

This chamber has a set of safety contacts that can be used to remove power to your test sample if the Limit Controller’s temperature limits are exceeded.

The safety contacts are rated as follows:

Resistive: 10 A, 250 VAC or 10 A, 28 VDC. Inductive: 7 A, 250 VAC

To access the safety contacts:

1. Unplug the chamber from the power source.
2. Remove the top cover.
3. Locate relay CR1 on the electrical sub panel as indicated below. Remove the retaining clip and unplug the relay. Connections to the safety contacts are at relay CR1 socket, terminals 6 and 8. Plug in the relay and reposition the retaining clip when finished.

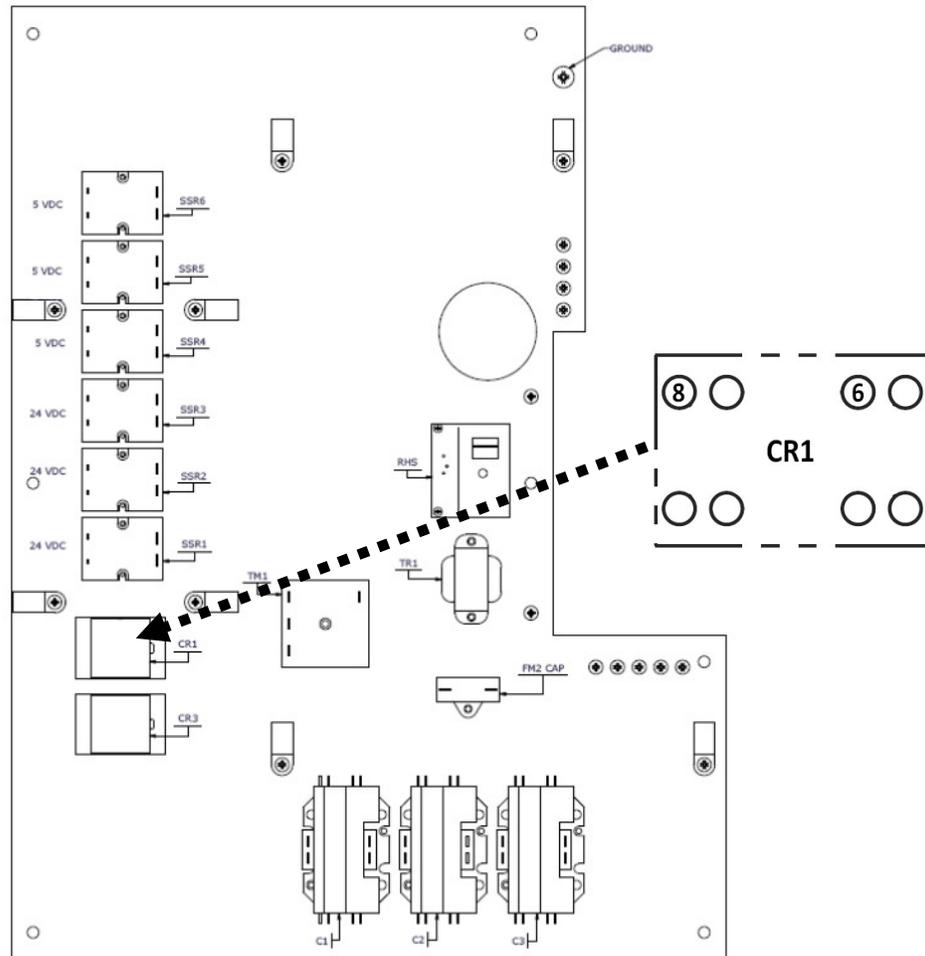


Figure 4-2 – Location of Safety Contact Connections on the Electrical Sub Panel



## Chapter 5 – Frequently Asked Questions

### **I need to send the chamber outside North America. Will it work with their power?**

Outside North America, most countries have 50 Hz. Nominal voltages in are typically 220 V to 240 V. You CANNOT simply step the voltage down to 120 V because the compressors have a 50 Hz rating of 100 V nominal (95 V min. to 110 V max.).

### **Why does my chamber heat or cool slower than the published specifications?**

Performance is significantly affected by the characteristics of your test sample. Factors include size, weight, material, shape, and power dissipation if energized. The test sample should be placed in the chamber in a manner that allows for air circulation. You should not place the test sample directly on the chamber floor. It should be placed on the shelf. Multiple test samples should be distributed throughout the chamber to ensure even airflow and minimize temperature gradients. If necessary, additional shelves should be used to evenly distribute the load. You can determine if the chamber is operating properly by following the procedure in “How to verify the chamber performance”.

### **How can I modify the chamber to cool faster?**

Unfortunately, there is little you can do to improve upon the designed-in performance. TestEquity does NOT recommend using CO<sub>2</sub> or LN<sub>2</sub> in this chamber to achieve faster cooling due to reliability and safety considerations, so it is NOT an available option. Modifying the chamber to add CO<sub>2</sub> or LN<sub>2</sub> will void the warranty.

### **Why is there water/ice/snow in the chamber?**

Any time the ambient air is subjected to temperatures below the dew point, moisture will condense out of the air. The effect is ice or frost during low temperature operation. When the chamber is heated above 0°C, the ice or frost will turn into water. To avoid moisture condensation, make sure the port plugs are inserted at all times. Also, avoid opening the chamber door while the chamber is operating at temperatures below room ambient. When a low temperature test is completed, warm the chamber to at least room ambient before opening the chamber door and before removing your test sample.

### **My test specification requires convection heat only. Can I turn the circulator motor off?**

NO! This will damage the heating and refrigeration systems and void the warranty. You need a “gravity convection oven” for that kind of test.

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## Chapter 5 – Frequently Asked Questions

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### **How accurate is the chamber?**

That's a loaded question! There is no "chamber accuracy" specification as such. The answer requires an understanding of several performance parameters.

Control Tolerance – The F4 Controller uses a thermocouple control sensor, which is located in the discharge airflow. Control tolerance is a measure of how much the temperature varies after stabilization at the control sensor. It is a measure of the relative variations, NOT the absolute accuracy of the readout. The control tolerance specification for this chamber is  $\pm 0.5^{\circ}\text{C}$ , or a total of  $1^{\circ}\text{C}$ . For example, the temperature set point may be  $-25.0^{\circ}\text{C}$ . The actual temperature varies between  $-25.4^{\circ}\text{C}$  and  $-24.5^{\circ}\text{C}$ . This corresponds to  $-0.4^{\circ}\text{C}$  and  $+0.5^{\circ}\text{C}$  or a total of  $0.9^{\circ}\text{C}$  of RELATIVE variations. These specifications are for an empty chamber. The addition of a test sample may affect the control variations. In some instances, the test sample will reduce these variations.

Uniformity – Also known as Gradients. This is a measure of variations in temperature at different locations throughout the chamber interior, at the same time, after stabilization. The uniformity specification for this chamber is  $\pm 0.5^{\circ}\text{C}$  or a total of  $1^{\circ}\text{C}$ , when measured at least 2" away from the chamber interior walls. These specifications are for an empty chamber. The addition of a test sample may affect the temperature uniformity. For example, an energized test sample will produce a higher temperature near the sample.

Controller Accuracy – This is the ability of the F4 Controller to accurately display a temperature measurement when compared to a standard. The controller display accuracy is  $\pm 1.66^{\circ}\text{C}$ . However, the total measurement accuracy in the chamber includes the thermocouple sensor wire accuracy. Thermocouple wire accuracy is  $\pm 1^{\circ}\text{C}$  or 0.75% of reading, whichever is greater. Therefore, total system accuracy over the chamber's operating range can be as much as  $\pm 2.66^{\circ}\text{C}$ , although the typical accuracy is often better than  $\pm 1.0^{\circ}\text{C}$ .

