Model 155
Temperature Chamber

U.S. Patent Number 10,126,032

Operation and Service Manual

Revision 4.03 and higher Firmware

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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

⚠ **WARNING:** The power cord is equipped with a NEMA 5-15P grounded/polarized plug. To prevent a shock hazard, DO NOT defeat the ground or polarization feature. This device MUST be plugged into a properly grounded and polarized outlet.

⚠ **WARNING:** This is a dual voltage product. Verify that the voltage selector switch on the rear panel is set for the correct voltage of either 115VAC or 230VAC.

⚠ **CAUTION:** The minimum clearance you should allow for proper ventilation must be at least 12" from the rear of the chamber.

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

Operation Safety Notices

⚠ **CAUTION:** When using Part Temperature Control, the Part Sensor must always be attached to the device under test (DUT). Failure to do this will result in erratic temperature control. If you do not want to attach the thermocouple to the DUT, then select "Air Control" on the F4T.

⚠ **CAUTION:** When using Part Temperature Control, the Part Sensor must never be placed outside the chamber. Failure to do this will result a thermal runaway, up to the F4T Limit Alarm High Limit Set Point.

⚠ **CAUTION:** The F4T 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 Watlow F4T Manuals 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:** Configuration files are unique to each particular model chamber and must NEVER be transferred to a different model chamber.

⚠ **CAUTION:** NEVER select "Factory" in the "Restore Settings From" prompt in the Device Details menu in Composer Software. This will erase all controller configuration settings. The chamber will not work if you do this.

⚠ **CAUTION:** Always verify that the F4T Limit Alarm settings for high and low limits are set to temperatures that are appropriate for your test sample.

⚠ **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 that 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. You are responsible for providing thermal protection devices to your test sample.

⚠ **CAUTION:** To prevent damage to your test sample and the chamber's compressor, do not exceed the live load rating of the chamber

Chapter 2 – Installation

Unpacking

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

1. Cut the bands that hold the packaging together.
2. Remove the top cover and top foam inserts.
3. Remove the outer box.
4. Carefully lift the chamber off the pallet. This should be done with at least two people.

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. Hand-tighten one of the supplied barbed fittings to the drain connection on the rear of the chamber. Put a container under the condensate drain. Alternatively, attach the supplied hose to the barbed fitting and run the hose to a remote container, drain, or condensate pump. NOTE: Not all applications will result in condensate flowing through the drain.
5. This is a dual voltage product. Verify that the voltage selector switch on the rear panel is set for the correct voltage of either 115VAC or 230VAC.
6. Attach the power cord to the receptacle on the chamber. Plug the chamber into the power source as selected in step 5 above.
7. Perform following the procedure “How to verify the chamber performance” in the Maintenance chapter of this manual to make sure that no damage has occurred in shipment.

Installation Location

The chamber will produce a moderate amount of heat during normal operation. Locate the chamber in an area with adequate ventilation to prevent excessive heat build-up. The chamber must be on a solid and level surface that is rated to hold at least 100 pounds.

⚠ **WARNING:** The power cord is equipped with a grounded/polarized plug. To prevent a shock hazard, DO NOT defeat the ground or polarization feature. This device MUST be plugged into a properly grounded and polarized outlet.

⚠ **CAUTION:** The minimum clearance you should allow for proper ventilation must be at least 12" from the rear of the chamber.

⚠ **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 condensate drain connection is located on the rear of the chamber. This provides a way to remove condensate that may accumulate on the evaporator (cooling coil) during 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 or the cooling system turns off, the ice or frost will turn into water.

The drain fitting accommodates a 1/4-inch male pipe thread. Right angle and straight barbed adapters are provided so you can easily connect 3/8-inch I.D. flexible tubing to it. The chamber drain water is not under pressure and is fed by gravity. Therefore, it must empty into a container or open floor drain.

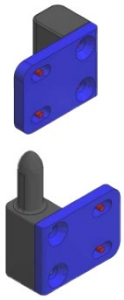
Under most circumstances, you will not see any water coming out of the drain.

Lift-Off and Reversible Chamber Door

The chamber door will lift off the hinges without the need for any tools. This is useful for applications required fixtures to be mounted on the door. You could have multiple doors with different fixtures and easily attach the doors to the chamber.

The chamber door can be mounted to open from the left or right side. The chamber cabinet has mounting holes on both sides for the hinges and door latch bracket.

To reverse the door opening, you will first need to remove the hinge assemblies from the chamber and the chamber door. Then, remove the hinges from the mounting plates. Next, reverse the orientation of the hinge hardware on the mounting plates. Then, attach the hinge assemblies on the opposite side. Finally, remove the latch bracket from the chamber and reattach it to the opposite side.



The hinges and latch bracket have slotted holes which enable you to adjust the door to correctly compress the door seal. After you reverse the door, see “How to inspect the door seal” in the Maintenance chapter of this manual to make sure the hinges and door latch are adjusted correctly.

Chapter 3 – Operation

Introduction

The Front Panel Switches control power to the temperature controller and all chamber functions. The Temperature Controller controls the temperature of the chamber. The Temperature Controller automatically turns the refrigeration system on or off as required based on the deviation from temperature set point.

Summary of Chamber Operation

1. Turn the POWER Switch ON.
2. Enter the desired temperature set point on the Temperature Controller.
3. Load your test sample in the chamber.
4. Attach the Part Sensor to your test sample if you want to control or monitor its temperature.
5. Press the Power button on the F4T controller to turn the chamber ON.

Front Panel Switch and Soft Buttons

POWER Switch

The POWER Switch controls power to the entire chamber. The POWER Switch does not illuminate.

Power Button

The Power button on the F4T Controller turns the chamber ON/OFF. There will be a green check mark on the Power button when it is ON.

Air Control Button

The control mode can be easily changed from Part Temperature Control or Air Control by pressing the Air Control key. The default condition is with the controller operating in Part Temperature Control mode (no green check mark in the Air Control box). See more information in the section entitled “Part Control vs. Air Temperature Control”.

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 that generate surface temperatures over 1000ºF. This is NOT an explosion-proof chamber.

⚠ **WARNING:** Do NOT put items in the chamber that 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.

⚠ **CAUTION:** To prevent damage to your test sample and the chamber's compressor, do not exceed the live load rating of the chamber.

Live Load Rating				
Temp	**+23°C**	**0°C**	**–10°C**	**–20°C**
Watts	200 W	150 W	100 W	35 W

Cable Slots and Port Plugs

Cable slots on the left and right side provide easy entry and removal of wires and sensors that are attached between your test sample and equipment outside the chamber without having to remove the wires. Silicone foam port plugs are provided to seal the cable slot. The port plugs have a gray silicone moisture-barrier on two sides. The port plug must be inserted with the gray silicone surfaces facing the inside and outside 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 affected by the characteristics of your test sample. Factors include size, weight, material, shape, and power dissipation if energized. The test sample should be placed in the chamber in a manner that allows for air circulation. The air plenum is located on the back wall of the chamber, where air is sucked in from the left side and exits from the right side. 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, an additional shelf 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.

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. 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 with the gray silicone surfaces facing the inside and outside of the chamber at all times. Any air gaps between the wires going through the ports will create a path for moisture migration and thermal losses. 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.

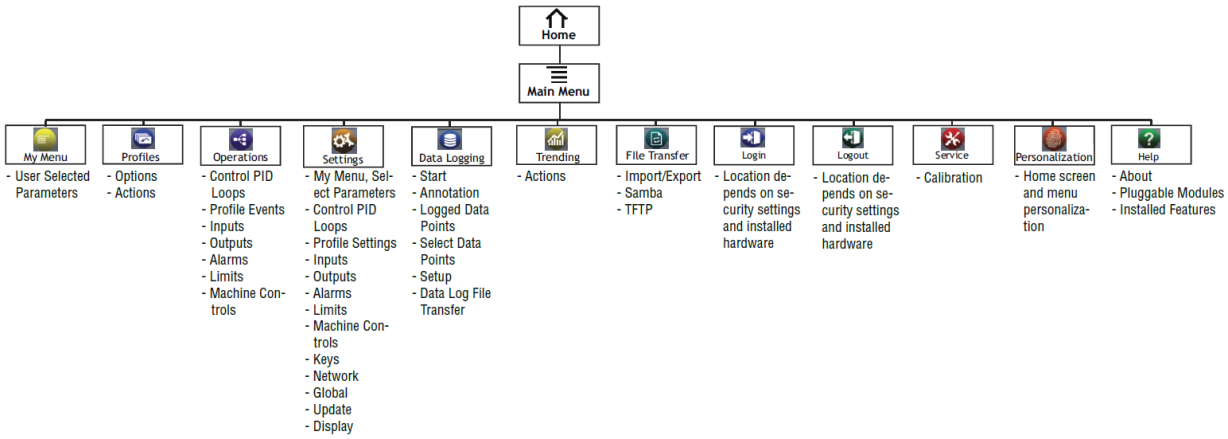
Chapter 4 – F4T Temperature Controller

F4T Menus

This chapter is designed to give you a better understanding of the structure and navigation of the F4T menus as viewed from the front panel.

Understanding F4T Menus

The graphic below illustrates at a high level the structure of the F4T menus.



Navigating and Understanding the User Interface

Home Screen

After powering up the controller a white screen will appear first while initializing. Once the startup process is complete the Home Screen will be presented as shown below. The image below shows the Home Screen while a profile is running.

① **Controller Status:** Indicates alarms and errors if they occur while also showing the current security level (see "Security" section). Also indicates if Data Logging is enabled and if a USB thumb drive is plugged into the USB host port. The button shown in the center of the status bar allows you to view alarm and error messages when pressed.

② **Profile Status Bar:** Provides visibility and information pertaining to running profiles as well as access to available profile actions (see "Creating and Editing Profiles" section).

③ **Vertical Ellipsis:** Displays current control mode while also providing access to other operational parameters such as the Ramp to Set Point, Autotune, PID Settings, and more (see "Changing Loop Operational Parameters" section).

④ **Next Page:** Home screen has been setup to display multiple pages (loops). The left and right arrows on each side of the home screen provides navigation from one to the other (see "Personalizing the Home Screen" section).

⑤ **Output Widget Bar:** Function keys and their output status (ON/OFF).

Home Screen Parameters

Parameters on the Home screen include:

- **Loop name:** "Temperature" and "Air Sensor" in the above example.
- **Control mode:** "Auto" shown in the above example.
- **Process Value or PV:** Actual Temperature.
- **Target Set Point or TSP:** The desired set point in a step when running a profile)
- **Current Set Point or CSP:** The instantaneous set point during a ramp step when running a profile. May be the same value as the TSP)
- **Set Point:** The desired Temperature to be maintained by the controller.
- **PWR:** % Output power levels (throttle) for heat and cool. The orange PWR bar is the heat throttle. The blue PWR bar is the cool throttle.
- **Output Actions:** Allows you to monitor the ON/OFF status of controller outputs.

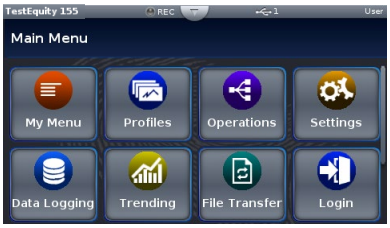
Front Panel Navigational Buttons

Four buttons at the bottom of the F4T are displayed as icons shown below. The text in this graphic is shown for clarity only and is not present on the front panel.

- **Home:** Regardless of the screen currently in view, when Home is pressed you will always return to the Home screen (shown on the previous page).
- **Menu:** Pressing the Menu button will provide access to other settings and functions within the controller.
- **Return:** Pressing this button will take you back to the previous screen until the top level of either the Home Screen or the Main Menu is reached.
- **Help:** Displays information about the controller such as part number and software revision.

Main Menu

The Main Menu provides access to settings and functions within the controller.



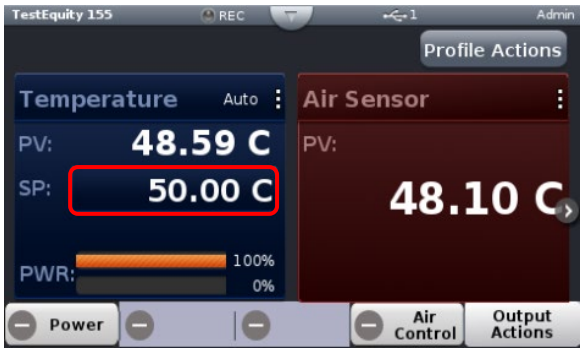
- **My Menu:** Quick access to user assignable functions.
- **Profiles:** Profiles are added, accessed, and edited from this menu.
- **Operations:** Contains access to alarms, control setting, profile events, inputs, and outputs.
- **Settings:** Contains access to network settings, global settings (controller name, date, time, °C/°F display), firmware update utility, and feature update utility.
- **Data Logging:** Contains access to settings for data logging.
- **Trending:** Contains access to settings for trend graphing and the trend graph display.
- **File Transfer:** Contains access to USB file transfer utilities for Import/Export of Configuration and Profiles and Export of Data Log files.
- **Login (Logout):** For password entry, shown with a user already logged in.
- **Service:** (not shown, appears when display is scrolled down in this pictured configuration). Provides access to the calibration menu.
- **Personalize:** The home screen layout is modified in this menu. This has been configured by TestEquity to only show if a user is logged in with a password.
- **Help:** (not shown, appears when display is scrolled down in this pictured configuration) Displays information about the controller such as part number and software revision.

Static Set Point (Manual Temperature Setting)

Set Point is the Temperature setting that you want the chamber to maintain. The F4T Controller is in Static Set Point Mode when it is not controlling a Profile. The Static Set Point is entered in the **Closed-Loop Set Point** screen.

Navigating the Closed-Loop Set Point Screen

To enter the **Closed-Loop Set Point** screen, press the area in the **Set Point (SP)** box on the Home Screen. The **Closed-Loop Set Point** screen will appear. Values can be added with the numeric keypad or the ↑ or ↓ arrow keys.



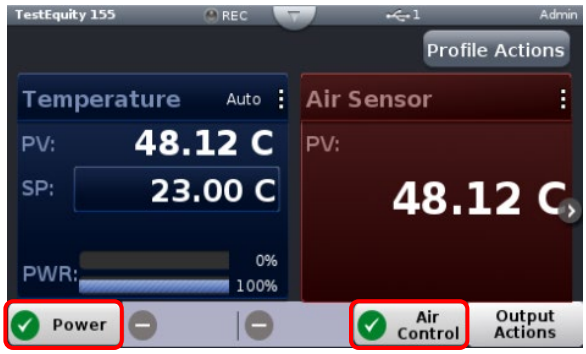
Pressing the numeric keys will directly enter a value in the **Closed-Loop Set Point** box. There is no need to clear the existing value first.

Pressing the ↑ or ↓ arrow keys will increment or decrement the existing Closed-Loop Set Point value in 0.01 increments each time the key is pressed.

- **Clear** will clear all entries in the **Closed-Loop Set Point** box.
- **Bksp** (backspace) will clear the last digit in the **Closed Loop Set Point** box.
- **Enter** will enter the values in the **Closed-Loop Set Point** box and return you to the **Home Screen**.
- **Cancel** will return you to the **Home Screen** without changing the Set Point.

