Section A

Chambers

1.0 Model 518 CONTROLLED ENVIRONMENT CHAMBER

Many applications require a controlled environment for testing, fabricating and/or storage. The Model 518 Microprocessor Controlled Environmental Chamber is a completely integrated system, fabricated from 0.375" clear and white acrylic that provides the user with undistorted visibility of the inside of the controlled environment section. It includes glove ports, equipment and sample access doors, circulating fan(s), lighting and accessory power outlets. The Chamber is capable of precisely controlling temperatures from 32-122°F (0-55°C) and humidity from 5-98% RH. (**NOTE:** The entire humidity range cannot be obtained at all temperatures).

The complete Model 518 measures 54"Wx22.5"Dx22"H (137x57x56 cm).

1.1 Chambers Controllers & Operating Systems

The controllers and some of the operating systems are housed in a separate compartment on the right side of the Chamber as shown in Figure 1.0-1.

Figure 1.0-1 Model 518 Controlled Environment Chamber

The systems are totally accessible by removal of the acrylic panel on the right side of the Chamber. Controllers and operating systems that are available with the Model 518 are as follows:

1. Microprocessor Temperature Controller - includes Model 554 RTD Temperature Sensor (Std.)

2. Integrated 500 Watt Heater (Std.)

3. Model 563 Liquid CO_2 Cooling System (Std.)

4. Microprocessor Humidity Controller - includes Model 554 Temperature Compensated RH Sensor (Std.)

5. Model 562 Ultrasonic Humidification System (Std.)

6. Choice of Dehumidification Systems:

    a. Model 561 Desiccant/Pump Dehumidification System – 1.0 lb. of Desiccant (Std.)

    b. Model 578 Self-Regenerating Dehumidification System (requires external air compressor or house air at 50-100 psi) (optional)

    c. Model 565 Dry Gas Dehumidification System (optional)

7. CALCOMMS Computer Software/Interface Package. Allows remote monitoring, charting and reprogramming of the Microprocessor Controllers from a PC. (Optional)

1.1.1 Front Panel Description

The front panel of the Model 518 Chamber is shown in Figure 1.0-3.

Figure 1.0-3 Model 518 Chamber Front Panel

1.1.1.1 Microprocessor Controllers

The Temperature Microprocessor Controller is the unit on the left. The Humidity Microprocessor Controller is the unit on the right. Refer to Sections 5.0 and 3.0 respectively for a full explanation of all functions and features.

1.1.1.2 Front Panel Switches

1. **'POWER' -** The Main Power Switch is the black rocker switch located directly below the Temperature Controller, to the left of the Fan Power Knob. This switch disconnects all power going to the Chamber and external operating systems. "I" is "ON", "O" is "OFF"

2. **'FAN' -** The Fan Power Knob is located to the right of the Power Switch. In the ETS Model 518 Environmental Control Chamber, this switch turns the circulation fans inside the cabinet workspace on and off.

3. **'STANDBY'**

   'TEMP' - Allows the user to manually disable the Temperature Control System. Placing this switch in the 'Off' ('0') position manually disconnects the AC Power from all of the Temperature Control Relays. The Microprocessor will still display the Temperature, the set point may still be adjusted, the internal LED's will still illuminate and the low voltage control signal will still be sent to the solid state Control Relays. The Relay 'Output' will 'close' but AC Power will no longer be connected to the Relay, therefore, the Temperature systems will not receive AC Power and will not operate.

   'RH' - Allows the user to manually disable the Humidity Control System. Placing this switch in the 'Off' ('0') position manually disconnects the AC Power from all of the Humidity Control Relays. The Microprocessor will still display the Relative Humidity, the set point may still be adjusted, the internal LED's will still illuminate and the low voltage control signal will still be sent to the solid state Control Relays. The Relay 'Output' will 'close' but AC Power will no longer be connected to the Relay, therefore, the Humidity systems will not receive AC Power and will not operate.

   'LIGHT' - The Light Switch is located to the right of the Standby Switches. In the ETS Model 518 Environmental Control Chamber, this switch controls the overhead light installed in the Chamber workspace.