### **Can I tilt the chamber to move it?**

You should be able to tilt the chamber 45 degrees to move it. After tilting it and moving it into place, perform the steps as outlined in "How to inspect the refrigeration machinery compartment" and "How to check the refrigerant charge" before placing the chamber back into service to make sure that no damage has occurred.

### **I'm not going to use the chamber for a while. Is there anything I should do to prepare it for storage?**

Perform ALL the steps in the Preventive Maintenance Schedule before placing the chamber into storage. This will ensure that the chamber will be ready to operate when it is taken out of storage. If the chamber has a problem and is still under warranty, these problems should be resolved before being placed into storage, since the warranty period starts from the date of shipment. The chamber should be stored in a conditioned environment. Do not store it outside or where it will be subjected to dirt or excessive moisture.

### **I haven't used the chamber for a while. Is there anything I should do to prepare it for operation?**

Perform ALL the steps in the Preventive Maintenance Schedule before placing the chamber back into service. This will ensure that nothing has been damaged and that a leak has not developed.

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## Chapter 5 – Frequently Asked Questions

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### **Can the person who services our air conditioning also service the chamber?**

Probably not. Most air conditioning mechanics are not familiar with low-temperature cascade refrigeration systems. While this chamber is relatively easy to maintain and repair, most air conditioning mechanics do not have the necessary refrigerants and may not be familiar with the microprocessor-based controls. This chamber should only be serviced by a qualified mechanic that is familiar with low-temperature cascade refrigeration systems. Call TestEquity to recommend one in your area, or to check if the one you would like to use is qualified.

### **Can/Should I put a filter in front of the condenser air inlet?**

No, TestEquity does not recommend this. Just follow the maintenance procedures and clean the condenser fins periodically.

### **How often should I charge the refrigeration system?**

This chamber uses a closed-loop refrigeration system. Just like your refrigerator at home, it does not need periodic charging. If the charge is low, this means that there is a leak. Leaks should be repaired before recharging.

### **What kind of Freon does the chamber use?**

The word Freon<sup>®</sup> is a DuPont registered trade name for their CFC-based refrigerants and is incorrectly used as a generic term for refrigerants. TestEquity chambers do not use CFC-based refrigerants. The high-stage system uses R-404A, which is also known as DuPont Suva<sup>®</sup> HP62. The low-stage system uses R-508B, which is also known as DuPont Suva<sup>®</sup> 95.



## Chapter 6 – Specifications

<b>Temperature Range</b>	-68°C to +175°C
<b>Control Tolerance</b>	±0.5°C (Measured at the control sensor after stabilization)
<b>Uniformity</b>	±0.5°C (Variations throughout the chamber after stabilization)

<b>Standard Humidity Range</b>	10% to 95%, in the temperature range of 10°C to 65°C limited by a 6°C dewpoint; 90% over 65°C up to 85°C. See chart on page 4-6.
<b>Control Tolerance</b>	±3%RH (Measured at the control sensor after stabilization)

<b>Live Load Capacity @</b>	<b>+23°C</b>	<b>0°C</b>	<b>-40°C</b>	<b>-55°C</b>	<b>-65°C</b>
	500 W	400 W	225 W	175 W	100 W

(Live load capacity is for non-humidity mode)

<b>Cool Down Transition Time*</b>		<b>End Temp</b>				
<b>Start Temp to →</b>	<b>+23°C</b>	<b>0°C</b>	<b>-40°C</b>	<b>-55°C</b>	<b>-65°C</b>	<b>-68°C</b>
<b>+23°C</b>	----	6 min	31 min	51 min	68 min	ultimate
<b>+50°C</b>	7 min	16 min	44 min	62 min	82 min	ultimate
<b>+85°C</b>	18 min	28 min	54 min	82 min	101 min	ultimate
<b>+150°C</b>	43 min	54 min	87 min	108 min	129 min	ultimate

<b>Heat Up Transition Time*</b>		<b>End Temp</b>				
<b>Start Temp to →</b>	<b>+23°C</b>	<b>+50°C</b>	<b>+85°C</b>	<b>+125°C</b>	<b>+150°C</b>	<b>+175°C</b>
<b>+23°C</b>	-----	2 min	12 min	24 min	33 min	ultimate
<b>0°C</b>	3 min	9 min	18 min	32 min	41 min	ultimate
<b>-40°C</b>	9 min	16 min	25 min	39 min	48 min	ultimate
<b>-55°C</b>	14 min	18 min	31 min	44 min	53 min	ultimate
<b>-65°C</b>	15 min	21 min	32 min	45 min	54 min	ultimate

\*Note: Transition times are measured after a 2-hour soak at the start temperature with an empty chamber.

<b>Input Power</b>	120 V nominal (110 to 126 VAC), 60 Hz, 1 PH Max Current Draw 18 A, Recommended Minimum Service 20 A (dedicated line)
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<b>Workspace Dimensions</b>	18" W x 16.5" H x 13.5" D (2.3 cubic feet)
<b>Outside Dimensions</b>	26" W x 63" H x 36.5" D (nominal). Vent tube adds 3" to height.
<b>Min. Installed Clearance</b>	6" from the left and right side, 12" from the rear
<b>Access Ports</b>	4" Port on left and right side (two total), Supplied with foam plugs
<b>Sound Level</b>	62 dBA (A-weighted, measured 36" from the front)
<b>Weight</b>	750 pounds

**NOTE:** Performance is typical and based on operation at 23°C (73°F) ambient and nominal input voltage. Designed for use in a normal conditioned laboratory. Operation at higher ambient temperatures may result in decreased cooling performance. Additional ports and shelves will also affect performance. Operation above 30°C (85°F) or below 16°C (60°F) ambient is not recommended.



### Chapter 7 – Maintenance

⚠ **WARNING:** Maintenance must be performed by properly trained personnel only.

#### ***Preventive Maintenance Intervals***

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##### **Daily or As Needed**

- Clean chamber interior and exterior.
- Listen for abnormal noise or vibration.
- Inspect the demineralizer cartridge (if provided).

##### **Every 3 Months**

- Inspect the door seal.
- Inspect the refrigeration machinery compartment.
- Verify the chamber performance.
- Drain the water recirculation system reservoir.

##### **Every 6 Months**

- Inspect the electrical compartment.
- Clean the condenser.
- Drain the humidity system.

##### **Every 12 Months**

- Verify the calibration.

### ***Maintenance Procedures***

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#### **How to Clean the Chamber Interior and Exterior**

- Wipe or vacuum out all debris.
- Clean surfaces with a damp cloth, mild detergent, or stainless-steel cleaner. Avoid cleaners that are abrasive or leave a residue. Do NOT use steel wool.
- If you clean the interior with something other than water, you may want to operate the chamber at high temperature (approximately +125°C) after cleaning. This helps to “bake out” any residue. Remove the port plugs to permit the residual vapors to escape.
- Clean the silicone door gaskets with a damp cloth or mild detergent.
- Clean the exterior painted surfaces with a damp cloth or mild detergent. If you are using a detergent, test a small inconspicuous area to make sure it does not damage the finish.

#### **How to Listen for Abnormal Noise or Vibration**

You should become familiar with normal operating noises. Being able to recognize changes from normal operating noises can be a valuable way to identify problems and prevent further damage. Examples of noises to be aware of include:

- Circulator motor and fan noises (with compressors off).
- Compressor start-up and running noises, sequential starting of compressors.
- Condenser fan noises.
- Relay and valve cycling noises when cool light is cycling.