Chamber Functions (Output Widget)

Chamber functions can be turned ON/OFF using the buttons on the Output Widget. The buttons may be named differently depending on your model chamber. The buttons can be pressed to toggle the functions ON/OFF in Static Set Point (manual) mode or while a profile is running.



Below is a summary of the button functions assigned by TestEquity.

Power Button

The **Power** button on the F4T Controller turns the chamber ON/OFF. There will be a green check mark on the **Power** button when it is ON.

Air Control Button

The control mode can be easily changed from Part Temperature Control or Air Control by pressing the **Air Control** key. The default condition is with the controller operating in Part Temperature Control mode (no green check mark in the Air Control box). Air Control will always be OFF any time the power is recycled.

See more information in the section entitled “Understanding Part Temperature Control (Cascade Control)”.

Temperature Limit Alarm

The F4T has a built-in independent Limit Alarm. The Limit Alarm 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 condition 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 functions.

⚠ **CAUTION:** Always verify that the Limit Alarm'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. You are responsible for providing thermal protection devices to your test sample.

How to Set the High and Low Temperature Safety Limits

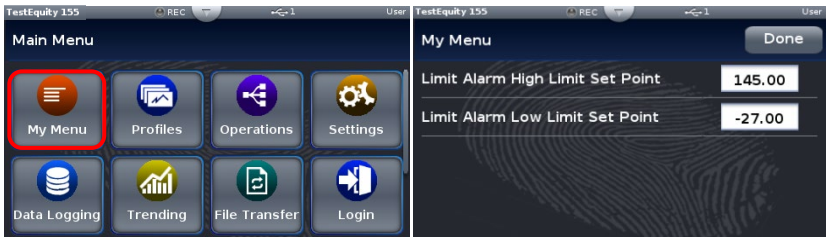
The Limit Alarm has separate Low Limit and High Limit Set Points. We recommend setting these at least 5°C beyond the highest and lowest temperatures that the chamber is programmed to reach to prevent nuisance tripping.

IMPORTANT NOTE: If you are operating in Part Temperature Control mode (Air Control button is OFF), the air temperature allowed to deviate in a controlled manner by up to +10°C or –10°C from the Part Temperature set point. This means if the set point is 85°C, the Air Temperature could go as high as 95°C if the Part Temperature lagged sufficiently during a heat up condition. In this example, you should set the High Limit Set Point to at least 100°C to prevent false tripping.

To enter the Limit Alarm settings, first press the **Menu** button (second button from the left below the display). Then, press the **My Menu** button.

There may be an approximately 15-second delay before **My Menu** is populated if it is the first time you press it after turning the chamber on.

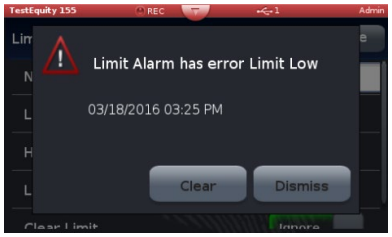
The screen which follows will provide access to the **Low Limit Set Point** and **High Limit Set Point**. Pressing the **Low Limit** or **High Limit Set Point** value will take you to a numeric key screen where you can enter new values.

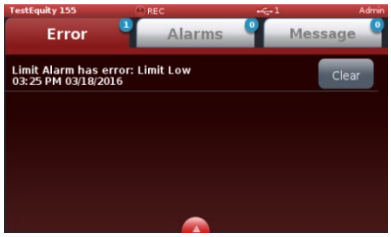


Resetting an Out of Limit Condition

If an alarm occurs the status bar (top of screen) will indicate its existence by blinking red. A pop-up window will indicate if the error is due to a Limit Low or Limit High condition. Pressing **Dismiss** will remove the pop-up display. The status bar will continue to blink red until the chamber temperature is within safe limits and the **Clear** button is pressed.

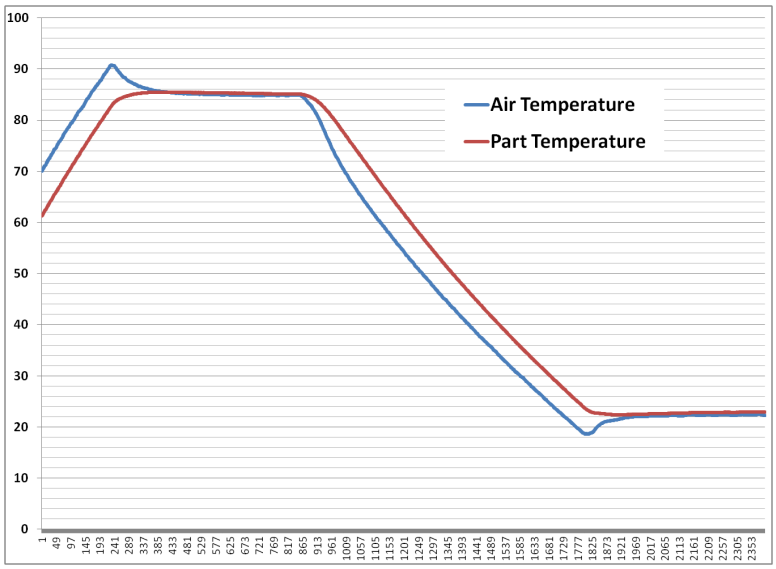
Pull the status bar down button to view the alarm message in the **Error** tab. Press **Clear** to clear the alarm after the chamber temperature is within safe limits.





Understanding Part Temperature Control (Cascade Control)

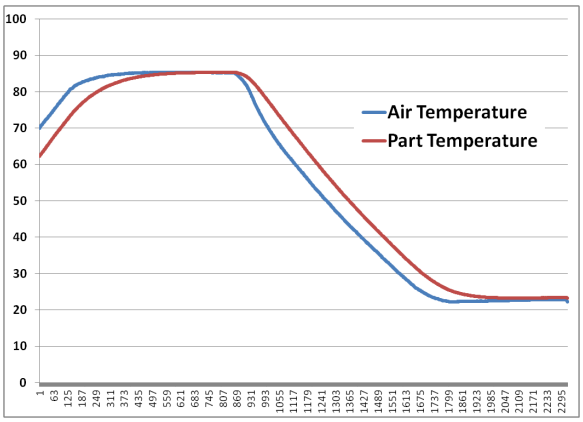
Overview



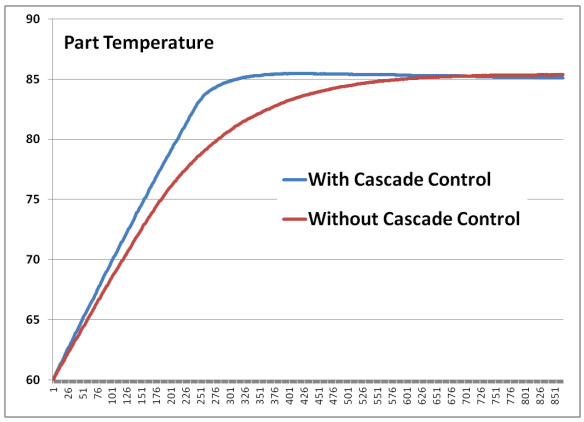
Cascade Control is the technical name for a multi-loop control system where the air temperature set point (Inner Loop) is determined by deviation of the part temperature (Outer Loop) from its set point. In this manual, the terms "Cascade Control" and "Part Temperature Control" are used interchangeably. The graph shown here represents Air Temperature vs. Part Temperature when Cascade Control (Part Temperature Control) is used. The Air Temperature is allowed to overshoot or under shoot as required in order to achieve the desired Part Temperature while minimizing lag time.

The controller is configured by TestEquity to allow the Air Temperature to deviate up to +10°C or –10°C from the Part Temperature set point. This means if the set point is 85°C, the Air Temperature could go as high as 95°C if the Part Temperature lagged sufficiently during a heat up condition. In the example shown above, the Air Temperature went as high as 90.7°C when the Product Temperature achieved 83.0°C. Conversely, the Air Temperature went as low as 18.6°C when the Product Temperature achieved 23.4°C in order to reach a 23.0°C set point. In both instances, The Air Temperature then began to approach the Part Temperature as the part began to stabilize, until the two temperatures were ultimately nearly identical.

Without Cascade Control the Part Temperature will take longer to stabilize due to its thermal mass as shown in the graphs below.



Air Temperature vs. Part Temperature without Part Temperature Control



Part Temperature's approach to set point with and without Part Temperature Control

Part Temperature Sensor

⚠ **CAUTION:** When using Part Temperature Control, the Part Sensor must always be attached to the device under test (DUT). Failure to do this will result in erratic temperature control. If you do not want to attach the thermocouple to the DUT, then select "Air Control" on the F4T.

⚠ **CAUTION:** When using Part Temperature Control, the Part Sensor must never be placed outside the chamber. Failure to do this will result a thermal runaway, up to the F4T Limit Alarm High Limit Set Point.

A Platinum RTD Sensor is provided for measuring the temperature of your Device Under Test (DUT). The sensor can be bolted to the DUT using a #4 screw. The sensor is plugged into the receptacle in the inside of the chamber, which is located on the upper left side of the back wall. The sensor must always be plugged into this receptacle to prevent an open-sensor error on the F4T controller.

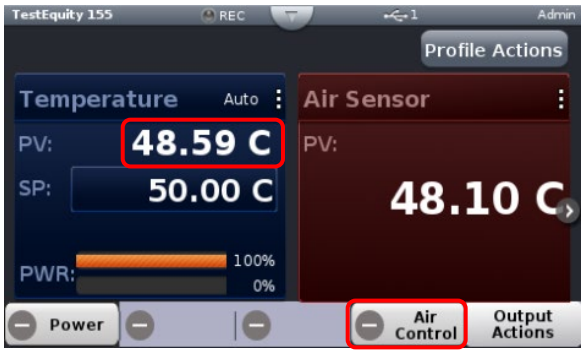
Alternatively, this sensor can be replaced with any 3-wire 100 Ω Platinum RTD Sensor with a DIN temperature coefficient of 0.00385 Ω/Ω/°C, attached to a 3-prong mini flat-pin connector.

When configured for Part Control (Air Control button has no green check mark), the F4T will attempt to control the temperature at the Part Sensor. In this mode, the Part Sensor must always be attached to your test sample. Failure to do this will result in erratic temperature control.

Part Temperature Control & Air Temperature Control Mode Selection

The control mode can be easily changed from Part Temperature Control or Air Control by pressing the **Air Control** button. The default condition is shown below, with the controller operating in Part Temperature Control mode (no green check mark in the **Air Control** box).

Part Temperature Control Mode



When configured for Part Control (**Air Control** button has no green check mark), the F4T will attempt to control the temperature at the Part Sensor. In this mode, the Part Sensor must always be attached to your test sample. Failure to do this will result in erratic temperature control.

The Air Sensor screen will always indicate chamber's Air Temperature. This will usually be different from the Part Temperature, especially during temperature transitions. The Air Temperature will tend to approach the Part Temperature as the part begins to stabilize. The two temperatures may never be the same, especially with a heavy test sample or an energized test sample.

The F4T is configured by TestEquity to allow the Air Temperature to deviate no more than +10°C or –10°C from the Part Temperature set point. This means if the set point is 85°C, the Air Temperature could go as high as 95°C if the Part Temperature lagged sufficiently during a heat up condition, or as low as –15°C if the set point is –5°C.

Part Control Mode During a Profile

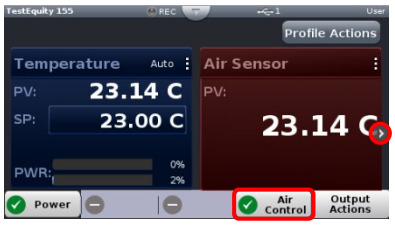
Part Control mode has an impact on these profile parameters:

Guaranteed Soak Deviation/Guaranteed Soak Values: The amount by which the actual part temperature is allowed to differ from the set point for steps with Guaranteed Soak Enable set to **On**. In such steps when the actual part temperature differs from the set point by more than this value, the step timer stops running until the actual part temperature returns to within the band defined by the set point plus or minus this value. Each profile can have its own set of Guaranteed Soak values.

Wait For Process: Holds the profile until the part temperature reaches the specified value.

Air Control Mode

When configured for Air Control (**Air Control** button has a green check mark), the F4T will attempt to control the temperature at the Air Sensor, shown at the PV (Process Value) in the Air Sensor screen. This is how a chamber without cascade control ordinarily works. In this mode, the Part Sensor does not have to be attached to anything.



If you press the arrow on the right side of the display you will get a screen that displays the Air Sensor, Part Sensor, and Alarm Sensor. You can use this screen to monitor the Part Sensor even if you are in Air Control Mode. Pressing the arrow on the left side of this screen will return you to the Home Screen.

In Air Control Mode, the PV (Process Value) in the Temperature screen is the Air Temperature.

Air Control will always be OFF any time the power is recycled.

Air Control Mode During a Profile

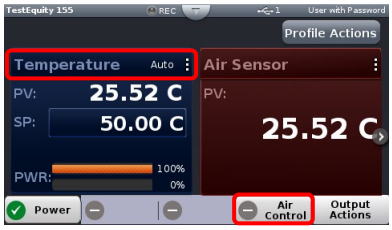
Part Control mode has an impact on the following profile parameters:

Guaranteed Soak Deviation/Guaranteed Soak Values: The amount by which the actual air temperature is allowed to differ from the set point for steps with Guaranteed Soak Enable set to **On**. In such steps when the actual air temperature differs from the set point by more than this value, the step timer stops running until the actual air temperature returns to within the band defined by the set point plus or minus this value. Each profile can have its own set of Guaranteed Soak values.

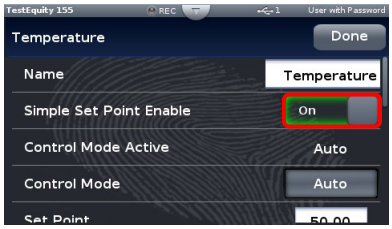
Wait For Process: Holds the profile until the air temperature reaches the specified value.

Simple Set Point Enable

This function is similar to turning Air Control ON. If you leave **Air Control** OFF and turn **Simple Set Point Enable** ON, the F4T will attempt to control the temperature at the Air Sensor. However, the Guaranteed Soak and Wait For Process will be controlled by the Part Sensor.



This function is located in the Temperature Loop Operational Parameter screen. Pressing the vertical ellipsis or anywhere within the outlined box shown below will provide access to the Loop Operational Parameter screen.



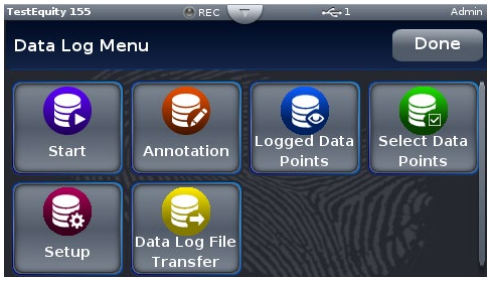
Simple Set Point Enable condition is persistent upon power recycle.