1.1.1.3 Sensors & PC Boards

The Sensor Input, Control Relays and Switches are contained on a pair of PC Boards located on the rear of the Front Panel. The PC Boards are mounted on standoffs and stacked on top of one another. In addition, there is a small PC Board located between the microprocessor

controllers used for interfacing the Model 554 Sensor with the microprocessor sensor inputs.

1. **Switches -** The switches are permanently mounted to the 'front' PC Board, referred to as the **'Switch PC Board'**.

2. **Relays -** The relays are removable and mounted in sockets (and secured with plastic cable ties) on the 'rear' PC Board, referred to as the **'Relay PC Board'**.

3. **Sensor Input -** The Sensor Input is the 5-pin DIN jack located in the lower left corner of the **'Switch PC Board'**. The ETS Model 554 Sensor contains both a RTD Temperature Sensor and a Temperature Compensated Relative Humidity Sensor. Both input signals interface with the system through this jack.

   The ETS Model 554 RH Sensor is plugged into this jack. The Model 554 Sensor Head (Sensing Elements) should be in the 532 Chamber Environment. The sensor is held in place on the divider wall with a ¾NPT plastic liquid-tight fitting.

   The input is configured at the factory to accept the signal from the ETS Model 554 Humidity/Temperature Sensor. The Model 554 signals are both 0-1VDC, equaling 0-100% RH and 0-100 °C (32-212°F), respectively.

4. **Sensor Interface PC Board –** The Sensor Interface PC Board is a dual channel device used to convert the 0-1VDC outputs from the Temperature and RH sensors into 0-50mVDC signals for input to their respective microprocessor controllers. Each channel includes a ZERO adjustment potentiometer and a SPAN adjustment potentiometer. This PC Board should be calibrated every time the Model 554 Sensor(s) is recalibrated.

   To calibrate the Sensor Interface Board:

   <u>Equipment Required:</u>

   1. 0-1 VDC signal source.

   2. Digital Volt Meter

Calibration Procedure:

1. Attach the 0-1 VDC signal source to the Senor Input Jack on the 'Switch PC Board', pins 1&4. Pin 1 = Humidity, Pin 4 = Temperature, Pin 2 = Ground.

2. Set the signal source to 0.000 VDC (ground).

3. Using the Meter, measure at the sensor inputs on each of the microprocessor controllers, positions 1 (+) and 2(-).

4. Measuring at the RH Microprocessor, adjust R3 for a reading of 0.000mVDC.

5. Measuring at the Temperature Microprocessor, adjust R1 for a reading of 0.000mVDC.

6. Set the signal source to 1.000 VDC.

7. Measuring at the RH Microprocessor, adjust R4 for a reading of 50.000mVDC.

8. Measuring at the Temperature Microprocessor, adjust R2 for a reading of 50.000 mVDC.

9. Check the actual RH Microprocessor display to verify it shows 0-100% RH for and input of 0-1VDC at the sensor jack (pin1). Adjust R3 & R4 if necessary.

10. Check the actual Temperature microprocessor display to verify it shows 0-100°C (32-212°F) for an input of 0-1VDC at the sensor jack (pin4). Adjust R1 & R2 if necessary.

1.1.2 Side Interface Panel Description

All user connections to the Chamber are made through the Side Interface Panel shown in Figure 1.0-2. Power connections, Operating Systems connections and the Computer interface are all on this panel. The Side Interface Panel is a modular layout that is configured to meet the specifications of the Operating Systems ordered with the Model 518. Tube fittings may be added/removed and power outlets may be added/removed. The following sections will describe the main features of the Side Interface Panel in the standard Model 518 configuration. For other configurations, specific installation instructions will be included.