#### **How to Inspect the Door Seal**

The door has two silicone gaskets to minimize thermal losses and moisture migration.

- Inspect the gaskets for dirt and tears.
- Repair minor tears with a high quality RTV silicone such as GE RTV167.
- Check the integrity of the door seal by closing the door on a sheet of paper. With the door closed, slowly pull the paper. You should feel the resistance getting lighter as the paper goes past the inner gasket. Repeat this all around the door at several places.
- If the seal is not tight, adjust the door latch. The catch bracket that is mounted to the chamber has slotted holes to permit adjustment.
- If the seal is still loose on the hinge side, adjust the door hinge. The hinges have slotted holes to permit adjustment.

### How to Inspect the Refrigeration Machinery Compartment

**⚠ WARNING:** Wear safety goggles when inspecting the machinery compartment to protect against a refrigerant line which could break.

1. Unplug the chamber from the power source.
2. Remove the side and rear panels.
3. Inspect for signs of water leaks.
4. Inspect for signs of refrigeration tubing abrasion.
5. Inspect for oil around refrigeration valves, fittings and joints. This may be a sign of leaks.
6. Inspect for loose hardware and tighten as required.
7. Inspect for signs of insect or rodent infestation. Yes, it does happen!

## **How to Verify the Performance (Non-controlled humidity mode)**

These tests verify the performance of the heating, cascade refrigeration mode, electrical controls, F4/F4T Controller, and air circulation systems. The chamber should meet all published performance specifications for non-controlled humidity conditions if all of these tests are successfully passed. These tests assume that the F4 Controller's setup and tuning values have not been changed from the values as shipped from TestEquity. Also, the EZ-Zone Limit Controller high limit must be set to over +85°C (+88°C would be fine), and the low limit set to -75°C. If the chamber fails any of these tests, it should be removed from service to prevent further damage until the cause of the problem is determined and resolved.

1. The chamber interior should be empty and at ambient temperature, approximately +23°C.
2. Turn ONLY the Power Switch ON.
3. Set the F4/F4T Controller temperature set point to +85°C. Event 2 (F4 Digital Output 2 or F4T Humidity button) must be Off. Turn the Conditioning Switch ON.
4. The Heat Light should be ON continuously and the Cool and Humidity lights should be OFF.
5. The chamber should heat up to about +80°C and begin controlling (Heat Light cycles ON/OFF) within 12 minutes. The chamber temperature should slowly increase and stabilize to +85°C. It should NOT overshoot beyond +85°C by more than a few tenths of a degree, and the compressors should NOT need to turn ON in order to maintain +85°C.
6. After stabilization, the chamber temperature should vary no more than  $\pm 0.2^{\circ}\text{C}$ , or a total of  $0.4^{\circ}\text{C}$ .
7. Let the chamber stay at +85°C for two hours.
8. After two hours at +85°C, set the F4/F4T Controller temperature set point to -65°C.
9. The high-stage compressor should turn ON within a few seconds. Then, the low-stage compressor should turn ON within approximately 30 seconds, the Cool Light should be ON continuously and the Heat Light should be OFF.
10. The chamber should cool down to about -60°C and begin controlling (Cool Light cycles ON/OFF) within 1 hour and 40 minutes (100 minutes).
11. The chamber temperature should slowly decrease and stabilize to -65°C. It should NOT undershoot beyond -65°C by more than a few tenths of a degree, and the compressors should NOT need to turn OFF in order to maintain -65°C.
12. After stabilization, the chamber temperature should vary no more than  $\pm 0.5^{\circ}\text{C}$ , or a total of  $1^{\circ}\text{C}$ .
13. Set the F4/F4T Controller temperature set point to +23°C. The chamber should begin to heat up. The compressors should turn off within approximately 1 minute.
14. This concludes the chamber performance verification tests.
15. Let the chamber heat up to +23°C before turning the Conditioning Switch OFF.

## **How to Verify the Performance (Controlled humidity mode)**

These tests verify the performance of the heating, single-stage refrigeration mode, humidification, electrical controls, F4/F4T Controller, and air circulation systems. The chamber should meet all published performance specifications for controlled humidity conditions if all of these tests are successfully passed. These tests assume that the F4 Controller's setup and tuning values have not been changed from the values as shipped from TestEquity. Also, the Limit Controller high limit must be set to over +85°C (+88°C would be fine). If the chamber fails any of these tests, it should be removed from service to prevent further damage until the cause of the problem is determined and resolved.

1. The chamber interior should be empty and at ambient temperature, approximately +23°C. Water Inlet must be connected to a source of filtered water or the optional water recirculation system.
2. Set the F4/F4T Controller temperature set point to 85.0°C, and humidity set point to 85.0% RH. Event 2 (F4 Digital Output 2 or F4T Humidity button) must be ON. Turn the Conditioning Switch ON.
3. The Heat Light and Humidity Mode Light should be ON continuously and the Cool light should be OFF. The Humidity Light should be ON continuously only after the humidifier fills up with water.
4. The chamber should heat up to about 80°C and begin controlling (Heat Light cycles ON/OFF) within 7 minutes.
5. The chamber temperature should slowly increase and stabilize to 85°C. It should NOT overshoot beyond 85°C by more than 1.0°C, and the compressor should NOT need to turn ON at this point in order to maintain 85°C.
6. The chamber humidity should begin to increase within approximately 5-10 minutes after the Humidity Light turns on. Then, the humidity should increase to 75% RH and the begin controlling (Humidity Light cycles ON/OFF)
7. After stabilization, the chamber temperature should be 85.0°C,  $\pm 0.5^\circ\text{C}$ . The humidity should be 85.0%RH,  $\pm 0.5\%$  on a short-term basis, with no more than a -3% RH dip on an occasional basis.
8. Next, change the temperature set point to 50.0°C. Leave the humidity set point at 85.0% RH
9. The high-stage compressor should turn ON (if it was not already ON), the Cool Light should be ON continuously and the Heat Light should be OFF. The humidity will drop at this point.
10. The chamber should cool down to about 55°C and begin controlling (Cool Light cycles ON/OFF) within a short time.
11. The chamber temperature should decrease and stabilize to 50°C. It should NOT undershoot 50°C by more than 2°C, and the compressors should NOT need to turn OFF in order to maintain 50°C. After stabilization, the chamber temperature should be 50.0°C  $\pm 0.5^\circ\text{C}$ , or a total of 1°C. It may take approximately 45 minutes to stabilize at 85.0%,  $\pm 2.0\%$  RH.
12. Next, change the humidity set point to 50.0%RH. Leave temperature set point at 50.0°C.
13. The Humidity light will be OFF. The chamber humidity should go down to about 60%RH fairly quickly. It may take approximately 15 additional minutes to stabilize at 50.0%,  $\pm 2.0\%$  RH.
14. This concludes the controlled-humidity chamber performance verification tests.

### How to Inspect the Electrical Compartment

1. Disconnect the chamber from the power source.
2. Remove the top cover.
3. Check for loose components, loose wires, burned insulation near terminals, and burned or excessively pitted contacts on contactors.

### How to Clean the Condenser

1. Disconnect the chamber from the power source.
2. Remove the lower front panel.
3. Clean the condenser and desuperheater fins with a vacuum cleaner.

**NOTE:** You may need to clean the condenser more frequently if the chamber is in a dusty environment. You may be able to clean the condenser less frequently if the chamber is in a very clean environment.