Data Logging

Overview

Data Logging can be enabled at any time and will log a user selectable list of data points. While data logging is enabled, the data log file is stored within either the USB thumb drive or internal memory. Once the file reaches a specified size (if being transferred automatically), it will be sent directly to one of three other destinations (USB thumb drive, TFTP server or a Samba server). The file transfer can also be initiated manually at any time. The file transfer process from internal memory, whether completed automatically or manually, will move all log files from internal memory to the selected destination.

Data Logging Menu



Start
Starts the logging of data.

Annotation
Allows you to annotate the log file at a point in time while the data is being logged. For example, if you wanted to annotate when the door was opened you can create a note which says “door opened”.

Logged Data Points
This menu indicates which data points have been selected.

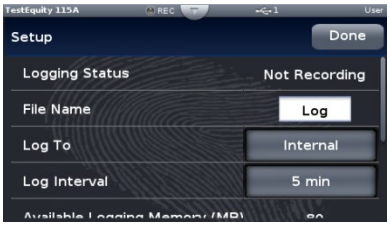
Select Data Points
You can select the parameters which get logged. TestEquity has pre-configured the controller to log the Set Point, Inner Process Value (air temperature sensor), and Outer Process Value (part temperature sensor).

Setup

- **Logging Status:** indicates whether or not recording is active or not.
- **File Name:** any alphanumeric characters, 63 maximum.
  Note: A new dedicated file is created when data logging starts and the filename format will be “file name” “date stamp” “time stamp”.csv.
- **Log To:** USB (thumb drive) or Internal Memory.
- **Log Interval:** defines the frequency in which the log will be written, 0.1 second to 60 minutes.
- **Available Logging Memory:** (read-only)
- **Available Logging Time:** (read-only) available time determined by the available memory, logging interval and number of data points that have been selected.
- **File Size Limit:** 20MB when using TFTP or Samba, 1GB when using USB.
- **Memory Full Action:** when log to device defined above is full, Overwrite or Stop.
  Note: Logging to USB allows for Stop only, when memory is full.
- **Date Format:** MM/DD/YYYY or DD/MM/YYYY.
- **Time Format:** 12 or 24 hour clock.

How to Enable Data Logging

There are three ways to initiate data logging:



To enable data logging using the front panel:

1. Press the **Menu** button.
2. Press the **Data Logging** button.
3. Select the desired log interval (0.1, 0.2, 0.5, 1, 2, 5, 10, 15, 30 seconds, 1, 2, 5, 10, 15, 30, 60 minutes)
4. Press the **Memory Full Action** button to define the desired action to take when memory is full [**Stop** or **Overwrite**].
5. Press the **Datalog Action** button to manually control data logging [**Start** or **Stop**].

Note: A new dedicated file is created when data logging starts and the filename format will be "file name" "date stamp" "time stamp".csv.

To enable data logging when running a profile:

1. Select the desired profile, press **Actions** and then **View/Edit Details**. Press **Yes** for **Log Data**.

Note: If data logging is already running when the profile starts with data logging enabled the data log filename will remain as stated in the note above with the profile log data concatenated to the currently running data log file. If data logging is not running, a new dedicated data log file is created when the profile starts and ends when the profile stops. The filename format will be "Profile name" "date stamp" "time stamp".csv.

To enable data logging (during a profile) using the Modbus communications protocol:

1. Load Modbus register 18888 (Profile Active File Number) with the desired profile number (1 to 40).
2. Load Modbus register 19038 "Log Data" with 106 (yes).
3. Write Modbus registers to the controller.

To enabling data logging (outside of a profile) using the Modbus communications protocol:

1. Think about and modify the following Modbus registers if need be:
    a. Memory Full Action, Modbus register 42350 [**Stop** or **Overwrite**]
    b. File Size Limit, Modbus register 42372 [**0** to **80** MB]
    c. Log Interval, Modbus register 42388 [0.1, 0.2, 0.5, 1, 2, 5, 10, 15 and 30 seconds, 1, 2, 5, 10, 15, 30 and 60 minutes]
2. Load Modbus register 42386 "Log Action" with 1782 [**start**].
3. Write Modbus registers to the controller.

Transferring Data Log Files

A user can transfer data log files manually or automatically.

Note: All closed data log files are transferred. If a file is open during the logging process, that file will not transfer until the data logging is stopped.

To transfer data log files to a USB thumb drive:

1. Insert a USB thumb drive into USB host port on the chamber.
2. Press the **Menu** button.
3. Press the **File Transfer** button. Allow time for the F4T to load the USB thumb drive. After it is loaded, the USB thumb drive name will appear.
4. Press the **Export** button. Them, press **Data Log**.
5. A progress bar will appear. File transfer is complete when the progress bar reaches 100%.

To transfer files automatically:

1. Press the **Menu** button.
2. Press the **Data Logging** button.
3. Press the Data Log File Transfer button.
4. Select **Auto Transfer Type**: **TFTP**, **Samba,** or **USB**.
   NOTE: If TFTP or Samba is selected above, the server must be configured.

Trend Charts

Graphical Trend Charts provide a display of the temperature over time.

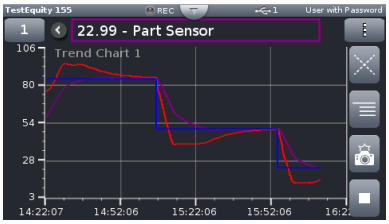
Up to four different trend charts can be set up. If you leave one chart to view another chart, you will lose all previously displayed information.

The trend chart will only record one screen of date before writing over itself. **You cannot retrieve data that is not shown on the screen.** If you want finer resolution and longer-term data, you should use the Data Logging function instead.

To access trend charts, press the **Menu** button and then the **Trending** button. Press the **Actions** button for **Trend Chart 1**. This chart has already been set up by TestEquity to display the Air Sensor, Part Sensor, and Set Point.

Press **View/Edit Details** to change the chart name, grid display On/Off, auto-scaling On/Off, and the horizontal timespan. **If you change the timespan while the chart is running, you will lose all previously displayed information.** You will need to Stop and then Resume the trending for changes in timespan to take effect.

Press **View** to view the chart. When viewing the chart, you can toggle between the values being charted by pressing the arrow next to the highlighted box on the top of the screen (Part Sensor temperature of 22.9°C in this example, pressing the arrow will toggle through Air Sensor temperature and Set Point).



Pressing the box with three horizontal dots on the right side of the screen will give you choices to (listed in order of appearance):

- Turns the grid Off/On.
- Go to choices for View/Edit Details and Edit Pens.
- Take a snapshot (.bmp image) and save it to the USB thumb drive (you must have a thumb drive plugged into the USB port to capture the snapshot).
- Stop/Resume the trending. **If you stop the trending, you will lose all previously displayed information once it is resumed.** In the above image, the bottom button is shown in running condition. When pressed (Stop), it till turn into a right-facing triangle.

You can leave the trend display, view the Home or other screens and come back to the trend display without losing any information, as long as you do not change any of the volatile trend settings. When you go back to the **Trending** menu you will see a clock icon, indicating that the trending information is continuing to be recorded. Pressing **Actions** and **View** will return you to the active trend chart.

Exporting/Importing Profiles and Configuration via USB

Transferring Profile Files

Profiles can be exported and imported as individual files via USB. This is useful for transferring profiles between different chambers and for archival purposes. The profile files contain all the profile steps that would ordinarily be entered via the front panel or Composer software. It does not contain any logged data.

To export a profile file to a USB thumb drive:
1. Insert a USB thumb drive into USB host port on the chamber.
2. Press the **Menu** button.
3. Press the **File Transfer** button.
4. Press **Export**, then press **Profile**.
5. A screen will pop up the names of each stored profile. Press the desired profile name to export it. A progress bar will appear and then indicate 100% when done.

To import a profile file to a USB thumb drive:
1. Insert a USB thumb drive into USB host port on the chamber.
2. Press the **Menu** button.
3. Press the **File Transfer** button.
4. Press **Import**, then press **Profile**.
5. A screen will pop up the names of each stored profile. Press the desired profile name to import it. A progress bar will appear and then indicate 100% when done.

Transferring Configuration Files

The F4T configuration file contains a "System Image" of all settings that determine how the controller inputs and outputs work and how the display appears. The configuration file also contains all profiles. It does not contain any logged data. The configuration can be exported for archiving purposes. It can also be imported to restore the configuration from a previous archive.

⚠ **CAUTION:** Configuration files are unique to each particular model chamber and must NEVER be transferred to a different model chamber.

To export a Configuration file to a USB thumb drive:
1. Insert a USB thumb drive into USB host port on the chamber.
2. Press the **Menu** button.
3. Press the **File Transfer** button.
4. Make sure the Import/Export button is selected for **Export**.
5. Press the **Export** button next to **Configuration**.
6. A progress bar will appear and then indicate 100% when done.

Importing a configuration file is accomplished similar to the profile import except you select Configuration and then selecting the desired configuration file.

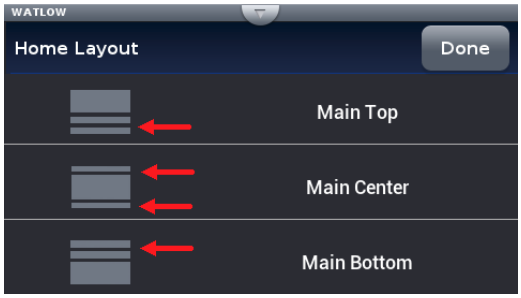
Personalizing the Home Screen

Placement of objects on the home screen can be modified by the user. You must have a password to enter the Personalization screen.

Note: Your controller might not have all the choices available depending on its configuration.

To personalize the Home screen, do the following:

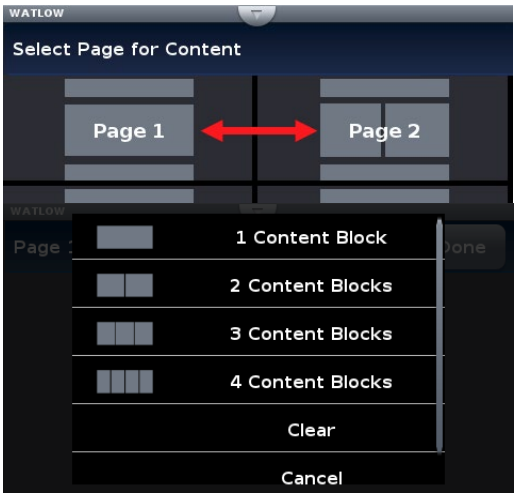
1. From any screen, press the **Menu** button.
2. Press **Personalize**.
3. Press **Basic Personalization**.
4. Select the desired **Home Layout** by pressing **Main Top**, **Main Center**, or **Main Bottom**.



The red arrows were placed on this graphic for emphasis only and represent what the focus of this operation is; that being, defining the location of the profile status and the output widget bars. As shown above, the options include placing them on the bottom, split screen top and bottom or on the top.

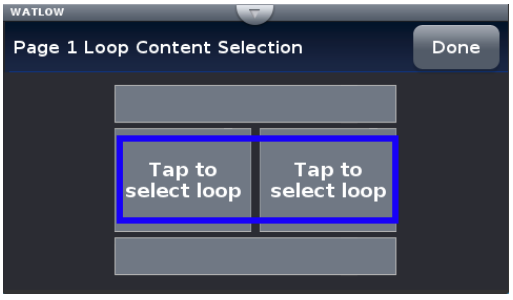
1. Tap each page (through 4) in which loop information will be displayed. In the graphic shown, each page has been configured to display from 1 to 4 loops on each page.

2. Define the content blocks (number of loops) that will be displayed on each page.

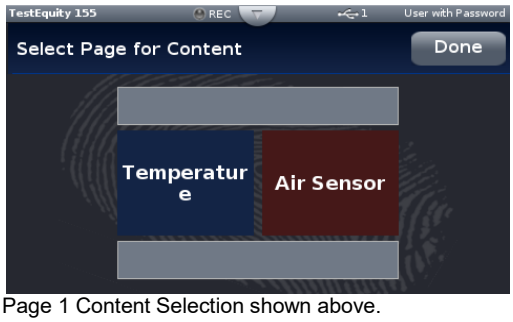


Defining page 1 to display two loops (content blocks):

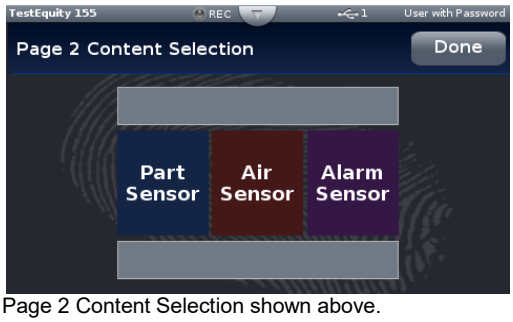
- From any screen, press the **Menu** button.
- Press **Personalize**.
- Press **Basic Personalization**.
- Select the desired **Home Layout** by pressing **Main Top**, **Main Center**, or **Main Bottom**.
- Press Page 1.
- Select "**2 Content Blocks**".



3. Press on each content block above to determine what content is shown as well as its color.

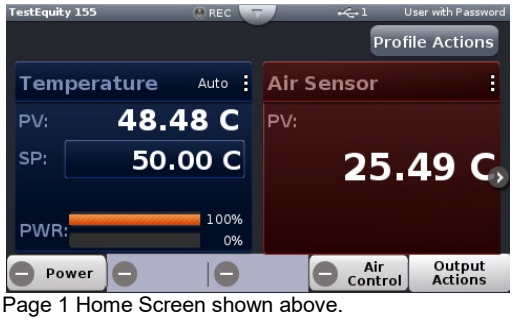


Page 1 Content Selection shown above.

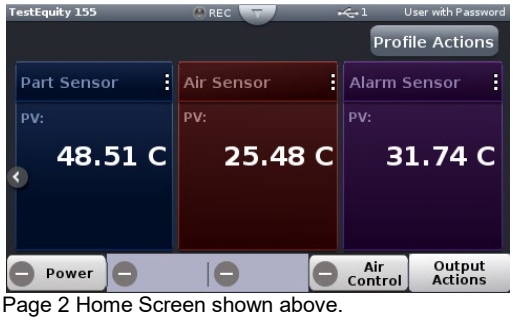


Page 2 Content Selection shown above.

4. Press the **Home** screen button to see the result of this operation.



Page 1 Home Screen shown above.

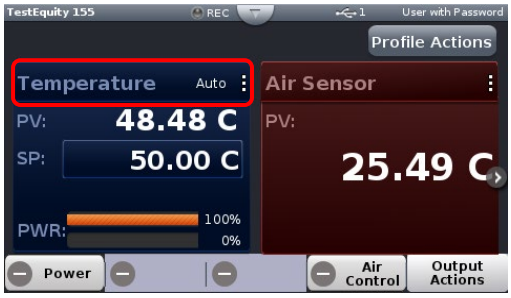


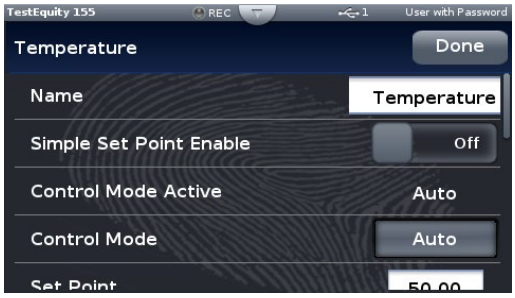
Page 2 Home Screen shown above.

