Model 1027C
Temperature Chamber

Operation and Service Manual

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 6/15/2009 Rev. 1.09

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Chapter 1 – Safety Instructions

Introduction

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

⚠ **CAUTION:** The minimum clearance you should allow for proper ventilation around the chamber must be at least 12" from both the left and right side, and 24" 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.

⚠ **CAUTION:** The Input Voltage label on the back of the chamber indicates the input voltage configuration as shipped from the factory. If the input voltage configuration is changed, this label must be replaced to reflect the new configuration. Replacement labels are available from TestEquity at no charge.

⚠ **CAUTION:** This chamber must be properly configured for either 208 V or 230 V nominal input. 208 V and 230 V are NOT the same. Do NOT guess! Do NOT assume you have "220 V". You must verify the exact type of electrical service you have. If there is any doubt, you must consult with a qualified electrician who is familiar with industrial plant wiring. In addition, the input line voltage should be measured while the chamber is operating in the COOL mode to ensure that the expected nominal voltage of either 208 V –5/+10% or 230 V ±10% is present. Operation below 198 V or greater than 253 V requires internal transformers, which can be supplied for a nominal charge.

⚠ **CAUTION:** This chamber should be connected to the AC power source by a qualified electrician who is familiar with industrial plant wiring.

Operation Safety Notices

⚠ **CAUTION:** This chamber has a crankcase heater to protect the high-stage compressor. The chamber must be connected to the power source AND the Main Disconnect Switch must be ON for 3 hours prior to operating the chamber. Although it may be safe to use the chamber immediately, this procedure ensures the longest possible life for the high-stage compressor if the chamber has been removed from the power source for more than 24 hours.

⚠ **CAUTION:** The "Series F4 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 F4SH-CKA0-01, as described on page A.7 of the "Series F4 User's Manual" are applicable. "Cascade Control" as described on page 3.6 of the "Series F4 User's Manual" is not applicable in this configuration. The "Retransmit" function is available as an option.

⚠ **CAUTION:** The Series F4 "Alarm" functions are NOT used in the chamber's safety system and are NOT connected. TestEquity does NOT recommend using the Series F4 alarm function as the main protection device. The independent Series 97 Limit Controller functions as the main protection device.

⚠ **CAUTION:** The Series F4 Temperature Controller has been properly configured by TestEquity to match the chamber's system requirements and to perform optimally over a wide range of operating conditions. Improper modifications to these setup values can result in erratic performance and unreliable operation. Setup examples in the "Series F4 User's Manual" are NOT applicable to this chamber. 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.

⚠ **CAUTION:** NEVER select "Full Defaults" in the Series F4 Controller's Factory/Test Menu. This will erase all the correct values which are documented in the "Series F4 Temperature Controller Setup Parameters" section of this manual.

⚠ **CAUTION:** The Series 97 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. Setup examples in the "Series 97 User's Manual" are NOT applicable to this chamber. If there is any doubt, please call TestEquity before proceeding. The correct values are documented in the "Series 97 Limit Controller Setup Parameters" section of this manual.

⚠ **CAUTION:** NEVER select "Default Settings" in the Series 97 Limit Controller's Factory Page. This will erase all the correct values which are documented in the "Series 97 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 1000ºF. 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

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.

Preparation For Use

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

Installation Location

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. 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.

The chamber must be on a solid and level floor.

⚠ **CAUTION:** The minimum clearance you should allow for proper ventilation around the chamber must be at least 12" from both the left and right side, and 24" 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.

Condensate Drain

The chamber has a condensate drain connection on the rear of the chamber. This provides a way to remove condensate that may accumulate in the chamber during low-to-high temperature cycling or when the refrigeration system runs to maintain moderate temperatures. 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. The fitting accommodates a ½-inch male pipe thread. The chamber drain water is not under pressure, and is fed by gravity. Therefore, it must empty into an open floor drain. Alternatively, the chamber drain can empty into a condensate pump. You can purchase a condensate pump from suppliers such as Grainger (www.grainger.com).

Input Power Configuration

Overview

This chamber can be easily configured for operation from a 208 V / 60 Hz or 230 V / 60 Hz, 3 Phase nominal input. Other input voltages and 50 Hz operation are available as special options, and are not covered in these instructions.

Your chamber was configured prior to shipment for the particular voltage that was specified at time of order. These instructions should be used to verify the input voltage configuration prior to installation, or to change the input voltage from one configuration to another.

⚠ **CAUTION:** This chamber must be properly configured for either 208 V or 230 V nominal input. 208 V and 230 V are NOT the same. Do NOT guess! Do NOT assume you have "220 V". You must verify the exact type of electrical service you have. If there is any doubt, you must consult with a qualified electrician who is familiar with industrial plant wiring. In addition, the input line voltage should be measured while the chamber is operating in a continuous HEAT mode to ensure that the expected nominal voltage of either 208 V –5/+10% or 230 V ±10% is present.

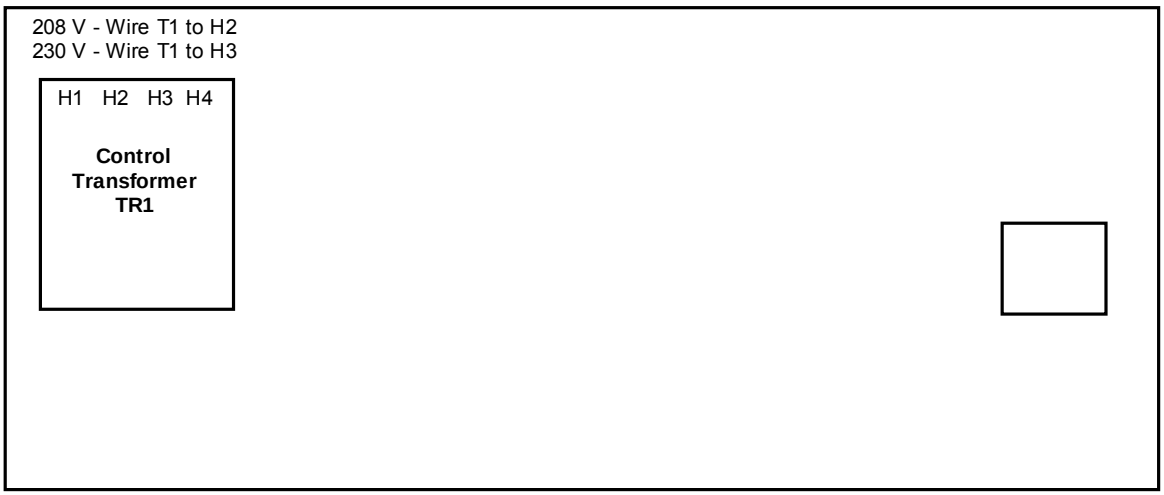


Figure 2-1 – Location of Input Configuration Terminals on the Electrical Sub Panel

NOTE: Refer to Figure 2-1 for the location of the input configuration terminals on the electrical sub panel that are described below.

230 V / 60 Hz Input Configuration

1. Turn the Main Disconnect switch to the OFF position.
2. Remove the lower door retaining screw located on the right side. Open the lower door.
3. Locate the Control Transformer TR1. Wire number T1 must be connected to the 230 V terminal H3 on Control Transformer TR1.

208 V / 60 Hz Input Configuration

1. Turn the Main Disconnect switch to the OFF position.
2. Remove the lower door retaining screw located on the right side. Open the lower door.
3. Locate the Control Transformer TR1. Wire number T1 must be connected to the 208 V terminal H2 on Control Transformer TR1.

Connection to the Power Source

⚠ **CAUTION:** This chamber should be connected to the AC power source by a qualified electrician who is familiar with industrial plant wiring.

The Main Disconnect Switch on the front panel removes primary power to the entire chamber. All branch circuits on the load side of the Main Disconnect Switch are individually fused. However, your local electrical code may require a separate disconnect switch within sight of the chamber.

Power Source Connection

1. Turn the Disconnect Switch to the OFF position.
2. Remove the lower door retaining screw located on the right side. Open the lower door.
3. Remove the chamber's right side panel.
4. Mount the input wire through the hole on the rear of the chamber, using an appropriate bushing. An additional 5-feet of wire will be needed need to reach to the terminals on the electrical subpanel. The the wires will need to pass through the Input Access Hole. This hole is located in the corner of the partition which separates the compressor compartment from the electrical compartment. Three tie points are provided on the side of the chamber to secure the input wiring with tie-wraps.
5. Connect the "Hot" input wires to terminals L1, L2 and L3 on the Main Disconnect Switch.
6. Connect the Ground wire (NOT A NEUTRAL) to the Ground terminal.

Phase Sequence

This chamber has a protective circuit to ensure the proper input power phase sequence. If the chamber does not function with the initial wiring hookup, then reverse two of the input lines.

Chapter 3 – Operation

Introduction

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

The 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 Temperature Controller controls the temperature of the chamber. It can function as either a single set point controller or as a programmable profile controller. The Temperature Controller automatically turns the refrigeration system on or off based on the demand for cooling.

⚠ **CAUTION:** This chamber has a crankcase heater to protect the high-stage compressor. The chamber must be connected to the power source AND the Main Disconnect Switch must be ON for 3 hours prior to operating the chamber. Although it may be safe to use the chamber immediately, this procedure ensures the longest possible life for the high-stage compressor if the chamber has been removed from the power source for more than 24 hours.

Summary of Chamber Operation

1. Turn the Main Disconnect Switch ON.
2. Enter the appropriate high and low temperature safety limits on the Limit Controller.
3. Enter the desired temperature set point (or program) on the Temperature Controller.
4. Load your test sample in the chamber.
5. Turn the Master Switch ON.

Front Panel Switches and Lights

Main Disconnect Switch

The Main Disconnect Switch controls power to the entire chamber and provides a mechanical safety interlock to the lower door.

In the ON position (clockwise) primary power is connected. The Temperature Controller, Limit Controller, and (optional) Chart Recorder are always functional when the Main Disconnect Switch is ON, regardless of the Master Switch position. The Main Disconnect Switch should be left ON if the chamber is usually used on a daily basis.

In the OFF position (counter clockwise) primary power is disconnected. The Main Disconnect Switch can be left OFF if the chamber is not used on a daily basis. It can also be locked in the OFF position with a padlock. The knob has a red insert that can be pushed in at the top to reveal the lock-hole.

⚠ **CAUTION:** This chamber has a crankcase heater to protect the high-stage compressor. The chamber must be connected to the power source AND the Main Disconnect Switch must be ON for 3 hours prior to operating the chamber. Although it may be safe to use the chamber immediately, this procedure ensures the longest possible life for the high-stage compressor if the chamber has been removed from the power source for more than 24 hours.

Master Switch

The Master Switch enables all chamber functions. The Master Switch illuminates when it is ON.

Light Switch

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

Silence Switch

The Limit Controller will sound an Audible Alarm in the event of an over-temperature or under-temperature condition. The Silence Switch lets you temporarily turn off the Audible Alarm.