### How to Drain the W100 Water Recirculation System Reservoir

1. This procedure drains the water in the recirculation system only, not the vapor generator.
2. If the chamber is running a humidity test, turn it off. Otherwise, this task can be done while the chamber is operational.
3. Place a basin capable of containing all the water in the reservoir under the drain valve. Or, disconnect the Water Recirculation System and move it to an area where the water can be drained into a floor drain or outside.
4. Open the drain valve to empty the tank.
5. Refill the tank with tap water or filtered drinking water (NOT spring water or distilled water).
6. Reconnect the Water Recirculation System if it was disconnected.

**NOTE:** You may need to drain and replace the water more frequently if the water appears dirty before the recommended maintenance interval of 3 months.



**Figure 7-1 – Reservoir Drain Valve**

### How to Drain the Humidity System

1. This procedure drains the water in the humidifier only, not the water recirculation system.
2. Wait at least 2 hours after running a humidity test before draining the system.
3. Disconnect the chamber from the power source.
4. Remove the lower rear panel.
5. Open the Drain Valve by turning its handle 90 degrees counter-clockwise (as if you were facing the front of the valve handle). Water will come out of the Drain fitting on the back of the chamber.
6. After the system is drained, close the Drain Valve by turning its handle 90 degrees clockwise (as if you were facing the front of the valve handle).



**Figure 7-2 – Humidity Drain Valve** (shown in the closed, or normal operating position)

### How to Verify the Temperature Calibration

**⚠ CAUTION:** TestEquity does not recommend performing the controller calibration procedures unless you have verified that the controller is actually out of calibration.

TestEquity recommends verifying the calibration before attempting to actually perform a calibration. The state-of-the-art instrumentation used in TestEquity chambers is of the highest quality and seldom goes out of calibration. If you try to calibrate the instrumentation before determining that calibration is necessary, you may make it worse if done incorrectly.

Variations in temperature throughout the chamber interior are NOT a measurement of controller accuracy. These variations, called “gradients”, are a function of the physical design of the chamber and its airflow, the characteristics of the test sample, and how it is oriented in the chamber. You cannot “calibrate” to improve gradients. The common practice of measuring multiple points in the chamber and adjusting the temperature controller’s calibration to correct for these errors is incorrect! The correct way to adjust what the temperature controller “displays” compared to what is measured at some point other than the controller’s sensor, is with the “Calibration Offset” parameter. The F4 or F4T Temperature/Humidity Controller User’s Manual for details. Calibration verification should be performed with the Calibration Offset set to 0.0 (zero).

Total system accuracy in the chamber includes the controller plus the thermocouple wire accuracy. Total system accuracy over the chamber’s operating range is typically  $\pm 1.55^{\circ}\text{C}$ ,  $\pm 1$  LSD or a theoretical total of  $\pm 2.55^{\circ}\text{C}$ . The easiest way to verify the instrumentation accuracy is with an independent calibrated temperature sensor and display. Place the sensor inside the chamber, near the chamber’s conditioner fan grille. If the readings agree within the specified limits, then no calibration adjustments are necessary.

**For the F4 Controller:** If calibration of the controller is necessary, refer to the “F4 Temperature/Humidity Controller User’s Manual”.

**For the F4T Controller:** If calibration of the controller is necessary, refer to the “F4T Touch Screen Controller User’s Guide”.

### How to Verify the Humidity Calibration

TestEquity recommends verifying the humidity calibration before attempting to actually perform a calibration. If you try to calibrate the instrumentation before determining that calibration is necessary, you may make it worse if done incorrectly.

A Vaisala HMM100 capacitive-type sensor is used to measure humidity. The HMM100 output is configured for 0-100%RH = 0-20 mA. The HMM100 sensor specifications are:

Sensor accuracy at –20°C to +40°C*	Sensor accuracy at –40°C to –20°C, +40°C to +175°C*
±2%RH (0 to 90 %RH) ±3%RH (90 to 100%RH)	±2.5%RH (0 to 90 %RH) ±3.5%RH (90 to 100%RH)
*Note: Chamber controlled humidity range is 10°C to 85°C	

The easiest way to verify the instrumentation accuracy is with an independent calibrated humidity sensor and display. Place the sensor near the chamber’s humidity sensor, which is located towards the right side of the conditioner fan grille. If the readings on the F4/F4T Controller agree within the specified limits above, then no calibration adjustments are necessary.

TestEquity recommends the Vaisala HM70 Handheld Humidity/Temperature Meter with the HMP77B Probe for verifying the humidity sensor calibration at all humidity conditions that the chamber is capable of achieving.

**For the F4 Controller:** If calibration of the controller is necessary, refer to the “F4 Temperature/Humidity Controller User’s Manual”.

**For the F4T Controller:** If calibration of the controller is necessary, refer to the “F4T Touch Screen Controller User’s Guide”.

### Humidity Sensor Calibration and Maintenance

TestEquity recommends the Vaisala HM70 Handheld Humidity/Temperature Meter with the HMP77B Probe for calibrating the humidity sensor at all humidity conditions that the chamber is capable of achieving. Alternatively, the humidity sensor can be calibration with Vaisala HMK15 Humidity Calibrator which uses saturated salt solutions. These items are available from Vaisala Inc. ([www.vaisala.com](http://www.vaisala.com)).

The Vaisala HMM100 sensor is calibrated per the procedure in the Vaisala HMM100 User’s Guide, which can be downloaded from [www.testequity.com/chambers-instruction-manuals](http://www.testequity.com/chambers-instruction-manuals).

The humidity sensor element (Vaisala HUMIKAP 180R) is replaceable. The end of the sensor probe has a stainless steel sintered filter (Vaisala HM47280SP), which can be removed by unscrewing it. Handle the sensor by its outer plastic support. **DO NOT TOUCH THE SENSOR PLATE.** The sensor and sintered filter can be cleaned with distilled water. Do not use any mechanical methods. If you are unable to calibrate the sensor, first try cleaning the sensor element and filter. If this does not help, then replace the sensor.

### ***Theory of Operation***

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#### **Overview**

Refer to the electrical and refrigeration drawings to identify the referenced items described below. The electrical items are referenced with a letter(s) and number. The refrigeration items are referenced with a number only or number followed by a single letter.

#### **Air Heating System**

The chamber is heated by an open-element nichrome heater (HT1). The heater is located in the air plenum. The F4/F4T Controller provides a time-proportioned output to a solid state relay (SSR1). This turns the heater on/off as required to maintain the temperature set point. Pilot light PL1 provides an indication on the front panel when the heater is on. Relay CR4, High Heat Interlock, provides staging for the available heat. When the compressors and humidity system is off, full heat of 1,000 Watts is available. Then the compressors or humidity system is on, half heat of 500 Watts is available. A fusible heat limiter (HL) provides failsafe protection against a catastrophic failure by opening the heater circuit at +240°C.

#### **Humidity System**

Water is heated by an immersion-type heater (HT2) to generate vapor. The heater is located in the humidifier tank. The F4/F4T Controller provides a time-proportioned output to a solid state relay (SSR2). This turns the humidifier heater on/off as required to maintain the humidity set point. Pilot light PL4 provides an indication on the front panel when the humidifier heater is on.

Water level in the humidifier is maintained by float a float valve assembly which is external to the humidifier tank.

The immersion heater has an embedded thermocouple which is connected to Input 3 of the F4/F4T Controller to control an Alarm output. This provides failsafe protection against a heater failure in the event of a low water condition by opening the humidifier heater contactor C4 if the heater reaches +125°C. The alarm will self-reset when the heater reaches +100°C.

### Refrigeration System (non-humidity mode)

In non-humidity mode, cooling is accomplished by a cascade refrigeration system. A cascade refrigeration system consists of two interdependent refrigeration systems. The low-stage provides cooling to the chamber interior through a finned evaporator coil (26), which is located in the air plenum. The high-stage provides cooling to the cascade condenser (21). The cascade condenser is a heat exchanger that has one circuit which is the evaporator of the high-stage, and another circuit which is the condenser of the low-stage.