Changing Loop Operational Parameters

Pressing the vertical ellipsis or anywhere within the red outlined box shown below will provide access to the loop name, control mode, PID settings and many other parameters. You must have a password to change the loop PID tuning parameters.

⚠ **CAUTION:** The F4T PID tuning 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.





Chapter 5 – Composer Software

Installation

Overview
Watlow Composer Software can be used to create, edit, and archive profiles. It can also be used to configure the controller. Since the controller is already configured by TestEquity for use in your chamber, configuration instructions are not provided.

Downloading the Software and System Requirements
Software can also be downloaded directly from www.testequity.com/Composer

In order to install and run this software successfully there are some baseline requirements for PC hardware and operating systems that must be observed. These requirements are listed below:

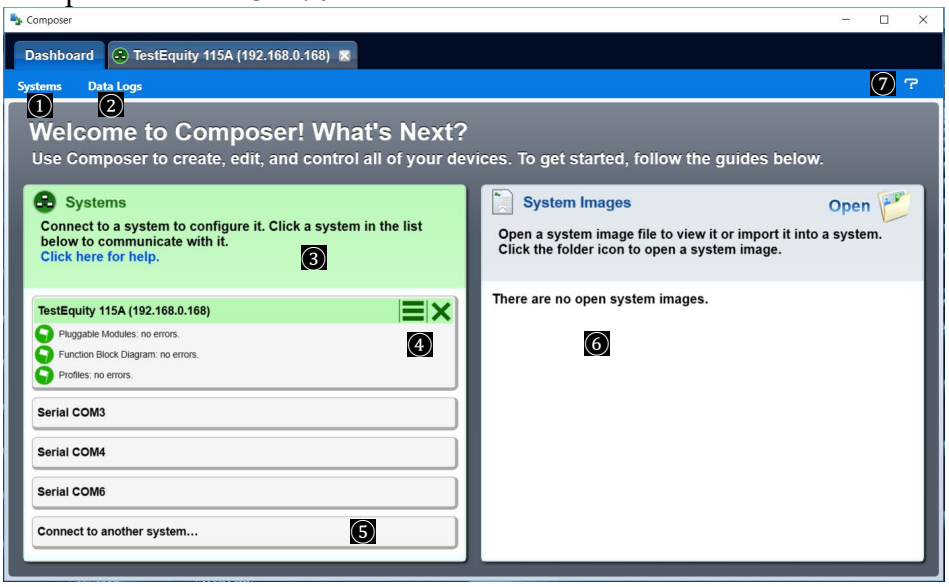
- 250 Megabytes or more of available hard disk drive space
- 300 Megabytes of available RAM
- Windows® 7 or higher (32 or 64 bit)
- Requires Microsoft® .NET Framework 4.0 (this installs automatically if not already on target machine)

Installing the Software
To install the software:
1. Double-click the Setup.exe.
2. Select the language of choice and click the OK to proceed.
3. Click the Next button to proceed.
4. After reading the Composer software license agreement click “I accept the terms in the License Agreement” radio button and then click on the Next button to proceed.
5. The next dialog box shows the default directory in which the software will be installed. The install location can be changed by clicking the Browse button and then point to the preferred location.
6. Click Next and then Install.
7. Clicking the Finish button will conclude the installation.

Network Configuration
See “Chapter 6 – Communications” in this manual for instruction on how to configure the Ethernet communications parameters in the F4T. You might need help from your IT department to configure this to match your computer settings.

Composer Welcome Screen Orientation

Composer Version 3.4.70 shown below:



① **Dashboard (Systems):** Displays options for on-line connections between PC and a controller or opening a previously saved system image.

② **Data Logs Menu:** Displays the contents of a data logged file (enc or csv). Depending on files size this may take several minutes to open.

③ **Systems:** Shows available systems that are online. **NOTE:** Prompts for Serial ports do not apply to the F4T Controller and should be ignored.

④ **Loaded System:** Click the loaded system to enter it (shown already clicked).

⑤ **Connect to another system:** (Composer Version 3.4.70 and higher) Opens a window allowing you to enter the IP address of an F4T that is on a network.

⑥ **Open a System Image:** Opens a window allowing you to open a previously saved system image to download to a controller.

⑦ **Help:** Allows you to change automatic software update settings, as well as initiate an immediate check for updates (internet connection is required). Clicking on **About** will display technical support contact information and the current firmware versions of the installed software and installed modules.

Using Composer Software

Establishing an Online Connection to a System Using Ethernet

See the chapter on Communications for more information on Ethernet connectivity. Connect the chamber to a PC through its native Ethernet port only. From the Welcome or Systems screen click on a connected system. It might take a minute until the controller is found it the F4T is configured for DHCP instead of a fixed IP address. Double clicking on the system will bring up the System Overview screen shown below.

System Overview Screen

Dashboard ①

Displays all devices connected on the system.

System ②

When clicked, a drop-down submenu will appear for navigation to Overview, Save Image, Save Image As, Import Image, Print, Export Settings, Global Settings, Security, Network

Device Menus ③

When clicked, a drop-down submenu will appear for navigation to Device Details, Pluggable Modules, Function Block Diagram, Personalization, Calibration, Datalogging, Trending, and Profile setup screens.

Security and Passwords

Located in **System** ②. The security feature is used to protect the system's configuration and settings from unwanted changes. The Admin user sets what access other users have to the systems features. When security is enabled, a user must enter a password to gain access to protected features through the controller's user interface or Composer software. There are three configurable user groups and an admin user:

- **User** - no password required, admin sets feature access
- **User with Password** - requires a password, admin sets feature access, is permitted to change the password for this user group.
- **Maintenance User** - requires a password, admin sets feature access, is permitted to change the password for this user group.
- **Admin** - requires a password, has unlimited access to features, sets permissions and passwords for all user groups.

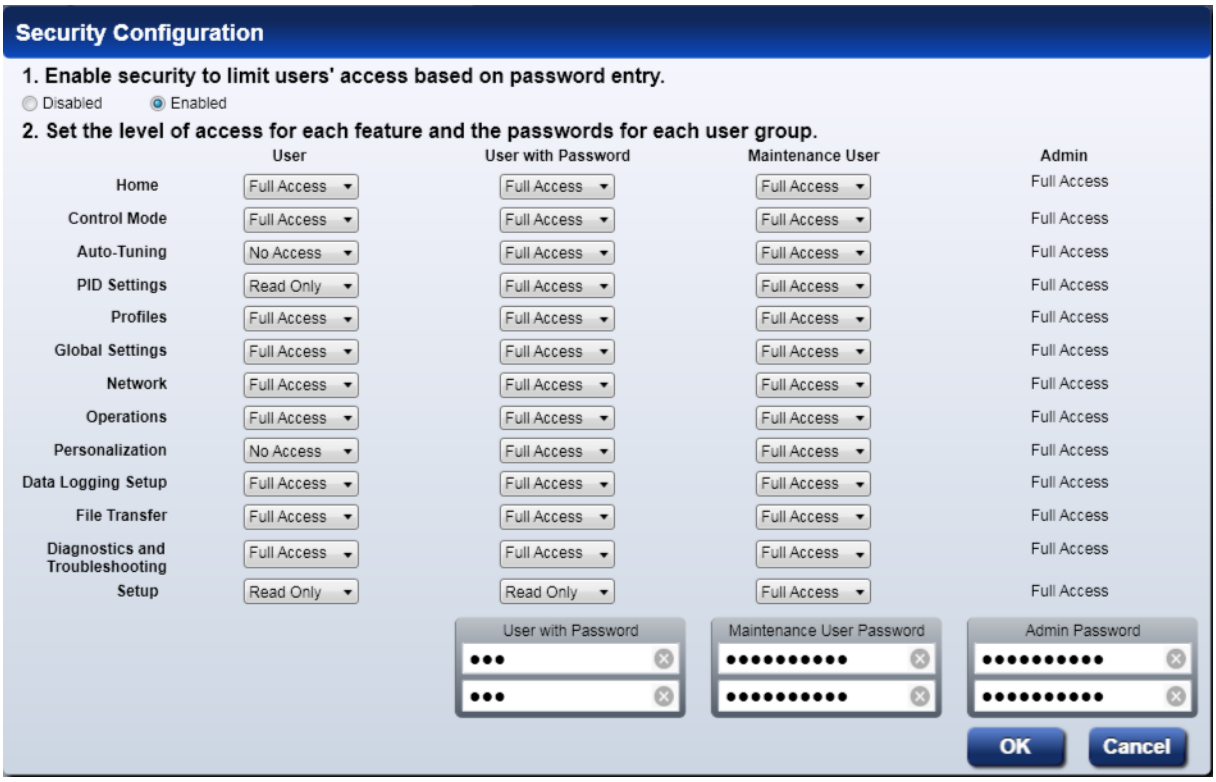
There are four entry levels when trying to acquire access to the controller. Those levels are:

- **User** - no password required with limited access based on settings.
- **User with Password** - password required with limited access based on settings.
- **Maintenance User Password** - password required with limited access based on settings.
- **Admin Password** - password required with full unlimited access.

The admin user can set each user groups' permission to allow full, read-only or no access to the following features:

- **Home**, controls access to controller's home screen.
- **Control Mode**, controls access to setting the control mode, set points and PID parameters.
- **Autotune**, controls access to running the autotune feature.
- **PID Settings**, controls access to the PID settings.
- **Profiles**, controls access to creating and editing ramp and soak profiles.
- **Global Settings**, controls access to the system's global settings, temperature units, AC line frequency and real time clock setting.
- **Network**, controls access to Ethernet settings.
- **Operations**, controls access to operational parameter settings.
- **Personalize**, controls access to customizing the controller's home screen.
- **Data Logging Setup**, controls access to settings for Data Logging.
- **File Transfer**, controls access to transfer of setup, profile, and log files.
- **Diagnostics and Troubleshooting**, controls access to the device details.
- **Setup**, controls access to the pluggable module configuration and the function block diagram.

The image below shows the security levels as configured by TestEquity. You must contact TestEquity to get the passwords for your chamber.



After making all the desired security settings, ensure that the security enabled radio button (top left in the graphic above) is checked. Once security is applied to the controller, only the administrator (Admin) can reconfigure or remove the security.

When the system file is saved, any applied security will be saved with it.

Save System Image

Located under System ②

(a) **Save**

Everything that will be saved is as listed below. After clicking on save image as, the save button will become active (gray to white). This allows a user to make changes to the system image and simply save it to the same location using the same filename.

- Device Details
- Pluggable Modules
- Function Block Diagram in its entirety
- System Security
- Profiles (if any were entered)
- Profile passwords
- All parameters that can be read and written to

(b) **Save As**

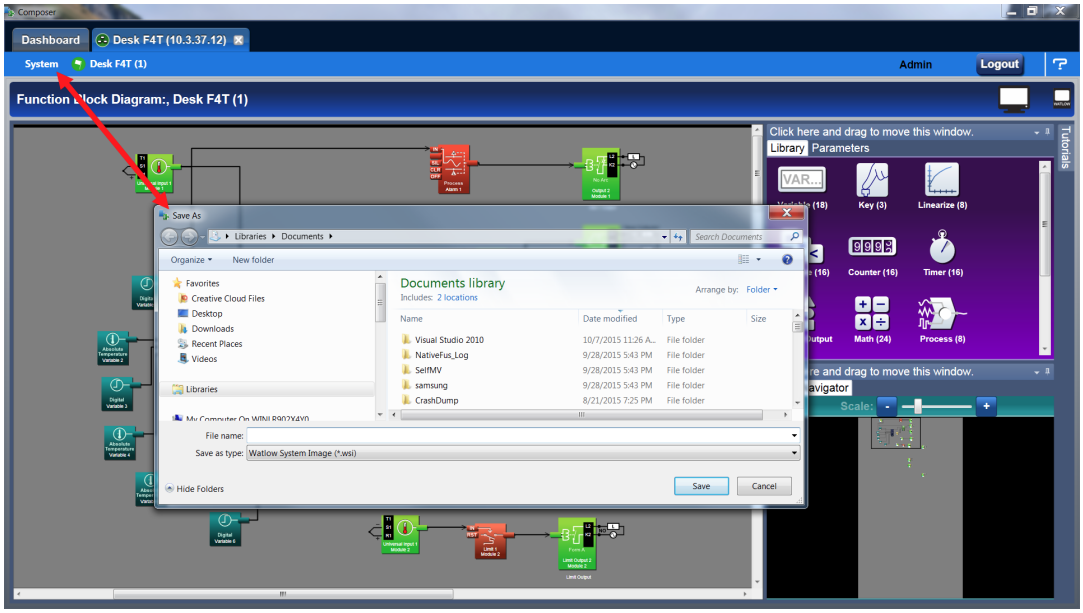
- Save a system image to a storage device. Saves everything listed above.

Note: The real-time clock is not saved or imported.

Saving a System Image

To save a system image the first time:

1. On any Composer screen click the Save As button.
2. Use the save as dialog to select the destination folder for the image.
3. Enter the desired filename.
4. Click Save.



Note: The system image filename will always have the extension **wsi** for Watlow System Image and cannot be changed.

Import System Image

Located under System ②. Restores a system image from a storage device to the controller. The list below shows what is restored:

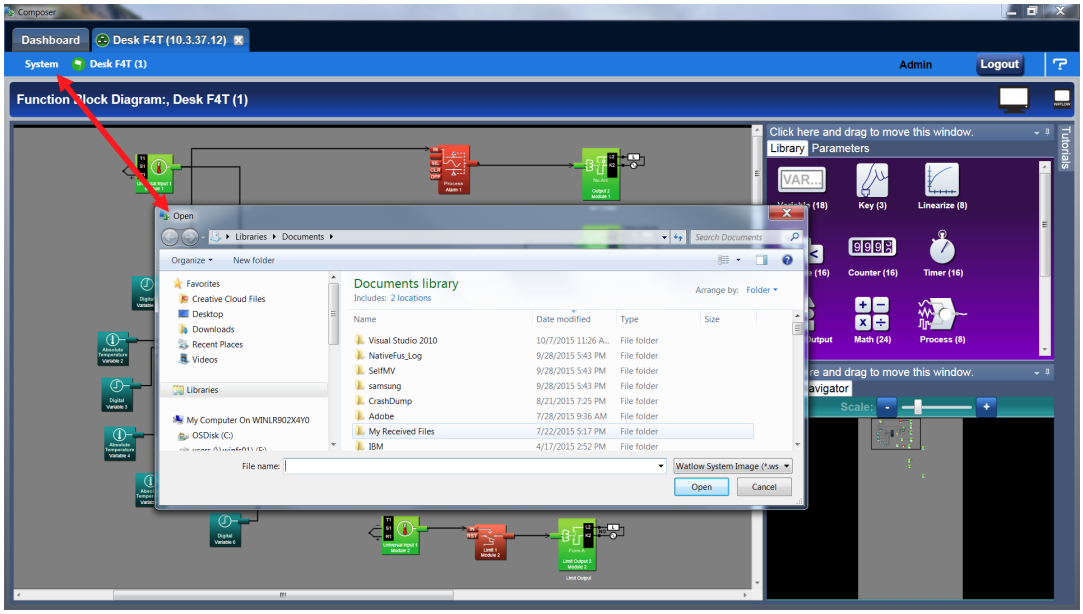
- Device Details
- Pluggable Modules
- Function Block Diagram in its entirety
- System Security
- Profiles
- Profile passwords
- All parameters that can be read and written to

Importing a System Image

NOTE: We recommend changing the IP Address Mode to Fixed instead of DHCP when importing a system image. You might need help from your IT department to configure your computer to match this setting.