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.

Loading 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 1000ºF. 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 1027C

Temp	**+23°C**	**0°C**	**–40°C**	**–55°C**	**–65°C**
Watts	2900 W	2600 W	2300 W	1750 W	1050 W

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.

Performance Considerations

The performance of all chambers is significantly effected 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 temperature controller indicates. 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, NOT by recalibrating the controller.

Avoiding Moisture

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.

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.

Chapter 4 - Temperature Controller

Introduction

The Series F4 Temperature Controller can function as either a single set point controller (static mode) or as a programmable profile controller. A four-line LCD display facilitates setup and programming, and presents informative messages about status, error, and alarm conditions. Digital outputs, profiles, and alarms can be named for easy reference. An Information Key gives you quick information about the pages, menus, parameters and values, as well as error and alarm conditions if they occur. The user-interface is organized into five "pages" of menus.

⚠ **CAUTION:** The Series F4 "Alarm" functions are NOT used in the chamber's safety system and are NOT connected. TestEquity does NOT recommend using the Series F4 alarm function as the main protection device. The independent Series 97 Limit Controller functions as the main protection device.

⚠ **CAUTION:** The Series F4 Temperature Controller has been properly configured by TestEquity to match the chamber's system requirements and to perform optimally over a wide range of operating conditions. 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. Setup examples in the "Series F4 User's Manual" are NOT applicable to this chamber. If there is any doubt, please call TestEquity before proceeding. The correct values are documented in the "Series F4 Temperature Controller Setup Parameters" section of this manual.

⚠ **CAUTION:** NEVER select "Full Defaults" in the Series F4 Factory/Test Menu. This will erase all the correct values which are documented in the "Series F4 Temperature Controller Setup Parameters" section of this manual.

Security Features

The Series F4 Controller has several levels of security to prevent unauthorized users from changing critical configuration parameters. Only the Set Point and Profile menus have "Full Access". TestEquity has configured all other menus to "Password", and have protected them with a password.

TestEquity does not recommend that these security levels be changed for most applications. However, there will be times when entry into these menus is necessary. For example, you may need to gain access to Setup Page in order to change from °C to °F display, or to change the time or date. You must call TestEquity at 877-512-3457 or 805-480-0638 to obtain the password.

Temperature Controller Keys and Displays

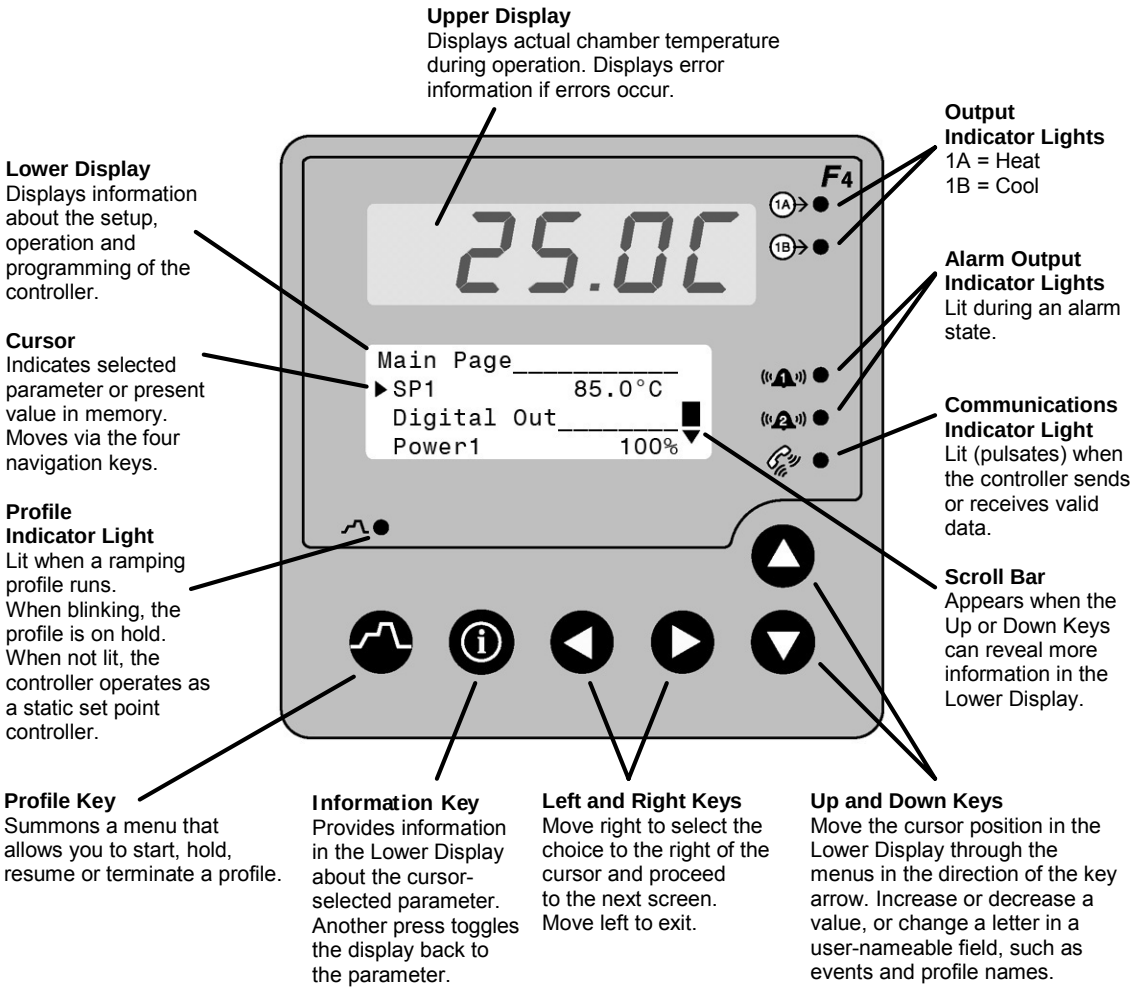


Figure 4.1 – Temperature Controller Keys and Displays

To navigate through the menus:

1. Use the ▲ or ▼ key to move the cursor to line up with the item to be selected in a menu on the lower display.
2. Press the ► key to select the item.
3. Enter or change the value, or make a choice with the ▲ or ▼ key.
4. Press the ► key to enter the value or choice.
5. Repeat until you return to the original list.

The ► key again saves the value and proceeds to the next parameter in the series.
The ◄ key saves the value and backs out of the series, and returns to the Main Page.

To edit a parameter, proceed through the series using the ► key without changing values until you find the parameter you want to change. After making the change with the with the ▲ or ▼ key, you may back using the ◄ key out or proceed using the ► key to the end of the series.

Main Page

The Main Page displays manual operating parameters, running program parameters and error messages. It also provides access to the Operations, Profiles, Setup and Factory pages. The following is a list of Main Page parameters and the description of their functions.

Main Page_____	
Current File	Displayed if running a profile, the name of the profile.
Current Step	Displayed if running a profile, the current step of the profile.
► SP1	Static (manual) temperature set point entry. If running a profile, the current set point.
Step Type	Displayed if running a profile, the type of step.
Target SP1	Displayed if running a profile, the target temperature during a ramp step.
WaitFor Status	Displayed if running a profile, the status during a WairFor step.
Time Remaining	Displayed if running a profile, the remaining time of the current step.
DigitalOut	Status of the event outputs 1 to 8. An "8" indicates when cooling system is ON.
Power1	The % of throttle of the heat (positive number) or cool (negative number) output.
DigitalIn	Status of the digital inputs 1 through 4.
Date	Real-time clock date.
Time	Real-time clock time.
TESTEQUITY 1027C	Identifies the chamber model number.
Go to Operations	Access to Operations Page
Go to Profiles	Access to Profiles Page
Go to Setup	Access to Setup Page. Not displayed if running a profile.
Go to Factory	Access to Factory Page. Not displayed if running a profile.

Static Set Point Control

The Temperature Controller is in Static Mode when it is not controlling a Profile. When in a Static Mode, the Profile Indicator Light is off (see Fig. 4.1). The Upper Display shows the actual chamber workspace temperature. The Static Set Point (SP1) prompt is accessed from the Main Page.

To enter a Static Set Point:

1. Press the ▲or ▼ key to position the Cursor next to the SP1 prompt. You may already be at this prompt.
2. Press the ► key once. You will see Static Set Point1 in the lower display with the current set point indicated below.
3. Press the ▲or ▼ key to change the temperature set point value.
4. Press the ► key once to enter the new temperature set point. You are now back to the Main Page.

```
Main Page_____________
► SP1        85.0°C
  DigitalOut_________  ▲
  Power1          50%  ▼
```

```
Static Set Point1:____
     85.0  °C
   ▲
   ▼ Adjusts Value
   ◄ Back   ► Next
```

Profile Programming

The Series F4 Temperature Controller can be programmed to store up to 256 steps into as many as 10 profiles. You do not need a computer to enter a profile – it can be easily done through the controller's front panel keys. A Profile is a set of instructions programmed as a sequence of steps. The controller handles the profile steps automatically, in sequence. As many as 40 different profiles and a total of 256 steps can be stored in non-volatile memory. The 256 steps are grouped by profile. So, one profile could have 256 steps; or 39 profiles could have 6 steps and one could have 22; or 32 profiles could have eight steps each. The maximum number of steps is 256, and the maximum number of profiles is 40.

Step Types

Use the six available step types – Autostart, Ramp Time, Ramp Rate, Soak, Jump and End – to create simple or complex profiles involving all inputs and outputs. The Series F4 prompts you to define each step's properties.

Autostart Step

The use of an Autostart step in a profile is optional. Autostart pauses a profile until the specified date or day, and time (of a 24-hour-clock). Define the Autostart by choosing:

- Day (of the week) or Date,
- Time

To invoke an Autostart step in a profile, you must activate the profile via the Profile Key and select the Autostart step.

Ramp Time Step

Ramp Time changes the set point to a new value in a chosen period of time. Define the Ramp Time step by choosing:

- *Wait for an event or process value
- Event outputs 1 through 7 to turn ON or OFF (For controlling the power to remote devices.)
- Time (in hours, minutes and seconds)
- Temperature Set Point
- PID set (One of five sets of heat/cool PID parameters. Normally, just leave at PID Set 1.)
- **Guaranteed Soak

Ramp Rate Step

Ramp Rate changes the set point to a new value in a chosen rate of time. Define the Ramp Rate step by choosing:

- *Wait for an event or process value
- Event outputs 1 through 7 to turn ON or OFF (For controlling the power to remote devices.)
- Rate (in degrees per minute)
- Temperature Set Point
- PID set (One of five sets of heat/cool PID parameters. Normally, just leave at PID Set 1.)
- **Guaranteed Soak

Soak Step
Soak maintains the set point from the previous step for a chosen time in hours, minutes and seconds. Define the Soak step by choosing:

- *Wait for an event or process value
- Event outputs 1 through 7 to turn ON or OFF (For controlling the power to remote devices.)
- Time
- PID set (One of five sets of heat/cool PID parameters. Normally, just leave at PID Set 1.)
- **Guaranteed Soak

Jump Step
Jump initiates another step or profile. Define the Jump step by choosing:

- Profile to jump to;
- Step to jump to; and
- Number of Repeats

NOTE: If a power-out condition occurs during a profile and more than 20 jump steps are stored in the F4's Profile Program memory, the controller will terminate the profile and turn off all outputs if Continue, Hold or Terminate was selected as the Power Out action. If Profile Reset or Go to Idle Set Point was selected, the controller will take those actions. A pop-up message will warn of this when the 21st jump step is programmed

End Step
End terminates the profile in a chosen state. All profiles must have an End step. It cannot be deleted or changed to another step type. Define the End by choosing Hold, Control Off, All Off or Idle end state.