The high-stage uses refrigerant R-404A. High pressure liquid refrigerant is fed from the condenser (part of 5) through the filter-drier (6), sight glass (7), solenoid valve (18/19B) to the thermostatic expansion valve (20). The thermostatic expansion valve controls the feed of liquid refrigerant to the evaporator circuit of the cascade condenser and, by means of an orifice, reduces the pressure of the refrigerant to the evaporating or low side pressure. The reduction of pressure on the liquid refrigerant causes it to boil or vaporize, absorbing heat which provides a cooling effect. The refrigerant vapor travels through the suction line to the suction accumulator (27) to the compressor (part of 5) suction inlet. The compressor takes the low pressure vapor and compresses it, increasing both the pressure and the temperature. The hot, high pressure vapor is forced out of the compressor discharge valve and into the condenser. As the high pressure vapor passes through the condenser, it is cooled by a fan, which blows ambient air across the finned condenser surface. The vapor condenses into a liquid and the cycle is repeated. The hot gas regulator (9B) is adjusted to keep the suction pressure at 10 PSIG during light loading conditions. A suction line cooling thermostatic expansion valve (11) senses the suction line temperature and injects liquid refrigerant to cool the suction return gas within safe limits.

The Low-Stage uses refrigerant R-508B. High pressure liquid refrigerant is fed from the condenser circuit of the cascade condenser (21), through the filter-drier (34), liquid-line solenoid valve (18/19A), to the capillary tube/strainer assembly (24 and 25). The capillary tube feeds the finned evaporator coil (26), which is located in the air plenum where heat is absorbed to provide a cooling effect within the chamber. The refrigerant vapor travels through the suction line to the compressor (1) suction inlet. The compressor takes the low pressure vapor and compresses it, increasing both the pressure and the temperature. The hot, high pressure vapor is forced out the compressor discharge valve and into the desuperheater (2). As the high pressure vapor passes through the desuperheater, it is air-cooled to remove some sensible heat. Next, the vapor goes through the oil separator (3), which returns any entrained oil back to the compressor's crankcase. The vapor flows through the condenser circuit of the cascade condenser, where it is condensed back into a liquid.

During a high temperature pull down or a continuous bypass condition, it is possible for excessive hot gas to return to the compressor. The suction line cooling thermostatic expansion valve (10) senses the suction line temperature and injects liquid refrigerant to cool the hot gas within safe limits.

The low-stage discharge pressure is kept within safe limits with a bypass pressure switch (14). If the discharge pressure exceeds 280 PSIG, the bypass pressure switch will energize the bypass solenoid valve (18/19C). This will “dump” refrigerant vapor into the expansion tanks (5). This refrigerant is slowly returned from the expansion tanks to the suction line through a strainer / capillary tube (22/23). The expansion tank also provides sufficient volume in the system to keep the “standby pressure” (also known as static or balance pressure), when the system is off, within safe limits.

Both the low- and high-stages each have a high pressure switch (8A, 8B respectively) which turns off the entire refrigeration system in the event of an out of limit condition.

The F4/F4T Controller cycles the low-stage liquid-line solenoid valve (SV1 or 18/19A) on/off through cool control relay CR2 to control the chamber temperature. When SV1 is on, liquid refrigerant flows through the capillary tube and evaporator to cool the chamber. When SV1 is off, the flow stops. The hot gas regulator (9A) is adjusted to keep the suction pressure at 5 PSIG when SV1 is off. This is also called “bypass mode”. Pilot Light PL2 provides an indication on the front panel when the F4 Controller is turning SV1 is on.

The F4/F4T Controller has internal logic to turn the compressors on if cooling is required to maintain the temperature set point. The low-stage compressor turns on 30 seconds after the high-stage turns on through Timing Module TM1. This reduces the system’s starting current, while allowing the cascade condenser to get cool before the low-stage turns on.

### **Refrigeration System (controlled-humidity mode)**

In controlled-humidity mode, cooling and dehumidification is accomplished by a single-stage refrigeration system. Only the R-404A refrigeration system is used, and the R-508B system is disabled. The Humidity mode is enabled through Event 2 (Digital Output 2) in the F4/F4T Controller. Also, the chamber workspace must be between +7°C and +90°C. If the chamber is outside this temperature range, the F4/F4T Controller’s Alarm2 light will turn ON (there is no indication on the F4T’s main display but it functions similarly) and the chamber will operate as though the Humidity Enable was OFF (non-humidity mode).

Dry-bulb cooling is accomplished through the ambient cool capillary tube (30) and the finned ambient coil (15) inside the chamber. The F4/F4T Controller cycles the ambient cool liquid-line solenoid valve (SV3 or 18/19E) on/off through cool relay CR1 to control the chamber temperature. Pilot Light PL2 provides an indication on the front panel when the F4 Controller is turning SV3 is on. A suction limit pressure switch (PS4 or 35) also cycles SV3 to limit peak cooling demands to acceptable limits.

Dehumidification is accomplished through the finned dehumidify coil (17) inside the chamber, which uses a capillary tube (17) as its metering device. The F4/F4T Controller cycles the dehumidify coil liquid-line solenoid valve (SV4, 18/19D) on/off through SSR3 to control the amount of dehumidification. If the compressor is off because no dry-bulb cooling was required, then TM2 enables the refrigeration system upon demand for dehumidification.

An evaporator pressure regulator (12) valve keeps the ambient coil and dehumidify coil at 68 psig, thus preventing freezing temperatures. The hot gas regulator (9B) is adjusted to keep the suction pressure at 10 PSIG when both S3 and SV4 are off. A suction line cooling thermostatic expansion valve (11) senses the suction line temperature and injects liquid refrigerant to cool the suction return gas within safe limits.

***Troubleshooting***

<b>SYMPTOM</b>	<b>CONDITION</b>	<b>CAUSES</b>
<b>Does not heat up at all.</b>	<ol style="list-style-type: none"> <li>1. If F4 controller light 1A is ON (F4T upper PWR bar is 100%), circulator fan is ON, circulator fan is ON, the Heat light is OFF.</li> <li>2. If the Heat light is ON.</li> </ol>	<ol style="list-style-type: none"> <li>1. Solid State Relay SSR1 is defective (open).</li> <li>2. Heat Limiter HL is open. Heater HT1 is open.</li> </ol>
<b>Heats up too slow.</b>	<ol style="list-style-type: none"> <li>1. Does not meet published specifications.</li> </ol>	<ol style="list-style-type: none"> <li>1. Chamber is in Humidity Mode. Full heat is only available when Humidity Mode (Event 2) is OFF.</li> <li>2. Chamber interior is overloaded. Circulator motor is not turning. Port plug is not in port. Verify that input voltage is within tolerance.</li> </ol>
<b>Heat is on all the time.</b>	<ol style="list-style-type: none"> <li>1. If F4 controller light 1A is OFF (F4T upper PWR bar is 0%).</li> </ol>	<ol style="list-style-type: none"> <li>1. Solid State Relay SSR1 is defective (shorted).</li> </ol>
<b>Does not cool at all.</b>	<ol style="list-style-type: none"> <li>1. If F4 controller light 1B is ON (F4T upper PWR bar is 100%), DigitalOut 8 (F4T Compressor Output) is ON, the Cool light on front panel is OFF, both compressors are OFF.</li> <li>2. Setpoint is low than chamber temperature but F4 DigitalOut 8 (F4T Compressor Output) is not ON.</li> <li>3. If the Cool light is ON, compressors are ON.</li> </ol>	<ol style="list-style-type: none"> <li>1. Pressure switch PS1 or PS2 is tripped.</li> <li>2. Controller is mis-configured. Re-enter values as documented in the controller manual.</li> <li>3. Solenoid valve SV1 (or SV3 if in Humidity mode) may be defective in closed position. Refrigeration leak, plugged capillary tubes.</li> </ol>
<b>R-404A pressure switch DPS1 trips. (on rear right side)</b>	<ol style="list-style-type: none"> <li>1. Trips after operating for a while.</li> <li>2. Trips immediately after turn on.</li> </ol>	<ol style="list-style-type: none"> <li>1. Ambient temperature may be too high, over 90°F. Dirty condenser, inadequate clearance from back of chamber to wall.</li> <li>2. Low charge (leak).</li> </ol>
<b>R-404A sightglass has bubbles or does not look full.</b>	<ol style="list-style-type: none"> <li>1. During all running conditions.</li> <li>2. Only when cool light is cycling.</li> </ol>	<ol style="list-style-type: none"> <li>1. Low charge (leak).</li> <li>2. No problem. This is normal.</li> </ol>
<b>Cools too slowly or does not reach -73°C.</b>	<ol style="list-style-type: none"> <li>1. R-508B standby is ok, no bubbles in R-404A sightglass.</li> </ol>	<ol style="list-style-type: none"> <li>1. Chamber interior is overloaded. Test sample is energized, giving off heat. Circulator motor is not turning. Port plug is not in port. Door is not sealing completely. Ice on evaporator.</li> </ol>