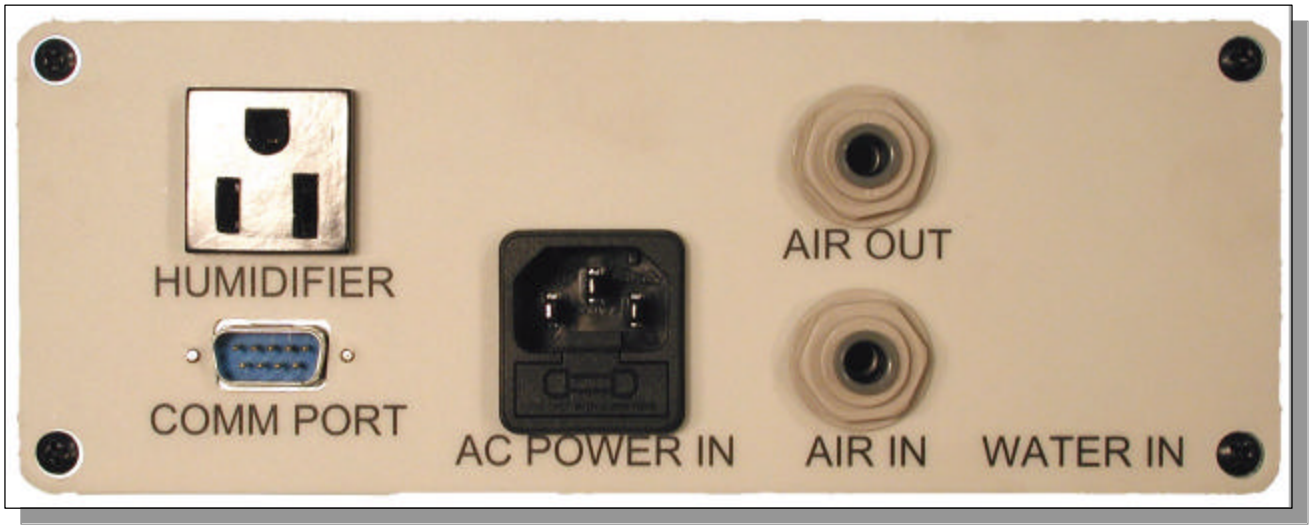

Figure 1.0-2 Model 518 Side Interface Panel

1.1.2.1 AC Power Cord Input (Mains)

Labeled **POWER**, this Universal IEC power connector is located on the bottom, center of the panel. **The Voltage supplied (Mains) must match the Chamber voltage**. All Chambers are 115 VAC / 60 Hz, unless otherwise specified.

1.1.2.2 COMM PORT (RS 485 & Analog Voltage Outputs)

The Comm Port is the 9-pin subminiature-D jack (sub-D) located to the left of the AC Power Input. This connector is used for both the analog sensor output signals and the RS485 communications output (optional) from the microprocessor controllers. The Comm Port is common to both the Temperature and Humidity Microprocessor Controller**. (See Sections 3.4 & 5.4 CALCOMMS Computer Interface)**

1. **RS 485 Computer Interface (Optional)**

   The standard Model 518 does not include the RS 485 Comm option. RS 485 Communication PC Boards must be ordered separately. They can either be installed when the Chamber is ordered or can be retrofitted in the field by the user.

The RS 485 portion of the Comm Port will only be active if the Controller is fitted with the COMMS option (see section 1.2.1 LEVL C). The COMMS option allows the microprocessor to communicate with a PC running the CALCOMMS software.

RS 485 Wiring Connections

Tx/Rx+ = Pin 7
Tx/Rx- = Pin 2
Ground = Pin 4

If runnng the CALCOMM computer program, see the "CALCOMM" section of this manual for set-up instructions.

2. **Analog Voltage Output**

The Analog Voltage Output is always active. Temperatures of 0-100°C (32-212°F) correspond to an output of 0-1VDC. Relative Humidity of 0-100% RH also corresponds to an output of 0-1VDC. The analog outputs are a direct voltage reading from the sensors.

This connector is configured as an Analog Voltage (0-1VDC) Output for monitoring the temperature and/or humidity levels using a chart recorder or other analog input recording device. Minimum acceptable input impedance for the analog recording device is 20k Ohms. An input impedance lower than 20k Ohms will load down the output signal and will affect the measurement and control accuracy of the entire system. An A/D converter can be used to convert the signal for use with a data logger or computer.