NOTE: TestEquity recommends having the end step type to be Hold or Idle. TestEquity does NOT recommend using an end step type of Control Off or All Off. This does not turn off the chamber fan. The chamber temperature can reach +55°C just from heat generated by the fan, and even higher if your test sample is energized.

***Wait For step option**
The use of Wait For in a profile is optional. Ramp Time, Ramp Rate and Soak steps can be programmed to wait for a particular chamber temperature or event input condition. The wait conditions must be satisfied before the time clock and the step activity proceeds. Digital inputs must first be configured in the System Menu as Wait For Events, with the condition to be met also specified. Then, to wait for this digital input, you must specify On, meaning the condition as configured in the Setup Page, or Off, meaning the opposite of that condition. The digital inputs have been configured to Off by TestEquity, so this option will not show unless reconfigured.

****Guaranteed Soak step option**
The use of Guaranteed Soak in a profile is optional. The Guaranteed Soak step requires the chamber temperature to be at the set point temperature, within the Guaranteed Soak Band value, before the time clock and the step activity proceeds. The Guaranteed Soak Band is configured by TestEquity for 3.0°C, and this can be changed in the System Menu.

How to Program a New Profile

1. **Go to the Profiles Page.**
Move the cursor down the Main Page to `Go to Profiles`, then press the ► key.
	`Main Page_____`
	`► Go to Profiles ▲`
	`  Go to Setup  ▐`
	`  Go to Factory ▼`

2. **Create a new Profile.**
The cursor will be on `Create Profile`. Press the ► key.
	`Main>Profile_____`
	`► Create Profile`
	`  Edit Profile  ▐`
	`  Delete Profile ▼`

3. **Name the profile.**
You can name your profiles for easy reference if desired. Names can have up to 10 characters. You can also use one of the default profile names (ex. Profile1), and skip this step. To name a profile:
• Press ► to enter the name space and the first position.
• Press the ▲or ▼ to scroll through the alphabet and stop at the letter or number desired.
• Press ► to move to the next position.
• Continue until the name is complete, or until you move through the name space into the next screen.
• Press ► to save the name of the profile.
	`Choose to Name:_____`
	`  No`
	`► Yes`
	
	`Enter Profile Name:_`
	`PROFILE1`
	`  ▲`
	`  ▼ Adjusts Char`
	`  ◄► Save Changes`

4. **Choose the step type.**
• There are six step types, each of which must be defined through different parameters. (See "Step Types," earlier in this chapter.)
	`Choose Step1 Type:____`
	`  Autostart`
	`► Ramp time  ▐`
	`  Ramp Rate  ▼`

5. **Define each step type.**
• The Series F4 prompts you to define the parameters of each step type. (See "Step Types," earlier in this chapter.)
	`Choose to wait:_______`
	`► Step does not wait`
	`  Step waits for...`
	
	`Enter Ramp Time:______`
	` 00:00:01  (H:M:S)`
	`  ▲`
	`  ▼ Adjusts Digit`
	`  ◄► Save Changes`
	
	`Enter Ch1 SP:_________`
	`  85.0 °C`
	`  ▲`
	`  ▼ Adjusts Value`
	`  ◄ Back  ► Next`

6. **Choose the end-state.**
• All profiles end with an End step, which is preprogrammed into the new profile. (See "End Step," earlier in this chapter.)
	`Choose End State:_____`
	`  Control Off  ▲`
	`  All Off  ▐`
	`► Idle`

7. **Save your settings.**
• Press ◄ to exit the Profiles Page.
• After exiting the Profiles Page, choose ▲ to save profile data.
	`Save profile data`
	`or restore values?`
	` ▼ Restore  ▲ Save`

Programming Hints

- The first step in a program should be an initialization step of 1-second, usually at a set point of +23°C.
- The next to last step establishes a condition to end on. For example, you may want to end the program by holding at +23°C, so this step would be to go to +23°C.
- The final step of every profile is End. You cannot delete an End step or change it to another type, but you can insert new steps before it.
- TestEquity recommends having the end step type to be Hold or Idle.
- TestEquity does NOT recommend using an end step type of All Off or Control Off. This does not turn off the chamber fan. The chamber temperature can reach +55°C just from heat generated by the fan, and even higher if your test sample is energized. See Protecting an Energized Test Sample in Chapter 5 for important information regarding energized test samples.

Profile Key

The Profile key:

- Initiates the profile mode;
- Initiates the Hold-profile state;
- Initiates the Resume-profile command;
- Initiates the Terminate-profile command.

The Profile Key functions only from the Main Page.

How to Start a Profile

To initiate the profile mode, press the Profile key and answer the questions that follow.

1. **Press the Profile key to enter the Profile Control menu.** • The Profile Indicator will begin blinking. • Press the ▲ key for Yes.	Start a Profile? ▼ No ▲ Yes
2. **Select the desired stored profile.** • Press the ▲or ▼ to scroll through the list of stored profiles. • Press ► to select the desired profile.	Start Profile:_____ Profile1 ► Profile2 ▐ Profile3 ▼
3. **Select the desired step to start on.** • Press the ▲or ▼ to scroll through the list of steps. Generally you would start on Step 1, but you can also start on any other step. • Press ► to select the desired start step and the profile will begin to run. The Profile Indicator will stay lit.	Start:_____ ► Step 1 Ramp Time Step 2 Soak ▐ Step 3 Ramp Time ▼ Main Page_____ ► Profile 2 Running Step 1 ▐ SP1 85.0°C ▼

While running a profile, the Main Page on the lower display will keep you informed about the progress of the profile. Use the ▲or ▼ key to scroll through the list of running profile parameters. You cannot manually change any operating condition while the profile is running.

How to Hold/Resume a Running Profile

1. **To Hold a running profile, press the Profile key to enter the Profile Control menu.**
• Then press ▲or ▼ to make your choice for Hold.
• Press ► to select Hold.
• The Main Page will appear with a profile status of Holding. The Profile Indicator will be off.
	Hold Profile:_____
	  Don't Hold
	► Hold
	  Terminate
	
	Main Page_____
	► Profile 2 Holding
	  Step 2 ▐
	  SP1 23.0°C ▼

2. **To Resume profile on hold, press the Profile key to enter the Resume Profile menu.**
• Then press ▲or ▼ to make your choice for Resume.
• Press ► to select Resume.
	Resume Profile:_____
	  Continue Holding
	► Resume
	  Terminate

While a profile is on Hold, the current set point can be adjusted at the SP1 prompt on the Main Page. When a profile is resumed during a Ramp step, the controller uses the Static Set Point from the Main Page to calculate the rate of change needed to get to the set point at the end of the step. When a profile is resumed in a soak step, the new set point value will be used as the soak value for the time remaining in the step.

How to Terminate a Running/Holding Profile

1. **Press the Profile key while the profile is running to enter the Resume Control menu.**
• Then press ▲or ▼ to make your choice for Terminate.
• Press ► to select Terminate.
	Hold Profile:_____
	  Don't Hold
	  Hold
	► Terminate

If you manually terminate a running profile, the profile ends with a set point of Off. This does not turn off the chamber fan. The chamber temperature can reach +55°C just from heat generated by the fan, and even higher if your test sample is energized. See Protecting an Energized Test Sample in Chapter 5 for important information regarding energized test samples.

How to Delete or Re-Name a Profile

1. **Go to the Profiles Page.**
Move the cursor down the Main Page to `Go to Profiles`, then press the ► key.
	Main Page_____
	► Go to Profiles ▲
	  Go to Setup ▐
	  Go to Factory ▼

2. **Choose Delete or Re-Name.**
• Press ▲or ▼ to scroll through your choice.
• Press ► to select your choice.
• The controller will prompt you to select the profile you want to delete or re-name.
	Main>Profile_____
	  Edit Profile ▲
	► Delete Profile ▐
	  Re-Name Profile

How to Edit a Profile

1. **Go to the Profiles Page.**
Move the cursor down the Main Page to `Go to Profiles`, then press the ► key.
	`Main Page_____`
	`► Go to Profiles`
	`  Go to Setup`
	`  Go to Factory`

2. **Choose Edit Profile.**
• Press the ▼ key to choose on `Edit Profile`.
• Then press the ► key.
	`Main>Profile_____`
	`  Create Profile`
	`► Edit Profile`
	`  Delete Profile`

3. **Select the desired stored profile to edit.**
• Press the ▲or ▼ to scroll through the list of stored profiles.
• Press ► to select the desired profile.
	`…Edit Profile:_____`
	`  Profile1`
	`► Profile2`
	`  Profile3`

4. **Choose how to edit the step.**
• Press the ▲or ▼ to scroll through the list of step edit choices.
• Press ► to select your choice.
	`Choose to:_____`
	`  Insert Step`
	`► Edit Step`
	`  Delete Step`
	`  Done`

5. **To edit a step.**
• Press the ▲or ▼ to scroll through the list of steps you want to edit.
• Press ► to scroll through the step parameters and make any desired changes.
	`Edit Step:_____`
	`► Step 1  Ramp Time`
	`  Step 2  Soak`
	`  Step 3  Ramp Time`

6. **To insert a step.**
• Choose `Edit Profile` (see step 4 above)
• Press the ▲or ▼ to scroll through the number of the step that the new step will precede.
• Press ► to enter the new step and follow the step parameter prompts.
	`Insert Before:_____`
	`  Step 1  Ramp Time`
	`► Step 2  Soak`
	`  Step 3  Ramp Time`

7. **To delete a step.**
• Choose `Delete Step` (see step 4 above)
• Press the ▲or ▼ to scroll through the number of the step you want to delete.
• Press ► to delete the step.
	`Delete Step:_____`
	`  Step 1  Ramp Time`
	`► Step 2  Soak`
	`  Step 3  Ramp Time`

8. **Save your settings.**
• Press ◄ successively to exit the Profiles Page.
• After exiting the Profiles Page, choose ▲ to save the new profile values, or ▼ to restore the old values.
	`Save profile data`
	`or restore values?`
	`▼ Restore  ▲ Save`

- Inserting or deleting a step will renumber all steps that follow.
- A Jump Step that jumps to an End Step cannot be deleted.
- An End Step cannot be deleted.
- Inserting a new ramp step usually requires inserting an associated soak step.
- Deleting a ramp step usually requires deleting the associated soak step.