## Chapter 7 – Maintenance

SYMPTOM	CONDITION	CAUSES
<p><b>Temperature readout on F4 Controller varies more than <math>\pm 0.5^{\circ}\text{C}</math> or <math>1^{\circ}\text{C}</math> total.</b></p>	<ol style="list-style-type: none"> <li>1. If tuning PID control parameters in F4/F4T Controller were changed.</li> <li>2. If tuning PID control parameters in F4/F4T Controller are as shipped from TestEquity.</li> <li>3. If tuning PID control parameters in F4/F4T Controller are as shipped from TestEquity and only occurs in cool mode.</li> </ol>	<ol style="list-style-type: none"> <li>1. Re-enter values as shipped from TestEquity.</li> <li>2. Control parameters may need to be changed for your unique test conditions.</li> <li>3. Solenoid valve SV1 (or SV3 if in Humidity mode) may be defective.</li> </ol>
<p><b>Compressors turn on and off too frequently.</b></p>	<ol style="list-style-type: none"> <li>1. If compressor control parameters in F4/F4T Controller were changed.</li> <li>2. If compressor control parameters in F4 Controller are as shipped from TestEquity.</li> </ol>	<ol style="list-style-type: none"> <li>1. Re-enter values as shipped from TestEquity.</li> <li>2. Solenoid valve SV1 (or SV3 if in Humidity mode) may be defective in the open position.</li> </ol>

### ***Refrigeration System Charging Instructions***

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**△ WARNING:** Repair of the refrigeration system must be performed only by a properly trained mechanic who is experienced in repairing cascade refrigeration systems. Do NOT substitute any component. Do NOT substitute refrigerants. Improper repairs will void the warranty.

These instructions are intended as guidelines for repairing TestEquity chambers. Details such as how to attach a gauge manifold are not covered. These are NOT do-it-yourself instructions!

#### **R-404A High-Stage Charge**

TestEquity does NOT recommend charging the system by relying on a clear sight glass only. Although a clear sight glass generally means the system is fully charged, it can be misleading. For example, if the system is charged on a cool day or with an empty chamber, it could be undercharged for hot days or with a heavy load. The proper charging procedure is as follows:

1. Repair any leaks before recharging.
2. Attach a vacuum pump and manifold gauge to the suction and discharge ports.
3. Evacuate the system to at least 100 microns. DO NOT GUESS! You must use a micron gauge.
4. Use a charging scale to weigh in 1 pound, 5 ounces (21 ounces) of R-404A.
5. Verify the cooling performance as outlined in “How to verify the chamber performance”.

NOTE: If the F4 Controller is cycling (Cool Light cycles on/off), the sightglass may appear 1/2 to 2/3 full. This is normal.

#### **R-508B Low-Stage Charge**

1. Repair any leaks before recharging.
2. Attach a vacuum pump and manifold gauge to the suction, discharge, and expansion tank ports. Attaching to the expansion tank is very important because it is otherwise very difficult to evacuate the tank through the pressure regulator or capillary tube that connects it to the system.
3. Evacuate the system to at least 100 microns. Do NOT guess! You must use a micron gauge.
4. Do NOT put any additives in the system. Pentane is NOT necessary or desirable.
5. Charge the system until the standby pressure is 125 PSIG. Allow time for the charge to equalize as read on the suction and discharge gauges. This is 5 PSIG higher than the target amount of 120 PSIG. See NOTE below.
6. Verify the cooling performance as outlined in “How to verify the chamber performance”.

NOTE: If the low-stage has been evacuated and recharged, the standby pressure should be rechecked after 24 hours to make sure it is 120 PSIG. This is because the refrigerant mixes with the POE oil in the compressor, causing a lower standby pressure than was initially observed. Do not mistake this initial loss of pressure with a leak. After verifying that there is no leak, you may need to top-off the charge if the pressure is too low.

### ***Recommended Spare Parts***

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Replacement parts are available from TestEquity. Parts are generally in-stock and ready for immediate shipment. Next-day delivery is always available. If you cannot risk being out of service for even one day, then you should purchase critical spare parts in advance. Although most parts are standard and available from a variety of local distributors, some parts are either harder to find or custom.

The following is a list of the kinds of parts that you may want to purchase in advance.

#### **Electrical Parts**

- Contactors
- Relays
- Fuses
- Heat Limiter
- Circulator Motor and Fan
- Switches

#### **Refrigeration Parts**

- Solenoid Valves
- Expansion Valves
- Regulator Valves

## Chapter 7 – Maintenance

### **Major Electrical Parts**

Description	Mfr	Mfr Part No.	Ref #	Part #	Qty	UOM
Line Cord	Intl. Config.	80560		200205	1	ea
Audible Alarm	Floyd Bell	MC-09-201-Q	AL1	200005	1	ea
Arc Suppressor	ITW Paktron	104MACQRL150	AS1-9	200296	9	ea
Contact, 1 Pole, 30A, 120V Coil	Hartland Controls	HCC-1XT02AA	C1-4	200237	4	ea
Relay, Octal DPDT 10A 120VAC	Idec	RR2P-UCAC120	CR1-6	200292	6	ea
Circulator Motor Kit	CUSTOM	CUSTOM	FM2	100585	1	ea
Heat Limiter	Thermodisc	G5A01240C	HL	200070	1	ea
Air Heater	CUSTOM	200277	HT1	200277	1	ea
Humidifier Heater	CUSTOM	222395	HT2	222395	1	ea
Lamp	Philips	T22, 125-130V, 15W, E14	LT1	200203	1	ea
Pilot Light	Chicago Miniature	6063-001-534R	PL1-4	222280	4	ea
Resistor, 1 kohm, 25W	Vishay / Dale	RH0251K000FE02	R1	200295	1	ea
Humidity Sensor	Vaisala	HMM100	RHS	200320	1	ea
Relay, Solid State, 10A, 24VDC In	Omron	G3NE-210T-US DC24	SSR1-3	200177	3	ea
Relay, Solid State, 10A, 5VDC in	Omron	G3NE-210T-US DC5	SSR4-7	200129	4	ea
Relay, Solid State 5A	Omron	G3NA-205B-DC5-24	SSR9-12	200032	4	ea
Switch	Carlingswitch	LRA211-RA-B/125N	SW1, 3	200023	2	ea
Switch, ON-OFF-ON	Carlingswitch	RC911-RA-B-0-N-XLR1	SW2	200275	1	ea
F4 Temp/Humidity Controller	Watlow	F4DH-CKCC-01AC	TCR1	200084	1	ea
F4T Temp/Humidity Controller	Watlow	F4T1L2EAA2F2018	TCR1	222511	1	ea
Limit Controller	Watlow	PM6L1AJ-AAAABAB	TCR2	200301	1	ea
Timing Module, On Delay, 30 Sec	Airotronics	THCU30SC	TM1	200287	1	ea
Timing Module, Off Delay	Airotronics	TH3ML1300SC	TM2	280200	1	ea
Transformer, 20VAC	Hammond	166D20	TR1	200087	1	ea
<b>Chart Recorder Option</b>						
Recorder, 2 Pen, 10"	Honeywell	DR4302-0000-G0100	RCD1	200098	1	ea
Paper, -90 to 210 C, 0 to 100	Graphic Controls	32002974 (Custom)		200155	1	ea
Pen, Purple, Six Pack	Honeywell	30735489-007		200097	1	ea
Pen, Red, Six Pack	Honeywell	30735489-002		200099	1	ea