Analog Voltage Output Wiring Connections

Temperature Positive (+) = Pin 9
RH Positive (+) = Pin 1
Common (Temp & RH) Ground (-) = Pin 4

1.1.2.3 DEHUMIDIFY IN/OUT

The Model 561 Desiccant/Pump Dehumidification System uses a pair of quick disconnect fittings. The pump is mounted inside the Chamber control cavity and the desiccant column is placed external to the chamber in a location determined by the user. These two fittings (Air In and Air Out) connect the column into the dehumidify loop. **(See Section 2.2.1 Model 561 Dehumidification System)**

1.1.2.4 COOL INPUT

When using the standard Model 563 Liquid CO_2 Cooling System, a brass quick disconnect fitting is located in the top, right corner of the acrylic Side Panel. This fitting protrudes through the acrylic panel for connection to the liquid CO_2 gas tank (user supplied). **(See Section 4.2.1 Model 563 Cooling System)**

1.2 Controlled Environment Description

The controlled environment section of the Model 518 Chamber is 13 ft^3. (0.32 m^3) and measures 39”Wx22.5”Dx22”H (99x57x56 cm). Mounted against the rear wall is an aluminum “screen” that protrudes 4” into the chamber. It contains the heater, thermal safety switch, variable speed 110 cfm fan(s) that are controlled by an ON/OFF switch located on the front panel to the left of the ‘STANDBY’ switches. Also included is a duplex accessory power outlet (North American Std) with a weather-tight cover. Mounted to the top of the unit is a weather-tight 18-Watt florescent light (controlled by an ON/OFF switch located on the front panel to the right of the ‘STANDBY’ switches).

The wall separating the controlled environment from the electronics compartment is 0.25” acrylic and contains the humidity and temperature sensor, dry air in/out ports plus the gas cooling fitting, if so equipped. Located on the upper middle portion of the wall is the humidifier output.

The left side of the Chamber contains a 12"W x 4"H opening with a hinged access door secured by three (3), ¾turn latches. Towards the rear is a 1.25" ID access hole for feeding cables and tubing to instrumentation placed inside. This hole should be sealed using the soft putty compound provided.

The front of the Chamber consists of a large door containing a pair of 8” (20cm) dia. ports to accept gloves or iris ports. The standard Model 518 is equipped with neoprene rubber accordion sleeves with removable #10 size gloves (other sizes and types of gloves are available). Silicon rubber iris ports or no ports at all are available as options. The access opening is 32"W x 14"H which enables large objects to be placed inside. To the right of the front door is the humidity and temperature control module. This module is easily removed for servicing by loosening the four (4) captive mounting screws.

Section B:

Humidity

2.0 HUMIDITY OPERATING SYSTEMS

2.1 Humidification System

The Model 518 Chamber includes an ETS Model 562 Ultrasonic Humidification System. The humidifier is a separate unit that sits adjacent to the right side of the Chamber. The humidifier is connected to the chamber by attaching the 1" I.D. clear tubing provided, to the input barb located on the upper right corner of the Side Access Panel (left of the cooling valve input).

Read the Model 562 Set-up instructions before using the Humidifier!!

The Model 562 Ultrasonic Humidifier produces a fine water mist through ultrasonic action. The mist is forced from the humidifier into the chamber by a small, quiet fan. The fan draws in ambient air. This is not a closed-loop system.

2.1.1 Set-up

1. Fill the water tank. **USE Distilled or Deionized water ONLY!!**

   Remove the water tank from the humidifier unit and inspect it for small cracks or any other damage that may have occurred during shipping (a small crack will allow air to enter the tank, which can cause the water to overflow the basin and possibly damage the unit). After inspection, fill the tank ¾ full with distilled or deionized water ONLY (user provided).

   NOTE

   Using tap water will destroy the ultrasonic transducer and the associated electronics. Tap water will also cause a white dust to form on all surfaces (including the humidity sensor, which will also be destroyed).

2. Replace the tank on the humidifier unit.

   The water will automatically drain from the tank into the basin and stop when the basin is full. If the tank is not installed properly, or the humidifier is not on a level surface, water may continue to flow after the basin is full. If this occurs,

remove the top immediately, check for problems and try again. If the problem persists, contact ETS.