Profile Examples

The following are examples of two typical profiles.

Profile Summary: -40ºC to 85ºC, no ramps, 30 minute soak time, 4 cycles. End with program hold at +23ºC.

Step Number	Step Type	Date Day, Time	Wait for	Choose Digit Out 1	2	3	4	5	6	7	Time H:M:S	Rate	Ch1 SP	PID Set	Guar. Soak	Jump to Profile	Step	Repeats	End Type
1	Ramp Time	—	>	>	>	>	>	>	>	>	00:00:01	—	23.0	1	—	—	—	—	—
2	Ramp Time	—	>	>	>	>	>	>	>	>	00:00:01	—	-40.0	1	—	—	—	—	—
3	Soak	—	>	>	>	>	>	>	>	>	00:30:00	—	—	1	Yes	—	—	—	—
4	Ramp Time	—	>	>	>	>	>	>	>	>	00:00:01	—	85.0	1	—	—	—	—	—
5	Soak	—	>	>	>	>	>	>	>	>	00:30:00	—	—	1	Yes	—	—	—	—
6	Jump	—	>	>	>	>	>	>	>	>	—	—	—	—	—	Name	2	3	—
7	Ramp Time	—	>	>	>	>	>	>	>	>	00:00:01	—	23.0	1	—	—	—	—	—
8	End	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Hold

Step Description

1 Establishes a recommended initialization step. Goes to +23ºC as quickly as possible.
2 Goes to -40ºC as quickly as possible.
3 Will hold for 30 minutes. Time will not start until chamber reaches -37ºC (within the 3º Guaranteed Soak Band*).
4 Goes to +85ºC as quickly as possible.
5 Will hold for 30 minutes. Time will not start until chamber reaches +82ºC (within the 3º Guaranteed Soak Band*).
6 Jumps back to step 2. Repeats this 3-times, for a total of 4-cycles.
7 After all cycles are completed, establishes the condition to end on. Goes to +23ºC as quickly as possible.
8 Holds at +23ºC indefinitely, until program is manually stopped.

Profile Summary: +50ºC to 0ºC, 1ºC/minute ramp, 1 hour soak time, 100 cycles. Test sample turned ON/OFF depending on step. End with return to +23ºC manual set point.

Step Number	Step Type	Date Day, Time	Wait for	Choose Digit Out 1	2	3	4	5	6	7	Time H:M:S	Rate	Ch1 SP	PID Set	Guar. Soak	Jump to Profile	Step	Repeats	End Type	Idle SP
1	Ramp Time	—	>	On	>	>	>	>	>	>	00:00:01	—	23.0	1	—	—	—	—	—	
2	Ramp Rate	—	>	On	>	>	>	>	>	>	—	1.0	50.0	1	—	—	—	—	—	
3	Soak	—	>	On	>	>	>	>	>	>	01:00:00	—	—	1	No	—	—	—	—	
4	Ramp Rate	—	>	Off	>	>	>	>	>	>	—	1.0	0.0	1	—	—	—	—	—	
5	Soak	—	>	Off	>	>	>	>	>	>	01:00:00	—	—	1	No	—	—	—	—	
6	Jump	—	>	>	>	>	>	>	>	>	—	—	—	—	—	Name	2	99	—	
7	Ramp Rate	—	>	Off	>	>	>	>	>	>	—	1.0	23.0	1	—	—	—	—	—	
8	End	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	Idle	23.0

Step Description

1 Establishes a recommended initialization step. Goes to +23ºC as quickly as possible. Test sample is turned ON via Event 1.
2 Goes to +50ºC at a controlled rate of 1ºC per minute. Test sample is turned ON via Event 1.
3 Will hold for 1 hour. Test sample remains ON via Event 1.
4 Goes to 0ºC at a controlled rate of 1ºC per minute. Test sample is turned OFF via Event 1.
5 Will hold for 1 hour. Test sample remains OFF via Event 1.
6 Jumps back to step 2. Repeats this 3-times, for a total of 4-cycles.
7 After all cycles are completed, establishes the condition to end on. Goes to +23ºC at a controlled rate of 1ºC per minute. Test sample is turned OFF via Event 1.
8 End of program. Controller returns to a +23ºC manual set point.. Test sample is remains OFF via Event 1.

Notes

* Guaranteed Soak Band is set at the factory for 3.0ºC. Can be changed in the System Menu.
\> Means no entry or selection is required. Just scroll through this prompt to the next prompt.
— Means prompt does not show for this step type.

Digital Event Outputs

The Temperature Controller has digital outputs which can be configured as Event Outputs to turn remote devices on and off. There are seven Event Outputs which are available for customer use. Output number eight is configured to control the refrigeration compressors and is not available for customer use. The Event Outputs are accessed from the Main Page.

To control the Event Outputs:

1. Press the ▲or ▼ key to position the Cursor next to the DigitalOut prompt.
2. Press the ► key once. You will see Choose Event Output prompt in the lower display.
3. Press the ▲or ▼ key to position the Cursor next to the EventOutput prompt which you want to change. You will be able to select from EventOutput1 through EventOutput7.
4. Press the ► key once to select the desired EventOutput. Then, press the ▲or ▼ key to select On or Off.
5. Press the ► key once to return to the Choose Event Output prompt.
6. Press the ◄ key once to return back to the Main Page.

Digital Output Connections

See page 12.9 of the "Series F4 User's Manual" for details on how to connect to the Digital Outputs.

Event Board Option

Your chamber may have been ordered with the Event Board option. The event board contains 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, 3.0 Amps. However, TestEquity recommends derating the maximum current to 2.5 Amps. The solid state relay mounting board is UL recognized/CSA certified for 120 VAC max. with the board-mounted fuses; 250 VAC max. with a #22 solid copper jumper wire instead of the fuses.

Connecting to the Event Board

1. Turn the Main Disconnect switch to the OFF position.
2. Remove the lower door retaining screw located on the right side. Open the lower door.
3. The Event Board is located next to the electrical subpanel. Connect to the events as follows:

Event Output	Event Board Terminals
Event 1	1, 2
Event 2	3, 4
Event 3	5, 6
Event 4	7, 8
Event 5	9, 10
Event 6	11, 12
Event 7	13, 14

4. The event outputs are just switches. You must provide power from an external source.
5. A 1/2-inch conduit hole is provided on the left side of the lower door to route your wires through. Use the appropriate wire/cable management fittings.

Operations Page

The Operations Page provides access to menus for control tuning (PID) and controller alarms. TestEquity has configured the security to require a password for access to all parameters in the Operations Page. You must call TestEquity at 877-512-3457 or 805-480-0638 to obtain the password.

⚠ **CAUTION:** The Series F4 Temperature Controller "Alarm" functions are NOT used in the chamber's safety system and are NOT connected. TestEquity does NOT recommend using the Series F4 alarm function as the main protection device. The independent Series 97 Limit Controller functions as the main protection device.

⚠ **CAUTION:** The Series F4 Temperature Controller PID values have been properly configured by TestEquity to match the chamber's system requirements and to perform optimally over a wide range of operating conditions. Improper modifications to these values can result in erratic performance and unreliable operation. Do not attempt to modify the PID values, unless you thoroughly understand what you are doing. Setup examples in the "Series F4 User's Manual" are NOT applicable to this chamber. If there is any doubt, please call TestEquity before proceeding. The correct values are documented in the "Series F4 Temperature Controller Setup Parameters" section of this manual.

⚠ **CAUTION:** The Autotune PID function is not appropriate for use in this chamber. Using this function will result in tuning values that will not work correctly.

Setup Page

The Setup Page provides access to menus for configuring the controller hardware. TestEquity has configured the security to require a password for access to the Setup Page. However, there will be times when entry into these menus is necessary. For example, you may need to gain access to Setup Page in order to change from °C to °F display, or to change the time or date. You must call TestEquity at 877-512-3457 or 805-480-0638 to obtain the password.

⚠ **CAUTION:** The Series F4 Temperature Controller setup values have been properly configured by TestEquity to match the chamber's system requirements and to perform optimally over a wide range of operating conditions. Improper modifications to these 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. Setup examples in the "Series F4 User's Manual" are NOT applicable to this chamber. If there is any doubt, please call TestEquity before proceeding. The correct values are documented in the "Series F4 Temperature Controller Setup Parameters" section of this manual.

Factory Page

The Factory Page provides access to menus for controller diagnostics and calibration. TestEquity has configured the security to require a password for access to the Setup Page. However, there will be times when entry into these menus is necessary. For example, you may need to gain access to Factory Page in order to perform a calibration, or to change the security password. You must call TestEquity at 877-512-3457 or 805-480-0638 to obtain the password.

⚠ **CAUTION:** NEVER select "Full Defaults" in the Factory/Test Menu. This will erase all the correct values which are documented in the "Series F4 Temperature Controller Setup Parameters" section of this manual.

Computer Interface

⚠ **CAUTION:** Every setting in the F4 Controller can be accessed via the computer interface. Improper modifications to configuration settings can result in erratic performance and unreliable operation. Setup examples in the "Series F4 User's Manual" are NOT applicable to this chamber. The correct values are documented in the "Series F4 Temperature Controller Setup Parameters" section of this manual.

RS-232C

The F4 Temperature Controller has an RS-232C interface. A DB-9 connector is located on the rear panel. It is wired to accommodate a null-modem cable. To communicate with the controller from a PC, you need to run software that uses the Modbus RTU protocol. Each controller function has a "register" number which can be read or written to (when applicable). These registers are listed Chapter Seven of the "Series F4 User's Manual". RS-232C Modbus programming resources and LabVIEW drivers can be downloaded from http://chamber.testequity.com/rs232.html .

Common Modbus Registers

- The actual chamber temperature reading is Modbus register 100 (Input 1 Value).
- The static temperature set point is Modbus register 300 (Set Point 1).
- The temperature set point during a profile is Modbus register 4122 (Set Point 1, Current Profile Status).
- The decimal points are implied. For example, 1005 is actually 100.5 and -230 is -23.0.

GPIB (optional)

The optional GPIB interface consists of an internal board which converts the F4 controller's serial interface to GPIB. Chambers with a GPIB interface have a GPIB connector in place of the RS-232C connector. GPIB programming resources and LabVIEW drivers can be downloaded from http://chamber.testequity.com/gpib.html .

Ethernet (optional)

The optional Ethernet interface, model TE-1055, consists of an external converter box that connects to the chamber's RS-232C interface.

Chapter 5 - Limit Controller

Introduction

The Series 97 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 Temperature 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 Temperature Controller.

This section provides a brief overview on how to operate the Limit Controller. For more detailed instructions, see the "Series 97 User's Manual".