To import a system image:

1. On any Composer screen click the Import System Image button.
2. Use the open dialog to select the folder location for the previously saved system image.
3. Double-click the desired filename or single-click the filename and then click the Open button.
4. After a system image is imported, we suggest you cycle power to the F4T Controller and restart Composer software.



Global Settings

Located under System ②.

- **Temperature Units** - will determine how the temperature is displayed (Fahrenheit or Celsius) on the front panel of the controller as well as throughout all configuration screens within Composer.
- **AC Line Frequency** - variable time outputs use this setting. This setting is not relevant to TestEquity chambers.
- **Date and Time** - sets the date and time to the current computer time and date or whatever the user enters.

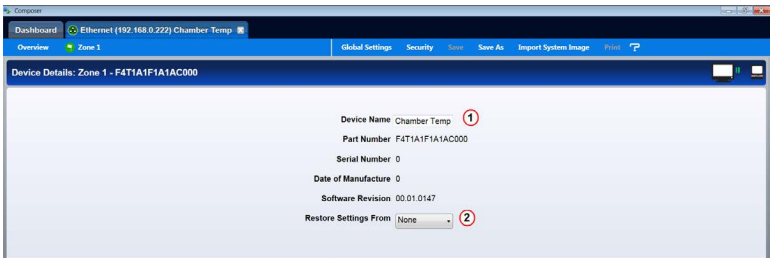
Device Details

The Device Details screen allows a user to make changes to the system settings described below. Descriptions are numbered correspondingly in the graphic below.

Device Name ①

Changes the name of the controller for easy identification.

Note: This name will also be displayed in the upper left corner of the user interface.



Restore Settings From ②

None - no action.
Factory - allows a user to bring the controller back to the factory default state. This is **NOT** the TestEquity default state and all configurations will be erased.

⚠ **CAUTION:** NEVER select "Factory" in the Restore Settings From prompt in the Device Details menu in Composer Software. This will erase all controller configuration settings. The chamber will not work if you do this.

To change any of the settings described above follow the steps below:

1. From the Menu bar click on Zone 1.
2. Within the drop-down menu click on Device Details.
3. Make desired changes (all changes are saved immediately).

Pluggable Flex Modules

This controller can have up to six Flex Modules (FM) installed in the chassis. The presence of each FM must be confirmed and accepted using Composer software. FMs can be fully configured as installed hardware or the user can type in a valid FM part number for later installation. The **Pluggable Module Screen** shows what modules are installed.

TestEquity has already installed and configured the correct modules for your chamber. Since this is not intended to be an ordinary user function, no further instructions will be covered in this manual.

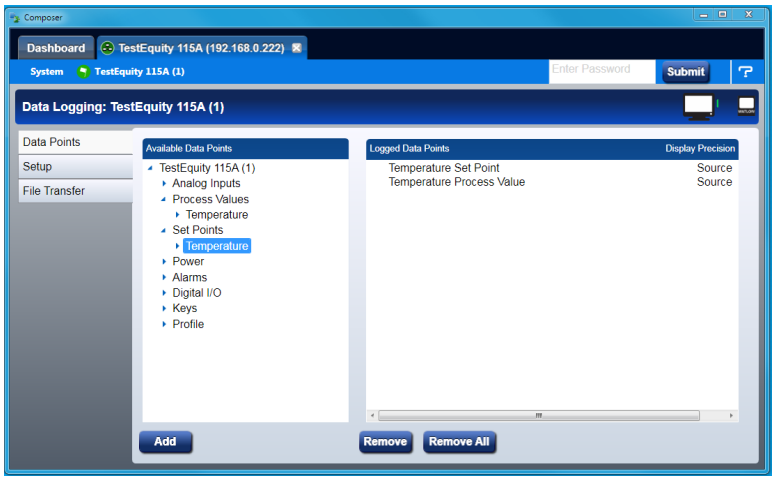
Personalization

Located in **Device Menus** ③. This is only viewable if you are logged in as a User or Admin.

See "Personalizing the Home Screen" in Chapter 2 for information on your choices for personalization.

Data Logging

See **Data Logging** in Chapter 2 for an explanation of these settings. TestEquity suggest you select the minimum number of relevant parameters to log. This will result in a smaller file size. In the example below for a temperature chamber, only Temperature Set Point and Temperature Process Value (the actual chamber temperature) were selected.



Trend Charts

See **Trend Charts** in Chapter 2 for an explanation of these settings. TestEquity suggest you select the minimum number of relevant parameters to plot. In the example below for a temperature chamber, only Temperature Set Point and Temperature Process Value (the actual chamber temperature) were selected. The chart shown below is only a representation of how the display on the F4T will appear with your choice of settings. Composer software cannot be used to plot this data.

Creating and Editing Profiles in Composer Software

This section describes the features of the Profile View in Composer Software and includes instructions for using it. A profile is a set of instructions consisting of a sequence of steps. When a profile runs, the controller automatically executes its steps in sequence.

Profile View Orientation: Describes the layout of the profile screens.

Profile Parameters: Settings that apply to a profile.

Step Parameters: Settings that apply to a step.

Opening the Profile View: Displays the list of profiles in the device.

Creating Profiles: Up to 50 profiles can be created.

Saving a Profile: Store profiles on the computer to make it easy to load them in other controllers or to restore one that was inadvertently changed or deleted from the controller.

Loading a Profile: Loads a profile that was previously saved to the controller's memory.

Duplicating a Profile: An easy way to create a new profile similar to one that was created previously.

Deleting a Profile: Removes unneeded profiles from the controller memory freeing up space for new profiles.

Opening the Step Editor: Displays the details of the step.

Adding Steps: Up to 50 steps can be included within any given profile.

Inserting Steps: Create a new step at a specific point in a profile.

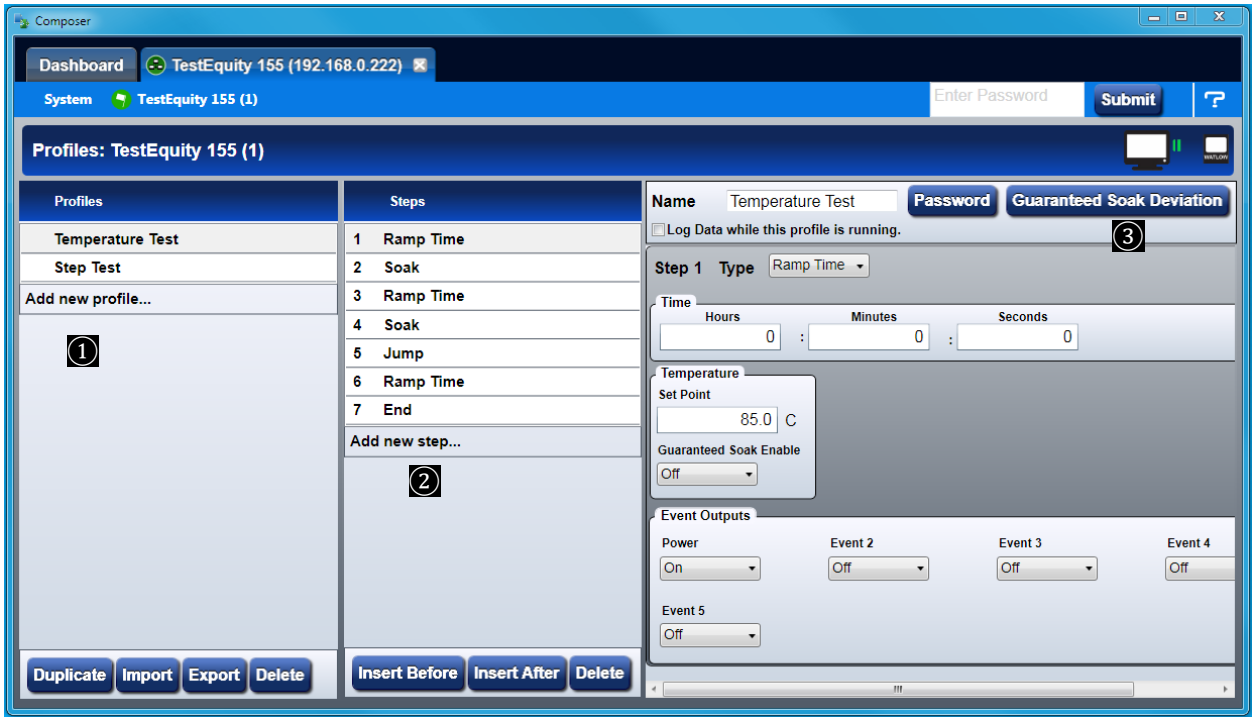
Deleting Steps: Remove a step from a profile.

Password Protect a Profile: Avoid unwanted and inadvertent changes to a profile with password protection.

Changing or Removing a Password from a Profile: When password protection is no longer needed it can be easily removed.

Profile View - Screen Orientation

The Profile View has the following features, numbered correspondingly in the graphic below.



① Profile List

- In this column a user can view all currently existing profiles as well as whether or not the profile has password protection.
- You can use **Add new profile...** or the buttons at the bottom to delete, duplicate, import, or export profiles.

② Step List

- Shows all currently existing steps for the selected profile ("Temperature Test" in the example above).
- You can use **Add new step...** or the buttons at the bottom to insert or delete a step.

③ Step Detail

- Shows all available selections for the selected step while also allowing each to be modified.
- You have the ability to give the profile a name as well as apply password protection.

Profile Parameters

The following settings apply to the entire profile.

Name

- User-entered identifier for the profile. The name follows the profile when it is saved in a file or moved to another controller.

Password

- User-set code that must be entered prior to editing a protected profile. A password may consist of up to ten characters, may include letters, numbers or symbols and is case sensitive.

Guaranteed Soak Deviation/Guaranteed Soak Values

- The amount by which the actual chamber temperature is allowed to differ from the set point for steps with Guaranteed Soak Enable set to **On**. In such steps when the actual chamber temperature differs from the set point by more than this value, the step timer stops running until the actual chamber temperature returns to within the band defined by the set point plus or minus this value. Each profile can have its own set of Guaranteed Soak values.

Data Logging

- Check "Log Data while the profile is running" to automatically initiated data logging during this particular profile.

Step Parameters

The following parameters set the behavior of a profile's steps. Only the parameters that apply to the selected step type appear in the step detail.

Step Type

Set the behavior of the step. Step Type options include:

- **Rate:** adjusts the temperature set point at the user-set Rate of change until it reaches the step's Set Point.
- **Soak:** maintains the temperature set point constant for the step's Time.
- **Jump:** repeats previous steps in the profile starting at the step set with Jump to Step for the Number of Times set. This option is not available for step 1.
- **Ramp Time:** adjusts the temperature set point gradually from the previous set point to the step's Set Point over the step's Time.
- **State:** sets the temperature set point to the step's Set Point without ramping from the previous set point and holds that set point for the step's Time.
- **Instant Change:** sets the temperature set point to the step's Set Point without ramping from the previous set point and holds that set point for the step's Time.
- **Wait For Process or Event:** holds the profile until the specified conditions on the event inputs are met. When multiple conditions are specified, the profile will not proceed until all the conditions are satisfied at the same time.
- **END:** Sets the temperature set points, and event output conditions when the profile ends. See page 16 for more information.

Time: Hrs Min Sec: Set the duration of the step.

Ramp Time: Set the speed at which the temperature set point is increased or decreased to the step's Set Point value.

Set Point: Set the value to which the loop's set point is changed by the step.

Guaranteed Soak Enable
- Set **On** to prevent step time from elapsing whenever the loop's process value differs from its Set Point by more than Guaranteed Soak Value for the loop.

Event Input 1 to Event Input 4
Only applicable if controller has Event Inputs configured. Set the condition on each input for a Wait For step. Event Input options include:
- **None:** do not wait for this input.
- **On:** wait until a digital input is on or true.
- **Off:** wait until a digital input is off or false.
- **Greater Than:** wait until the process value is greater than the setting of the corresponding Input Value parameter.
- **Less Than:** wait until the process value is less than the setting of the corresponding Input Value parameter.

Input 1 Value to Input 4 Value
- Set the process value against which the corresponding condition is evaluated in a Wait For step.

Jump To Step
- Set the step number at which the profile should begin to repeat steps.

Number of Times
- Set the how many times the Jump Loop step repeats the previous profile steps.

Note: Number of Times is the number of times the steps are repeated not including the time they are executed prior to reaching the Jump Loop step. For example if step 5 of a six step profile is a Jump Loop with Jump To Step set to 2 and Number of Times set to 1, when the profile is run starting at step 1 it executes steps as follows: 1, 2, 3, 4, 5, 2, 3, 4, 5, 6.

Event Outputs: Event Output 1 to Event Output 4
Set the state to which the profile sets each event output at the start of the step. Event Output options include:
- **On:** the step sets the event output on or true.
- **Off:** the step sets the event output off or false.
- **Unchanged:** the step does not set the event output; it remains in whatever state was previously set.

End Action
Set what the Temperature condition will be after the profile is complete. See page 16 for more information. Options include:

- **User:** program will end with the same Temperature Static Set Point values that were entered before the profile was run. See page 16 for more information.
- **Off:** the Temperature control mode is set to Off.
  NOTE: Selecting **Off** as the End Action is not recommended. See page 16 for more information.
- **Hold:** the Temperature Set Point is set to the last value used in the profile. See page 16 for more information.

Opening the Profile View

To view the profile listing:
1. Click the device to view the device toolbox.
2. Click **Profiles** to bring up the profile listing.

Creating Profiles

To create a new profile in the controller:
1. Click the **Click to add...** button.
2. If desired, click in the Name field and change the profile's name.

Note: A profile name is limited to 20 characters.

Saving a Profile to a Storage Device

To save a profile:
1. Select the profile by clicking it in the profile list.
2. Click the **Save** button at the bottom of the profile list.
3. Use the Save As dialog to edit the name and select the desired location and click the **Save** button.

Hint: Save is an option on the profile pop-up menu.

Note: A profile that has a password applied will be saved with the password.

Loading a Profile

To load a profile previously saved on the computer in to controller memory:
1. Click the **Load** button.
2. Use the open dialog to locate and select the desired profile file.
3. Click Open.