3. Turn on the humidifier POWER switch.

   If used with an ETS Automatic Humidity Controller, see “Humidifying” in the Controller manual. The power indicator light will turn on immediately and the internal blower will begin to operate. When the basin is full, the automatic water level switch will activate and provide power to the ultrasonic transducer. When this happens, the unit will start producing a fine mist.

4. Rotate the MIST INTENSITY control.

   This control determines how fast the water is converted from a liquid to a mist. For most applications, set the control at mid-point. Rotating the knob clockwise will produce a denser mist, rotating the knob counter-clockwise will produce a finer mist. When operating at high temperatures or in large enclosures, set the knob at maximum for best results.

2.1.2 Operation

If the system is set up properly, the user does not have to do anything else. Total operation will be under the control of the Model 518 Microprocessor Humidity Controller. Refer to **Section 3.2 Microprocessor Humidity Controller Operation.**

Continue only after reading the Model 562 section of this manual and completing the preliminary set-up.

1. Remove the green Caplug covering the Chamber Vent.

   The vent inside the chamber is the 1” hose barb on the right wall (the green plug will be found here). The vent passes through to the outside right wall to the 1” barb on the outside wall. It should remain open.

2. Set the Model 518 humidity controller set point to a value above the ambient humidity (Refer to **Section 3.2.1 Microprocessor Humidity Controller Operation**).

3. Turn on the “RH” STANDBY switch on the front panel of the Model 518.

   This will not automatically turn on the humidifier. Turning on the “RH” STANDBY switch only makes the humidifier *available* to the microprocessor controller.

When the microprocessor tells the humidifier to activate, the small green LED in the upper, left corner of the microprocessor display will light. The humidifier will begin producing a mist and forcing it into the chamber through the humidity input barb.

4. The microprocessor will determine the amount of humidification needed to maintain the desired set-point.

   If less than the full capacity of the humidifier is needed, the controller will provide pulses of power to the unit to limit the output. The humidifier will be turned on and off cyclically to obtain an average humidity output that is lower than the full capacity of the Humidifier.

NOTE

To obtain a smooth, even humidity output the Model 518 Cycle Time (CYC.t) should be set to 1.0 second. Longer cycle times will create longer "gaps" between humidification pulses. **DO NOT SET THE CYCLE TIME LESS THAN 1.0 SECOND.** Shorter pulses may damage the Model 562.

2.1.2.1 Operating Precautions

The Model 562 should operate reliably if the following precautions are observed:

1. Always run the humidifier directly to the chamber.

Never attempt to combine the humidifier output with another air or gas source.

2. Always provide a vent on the chamber being humidified.

3. Clean the ultrasonic transducer frequently and thoroughly.

Any dirt or particle build-up on the transducer will stress the electronics. Once the electronics overheats and stops working, the humidifier must be replaced. With frequent cleaning, the electronics should operate reliably for many years.

4. Use distilled or deionized water only.

2.1.2.2 Maintenance & Cleaning

1. Always unplug the humidifier from the Model 518 Chamber before cleaning.

2. Empty all the water from the unit. Siphon water out or soak it up with a sponge.

3. Disconnect (or remove) the water tank.

4. **Clean the surface of the transducer using distilled vinegar and a soft, clean cloth.**

   This is very important. If the transducer is not kept clean, it will fail. Using distilled or deionized water keeps the build-up to a minimum, but cleaning with distilled vinegar cannot be ignored.

NOTE

Do not use any tools with metal parts or sharp edges to clean the transducer. Scratching the transducer may cause fatal damage to the unit.

5. To clean thick or heavy deposits, pour a small amount of vinegar into the humidifier until the transducer surface is completely covered. Let it stand for 30-60 minutes. Wipe clean with a soft cloth. If further cleaning is needed, a soft, plastic bristle brush may be used to gently clean the transducer surface.

6. Never leave water in the humidifier or water tank when the humidifier is not in service.

   Always empty all water and thoroughly dry all parts of the humidifier when it is to be stored or taken out of service for any period longer than one week. Do not seal the water tank in storage. Leave the top off to allow the air to completely dry the tank. Any residual moisture will encourage bacterial growth.