## Chapter 7 – Maintenance

### **Major Refrigeration Parts**

Description	Mfr	Mfr Part No.	Ref #	Part #	Qty	UOM
Accumulator	CUSTOM	100345	27	100345	1	ea
Ambient Coil	CUSTOM	100505	15	100505	1	ea
Capillary Tube, Amb Cool, 0.050	J/B Industries	TC50	30	100019	60	in
Capillary Tube, Bleed, 0.050	J/B Industries	TC50	23	100019	36	in
Capillary Tube, DH, 0.042	J/B Industries	TC42	16	100340	96	in
Capillary Tube, Equalizer, 0.031	J/B Industries	TC31	28 (x2)	100320	120	in
Capillary Tube, Main Cool, 0.050	J/B Industries	TC50	25	100019	60	in
Cascade Condenser	Flatplate	CUSTOM	21	100601	1	ea
Check Valve	Mueller	A 17936 CMV-8S	13	180425	1	ea
Compressor, 1/2 HP	Tecumseh	AE2425Z-AA3C	1	383231	1	ea
Condensing Unit, 1/2 HP	Tecumseh	AE2425Z-AA3CDG	5	383230	1	ea
Dehumidification Coil	CUSTOM	180450	17	180450	1	ea
Desuperheater	CUSTOM	100508	2	100508	1	ea
Discharge Pressure Limit	Johnson Controls	P20EA-1D	14	100342	1	ea
EPR Valve	Sporlan	ORIT-6-30/100	12	100332	1	ea
Expansion Tank	CUSTOM	100346	36	100346	2	ea
Expansion Valve, R404A Main	Danfoss	068U2317	20	100471	1	ea
Expansion Valve, Suction Cooling	Danfoss	068U202700	11	100314	1	ea
Expansion Valve, Suction Cooling	Danfoss	068U2284	10A	180395	1	ea
Filter Drier	Danfoss	023Z5048	6, 34	100524	2	ea
High Pressure Cutout	Johnson Controls	P20DB-1D	8A, 8B	100341	2	ea
Hot Gas Bypass Regulator	Sporlan	ADRI-1/4-0/55	9A, 9B	100497	3	ea
Low Stage Evaporator	CUSTOM	100504	26	100504	1	ea
Oil Separator	Temprite	900	3	100536	1	ea
Orifice for 100471	Danfoss	068U1033	p/o 20	100607	1	ea
Orifice for 180395	Danfoss	068U1031	10B	180396	1	ea
Pressure Control, Suction Limiter	Johnson Controls	P70EA-10C	35	100326	1	ea
Purge Solenoid Valve	Asco	8262G22	SV7	100305	1	ea
Sight Glass	Henry	MI-30-1/4S	7	100608	1	ea
Solenoid Coil	Sporlan	MKC-1-120/50-60	SV1-5	100011	5	ea
Solenoid Valve	Sporlan	E3S130, 3/8 X 3/8ODF	19A-E	100010	5	ea
Strainer	Supco	S211	29	100606	3	ea

### **General Parts**

Description	Mfr	Mfr Part No.	Ref #	Part #	Qty	UOM
Door Gasket	CUSTOM	CUSTOM		380031	1	ea
Door Latch, Chamber Workspace	Southco	A7-10-301-20		300216	1	ea
Port Plug, Foam, 4"	CUSTOM	CUSTOM		300534	2	ea
Shelf with 4 Clips	CUSTOM	CUSTOM		TE-0231	1	ea
Shelf Retainer Clip	Kason	Style 66, #0066000008		300015	4	ea
Window, Heated	CUSTOM	CUSTOM		300709	1	ea

## ***EZ-Zone Limit Controller Setup Parameters***

**△ CAUTION:** The EZ-Zone Limit Controller has been properly configured by TestEquity to match the chamber’s system requirements. Improper modifications to these setup values can result in erratic performance and unreliable operation. Do not attempt to modify the setup values, unless you thoroughly understand what you are doing. If there is any doubt, please call TestEquity before proceeding.

### **Setup Menu**

Prompt	Function	Setting	Alternate Setting
<b>LoC</b>	Lockout Menu	<b>2</b>	See NOTE 1 below
<b>SEn</b>	Sensor Type	<b>tC</b>	Do Not Change
<b>L<sub>in</sub></b>	Linearization	<b>t</b>	Do Not Change
<b>dEC</b>	Decimal	<b>0</b>	Alt. “0.0”
<b>C<sub>F</sub></b>	°C or °F	<b>C</b>	Alt. “F”
<b>rLo</b>	Range Low	<b>-75</b>	Do not make any lower
<b>rHi</b>	Range High	<b>180</b>	Do not make any higher
<b>Fn2</b>	Output 2 Function	<b>L<sub>177</sub></b>	Do Not Change
<b>LSd</b>	Limit Sides	<b>both</b>	Alt. “high” (High only) or “LoW” (Low only)
<b>LhY</b>	Limit Hysteresis	<b>2</b>	Change not recommended
<b>ALY</b>	Alarm Type	<b>oFF</b>	Do Not Change
<b>PAR1</b>	Upper Display	<b>ACP<sub>U</sub></b>	Alt. “none”
<b>PAR2</b>	Lower Display	<b>LS<sub>t</sub></b>	Alt. “Lh.s” (High Set Point) or “LL.S” (Low Set Point)
<b>AdS</b>	Zone Address	<b>1</b>	Not functional for this application

NOTE 1: The Lockout Menu **LoC** sets the security clearance level as follows:

<b>1</b>	Operations Menu, read only
<b>2</b>	Operations Menu, set point read/write
<b>3</b>	Operations Menu, set point read or write (same as level 2)
<b>4</b>	Operations Menu, full access read/write (required to access Calibration Offset below)
<b>5</b>	Operations Menu and Setup Menu full access (required to access Setup Menu and Calibration Offset below)

### **Operations Menu**

Prompt	Function	Setting	Alternate Setting
<b>LLS</b>	Low Set Point	<b>-75</b>	Appropriate Low Limit Set Point
<b>LhS</b>	High Set Point	<b>180</b>	Appropriate High Limit Set Point
<b>.CR</b>	Calibration Offset	<b>0</b>	Calibration Offset as required (see NOTE 2 below)

NOTE 2: LoC parameter in Setup Menu must be set for 4 or 5 to access the Calibration Offset parameter.