⚠ **CAUTION:** The "Series 97 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 97A0-DAAA-00-RG, as described on page A.20 of the "Series 97 User's Manual" are applicable. Please note that only the Series 97 "Limit" functions are applicable.

⚠ **CAUTION:** The Series 97 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. Setup examples in the "Series 97 User's Manual" are NOT applicable to this chamber. If there is any doubt, please call TestEquity before proceeding. The correct values are documented in the "Series 97 Limit Controller Setup Parameters" section of this manual.

⚠ **CAUTION:** NEVER select "Default Settings" in the Factory Page. This will erase all the correct values which are documented in the "Series 97 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

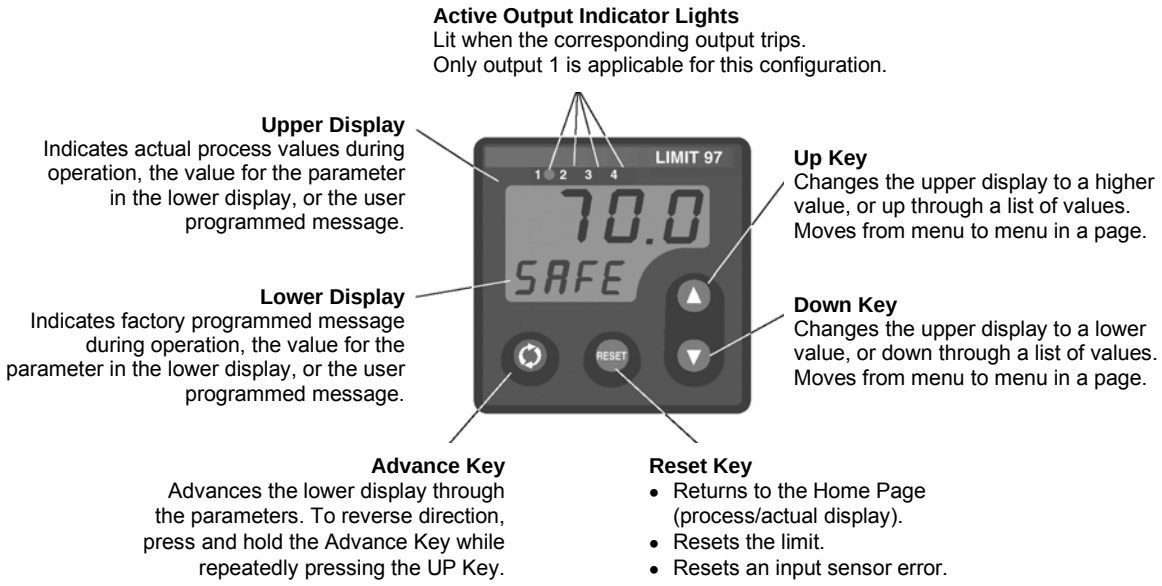


Figure 5.1 – Limit Controller Keys and Displays

How to Set the High and Low Temperature Safety Limits

1. Press the ▲AND ▼ keys together for ONLY three seconds, until the [OPEr] prompt appears in the Lower Display. The Upper Display should say [L 107].
2. Press the ◉ key once to get the [L Lo] prompt. This is the Low Limit Set Point prompt.
3. Press the ▲or ▼ key to enter the desired Low Limit Set Point. Make sure it is lower than your actual chamber temperature set point, and at least below room temperature to prevent nuisance tripping.
4. Press the ◉ key once to get the [L Hi] prompt. This is the High Limit Set Point prompt.
5. Press the ▲or ▼ key to enter the desired High Limit Set Point. Make sure it is higher than your actual chamber temperature set point to prevent nuisance tripping.
6. Press the RESET key to save these values and return to the Home Page.

If you press the ◉ key after the [L Hi] prompt, you will get the [CAL 1] prompt, which is the Calibration Offset. This is an adjustment to eliminate a difference between the indicated value and the actual process value.

Resetting a Limit Condition

If either the High or Low Limit is exceeded, the Limit Controller will indicate either [L Hi] or [L Lo] respectively in the lower display. It will also shut down all chamber functions and sound the Audible Alarm. The Limit Controller cannot be reset until the temperature returns to within the limit set points. Then, you must press the RESET Key to resume normal operation.

Silencing the Audible Alarm

The SILENCE 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. Turn the Main Disconnect Switch to the OFF position.
2. Remove the lower door retaining screw located on the right side. Open the lower door.
3. Locate the Terminal Strip on the electrical sub panel. Connections to the safety contacts are at terminals A1 and A2.

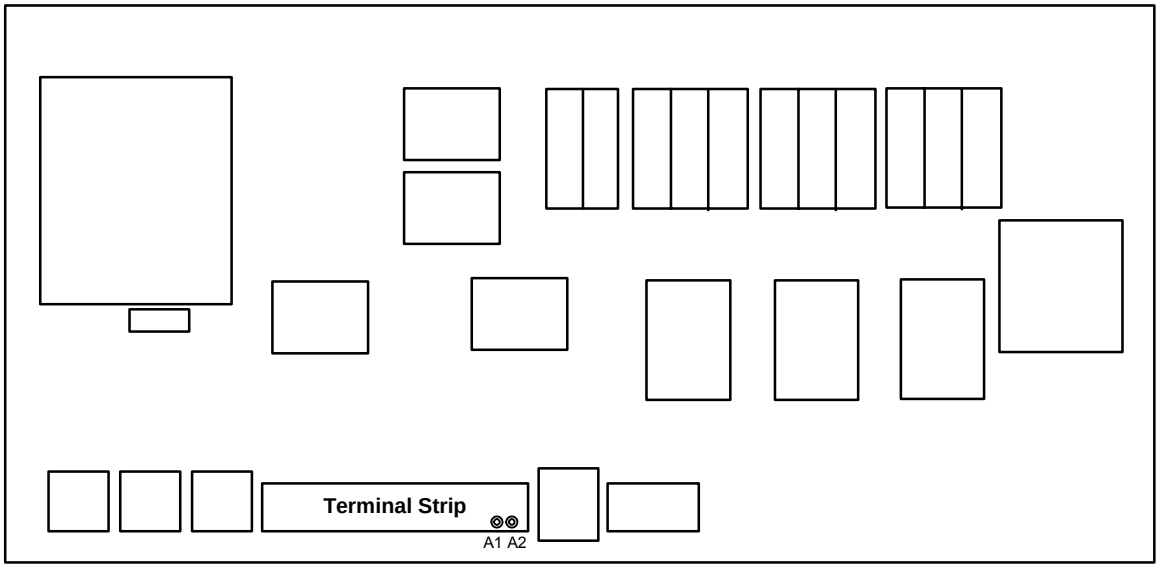


Figure 5-2 – Location of Safety Contact Connections on the Electrical Sub Panel

Chapter 6 – Frequently Asked Questions

The input voltage label says 230 (or 208) VAC. I thought I had 220 (or 240) VAC. Is that ok?
220 V is a misnomer—there is no such standard as nominal 220 V in the United States. You must verify the exact type of electrical service you have. If there is any doubt, you must consult with a qualified electrician who is familiar with industrial plant wiring. In addition, the input line voltage should be measured while the chamber is operating in a continuous HEAT mode to ensure that the expected nominal voltage of either 208 V –5/+10% or 230 V ±10% is present. Also, make sure the chamber is properly configured for either 208 V or 230 V nominal input as described in Chapter 2 - Input Power Configuration. If you have a 208 V line that measures under 198 V, the chamber will require boost transformers. If you have a 240 V line that measures over 252 V (a 240 V line which is 10% high could measure up to 264 V), the chamber will require bucking transformers.

Why doesn't the chamber come with a power cord and plug?
Most local electrical codes require permanent wiring for this type of equipment. If used as a portable device, a flexible wire with a plug may be acceptable, but local codes may limit the length to 6 feet. TestEquity recommends that the appropriate method for your installation be determined by a qualified electrician who is familiar with industrial plant wiring.

I need to send the chamber outside North America. Will it work with their power?
Outside North America, most countries have 50 Hz. Standard voltages in Europe are typically 220 V to 240 V, while Japan is 200 V. Operation over 220 V ±10% / 50 Hz requires bucking transformers to lower the voltage at the compressor to its 50 Hz rating of 200 to 220V. Note that the cooling performance will be reduced by 17% at 50 Hz. Please call TestEquity for details on reconfiguring for 50 Hz operation.

Why does my chamber heat or cool slower than the published specifications?
Performance is significantly effected 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_2 or LN_2 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_2 or LN_2 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.

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 Temperature 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 ±0.5°C, or a total of 1°C. For example, the temperature set point may be –25.0°C. The actual temperature varies between –25.4°C and –24.5°C. This corresponds to –0.4°C and +0.5°C or a total of 0.9°C of RELATIVE variations. These specifications are for an empty chamber. The addition of a test sample may effect 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 ±1.0°C or a total of 2°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 effect 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 temperature controller to accurately display a temperature measurement when compared to a standard. The controller display accuracy is ±1.66°C. However, the total measurement accuracy in the chamber includes the thermocouple sensor wire accuracy. Thermocouple wire accuracy is ±1°C or 0.75% of reading, whichever is greater. Therefore, total system accuracy over the chamber's operating range can be as much as ±2.66°C, although the typical accuracy is often better than ±1.0°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.

This chamber has a crankcase heater to protect the high-stage compressor. The chamber must be connected to the power source AND the Main Disconnect Switch must be ON for 3 hours prior to operating the chamber. Although it may be safe to use the chamber immediately, this procedure ensures the longest possible life for the high-stage compressor if the chamber has been removed from the power source for more than 24 hours.

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® 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® HP62. The low-stage system uses R-508B, which is also known as DuPont Suva® 95.

Chapter 7 – Specifications

Model 1027C Chamber Specifications

Temperature Range –73°C to +175°C
Control Tolerance ±0.5°C (±0.2°C Typical) (Measured at the control sensor after stabilization)
Uniformity ±1.0°C (Variations throughout the chamber after stabilization)

Live Load Capacity @	**+23°C**	**0°C**	**–20°C**	**–40°C**	**–55°C**	**–65°C**
	2900 W	2600 W	2300 W	1750 W	1450 W	1050 W

Cool Down Transition Time (empty chamber)

		End Temp				
Start Temp to →	**+23°C**	**0°C**	**-20°C**	**-40°C**	**-55°C**	**-65°C**
+23°C	-----	1.5 min	7.5 min	11 min	14 min	18 min
+85°C	9 min	15 min	21 min	28 min	35 min	40 min
+150°C	23 min	30 min	37 min	45 min	26 min	60 min

Cool Down Transition Time (80 lb static aluminum load)

		End Temp				
Start Temp to →	**+23°C**	**0°C**	**-20°C**	**-40°C**	**-55°C**	**-65°C**
+85°C	15 min	26 min	35 min	48 min	59 min	68 min
+150°C	32 min	41 min	50 min	61 min	69 min	76 min

Heat Up Transition Time (empty chamber)

		End Temp				
Start Temp to →	**+23°C**	**+50°C**	**+85°C**	**+125°C**	**+150°C**	**+175°C**
+23°C	-----	1.5 min	7 min	14 min	20 min	25 min
0°C	1.5 min	3.5 min	13 min	20 min	23 min	31 min
-10°C	2.2 min	4.2 min	14 min	22 min	25 min	33 min
-40°C	6 min	11 min	17 min	24 min	30 min	35 min
-55°C	8 min	13 min	19 min	26 min	32 min	37 min
-65°C	10 min	14 min	21 min	28 min	34 min	39 min

***Note:** Transition times are measured after a 2 hour soak at the start temperature. To calculate rate of change for a particular condition, take the difference between the Start Temp and End Temp and divide by the Transition Time.
Cool Down Example (empty): From +85°C to -40°C = 125°C / 28 min = 4.46°C/min.
Cool Down Example (80 lb): From +85°C to -40°C = 125°C / 48 min = 2.98°C/min.
Heat Up Example (empty: From -40°C to +85°C = 125°C / 17 min = 7.35°C/min.