   Never clean any parts of the humidifier with water above 120°F.

2.2 Dehumidification System

The Model 518 Chamber includes an ETS Model 561 Desiccant-Pump Dehumidification System as standard. As an option, the Model 578 Self-Regenerating Dehumidification System and the Model 565 Dry Gas Dehumidification System are available. Operation of each system is described below.

2.2.1 Desiccant/Pump Dehumidification System

The Model 561 Dehumidification System is a closed loop system, designed to reduce the relative humidity in the Model 518 Chamber to less than 10% RH. When paired with the Model 518 Microprocessor Humidity Controller, the humidity inside the chamber can be controlled to within +/- 0.2% RH of the set-point at the sensor.

2.2.1.1 Description

The Model 561 Dehumidification System includes a small air pump (located inside the Chamber control cavity), 1.0 lb. of indicating calcium sulfate ($CASO_4$) in a clear plastic column (located outside the chamber), and 5/16" I.D. tubing to interface the drying column with the pump. The tubing connects to the chamber through the quick-connect fittings on the right side of the Chamber. The desiccant column may be placed on top of, or next to, the Chamber.

The air pump is internally connected to the humidity controller. All the user needs to do is connect the desiccant column into the system using the provided 5/16" ID Tubing.

The desiccant removes moisture from the air. This dried air is then forced back into the chamber working space. The desiccant contains an indicator that turns the normally blue colored desiccant pink as it absorbs moisture. When the cylinder is mostly pink, the desiccant should be renewed or replaced.

A 2.5 lb. desiccant column is available as an option or multiple 1 lb columns can be connected in series. This will extend the time between desiccant changes, but will reduce the air flow, thereby increasing the drying time.

2.2.1.2 Unit Specifications

1. Average air flow rate is 0.67 cfm (19 lpm).

2. Air is dried to a dewpoint of -100°F.

3. Capacity for water vapor is up to 100 grams.

4. Power – 115 VAC/60 Hz, 1.1 Amps
   230 VAC/50 Hz, 0.6 Amps

5. Desiccant Column is safe for working pressures up to 90 psig.

6. Contents: 1 lb. of #8 mesh $CASO_4$ Indicating Desiccant.

7. All connections are made using 5/16" ID tubing. ¼" ID x 5/16" OD hose barb adapters are included to adapt from the ¼" OD fittings on the 'Side Interface Panel' to the desiccant column.

8. Plastic cap is fitted with "O-Ring" gasket.

9. Desiccator coil spring is made of cadmium plated steel.

The system delivers air dried to a dew point of -100°F. At room temperature, the system will lower the humidity in the Model 518 Chamber from 50% RH to 12% RH in about 2 hours.

2.2.1.3 Desiccant Dehumidification System Set-Up

1. Place the desiccant column somewhere near the chamber. Next to or on top of the chamber are good locations.

2. Cut 2 pieces of the 5/16" ID tubing long enough to connect the desiccant column to the 'Side Interface Panel' of the Chamber.

3. Connect one piece of the tubing from the fitting labeled "DEHUMIDIFY OUT" on the 'Side Interface Panel' to the lower fitting on the desiccant column.

   To connect the hose barb adapters to the ¼" OD tubing fittings: Push the barb adapter into the fitting as far as possible. The tube will lock into place automatically. To release the adapter, push in on the collar of the fitting and gently pull out the adapter.

4. Connect the second piece of tubing between the upper fitting on the desiccant column and the fitting labeled "DEHUMIDIFY IN" on the 'Side Interface Panel' of the Chamber.

5. Cover the chamber vent with the supplied 1" green Caplug.

6. The chamber vent, inside of the Chamber, is the 1" opening on the right wall (the green plug should be placed in the opening). The vent passes through to the outside right wall, the 1" barb on the outside should remain open.

7. Set the Model 518 Humidity Controller set-point to a value below the ambient humidity (refer to Model 518 Microprocessor Humidity Controller Operation).