Duplicating a Profile

To duplicate a profile:

- Right-click the profile and click **Duplicate** in the pop-up menu.

Or

- Click the profile, then click the **Dup** button at the bottom of the profile list.

Notes:

- The duplication process automatically appends the duplicated profile to the end of the profile list.
- If a profile is locked with a password and duplicated, the duplicated profile is not pass-word protected.
- The name of the duplicate profile is the original profile's name with the words "Copy of" added to the beginning. The result may be truncated so as not to exceed 20 characters.

Deleting Profiles

To delete a profile:

- Right-click the profile, click **Delete** in the pop-up menu and then click **OK** to confirm

Or

- Click the profile, click **Delete** button at the bottom of the profile list and then click **OK** to confirm.

Or

- Click the profile, press the **Delete** key on the computer keyboard and click **OK** to confirm.

Opening the Step Editor

To open the step editor:

- Click any step in the step list.

Adding Steps

To add a step to a profile:

- Right-click a step and choose **Add** in the pop-up menu

Or

- Click the **Click to Add...** button in the step list.

Hint: When clicking on **Add new step...**, if a step is selected, a duplicate of the selected step is added, if no step is selected, a duplicate of the last step is added.

Inserting Steps

To insert a new step ahead of an existing step:

- Right-click the step and choose **Insert Step Before** in the pop-up menu.

Or

- Click the step and then click the **Insert Before** button at the bottom of the step list.

Deleting Steps

To delete a step:

- Right-click the step and choose **Delete Step** in the pop-up menu.

Or

- Click the step and then click the **Delete** button at the bottom of the step list.

Or

- Click the step and press the **Delete** key on the computer keyboard.

Password Protect a Profile

To avoid inadvertent changes to a profile, apply password protection to it.

To set a password for a profile:

1. Click the **Password** button.
2. In the dialog box enter a password (10 characters maximum).
3. Re-enter the same password to verify it.
4. Click **OK**.

Note: A password protected profile requires the password be entered to edit but not to copy it or to delete it. If the profile is duplicated, the duplicate is not password protected.

Changing or Removing a Password from a Protected Profile

To change or remove a profile's password, the password must be known.

To change a profile's password:

1. Select the profile by clicking it in the profile list.
2. Enter the password and click **OK**.
3. Click the **Password** button.
4. Enter a new password (10 characters maximum).
5. Re-enter the same password to verify it.
6. Click **OK**.

To remove a profile's password:

1. Select the profile by clicking it in the profile list.
2. Enter the password and click **OK**.
3. Click the **Password** button.
4. Click the **Remove** button.

Chapter 6 – Communications

Ethernet Parameters

This section describes how to configure the Ethernet Communications settings in the F4T controller.

Changing Ethernet Parameters

1. Press the **Menu**, **Settings** and **Network** buttons, in that order.
2. Under **Communications Channels** press **Ethernet**.
3. Change the desired settings.
4. Recycle the power to put the new settings into effect.

Ethernet Parameters and Settings

The bracketed bold settings below represent the defaults as delivered from the factory:

- **IP Address Mode**: [DHCP], Fixed
  - DHCP, Dynamic Host Configuration Protocol, allows for dynamic distribution of network settings by a DHCP server.
  - Fixed, also referred to as a static IP address, is configured manually for a specified network.
- **Actual IP Address**: [192.168.0.222]
- **Actual IP Subnet**: [255.255.255.0]
  - Subnet, a method used to logically divide and isolate networks.
- **Actual IP Gateway**: [0.0.0.0]
  - Gateway, is a device used on the network to route messages with IP addresses that do not exist on the local network.
- **MAC Address**: xx:xx:xx:xx:xx:xx (Will be different and unique for each controller)
  - MAC address, is a manufacturer supplied address for the network interface card.
- **Display Units**: °F, °C [configured by TestEquity for °C]
- **Modbus® TCP Enable**: [Yes], No
  - Modbus is an industrially hardened field bus protocol used for communications from the controller to other devices on the network.
- **Modbus Word Order**: [Low High], High Low
  - Modbus allows a user to select the word order of two 16-bit words in floating point values.
- **Data Map**: [1], 2, 3
  - Data Map, the user can switch Modbus registers from the comprehensive listing of F4T registers.
  - Map 1 = F4T registers (default)
  - Map 2 = Not applicable to this Model 155 or controllers with Cascade Control (Part Temperature Control)
  - Map 3 = For controllers with Cascade Control including this Model 155. Limited set of F4 compatible registers (for compatibility with software written for the F4).

Connecting directly to a PC or Ethernet Router

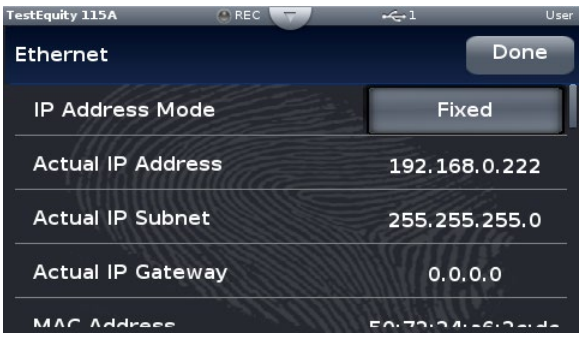
To connect the F4T directly to a PC or a wired Ethernet Router and the PC's network adapter must be set for a Fixed IP address.

How to change your PC to a Fixed IP address (Windows 10):

- On the PC navigate to the control panel and click on Network and Sharing Center
- Click on Change adapter settings
- Double-click on the Local Area Connection (the Ethernet port where cable is connected to).
- Click the Properties button.
- Double-click on Internet Protocol Version 4 (TCP/IPv4) button.
- Click the radio button identified as Use the following IP address.
- Change the IP address to 192.168.0.2, Subnet mask to 255.255.255.0 (this assumes the F4T is configured for 192.168.0.222 which is how they ship from TestEquity, you can choose a different IP address).
- Click OK when done (this change to the IP address will take effect immediately)

How to Change the F4T to Fixed IP Address:

- Press the Menu, Settings, and Network buttons, in that order.
- Under Network press Ethernet.
- If the IP Address Mode button indicates DCHP, press the button and select Fixed.
- Scroll down and entered the desired IP address in Fixed IP Address Part 1 through 4.
    - IP Fixed Address Part 1, Part 2, and Part 3 should be the same Address Number of your computer or router.
    - IP Fixed Address Part 4 should be unique/different.
- Continue scrolling down to IP Subnet Part 1 through 4 and Fixed IP Gateway Part 1 through 4 to enter those respective settings. Typically, the IP Subnet is 255 255 255 0 and the Fixed IP Gateway is 0 0 0 0 but your network may be setup differently.
- Press Done. Power to the F4T (chamber) needs to be recycled for the new settings to take effect.



Connecting to an Ethernet Switch & Wireless Router

The F4T can be configured for DHCP when connecting to an Ethernet Switch. The wired Ethernet connections on a "Wireless Router" are really an Ethernet Switch. In this case, the DHCP Server in the switch will assign an IP address to the F4T. If the System is to be setup for DHCP, then the IP Address Mode in the F4T must be set for "DHCP". This address will show in the F4T's display for Actual IP Address, Subnet and Gateway.

How to Change the F4T to DHCP:

- Press the Menu, Settings, and Network buttons, in that order.
- Under Network press Ethernet. If the IP Address Mode button is already DHCP then you do not need to do anything.
- If the IP Address Mode button indicates Fixed, press the button and select DHCP. Power Cycle the F4T for this change to take effect.

Watlow Composer Software Configuration

To work with a direct PC connection or through a router, the F4T must be set for a fixed IP address and you must have Watlow Composer version 3.4.70 or later. See www.testequity.com/composer for Watlow Composer Software.

- If the F4T is connected directly to a PC or a wired Ethernet Router, then in the Composer Software; select "Connect to another system". Then "Enter the IP Address or DNS name of the system" in the box shown and then press "Connect".
- If there is no Router between the Computer and the F4T, then when Composer Software allows you to "Connect to a System to Configure it" the F4T Name/IP Address should automatically be displayed. Select this F4T Name/IP Address to use Composer with this F4T (this chamber that is).

RS-232 Parameters

This section describes how to configure the RS-232 Modbus Communications settings in the F4T controller.

Changing RS-232 Parameters

1. Press the **Menu**, **Settings** and **Network** buttons, in that order.
2. Under **Communications Channels** press **Modbus**.
3. Change desired settings.
4. Recycle the power to put the new settings into effect.

RS-232 Parameters and Settings

The bracketed bold settings below represent the defaults as delivered from the factory:

- **Modbus Address**: [1]
  - Each device is given a unique address. Up to 247 devices can be on the same data link.
- **Baud Rate**: [9600]
  - Must match the baud rate of your computer's serial port and software.
- **Parity**: [None]
  - Must match the parity of your computer's serial port and software.
- **Display Units**: °F, °C [configured by TestEquity for °C]
- **Modbus Word Order**: [Low High], High Low
  - Modbus allows a user to select the word order of two 16-bit words in floating point values.
- **Data Map**: [1], 2, 3
  - Data Map, the user can switch Modbus registers from the comprehensive listing of F4T registers.
  - Map 1 = F4T registers (default)
  - Map 2 = Not applicable to this Model 155 or controllers with Cascade Control (Part Temperature Control)
  - Map 3 = For controllers with Cascade Control including this Model 155. Limited set of F4 compatible registers (for compatibility with software written for the F4).

Modbus

The F4T controller is equipped with Modbus® TCP as an embedded protocol.

Introduction to the Modbus Protocol

Modbus provides the advantage of being extremely reliable in exchanging information. This protocol works on the principle of packet exchanges. The packet contains the address of the controller to receive the information, a command field that says what is to be done with the information, and several fields of data. Each parameter has a unique Modbus register number.

All Modbus registers are 16-bits and are listed in the following table as relative addresses (actual). Some F4T parameters are contained within 32 bits (IEEE Float, signed 32 bit). Notice that only one (low order) of the two registers is listed on the next page. By default, the low order word contains the two low bytes of the 32-bit parameter. As an example, in the table below see Actual Chamber Temperature. Note that it lists register 27586. Because this parameter is a float, it is actually represented by registers 27586 (low order bytes) and 27587 (high order bytes). The Modbus specification does not dictate which register should be high or low order therefore, the controller provides the user the ability to swap this order.

F4T and F4 Modbus Mapping

For making an easy transition from the F4 to the F4T controller using Modbus, a special set of the most commonly used F4 registers were created. Notice that there are two tables of Modbus registers, they are unique sets of registers (not interchangeable) and the user must select one set or the other when implementing using Modbus.

- Map 1 = F4T registers (default)
- Map 2 = Not applicable to this model. Do not select
- Map 3 = Limited set of F4 compatible registers (for compatibility with software written for the F4)
-

To change the Modbus mapping using the F4T front panel:

1. From any screen, press the **Menu** button
2. Press the **Settings** button and then the **Network** button
3. Select the **Ethernet** (for LAN) or **Modbus** (for RS-232) communications channel
4. Scroll the screen down to find **Data Map** and select **1** (for F4T) or **3** (for legacy F4 Compatibility Mode).
5. Recycle the power to put the new settings into effect.

Common Modbus Registers

The following registers are applicable in the F4T Mode (Data Map 1). These are the most common registers that would need to be used in an automation environment. These registers are different from F4T controllers that do not have Cascade Control. Data Map 2 (legacy F4 compatibility mode) is irrelevant because the advanced capability of the F4T used in this product do not map over to the legacy F4 controller.

Some F4T parameters are contained within 32 bits (IEEE Float). Notice that only one (low order) of the two registers is listed. By default, the low order word contains the two low bytes of the 32-bit parameter. As an example, in the table below see Actual Air Temperature. Note that it lists register 4182. Because this parameter is a float, it is actually represented by registers 4182 (low order bytes) and 4183 (high order bytes).

Parameter Name	Register	Data Type and Access (Read or Write)	
Temperature Set Point	4042	IEEE Float RW	
Closed Loop Set Point*	4190	IEEE Float R	
Target Set Point**	16602	IEEE Float R	
Actual Part Temperature	4180	IEEE Float R	
Actual Air Temperature	4182	IEEE Float R	
Event 1 (Chamber Power)	16594	16-bit RW	Off = 62, On = 63

* Instantaneous Set Point during a ramp or profile

Manual Ramp Parameters (Ramp to Set Point without a profile)

Ramp Action (Temperature)	2794 Off = 62 Startup = 88 Set Point = 85 Both = 13
Ramp Scale (Temperature)	2796 °/Minutes = 57 °/Hours = 39
Ramp Rate (Temperature)	2798

Profile Parameters - All 16-bit R or RW

Parameter Name	**Register**	**Range**
Start Profile	16558 (RW)	1 to 40
Start Step	16560 RW)	1 to max step # in profile
Profile Action Request	16562 (RW)	None = 61 Start = 1782 Calendar Start = 1783
Profile Action Request	16564 (RW)	None = 61 Resume = 147
Profile Action Request	16566 (RW)	None = 61 Pause = 146 Terminate = 148
Profile State	16568 (R)	Off = 62 Running = 149 Pause = 146 Not Started = 251 Completed Normal = 252 Terminated = 253 Calendar Start = 1783
Current Profile	16588 (R)	0 to 40
Current Step	16590 (R)	0 to 50
Step Type	16592 (R)	Soak = 87 Wait For = 1542 Instant Change = 1927 Ramp Time = 1928 Ramp Rate = 81 End = 27

F4 Compatibility Mode (Data Map 3)

The following common registers are available in the F4 Compatibility Mode (Data Map 3). This will allow you to use software that was written for the original F4 Controller. Only a limited set of parameters are available in this compatibility mode, but it should be sufficient for most applications. This register list is only valid for Firmware Revision 03:06:0011, released May 5, 2017 and higher. Older firmware revisions do not have an F4 Compatibility Mode for controllers with Cascade Control.

Parameter Name	Register	Data Type and Access (Read or Write)	
Temperature Set Point	300	16-bit Signed RW	
Air Temperature	100	16-bit Signed R	
Air Temp Input Precision	606	16-bit Signed RW	0 (0), 0.0 (1), 0.00 (2), 0.000 (3)
Part Temperature	108	16-bit Signed RW	
Part Temp Input Precision	626	16-bit Signed RW	0 (0), 0.0 (1), 0.00 (2), 0.000 (3)
°C or °F	901	16-bit Signed RW	°C (1), °F (0)
Air Temp Input Error	101	16-bit R	No Error = 0, Error = 1
Part Temp Input Error	109	16-bit R	No Error = 0, Error = 1
Event 1 (Power)	2000	16-bit RW	Off = 0, On = 1
Profile Action:			
Resume Profile	1209	16-bit R	
Hold Profile	1210	16-bit W	
Terminate Profile	1217	16-bit W	
Profile Start:			
Profile Start File #	4000	16-bit W	
Profile Start Step #	4001	16-bit W	
Profile Action Start:	4002	16-bit W	Create (1) Insert Step (2) Delete Current profile (3) Delete Step (4) Start Profile (5) Delete all Profiles (256)

SCPI Programming Mode

SCPI commands are ASCII text strings with a wide array of defined SCPI commands, all of which are not included in this implementation. The SCPI protocol is only available over Ethernet port 5025. The only available SCPI commands for the F4T are shown below. This complete list is only valid for Firmware Revision 04:03:0108, released Jan 9, 2019 and higher. Firmware revision 03:05:0001 or older than do not have an SCPI commands for controllers with Cascade Control.