Input Power Requirements
230 V ±10%, 60 Hz, 3 PH Max Current Draw 39 A; Recommended Service 50 A
208 V -5/+10%, 60 Hz, 3 PH Max Current Draw 35 A; Recommended Service 45 A
Input may be configured for nominal 208 V or 230 V in the field by changing jumpers.
Call for other voltages or 50 Hz operation.

Workspace Dimensions 40" W x 32" H x 36.5" D (27 cubic feet)
Outside Dimensions 49" W x 73.25" H x 63" D (nominal)
Door latch adds 3" to width on right side. Circulator motor housing adds 6" to height.
Min. Installed Clearance 12" from the left and right side, 24" from the rear
Access Ports 4" Port on left and right side (two total), Supplied with foam plugs
Weight 1600 pounds

NOTE: Performance is typical and based on operation at 23°C (73°F) ambient and nominal input voltage. This product is 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.

F4 Temperature Controller Specifications

Specifications as configured for the TestEquity 1027C Chamber

Accuracy & Sensor Conformity*	±1.55°C (above –50°C) ±1.66°C (below –50°C)
Stability	±0.1°C/°C rise in ambient
Digital Inputs	(Four) Contact closure or dc voltage, 10 kΩ impedance
Retransmit Outputs (Optional)	(Two) User-selectable ranges: 0 to 10 VDC, 0 to 5 VDC, 1 to 5 VDC 0 to 20 mA, 4 to 20 mA
Alarm Outputs	(Two) Electromechanical relay; Form C, 2 A @ 20 VDC or 240 VAC max.
Digital Outputs	(7 available for customer use) Open collector output OFF: 42 VDC @ 10 µA max. ON: 0.2 VDC @ 50 mA sink max. Internal supply: 5 VDC @ 80 mA
Communications	EIA-232 and EIA-485 serial communications with Modbus™ RTU protocol
Safety & Agency Approvals	UL/c-UL 916-listed, File #E185611 CE to EN61010 NEMA 4X and IP65 CE EMC to EN50082-2 CE EMC to EN55011
Displays	**Process:** 5, seven-segment red LED. **Interface Display:** 4-line high-definition green LCD; selectable °C or °F
Data Retention	Retention upon power failure via nonvolatile memory (seven years for battery-backed RAM)

***Note:** Total system accuracy in the chamber includes thermocouple wire accuracy. Thermocouple wire accuracy is ±1°C or 0.75% of reading, whichever is greater. Therefore, total system accuracy over the chamber's operating range can be as much as ±2.66°C, although the typical accuracy is often better than ±1.0°C.

Chapter 8 – Maintenance

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

Preventive Maintenance Intervals

Daily or As Needed
- Clean chamber interior and exterior.
- Listen for abnormal noise or vibration.

Every 3 Months
- Inspect the door seal.
- Inspect the refrigeration machinery compartment.
- Check the low-stage refrigeration charge.
- Check the high-stage refrigeration charge.
- Verify the chamber performance.

Every 6 Months
- Inspect the electrical compartment.
- Clean the condenser.

Every 12 Months
- Verify the calibration.

Maintenance Procedures

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 stainless-steel catch (on the 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 (on the door side) 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. Turn the Main Disconnect Switch OFF.
2. Remove the side and rear panels.
3. Inspect for signs of refrigeration tubing abrasion.
4. Inspect for oil around refrigeration valves, fittings and joints. This may be a sign of leaks.
5. Inspect for loose hardware and tighten as required.
6. Inspect for signs of insect or rodent infestation. Yes, it does happen!

How to check the low-stage refrigerant charge.

The low-stage refrigerant charge is checked by observing the "standby pressure" (also known as static or balance pressure).

1. Make sure the chamber has been off for at least 8 hours.
2. Locate the two low-stage gauges marked R-508B on the left side of the rear of the chamber.
3. The two gauges have different scales. However, they should read the same value of pressure. This indicates that the system is equalized and an accurate reading can be taken.
4. Both R-508B gauges should read approximately 120 PSIG.
5. If the pressure is low, this indicates that there is probably a leak.
6. If one gauge is low and the other is high, then the system is not equalized yet and an accurate reading cannot be made. Wait until both gauges read the same pressure.

NOTE: If the low-stage has been evacuated and recharged after a repair, the standby pressure should be rechecked after 24 hours to make sure it is 120 PSIG. This is because the R-508B refrigerant mixes with the oil in the compressor, causing a lower standby pressure. 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. This note only applies to systems that have been evacuated and recharged.

How to check the high-stage refrigerant charge.

The high-stage refrigerant charge is checked by observing the sightglass.

1. The sight glass is located behind the rear bottom panel, on the right side.
2. Set the Temperature Controller to a low-temperature Set Point. The Cool Light should be on continuously.
3. After about 5 minutes of operation in this mode, inspect the sightglass.
4. If you see bubbles or it appears partially full, then this indicates that there is probably a leak.
5. When the Temperature Controller is cycling (Cool Light cycles on/off), the sightglass may appear 1/2 to 2/3 full. This is normal.

How to verify the chamber performance.

These tests verify the performance of the heating, refrigeration, electrical controls, temperature controller, and air circulation systems. The chamber should meet all published performance specifications if all of these tests are successfully passed.

These tests assume that the Temperature 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), 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. Set the Temperature Controller Set Point to +85°C and turn the Master Switch ON.
3. The Heat Light should be ON continuously and the Cool Light should be OFF.
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 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 ±0.5°C, or a total of 1°C.
7. Let the chamber stay at +85°C for two hours.
8. After two hours at +85°C, set the Temperature Controller Set Point to –65°C.
9. The compressor should turn ON within a few seconds and the Heat Light should be OFF. After another 30 seconds, the Cool Light should be ON continuously.
10. The chamber should cool down to about –60°C and begin controlling (Cool Light cycles ON/OFF) within approximately 38 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 ±0.5°C, or a total of 1°C.
13. Set the Temperature Controller 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 Master Switch OFF.

How to inspect the electrical compartment.

1. Disconnect the chamber from the power source.
2. Turn the Main Disconnect Switch to the OFF position.
3. Remove the lower door retaining screw located on the right side. Open the lower door.
4. 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. Turn the Main Disconnect Switch to the OFF position.
3. Remove the lower door retaining screw located on the right side. Open the lower door.
4. 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 verify the 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 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 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. See page 6.2 of the "Series F4 User's Manual" for details. Calibration verification should be performed with the Calibration Offset set to 0.0 (zero).

The F4 Temperature Controller accuracy is specified ±1.55°C (above –50°C) and ±1.66°C (below –50°C). Total system accuracy in the chamber includes the controller plus the thermocouple wire accuracy of ±1.0°C. Total system accuracy over the chamber's operating range is can be as much as ±2.66°C, although it is typically better than ±1.0°C.

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

If calibration of the temperature controller is necessary, refer to page 9.2 of the "Series F4 User's Manual" and follow the instructions for "Thermocouple Input Procedure". If calibration of the limit controller is necessary, refer to page A.11 of the "Series 97 User's Manual" and follow the instructions for "Thermocouple Input Procedure".

Theory of Operation

Overview

The chamber is heated by an open element nichrome heater. Cooling is accomplished by a cascade refrigeration system. The air is circulated by a propeller fan. The heater, evaporator (cooling coil), and fan are located within an air plenum which is on the back wall of the chamber interior.

The heater, compressor, and circulator fan motor operate directly from the 208/230 VAC input line. All line branch circuits are individually fused. A stepdown transformer provides 115 VAC for all instrumentation and control elements.

Refer to the electrical and refrigeration drawings to identify the referenced items described below.

Heating System

The chamber is heated by an open-element nichrome heater (HT1). The heater is located in the air plenum. The temperature controller provides a time-proportioned output to the solid state relays (SSR1, 2). 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.

Fusible heat limiters (HL1, 2, 3) provide failsafe protection against a catastrophic failure by opening the heater circuits at +240°C. The master heat contactor C1 provides a power interlock for the heaters, circulator fan motor, and the control system. C1 is controlled by both the Master Switch, the safety relay (CR3), and the phase control relay (PCR1). CR3 is controlled by the temperature limit controller (TCR2). If either the high or low temperature safety limits are exceeded, TCR2 turns off CR3, which turns off C1. PCR1 will disable CR1 if the input power phase-sequence is incorrect.

Refrigeration System

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, which is located in the air plenum. The high-stage provides cooling to the cascade condenser. 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 through the liquid line, filter-drier, and sight glass to the thermostatic expansion valve. 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 compressor 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 Low-Stage uses refrigerant R-508B. High pressure liquid refrigerant is fed from the condenser circuit of the cascade condenser, through the filter-drier and liquid-line solenoid valve to the thermostatic expansion valve. The thermostatic expansion valve feeds the finned evaporator coil, 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 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. The desuperheater removes some of the heat of compression. Next, the vapor goes through the oil separator, 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.

The temperature controller cycles the low-stage liquid-line solenoid valve (SV1) ON/OFF to control the chamber temperature. When SV1 is ON, liquid refrigerant flows through the thermostatic expansion valve and evaporator to cool the chamber. When SV1 is OFF, the flow stops. The hot gas bypass solenoid valve (SV2) is ON whenever SV1 is OFF. SV2 feeds high pressure vapor to the hot gas regulator, which meters a precise amount into the suction line to maintain a minimum load on the system and keep it out of a vacuum. The hot gas regulator is adjusted to keep the suction pressure at 8 PSIG when SV1 is OFF. This is also called "bypass mode". The temperature controller alternately cycles SV2 and SV1 through cool relay CR1. Pilot Light PL2 provides an indication on the front panel when SV1 is ON.