8 Turn on the “RH” STANDBY switch on the front panel.

This will not automatically turn on the dehumidification system. Turning on the “RH” STANDBY switch only makes the dehumidification system *available* to the microprocessor controller.

When the controller tells Dehumidification System to activate, the small red LED on the lower right side of the microprocessor display will light. The internal air pump will begin moving. The pump will draw moist air from the Chamber working space and force it through the desiccant column. The dried air will then be returned to the chamber.

10. The microprocessor controller will determine the amount of drying needed to maintain the desired set-point.

If less than the full drying capacity of the Desiccant Dehumidification System is needed, the controller will provide pulses of power to the unit to limit the quantity of dried air coming into the chamber. The pump will be turned on and off cyclically to obtain an average input of dried air less than the full capacity of the Dehumidification System.

To achieve a smooth, even dehumidification process the humidity microprocessor Cycle Time 2 (CYC.2) should be set to 2.0 seconds. Longer cycle times will create longer “gaps” between dried air pulses. **DO NOT SET THE CYCLE TIME LESS THAN 1.0 SECOND.** Shorter pulses may damage the Model 561 pump.

2.2.2 Self-Regenerating Dehumidification System

The Model 578 Self-Regenerating Dehumidification System is capable of drying the Model 518 Chamber from 50% RH to 12% RH in less than 3 hours, at room temperature.

2.2.2.1 Description

The Model 578 Self-Regenerating Dehumidification System requires 50-100 psi of air pressure at 2.6 cfm to operate. For normal, short term use an internal 50 psi pump may be supplied. Since air must be provided continuously either a separate air compressor or house air should be used for long-term dehumidification applications to ensure long-term air delivery reliability.

The basic Self-Regenerating Dehumidification System consists of a high-pressure air pump (50 psi., minimum), a dual column self-regenerating desiccant dryer utilizing molecular sieve desiccant, and a 3-way control valve. The high-pressure pump and dual column dryer

operate continuously to assure a constant supply of dried air on demand. The 3-way control valve controls the flow of dried air into the chamber workspace.

The air pump, dryer and valve are mounted inside the control section of the Chamber. The air intake to the pump is muffled and is very quiet.

The pump draws in ambient air and compresses it to 50 psi. The compressed air is passed on to the dual column dryer where it is forced through one of the desiccant columns. The desiccant removes the moisture and dries the air down to a dew point of -40 °F, minimum.

The dried air is then split in two directions: Most of the dried air is sent to the output. A small portion of the dried air is diverted from the main flow and directed into the second column to regenerate the desiccant in the second column. The flow into the second column is in the opposite direction from the flow in the first column. The dried air, under high pressure, forces out any moisture in the second column through the dryer vent (located internally).

Every 30 seconds, the process reverses and the second column will perform the air drying while the first column is regenerating. The flip-flop process continues as long as the system is in use.

The dried air not used for regeneration is sent to the dryer output. The output of the dryer is attached to the 3-way control valve. When dry air is needed in the chamber, the valve is energized and opens to allow dry air to flow into the workspace. When the valve is not energized, the dry air is vented.

2.2.2.2 Unit Specifications

1. The average flow rate from the unit is 0.26 cfm (7.3 lpm).

2. The air will be dried to a minimum dew point of -40°F with a saturated input at 90°F.

3. Power – 115 VAC/60 Hz, 4.30Amps
   - 230 VAC/50 Hz, 2.15Amps

4. Working Pressure is 50-60 psig. However, compressed air systems up to 120 psig may be used.

5. Dual column dryer uses a molecular sieve desiccant.

2.2.2.3 Self-Regenerating Dehumidification System Set-Up

The standard self-regenerating dehumidification system is contained entirely within the chamber control section.

If house air is used, a quick disconnect air fitting will be installed on the Chamber Side Interface Panel.

2.2.2.4 Operation

To operate the self-regenerating system proceed as follows:

1. Open the chamber vent by removing the supplied 1” green Caplug.

2. The Chamber Vent, inside of the chamber, is the 1” opening on the right wall (the green plug should be removed). The vent passes through to the outside right wall. the 1” barb on the outside should also remain open.