Description	SCPI Command	SCPI Values	R/W	Comments
Query Comm. Temperature units	:UNIT:TEMPERATURE?	C|F	R	Ethernet units
Set Comm. Temperature units to F	:UNIT:TEMPERATURE F		W	Ethernet units to Fahrenheit
Set Comm. Temperature units to C	:UNIT:TEMPERATURE C		W	Ethernet units to Celsius
Query Display Temperature units	:UNIT:TEMPERATURE:DISPLAY?	C|F	R	Front panel display units
Set Display Temperature units to F	:UNIT:TEMPERATURE:DISPLAY F		W	Front panel display units to Fahrenheit
Set Display Temperature units to C	:UNIT:TEMPERATURE:DISPLAY C		W	Front panel display units to Celsius
Read Set Point (Cascade)	SOURCE:CASCADE1:SPOINT?	*<floating point value>*	R	User set point
Write Set Point (Cascade)	SOURCE:CASCADE1:SPOINT *<value>*		W	User set point
Read Outer Loop PV (Cascade)	SOURCE:CASCADE1:OUTER:PVALUE?	*<floating point value>*	R	Source Value A
Query Outer Loop Input Error (Cascade)	SOURCE:CASCADE1:OUTER:ERROR?	ERROR|NONE	R	Input error status
Read Inner Loop PV (Cascade)	SOURCE:CASCADE1:INNER:PVALUE?	*<floating point value>*	R	Source Value B
Query Outer Loop Input Error (Cascade)	SOURCE:CASCADE1:INNER:ERROR?	ERROR|NONE	R	Input error status
Read Outer Loop Set Point (Cascade)	SOURCE:CASCADE1:OUTER:SPOINT?	*<floating point value>*	R	
Read Inner Loop Set Point (Cascade)	SOURCE:CASCADE1:INNER:SPOINT?	*<floating point value>*	R	
Set ramping off	SOURCE:CLOOP1:RACTION OFF		W	controls instantly to set point
Set ramping on startup	SOURCE:CLOOP1:RACTION STARTUP		W	ramps to set point on controller power on
Set ramping on set point change	SOURCE:CLOOP1:RACTION SETPOINT		W	ramps to set point on change of set point
Set ramping on both events	SOURCE:CLOOP1:RACTION BOTH		W	ramps to set point on controller power on OR change of set point
Write ramp scale to minutes	SOURCE:CLOOP1:RSCALE MINUTES		W	ramp rate is per minute
Write ramp scale to hours	SOURCE:CLOOP1:RSCALE HOURS		W	ramp rate is per hour
Read ramp rate	SOURCE:CLOOP1:RRATE?	*<floating point value>*	R	rate that controller ramps to set point
(as above - for backward compatibility)	SOURCE:CLOOP1:RTIME?	*<floating point value>*	R	time that controller ramps to set point
Write ramp rate	SOURCE:CLOOP1:RRATE *<value>*		W	rate that controller ramps to set point
(as above - for backward compatibility)	SOURCE:CLOOP1:RTIME *<value>*		W	rate that controller ramps to set point
Set event output on	:OUTPUT#:STATE ON		W	# = outputs 1-7
Set event output off	:OUTPUT#:STATE OFF		W	# = outputs 1-7
Query event output state	:OUTPUT#:STATE?	OFF|ON	R	# = outputs 1-7
Select a profile	:PROGRAM:NUMBER *<value>*	1-40	W	selects the desired profile to control
Read selected profile name	:PROGRAM:NAME?	*<string value>*	R	the selected profile
Select a step	:PROGRAM:STEP *<value>*	1-50	W	the selected profile
start profile	:PROGRAM:SELECTED:STATE START		W	the selected profile
stop profile	:PROGRAM:SELECTED:STATE STOP		W	the selected profile
pause profile	:PROGRAM: SELECTED:STATE PAUSE		W	the selected profile
resume profile	:PROGRAM: SELECTED:STATE RESUME		W	the selected profile
Identification	*IDN?	"Watlow Electric",*<string value>*,*<integer value>*,*<string value>*		
	(manufacturer)		R	
	(model number)			
	(serial number)			
	(firmware level)			

GPIB and Ethernet Modbus Interface Converters (optional)

Serial Modbus-to-GPIB Converter (Options 1052 and 0003)

Your chamber may have been ordered with a GPIB Interface option. GPIB communications is achieved through an ICS Electronics 4899A (external, TestEquity Option 1052) or 4809A (internal, TestEquity Option 0003) GPIB-to-Modbus Interface Converter. The ICS 4899A converts GPIB commands to serial Modbus commands that are transmitted over RS-232. The GPIB Converter also takes care of calculating block checksums that are required for communications to and from the F4T Controller. For more details, see the documentation that came with the GPIB interface option.

NOTE: Composer software will only work with the native F4T Ethernet interface and Data Map 1, not the Serial Modbus-to-GPIB Converter.

Serial Modbus-to-Ethernet Converter (Option 1056)

Your chamber may have been ordered with a Serial Modbus-to-Ethernet Interface option. GPIB communications is achieved through an ICS Electronics 9099 (TestEquity Option 1056). The programming syntax is the same as the GPIB Interface Converter mentioned above. For more details, see the documentation that came with the Ethernet interface option.

Why use the Ethernet Converter when the F4T Controller has an Ethernet Interface?
The native F4T Ethernet Interface uses the Modbus TCP protocol. The 1056 Ethernet Interface Converter converts the controller's RS-232 Modbus interface to Ethernet. The converter takes care of the Modbus packet formatting so the command structure is simplified. The most compelling reason why you would want to use 1056 Ethernet Interface Converter instead of the F4T's native Ethernet interface is if you wanted to program using simple ASCII commands instead of Modbus packets.

NOTES:

Composer software will only work with the native F4T Ethernet interface and Data Map 1, not the TE-1056 Serial Modbus-to-Ethernet Converter.

The F4T's native Ethernet Interface accepts both Modbus and SCPI commands. You do not need the TE-1056 Serial Modbus-to-Ethernet Converter if you want to send SCPI commands directly to the F4T's native Ethernet Interface! F4T native SCPI commands will not work with the TE-1056 Serial Modbus-to-Ethernet Converter.

Programming Syntax for the F4T Controller

The following applies if the F4T serial interface is configured for Data Map 1. This only applies for programming through the GPIB or Ethernet Modbus converters.

The F4T Controller uses two consecutive register to control a value or to read back a process variable. The two registers hold an IEEE-754 32-bit floating point word. The registers are read and written to in the low word-upper word order. The RF? query reads a 32-bit floating point value from two sequential register in low word-upper word order. The RF? does not require the number of registers to read since it is fixed at two registers.

Some registers in the F4T Controller are 16-bit words.

Modbus Register Read / Write Commands

The RF command reads the num value in floating point format to two consecutive registers starting with the low word register. Use this to read 32-bit floating point registers.

RF? reg Read 32-bit floating point register command

The R command reads the numeric value in one register. Use this to read 16-bit registers.

R? reg, 1 Read 16-bit register command

The WF command writes the num value in floating point format to two consecutive registers starting with the low word register.

WF reg, data Write register command
Reg = Modbus register plus next consecutive register
Data = ASCII data written as a direct numerical value

Examples:

Write Temperature Set Point	WF 2782, value	
Read Chamber Temperature	RF? 27586	
Read Closed Loop Set Point	RF? 2810 (instantaneous temperature set point during a ramp or profile)	
Turn (Event 1) ON	W 16594, 63	Event 1 is “Power”
Turn (Event 1) OFF	W 16594, 62	

Manual Ramp Parameters (Ramp to Set Point without a profile)

Ramp Action (Temperature)	W 2794, ## (where ## is one of the four choices below) Off = 62 Startup = 88 Set Point = 85 Both = 13
Ramp Scale (Temp. °/Minutes)	W 2796, 57
Ramp Scale (Temp. °/Hours)	W 2796, 39
Ramp Rate (Temperature)	WF 2798, value (0 to 99,999)

Programming Syntax for the F4T Controller, Data Map 3

The following applies if the F4T serial interface is configured for Data Map 3, F4 Compatibility Mode. **This list only applies for programming through the GPIB or Ethernet Modbus converters.**

Modbus Register Read / Write Commands

R? reg, n	Read register command Reg = Modbus register n = number of registers to send
W reg, data	Write register command Reg = Modbus register Data = ASCII data written as 16-bit decimal value

Examples:

Write Temperature Set Point	W 300, value
Read Chamber Temperature	R? 100, 1
Event 1 ON	W, 2000, 1
Event 1 OFF	W, 2000, 0

Chapter 7 – Frequently Asked Questions

Why does my chamber heat or cool slower than the published specifications?
Performance is significantly affected by the characteristics of your test sample. Factors include size, weight, material, shape, and power dissipation if energized. The test sample should be placed in the chamber in a manner that allows for air circulation. You should not place the test sample directly on the chamber floor. It should be placed on the shelf. Multiple test samples should be distributed throughout the chamber to ensure even airflow and minimize temperature gradients. If necessary, an additional shelf 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 or colder?
Unfortunately, there is nothing 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 colder or 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 permanently damage the chamber and 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. A condensate drain is provided to remove condensate from the chamber.

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 – Control tolerance is a measure of how much the temperature varies over a short term, 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 ±0.08°C, or a total of 0.16°C. The actual temperature where the controller settles might not be arithmetically within the center of the total 0.16°C deviation due to the characteristics of proportional control systems. For example, the temperature set point may be 23.00°C. The actual temperature varies between 22.96°C and 23.12°C. This corresponds to –0.04°C and +0.12°C or a total of 0.16°C of RELATIVE variations. These specifications are for an empty chamber. The addition of a test sample may affect the control variations. In some instances, the test sample will reduce these variations.

Uniformity – Also known as Gradients. This is a measure of variations in temperature at different locations throughout the chamber interior, at the same time, after stabilization. The uniformity specification for this chamber is ±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 affect the temperature uniformity. For example, an energized test sample will produce a higher temperature near the sample.

Controller Accuracy – This is the ability of the temperature controller to accurately display a temperature measurement when compared to a standard. The F4T published accuracy is ±2.0°C. However, the total measurement accuracy in the chamber includes the thermocouple sensor wire accuracy. RTD sensor 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 ±3°C, although the typical accuracy is actually better than ±1.0°C.

Can I operate or transport the chamber on its side?
No, the chamber can only be operated or transported in the upright position. Operating or transporting the chamber on its side may cause permanent damage to the refrigeration system and void the warranty.

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.

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. This system uses refrigerant R-404A.

Chapter 8 – Specifications

Temperature Range –20°C to +130°C

Control Tolerance ±0.08°C, ±0.05°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**	**–10°C**	**–20°C**
(Watts)	200 W	150 W	100 W	35 W

Heat Up Transition Time 5°C/minute (empty chamber, typical)

Cool Down Transition Time (empty chamber, typical)

		End Temp				
Start Temp to →	**+23°C**	**0°C**	**–5°C**	**–10°C**	**–15°C**	**–20°C**
+23°C	-----	6 min	8 min	11 min	15 min	Ultimate
+85°C	13 min	19 min	21 min	25 min	30 min	Ultimate

***Note:** Transition times are measured after a 30 minute 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 –15°C = 100°C / 30 min = 3.33°C/min.

Input Voltage 90 to 132VAC / 6A or 180 to 264VAC / 3 A, 50/60 Hz
(rear panel switch for voltage range)

Heat of Rejection 3815 BTUH (During maximum cooling rate from high temperature soak.)
1219 BTUH (Holding low temperatures with non-energized test sample.)

Workspace Dimensions 12" W x 8" H x 10" D (0.55 cubic feet, 15.73 liters)

Outside Dimensions 16.38" W x 21.88" H x 22.72" D (nominal)

Min. Installed Clearance 12" from the rear

Cable Slot 3" x 1.75" on left and right side (two total). Supplied with silicone foam plugs.

Weight 88 pounds

Sound Level 59 dBA in cooling mode
(A-weighted, measured 36" from the front surface, 63" from the floor, in a free-standing environment)

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 will result in decreased cooling performance. Low end limit derates to -38°C when operating above 27°C (80°F) ambient. Operation above 30°C (85°F) or below 16°C (60°F) ambient is not recommended.

Chapter 9 – Maintenance

Preventive Maintenance Schedule

Daily or As Needed

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

Every 6 Months

- Inspect the door seal.
- Clean the condenser.
- Inspect the electrical/refrigeration compartment.
- Verify the chamber performance.

Every 12 Months

- Verify the calibration.

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. NEVER use steel wool.
- If you clean the interior with something other than water, you may want to operate the chamber at high temperature (approximately +85°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 noise (with compressor off).
- Compressor start-up and running noise.
- Condenser fan noise.
    - Valve cycling noise.

How to inspect the door seal

The door and chamber opening have 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. Repeat this all around the door at several places.
- If the seal is not tight on the latch side, adjust the latch bracket. The latch bracket is mounted to the chamber, and has slotted holes to permit adjustment.
- If the seal is not tight on the hinge side, adjust the door hinge. The hinges have a slotted hole on the door side to permit adjustment.

How to clean the condenser

1. Unplug the chamber from the power source.
2. Remove the condenser grille from the front of the chamber.
3. Clean the condenser 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 inspect the electrical/refrigeration compartment

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

1. Unplug the power cord.
2. Remove the top cover.
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. Check for loose wires and burned insulation near terminals.
7. Inspect for signs of insect or rodent infestation. Yes, it does happen!

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 (+100°C would be fine), and the low limit set to –27°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. Plug the chamber into an AC outlet which matches the position of the 115V/230V input selector switch. Turn the POWER Switch ON.
3. Set the Temperature Controller Set Point to +85.00°C. Press the Air Control button to turn it ON. Press the Power button to turn it ON.
4. The chamber should heat up to about +80°C and begin controlling (orange PWR bar should show less than 100%) within approximately 14 minutes.
5. The chamber temperature should slowly increase and stabilize to +85°C. It should not overshoot beyond +86°C.
6. Let the chamber stabilize at +85°C for 30 minutes.
7. After stabilization, the chamber air temperature should vary no more than ±0.08°C, or a total of 0.16°C.
8. After 30 minutes at +85°C, set the Temperature Controller Set Point to +23.00°C.
9. The compressor should turn ON. The chamber should cool down to about +27.5°C and begin controlling (blue PWR bar should show less than 100%) within approximately 8 minutes. You should also begin to hear the compressor speed slowing down.
10. The chamber temperature should slowly decrease and stabilize to +23°C. It should not undershoot beyond +22°C.
11. After stabilization at +23°C for 15 minutes, the chamber air temperature should vary no more than ±0.08°C, or a total of 0.16°C.
12. Set the Temperature Controller Set Point to –20.00°C.
13. The chamber air temperature should pass –15°C within approximately 14 minutes.
14. The chamber should begin controlling (blue PWR bar should show less than 100%) at approximately –16°C.
15. The chamber should continue to cool down to –20.00°C within approximately 22 minutes. It may continue to undershoot to –21.7°C before beginning to stabilize at –20.00°C.
16. After stabilization at –20°C for 15 minutes, the chamber air temperature should vary no more than ±0.08°C, or a total of 0.16 °C. The compressor will remain running at full speed.
17. Set the Temperature Controller Set Point to +23°C. The chamber should begin to heat up. The compressor should turn off in 2 minutes.
18. Let the chamber heat up to +23°C before turning the Power button OFF.
19. This concludes the chamber performance verification tests.