During a high temperature pulldown or a continuous bypass condition, it is possible for excessive hot gas to return to the compressor. A suction line cooling thermostatic expansion valve (on both high- and low-stages) 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 the discharge pressure regulator valve. If the discharge pressure exceeds 285 PSIG, the discharge pressure regulator valve will "dump" refrigerant into the expansion tank. This refrigerant is slowly returned from the expansion tank to the suction line through a capillary tube. 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 high- and low-stages each have a high/low pressure switch which turns off the entire refrigeration system in the event of an out of limit condition. The high-stage compressor has a crankcase heater to prevent refrigerant from condensing in the oil when the compressor is off.

The temperature 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.

Troubleshooting

SYMPTOM	CONDITION	CAUSES
Chamber completely inoperative.	1. Power is applied to chamber but nothing lights up.	1. Incorrect phase sequence. Reverse two of the input lines. 2. Control fuse F3 open. Likely cause is shorted solenoid coil on SV1 or SV2.
Does not heat up at all.	1. If controller light 1A is ON, circulator fan is ON, the Heat light is OFF. 2. If controller light 1A is ON, circulator fan is ON, the Heat light is ON.	1. Solid State Relay SSR1or SSR2 is defective. 2. At least two Heat Limiters HL are open.
Heats up too slow.	1. Does not meet published specifications.	1. Chamber interior is overloaded. Port plug is not in port. Verify that input voltage is within tolerance. One heat limiter HL or one heater winding is open.
Heat is on all the time.	1. If temperature controller light 1A is OFF, the Heat light is ON.	1. Solid State Relay SSR1 or SSR2 is defective. Heater is shorted to chassis.
Does not cool at all.	1. If temperature controller light 1B is ON, the Cool light is OFF, both compressors are OFF. 2. If temperature controller light 1B is ON, the Cool light is ON, both compressors are ON.	1. Pressure switch DPS1 or DPS2 is tripped. 2. Solenoid valve SV1 may be defective in closed position.
R-404A pressure switch DPS1 trips.	1. Trips shortly after turn on. 2. Trips after operating for a while.	1. Ambient temperature may be too high. Low charge (leak). 2. Dirty condenser, inadequate clearance from back of chamber to the wall. R-404A hot gas bypass regulator may be defective or set too low.
R-508B pressure switch DPS2 trips.	1. If cooling from high to low temp is reduced. 2. Trips during a high temp pull down. 3. Trips when the cool light cycles from on to off.	1. Low charge (leak). 2. R-508B discharge pressure regulator may be defective. 3. Solenoid valve SV2 may be defective. Hot gas bypass regulator may be defective or set too low.

SYMPTOM	CONDITION	CAUSES
R-508B standby pressure is less than 120 PSIG.	1. When unit is off and system is equalized.	1. Low charge (leak).
R-404A sightglass has bubbles or does not look full.	1. During all running conditions. 2. Only when cool light is cycling.	1. Low charge (leak). 2. No problem. This is normal.
Cools too slow or does not reach –73°C.	1. R-508B standby is ok, no bubbles in R-404A sightglass.	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.
Cools all the time.	1. When cool light is OFF.	1. Solenoid valve SV1 may be defective in open position.
Temperature varies more than ±0.5°C or 1°C total.	1. If tuning PID control parameters in temperature controller were changed. 2. If tuning PID control parameters in temperature controller are as shipped from TestEquity. 3. If tuning PID control parameters in temperature controller are as shipped from TestEquity and only occurs in cool mode.	1. Re-enter values as shipped from TestEquity. 2. Control parameters may need to be changed for your unique test conditions. 3. Control parameters may need to be changed for your unique test conditions. R-508B hot gas bypass regulator may be defective or set too high. R-508B expansion valve may be defective.
Compressors turn on and off too frequently.	1. If compressor control parameters in temperature controller were changed. 2. If compressor control parameters in temperature controller are as shipped from TestEquity.	1. Re-enter values as shipped from TestEquity. 2. Control parameters may need to be changed for your unique test conditions. Solenoid valve SV1 may be defective in open position.
Excessive noise and vibration when the compressor starts.	1. Chamber has been off for several hours or more and is not connected to source of power, or main disconnect switch is off during that time. 2. Chamber has been off for several hours or more, and is connected to source of power and main disconnect switch is on during that time.	1. The chamber must be connected to the power source AND the main disconnect switch must be on for 3 hours prior to operating the chamber. 2. Crankcase heater defective (open).

Refrigeration System Charging Instructions

⚠ **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 80 ounces (5 pounds) of R-404A.
5. Verify the cooling performance as outlined in "How to verify the chamber performance".

NOTE: If the Temperature 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 is 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 130 PSIG. Allow time for the charge to equalize as read on the suction and discharge gauges. This is 10 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

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

Major Electrical Parts

Description	Mfr	Mfr Part No.	Ref #	Part #	Qty	UOM
Appliance Light, 40W, 120V	Generic	Generic	LT1	300096	1	ea
Arc Suppressor	ITW Paktron	104M06QC100	AS1, 2	200115	2	ea
Audible Alarm	Floyd Bell	MC-09-201-Q	AL1	200005	1	ea
Circulator Motor, 230V 3000 RPM	CUSTOM	CUSTOM	FM3, 4	200022	2	ea
Contactor, 3 P 30A	Hartland	HCC-3XT02SX	C1, 2, 3	200245	3	ea
Control Transformer	Hammond	PT300ML1	TR1	200219	1	ea
Disconnect Switch, 3 Pole, 45A	ABB	OT45E3	DSW	200014	1	ea
Fuse, 4A	Bussman	FNQ-R-4	F1, 2	200083	2	ea
Fuse, 3A	Bussman	FNM-3	F3	200186	1	ea
Fuse, 20A	Bussman	FNQ-R-20	F4-6	200242	3	ea
Fuse, 20A	Bussman	LP-CC-20	F7-12	200206	6	ea
Heat Limiter	Thermodisc	G5A-01-240C	HL1, 2, 3	200070	3	ea
Heater, Air	CUSTOM	CUSTOM	HT1	200061	1	ea
High/Low Limit Controller	Watlow	97A0-DAAA-AEAG	TCR2	200002	1	ea
Indicator, Panel, 120V Neon	SoLiCo	S412-2-1-N1	PL2	200025	1	ea
Indicator, Panel, 240V Neon	SoLiCo	S412-2-1-N2	PL1	200026	1	ea
Relay, Octal DPDT 10A 120VAC	Omron	MK2PSAC120	CR1-3	200031	3	ea
Relay, Phase Control	Crouzet	DWRS220A	PVR1	200067	1	ea
Solid State Relay, 10A	Omron	G3NE-210T-US DC5	SSR2	200129	1	ea
Solid State Relay, 25A	Siemens	SSRT-240D25	SSR1, 2	200021	2	ea
Switch, SPST, Momentary ON	Carlingswitch	RD221-MR-B-0-N	SW3	200024	1	ea
Switch, SPST, Rocker	Carlingswitch	LRA211-RA-B/125N	SW1, 2	200023	2	ea
Temperature Controller	Watlow	F4SH-CKA0-01AE	TCR1	200001	1	ea
Timing Module	Airotronics	THC1030SC	TM1	200243	1	ea
Chart Recorder Option						
Recorder, 1 Pen, 10"	Honeywell	DR4301-0000-G0100	RCD1	200094	1	ea
Chart paper, -90 to 210 C	Honeywell	24001660-034		200095	1	ea
Chart paper, -130 to 410 F, Alternate	Honeywell	24001660-033		200096	1	ea
Pen, Purple, Six Pack	Honeywell	30735489-007		200097	1	ea

Major Refrigeration Parts

Description	Mfr	Mfr Part No.	Ref #	Part #	Qty	UOM
Capillary Tube, 0.036 x 36"	J/B	TC-36	14	100043	4	ea
Capillary Tube, 0.050 x 12"	J/B	TC-50	19	100019	1	ea
Cascade Condenser	Flat Plate	CH3-1/2	27	100072	1	ea
Compressor	Copeland	ZF11K4E-TF5-241	1 (part of), 17	100059	2	ea
Crankcase Heater, 40 W, 120 V	Copeland	018-0041-01	2 (CC1)	100071	1	ea
Desuperheater Coil	CUSTOM	CUSTOM	16	100061	1	ea
Discharge Pressure Regulator	Sporlan	ORI-6-80/325-H	23	100069	1	ea
Distributor	Sporlan	D260-2-1/4-2-L	7	100491	1	ea
Dual Pressure Control	Johnson	P70NA-1C	11 (DPS1, 2)	100015	2	ea
Evaporator Coil	CUSTOM	CUSTOM	8	100060	1	ea
Expansion Tank	Ref. Research	9027	22	100075	1	ea
Expansion Valve, HS	Danfoss	068U2317	24	100471	1	ea
Expansion Valve, Main	Danfoss	068U3317	28	100487	1	ea
Expansion Valve, Suction Cool, HS	Sporlan	SBFJ-AA-C	25	100077	1	ea
Expansion Valve, Suction Cool, LS	Sporlan	SBFS-B-ZP 3/8 x 5/8 odf	26	100507	1	ea
Filter Drier	Sporlan	C-083-S	4	100070	2	ea
Gauge, 0 x 400 PSIG Pressure	Miljoco	CUSTOM	14	100495	2	ea
Gauge, 30" x 200 PSIG Compound	Miljoco	CUSTOM	12	100494	2	ea
Hot Gas Bypass Regulator, HS	Sporlan	ADRI-1-1/4-0/55	10	100078	1	ea
Hot Gas Bypass Regulator, LS	Sporlan	ADRS-2-0/30	29	100068	1	ea
Oil Separator	Temprite	601	19	100390	1	ea
Orifice for 100471, 100487	Danfoss	068U1037	24A, 28A	100472	2	ea
Sight Glass	Danfoss	140-0143	3	100081	1	ea
Solenoid Valve	Sporlan	E6S130, 3/8 x 3/8 ODF	5	100067	2	ea
Solenoid Valve Coil	Sporlan	MKC-1-120/50-60	(SV1, 2)	100011	2	ea
Strainer	Suppco	S-218	20	100050	1	ea

General Parts

Description	Mfr	Mfr Part No.	Ref #	Part #	Qty	UOM
Caster, Rigid					2	ea
Caster, Swivel					2	ea
Door Gasket, Inner	CUSTOM	CUSTOM		300636	1	ea
Door Gasket, Outer	CUSTOM	CUSTOM		300637	1	ea
Door Latch, Chamber Workspace	Southco	A2-10-501-21		300009	1	ea
Fan, Alum, 7" D, 5/16" Bore, CW	CUSTOM	CUSTOM		300533	2	ea
Port Plug, Silicone Foam, 4"	CUSTOM	CUSTOM		300534	2	ea
Shelf with Clips	CUSTOM	CUSTOM	TE-2701		1	ea
Shelf Retainer Clip only	Kason	Style 66, #0066000008		300015	4	ea
Window	CUSTOM	CUSTOM		300273	1	ea

Series F4 Temperature Controller Setup Parameters

⚠ **CAUTION:** The "Series F4 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 F4SH-CKA0-01, as described on page A.7 of the "Series F4 User's Manual" are applicable. "Cascade Control" as described on page 3.6 of the "Series F4 User's Manual" is not applicable in this configuration. The "Retransmit" function is available as an option.