## **Chapter 8 - Warranty**

### **TestEquity LLC Limited Warranty**

TestEquity LLC (TestEquity) warrants Environmental Chambers (Equipment) manufactured by TestEquity and supplied under this contract to be free from defects in materials and workmanship under normal use and proper maintenance.

TestEquity will repair or replace any defective part for a period of THREE YEARS from the date of invoice. TestEquity reserves the right to require any defective part be returned, freight prepaid, to TestEquity's factory or to inspect any defective part at the Purchaser's site. TestEquity shall have sole discretion to determine whether any part is defective and whether any defective part will be repaired or replaced. This limited warranty shall extend to any standard chamber accessory and component part which is normally sold by TestEquity. Non-standard accessories and component parts specified by the Purchaser shall be warranted only to the extent of the original manufacturer's warranty, if any exists.

If the repair or replacement is performed in the FIRST YEAR from the date of invoice, TestEquity will also pay for the labor associated with the repair at the Purchaser's site, subject to TestEquity's prior approval. During the SECOND and THIRD YEAR of the warranty period, Purchaser will be responsible for the installation and cost of installation of replacement or repaired parts, and the cost of refrigerant. Purchaser shall notify TestEquity in writing of any alleged defect within 10 days after its discovery within the warranty period. TestEquity reserves the right to satisfy the labor portion of this limited warranty either through its own service personnel or an authorized agent. In order to provide expeditious service, TestEquity reserves the right to satisfy its limited warranty obligation by sending replacement parts to be installed by the Purchaser if they can be installed easily without special tools or training. TestEquity reserves the right to satisfy this limited warranty by requiring the Purchaser to return the Equipment to TestEquity when such return is feasible.

The following parts are excluded from this limited warranty and are sold as-is or are considered expendable: interior light bulb, viewing window, paint and cosmetic surface finishes and treatments, port plugs, refrigerant.

This limited warranty shall extend in full to Equipment installed within continental United States and Canada. For all other locations, Purchaser is responsible for all labor costs for repairs or parts installation, and for all shipping costs associated with providing replacement parts.

This limited warranty does not cover: (1) Defects or damages arising as the result of shipment by common carriers or private transportation, unless TestEquity undertakes shipment and transportation of the Equipment to Purchaser's site or contractually assumes the risk of damage to the Equipment in shipment; (2) Defects or damages arising out of, or as the result, of mishandling, modification, or improper start up, installation or maintenance of the Equipment (including start up, installation or maintenance not in accordance with TestEquity's written procedures); (3) Defects or damages resulting from, or arising out of, abuse, misuse, neglect, intentional damage, accident, fire, flood, earthquake, or any other act of God.

This warranty as to Equipment is LIMITED to repair or replacement of parts or Equipment in the determination of TestEquity LLC THE FORGOING LIMITED WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES INCLUDING THE IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE AND MERCHANTABILITY. TestEquity LLC DISCLAIMS ANY LIABILITY FOR ANY DAMAGES RESULTING FROM DELAY OR LOSS OF USE IN SERVICE OR REPAIR, OR FOR INCIDENTAL OR CONSEQUENTIAL DAMAGES ARISING OUT OF OR IN CONNECTION WITH THE USE OR PERFORMANCE OF THE EQUIPMENT, EXCEPT AS STATED IN THIS PARAGRAPH.

This limited warranty cannot be modified in any way except in writing by both TestEquity and Purchaser. Invalidation of any one or more of the provisions of this limited warranty shall in no way affect any of the other provisions hereof, which remain in full force and effect.

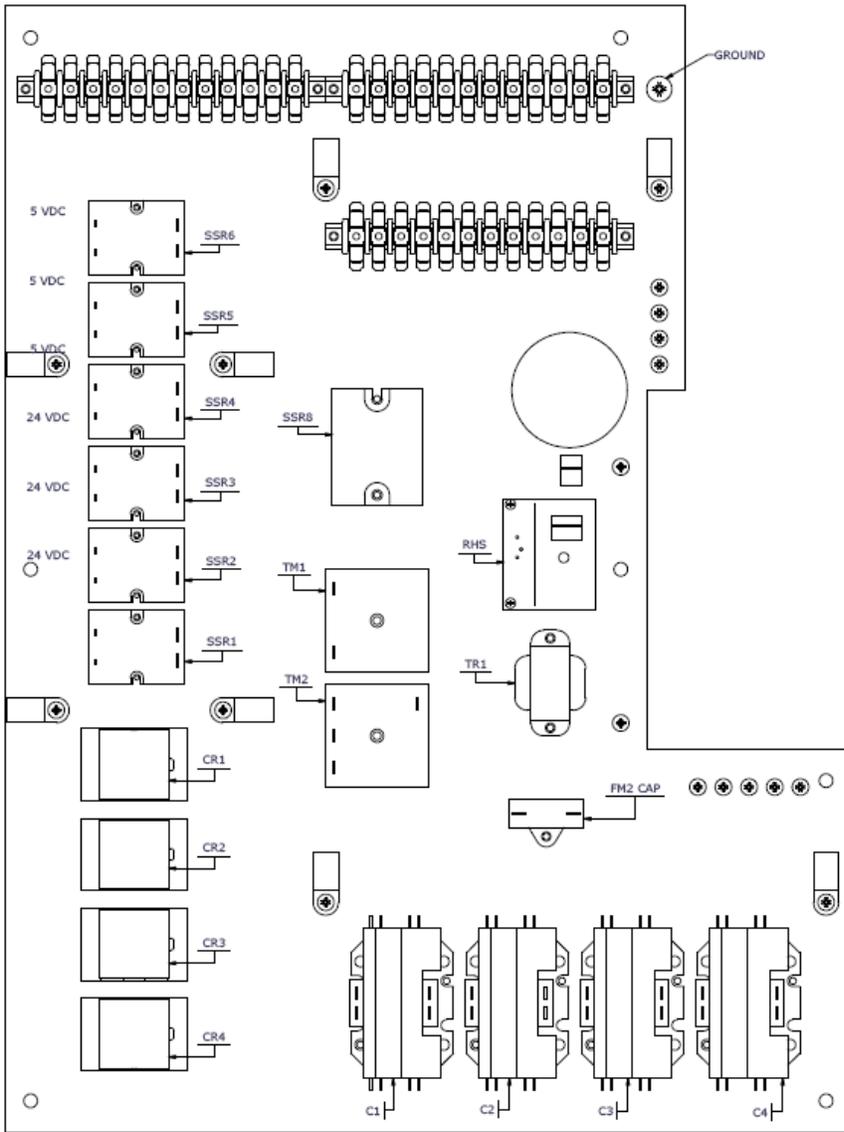
This limited warranty shall be extended only to the first Purchaser of this Equipment and is not transferable.



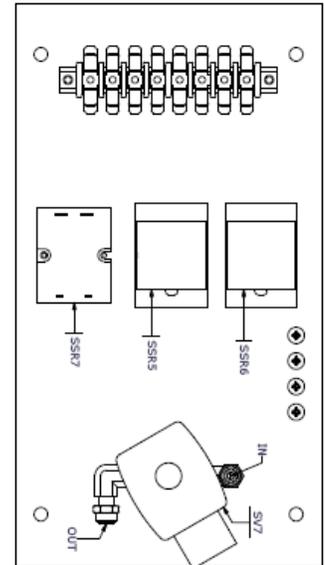
**Chapter 9 – Drawings**



# Electrical Subpanel Component Location



Main Subpanel



Purge Subpanel