How to verify the calibration

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

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

Variations in temperature throughout the chamber interior are NOT a measurement of controller accuracy. These variations, called “gradients”, are a function of the physical design of the chamber and its airflow, the characteristics of the test sample, and how it is oriented in the chamber. You cannot “calibrate” to improve gradients. The common practice of measuring multiple points in the chamber and adjusting the temperature controller’s calibration to correct for these errors is incorrect! The correct way to adjust what the temperature controller “displays” compared to what is measured at some point other than the controller’s sensor, is with the “Calibration Offset” parameter.

The 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 adjustment of the F4T Temperature Controller is necessary, refer to the information on the next page.

F4T Controller Calibration

⚠ **CAUTION:** Calibrating the F4T Controller requires the electrical compartment to be exposed. Live and potentially lethal voltages will be present. Use extreme caution to prevent injury and death.

⚠ **CAUTION:** The Power button on the F4T Controller must be OFF (no green check mark) when performing the calibration procedure to prevent a thermal runaway condition.

Equipment Required

- Precision Resistance Source, 50.00 Ω and 350.0 Ω for Air Sensor and Part Sensor.
- Precision Voltage Source, 0.000 mV and 50.000 mV for Alarm Sensor.

Input Setup and Calibration

Make sure the Power button on the F4T Controller is OFF (no green check mark) before performing the following. Disconnect the chamber from the power source and remove the top cover. See F4T diagram on the next page for the terminal locations.

For Air Sensor Calibration

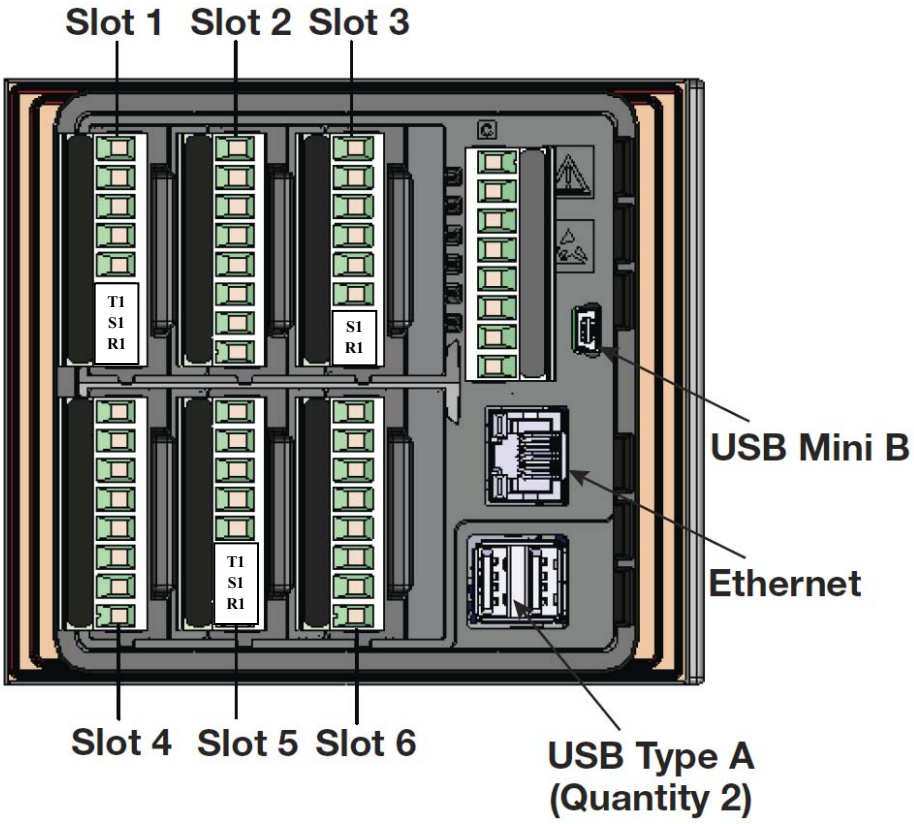
- Remove the wires from terminals R1, T1 and S1 on F4T Module 1
- Connect the Precision Resistance source as follows:
  One lead to R1 on Module 1
  Other lead to T1 and S1 on Module 1
- Reconnect the chamber to the power source and turn the Power switch on the front panel ON. The Power button on the F4T must remain OFF.
- To enter the Calibration menu, press the Menu button, then the Service button, then the Calibration button, then the Air Sensor Action button. Next, press Perform Field Calibration and follow the on-screen prompts.

For Part Sensor Calibration

- Remove the wires from terminals R1, T1 and S1 on F4T Module 5
- Connect the Precision Resistance source as follows:
  One lead to R1 on Module 5
  Other lead to T1 and S1 on Module 5
- Reconnect the chamber to the power source and turn the Power switch on the front panel ON. The Power button on the F4T must remain OFF.
- To enter the Calibration menu, press the Menu button, then the Service button, then the Calibration button, then the Part Sensor Action button. Next, press Perform Field Calibration and follow the on-screen prompts.

For Alarm Sensor Calibration

- Remove the wires from terminals R1 and S1 on F4T Module 3
- Connect the Precision Voltage source as follows:
  Positive (+) lead to R1 on Module 3
  Negative (–) lead to S1 on Module 3
- Reconnect the chamber to the power source and turn the Power switch on the front panel ON. The Power button on the F4T must remain OFF.
- To enter the Calibration menu, press the Menu button, then the Service button, then the Calibration button, then the Alarm Sensor Action button. Next, press Perform Field Calibration and follow the on-screen prompts.



Theory of Operation

Overview

The chamber is heated by a nichrome heater. Cooling is accomplished by a single-stage refrigeration system. The air is circulated by a propeller fan. The heater, evaporator, and fan are located within an air plenum, which is on the back wall of the chamber interior. The heater, compressor, and condenser fan motors are powered by a 48VDC power supply. This enables the chamber to operate at 115VAC or 230VAC, 50/60Hz, by changing the position of a voltage selection switch on the rear panel. This voltage selection switch enables a 230V/115V step-down transformer to provide 115V for the solenoid valve and conditioner fan.

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

Heating and Safety Systems

The temperature controller provides a time-proportioned output to a solid state relay (SSR1). This turns the heater ON/OFF as required to maintain the temperature set point.

A fusible heat limiter (HL) provides failsafe protection against a catastrophic failure by turning off the DC power supply at +192°C. The temperature controller has an independent thermocouple to sense the chamber air temperature and provide high/low temperature shutdown though its limit alarm function.

Refrigeration System

Cooling is accomplished by a single-stage refrigeration system. The refrigeration system provides cooling to the chamber interior through a finned evaporator coil, which is located in the air plenum.

The system uses refrigerant R-404A. High pressure liquid refrigerant is fed from the condenser through the filter-drier, then solenoid valve, to the capillary tube. The capillary tube feeds the finned evaporator coil, which is located in the air plenum where heat is absorbed to provide cooling within the chamber. 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 accumulator 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 exits the compressor discharge and into the condenser. As the high pressure vapor passes through the condenser, it is cooled by fans which blow ambient air across the finned condenser surface. The vapor condenses into a liquid and the cycle is repeated.

The temperature controller's cool output cycles the liquid-line solenoid valve (SV1) ON/OFF over a fixed time-base in proportion to the % cool throttle to control the chamber temperature. When SV1 is ON, liquid refrigerant flows through the capillary tubes to the evaporator, providing full-capacity cooling. When SV1 is OFF, liquid refrigerant flow is stopped, causing cooling to stop while the compressor remains ON. In this mode, the hot gas regulator (HGR1) keeps the suction pressure above 10 PSIG. The temperature controller also varies the compressor speed linearly in proportion to the % cool throttle, providing substantial savings in energy consumption (patent pending control algorithm). At temperatures below –16°C, the compressor speed will remain at 100% while the % cool throttle continues to cycle SV1.

During a high temperature cool-down or when SV1 is cycled OFF, it is possible for excessive hot gas to return to the compressor. The suction line cooling thermostatic expansion valve (TEV1) senses the suction line temperature and injects liquid refrigerant to cool the hot gas within safe limits.

This above described refrigeration system is patented by TestEquity under U.S. Patent Number 10,126,032.

Troubleshooting

SYMPTOM	CONDITION	POSSIBLE CAUSES
Chamber does not function.	If POWER switch is ON.	a) F4T Power button needs to be turned ON.
	If POWER and F4T Power button is ON, no alarm messages on the F4T.	a) Heat Limiter HL is open.
Does not heat up at all.	F4T heat PWR bar is 100%, circulator fan is ON.	a) Heater HT1 is open. b) Solid State Relay SSR1 is defective. c) DC Power Supply PS1 defective.
Heats up too slow.	If F4T Heat PWR bar is 100%.	a) Chamber interior is overloaded.
Heat is on all the time.	If F4 F4T Heat PWR bar is 0%.	a) Solid State Relay SSR1 is defective. b) Temperature controller's heat output is defective.
Does not cool at all.	Compressor is running.	a) Refrigerant leak. b) Plugged capillary tube.
	Compressor is not running. F4T Cool & Compressor outputs are ON.	a) DC Power Supply PS1 defective. b) Compressor is defective.
Cools too slowly or does not cool down to –20°C.	Compressor is running.	a) Chamber interior is overloaded. b) Test sample is energized, giving off heat. c) Port plug is not in port. d) Refrigerant leak. e) Capillary tube is plugged.
Temperature varies more than ±0.08°C or ±0.16°C total.	If tuning PID control parameters in temperature controller were changed.	a) Re-enter values as shipped from TestEquity.
	If tuning PID control parameters in temperature controller are as shipped from TestEquity.	a) If using part temperature control, the part sensor must be attached to your DUT or a dummy load. Try using Air Control. b) Control parameters may need to be changed for your unique test conditions.
	If tuning PID control parameters in temperature controller are as shipped from TestEquity and only occurs in cool mode.	a) Control parameters may need to be changed for your unique test conditions. b) Solenoid valve SV1 may be defective.
Compressor turns on and off too frequently.	If controller Compressor Output parameters were changed.	a) Re-enter values as shipped from TestEquity.
	If controller Compressor Output parameters are as shipped from TestEquity.	a) Control parameters may need to be changed for your unique test conditions.

Refrigeration System Charging Instructions

⚠ **WARNING:** Repair of the refrigeration system must be performed only by a properly trained mechanic. 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 Charge

The proper charging procedure is as follows:

1. Repair any leaks before recharging. Replace the filter/drier.
2. Evacuate the system to 100 microns. DO NOT GUESS! You must use a micron gauge.
3. Use a charging scale to measure in 5.7 ounces of R-404A. DO NOT GUESS! You must use an accurate charging scale.
4. Verify the cooling performance as outlined in “How to verify the chamber performance”.

Replacement Parts

Replacement parts are available from TestEquity. Parts are usually in-stock and ready for immediate shipment. Next-day delivery is always available.

Major Electrical Parts

Description	Mfr	Mfr Part No.	Ref #	Part #	Qty	UOM
Heater, Air	CUSTOM	200305	AH1	200305	1	ea
Arc Suppressor	ITW Paktron	104MACQRL150	AS1	200296	1	ea
Relay, SPST	Hartland Controls	HCRY51XTAB 120 VAC	CR1	222429	1	ea
Fuse, 8A	Littlefuse	576-0312008.MXP	F1	222427	1	ea
Fuse, 3/10A	Bussman	MDL-3/10	F2	200130	1	ea
Circulator Motor Kit	CUSTOM	222424	FM1	222424	1	ea
Condenser Fan	EMB Pabst	3218 NH	FM1-3	222345	3	ea
Heat Limiter Assembly	CUSTOM	222465	HL	222465	1	ea
Motor Control	CUSTOM	Included w/180437 Compressor	MC1	n/a	1	ea
DC Power Supply	Mean Well	SP-750-48	PS1	222422	1	ea
SSR, DC In, DC Out	Omron	G3NA-D210B-DC5-24	SSR1	222425	1	ea
RTD, Chamber Air Sensor	CUSTOM	222306	RTD1	222306	1	ea
RTD, Part Sensor	CUSTOM	222436	RTD2	222436	1	ea
SSR, DC In, AC Out	Omron	G3NE-220T-US DC5	SSR2	222426	1	ea
Switch, Rocker, DPDT	Carlingswitch	691-RGSCC901-R-B-B-E	SW1	222430	1	ea
Slide Switch, 230/115V	C&K	V80212SS05Q	SW2	222248	1	ea
F4T Temperature Controller	Watlow	F4T1L2EAA2G7049	TCR1	222512	1	ea
Autotransformer	Triad	N-6U	TR1	222423	1	ea

Major Refrigeration Parts

Description	Mfr	Mfr Part No.	Ref #	Part #	Qty	UOM
Capillary Tube, 0.031 x 80” (x2)	JB	TC-31	5 (2 required)	100320	80	inches
Compressor	CUSTOM	180437	1	180437	1	ea
Condenser	CUSTOM	180436	6	180436	1	ea
Evaporator Coil	CUSTOM	180435	7	180435	1	ea
Expansion Valve, Suction Cooling	Danfoss	068U2027	8 (TEV1)	100314	1	ea
Filter Drier	Danfoss	023Z5048	2	100524	1	ea
Hot Gas Regulator	Sporlan	ADRI-1/4-0/55	12 (HGR1)	100497	1	ea
Solenoid Valve	Sporlan	E3S120, 1/4 x 1/4 ODM	13 (SV1)	100310	1	ea
Solenoid Valve Coil	Sporlan	MKC-1-120/50-60	14 (SV1)	100011	1	ea

General Parts

Description	Mfr	Mfr Part No.	Ref #	Part #	Qty	UOM
Door Latch	Southco	A7-10-301-20		300216	1	ea
Port Plug, Silicone Foam, 3x1.75”	CUSTOM	383652		383652	1	ea
Shelf	CUSTOM	383662		383662	1	Ea

Chapter 10 – 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.

TestEquity must initiate field service for in-warranty claims. Purchaser will not be reimbursed for labor if they initiate service on their own without prior approval from TestEquity. Replacement parts must be supplied by TestEquity for in-warranty claims. Purchaser will not be reimbursed for parts they buy on their own without prior approval from TestEquity.

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, and 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 11 – Drawings

Electrical Subpanel Component Location