⚠ **CAUTION:** The Series F4 Temperature Controller has been properly configured by TestEquity to match the chamber's system requirements and to perform optimally over a wide range of operating conditions. Improper modifications to these setup values can result in erratic performance and unreliable operation. Setup examples in the "Series F4 User's Manual" are NOT applicable to this chamber. 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.

⚠ **CAUTION:** The alarm outputs of the Temperature Controller are NOT connected to the chamber's safety system. TestEquity does NOT recommend using the Temperature Controller's alarm function as the main protection device.

⚠ **CAUTION:** NEVER select "Full Defaults" in the Factory/Test Menu. "Full Defaults" are NOT the TestEquity configuration parameters for this chamber. If you select "Full Defaults", you must reconfigure all System and Operation Parameters as documented in the TestEquity manual, NOT the "Series F4 User's Manual".

TestEquity has configured the Temperature Controller with the parameters as documented on the following pages.

Series F4 Setup Parameters

System Menu
Main Page\Go to Setup\System

GSB 1 Source	Input 1
Guar. Soak Band 1	3.0 °C (5.4 if °F)
Current Time	(local time)
Current Date	(local date)
PID Units	US, Reset/Rate
°F or °C	°C
Show °F or °C	Yes, Upper Display
Ch1 Autotune SP	90%
Input 1 Fail	0%
Open Loop Ch1	Off
Power-Out Time	10 Sec
Power-Out Action	Continue

Analog Input Menu
Main Page\Go to Setup\Analog Input1

Sensor	Thermocouple
Type	T
Decimal	0.0
SP Low Limit	-75.0 °C (-103.0 if °F)
SP High Limit	175.0 °C (347.0 if °F)
Calibration Offset	0.0
Filter Time	1.0 sec
Error Latch	Self-Clear

Digital Input Menus
Main Page\Go to Setup\Digital Input (1-4)

Name	No
Function	Off

Control Output Menus
Main Page\Go to Setup\Control Output 1A

Function	Heat
Choose Cycle Time	Fixed Time
Enter Cycle Time	3.0 sec
Hi Power Limit	100 %
Low Power Limit	0 %

Main Page\Go to Setup\Control Output 1B

Function	Cool
Choose Cycle Time	Fixed Time
Enter Cycle Time	6.0 sec
Hi Power Limit	100 %
Low Power Limit	0 %

Alarm Output Menus
Main Page\Go to Setup\Alarm Output (1-2)

Name	No
Alarm Type	Process
Source	Input 1
Latching	Alarm Self-Clears
Silencing	Yes
Hysterisis	1.7 °C (3.0 if °F)
Alarm Sides	Both
Alarm Logic	Open on Alarm
Show Message	Yes on Main Page

NOTE: The alarm outputs of the Temperature Controller are NOT connected to the chamber's safety system. TestEquity does NOT recommend using the Temperature Controller's alarm function as the main protection device.

Retransmit Output Menu
(if retransmit option is ordered)

Main Page\Go to Setup\ Retransmit Output 1

Retransmit Source	Set point 1
Analog Range	0-5V
Low Scale	-75.0°C (-103.0 if °F)
High Scale	175.0°C (347.0 if °F)
Scale Offset	0.0

Main Page\Go to Setup\ Retransmit Output 2

Retransmit Source	Input 1
Analog Range	0-5V
Low Scale	-75.0°C (-103.0 if °F)
High Scale	175.0°C (347.0 if °F)
Scale Offset	0.0

Digital Output Menu
Main Page\Go to Setup\ Digital Output (1-7)

Name	No
Function	Event Output

Main Page\Go to Setup\ Digital Output 8

Function	Compressor
Comp. On % Power	-2%
Comp. Off % Power	2%
Compressor Off Delay	60 sec
Compressor On Delay	10 sec

Communications Menu
Main Page\Go to Setup\ Communications

Baud Rate	9600
Address	1

Custom Main Page Menu
Main Page\Go to Setup\ Custom Main Page

P1	Current File
P2	Current Step
P3	Set Point 1
P4	Step Type
P5	Target SP1
P6	WaitFor Status
P7	Time Remaining
P8	Digital Outputs
P9	% Power 1
P10	Digital Inputs
P11	Date
P12	Time
P13	Custom Message 1
P14	None
P15	None
P16	None

Static Page Menu
Main Page\Go to Setup\ Static Message

Message 1	TESTEQUITY 1027C

Series F4 Operations Parameters

PID Set Channel 1 Menu

Main Page\Go to Operations\Edit PID\PID Set Channel 1\ PID Set (1-5)

Proportional BandA	5.0 °C (9.0 if °F)
Reset A	0.05 min
Rate A	0.00 min
Dead Band A	0.0 °C
Proportional BandB	5.0 °C (9.0 if °F)
Reset B	0.05 min
Rate B	0.00 min
Dead Band B	0.0
Hysteresis	0.0

Alarm Setpoints Menu

Main Page\Go to Operations\Alarm Setpoints\Alarm1

Alarm1 Low SP	-75.0°C (-103.0° if °F)
Alarm1 High SP	175.0 °C (347.0 if °F)

Main Page\Go to Operations\Alarm Setpoints\Alarm2

Alarm2 Low SP	-75.0°C (-103.0° if °F)
Alarm2 High SP	175.0 °C (347.0 if °F)

NOTE: The alarm outputs of the Temperature Controller are NOT connected to the chamber's safety system. TestEquity does NOT recommend using the Temperature Controller's alarm function as the main protection device.

Series F4 Set Lockout Parameters

The Series F4 Controller has several levels of security to prevent unauthorized users from changing critical configuration parameters. Only the Set Point and Profile menus have "Full Access". TestEquity has configured all other menus to "Password", and have protected them with a password.

TestEquity does not recommend that these security levels be changed for most applications. However, there will be times when "Full Access" is necessary. For example, you may need to gain access to Setup Page in order to change from °C to °F display, or to change the time or date. You must call TestEquity at 877-512-3457 or 805-480-0638 to obtain the password.

Set Lockout Menu

Main Page\Go to Factory\Set Lockout

Set Point	Full Access
Oper. Autotune PID	Password
Oper. Edit PID	Password
Oper. Alarm SP	Password
Profile	Full Access
Setup	Password
Factory	Password

Series 97 Limit Controller Setup Parameters

For more detailed instructions, see the "Series 97 User's Manual".

⚠ **CAUTION:** The "Series 97 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 97A0-DAAA-00-RG, as described on page A.20 of the "Series 97 User's Manual" are applicable. Please note that only the Series 97 "Limit" functions are applicable.

Home Page

97 Process Value
SAFE Limit Status

Operations Page

LIM Limit Menu
OPEr Operations Page
L Lo Low Limit Set Point -75
L h i High Limit Set Point 175
CAL 1 Calibration Offset 0

MMon Monitor Menu
OPEr Operations Page
Pr 1 Process 1 --
L St Limit Status SAFE

Setup Page

InP 1 Input 1 Menu
SEt Setup Page
SEn 1 Sensor Type 1 tc
In 1 Input 1 t
rL 1 Range Low 1 -75
rh 1 Range High 1 175
dEC 1 Decimal 1 0
Ftr 1 Input Software Filter 1 0

Out 1 Ouput 1 Menu
SEt Setup Page
LS id Set Limit Active Sides both
LHYS Limit Hysteresis 1

d iSP Display Menu
SEt Setup Page
UdSP Upper Display Pr 1
LdSP Lower Display L St

GLbL Global Menu
SEt Setup Page
C-F C or F °C
Err Input Error Latching nLAt

Factory Page

LOC Lockout Menu
FctY Factory Page
OPEr Operations Page Mode chnG
SEt Setup Page Lock chnG
CAL Calibration Menu Lock chnG

Chapter 9 - 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. 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.

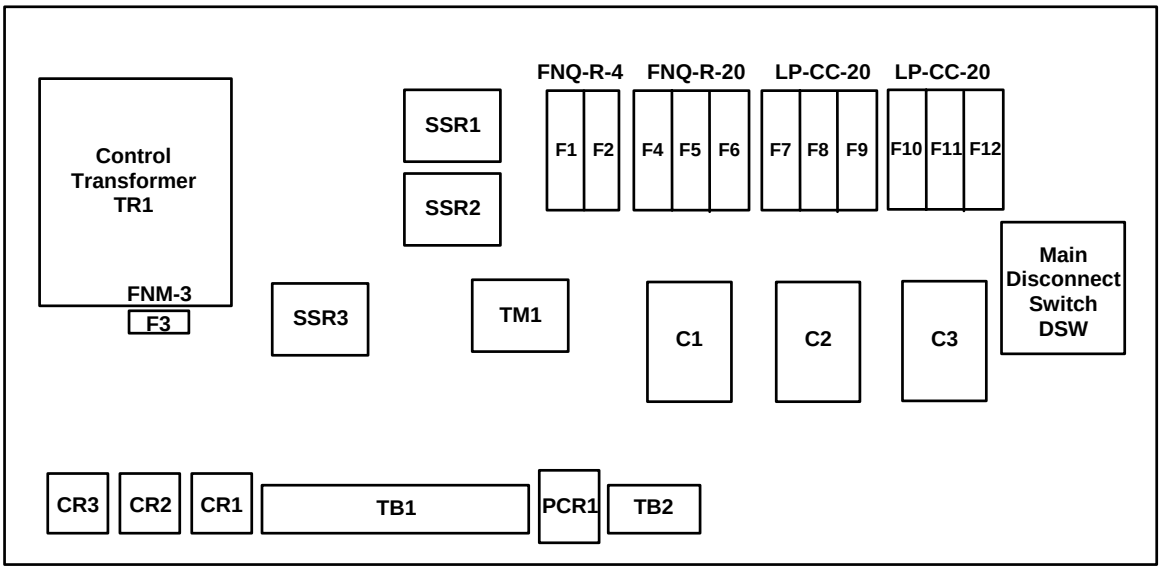
This warranty as to Equipment is LIMITED to repair or replacement of parts or Equipment in the determination of TestEquity LLC THE FORGOING LIMITED WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES INCLUDING THE IMPLIED WARRANTIES OF FITNESS FOR A PARTICULAR PURPOSE AND MERCHANTABILITY. TestEquity LLC DISCLAIMS 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.

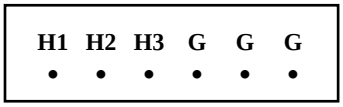
This limited warranty shall be extended only to the first Purchaser of this Equipment and is not transferable.

Chapter 10 – Drawings

Electrical Subpanel Component Location



TB2 Terminals



TB1 Terminals