   The Model 578 is a positive pressure system. Without adequate ventilation, the System will pressurize the working space. Pressurizing the Chamber is not recommended and may cause damage.

3. Set the microprocessor humidity controller set-point to a value below ambient humidity.

4. Turn on the “RH” STANDBY switch on the front panel.

   This will do two things:

   a. It will activate the high-pressure pump and the dual column dryer. They will begin producing dry air as soon as the “RH” STANDBY switch is turned on. However, no dry air will be allowed into the chamber workspace until the 3-way control valve is energized.

   b. Turning on the “RH” STANDBY switch makes the 3-way control valve *available* to the microprocessor controller.

      When the microprocessor controller tells the control valve to energize, the small red LED in the lower right corner of the Humidity display will light. The valve will open and dried air will flow into the chamber workspace.

5. The microprocessor will determine the amount of drying needed to maintain the desired set-point.

   If less than the full drying capacity of the Self-Regenerating Dehumidification System is needed, the controller will provide pulses of power to the control valve to limit the quantity of dried air coming into the chamber. The controller will open and close the control valve cyclically to obtain an average input of dried air less than the full capacity of the system.

   To achieve a smooth, even dehumidification process, the humidity microprocessor Cycle Time 2 (CYC.2) should be set to a low value. However, a short cycle time will prematurely wear out the control valve. As a compromise, CYC.2 should be set to 5.0 seconds. Shorter cycle times will afford better low humidity control at the desired set-point, but at the risk of accelerating valve wear.

3.0 MICROPROCESSOR HUMIDITY CONTROLLER

3.1 System Description

The Model 518 Microprocessor Humidity Controller with the Model 554 temperature compensated RH sensor is capable of controlling the relative humidity in the chamber working space by supplying a proportionally controlled power output to the Humidification System and/or Dehumidification System.

The controller provides low voltage (6 VDC) control signals to the HEAT and COOL solid-state relays, located on the 'RELAY PC Board'. When the low voltage signal is applied to the relay 'Input', the 'Output' of the relay 'closes' and allows AC Power to flow to the connected device.

When the "RH" STANDBY switch on the front panel is in the 'OFF' ('0') position, AC power is manually disconnected from the control relays and no humidification or dehumidification can take place until the switch is placed in the 'ON' ('I') position.

All devices in the Model 518 are connected using screw terminals on the 'Relay PC Board'. All relays and screw terminals are labeled.

3.2 Microprocessor Humidity Controller Operation

3.2.1 Set-Point Adjust

1. Press and hold the "∗" button. The letters "rh" will appear, followed by the current set-point value. While holding the "∗" button, the current set point value and 'rh' will alternately appear in the microprocessor display.

2. To adjust the set point higher, press the "▲" button. To adjust the set point lower, press the "▼" button.

3. Release the "∗" button.

3.2.2 Humidification System

To operate the Model 518 Humidification System:

1. Read the Humidifier operating instructions.

2. Plug the Humidifier into the 'HUMIDIFY' outlet on the 'Side Interface Panel'.

3. Adjust the RH set-point to a value above the ambient RH conditions.

4. Turn on the "RH" STANDBY switch on the Model 518 Front Panel.

   This will not automatically apply power to the Humidifier. Turning on the "RH" STANDBY switch only makes the 'HUMIDIFY' outlet *available* to the microprocessor controller.

   When the controller activates the outlet, the small green LED in the upper left corner of the RH display will illuminate. The humidifier will activate and begin pushing a fine water mist into the chamber.

5. The controller will determine the amount of humidification needed to maintain the desired set-point in the chamber.

   If less than the full output capacity of the humidifier is needed, the controller will provide pulses of power to the unit to limit the output. The humidifier will be turned on and off cyclically to obtain an average humidity output lower than the full capacity of the humidifier, appropriate to maintain the desired set-point in the enclosure.

   For best results, the Cycle Time (CyC.t) should be set as short as possible. Refer to the Humidification System instructions for minimum cycle time recommendations.

The minimum cycle time for the ETS Model 562 is 1.0 second.

3.2.3 Dehumidification System

The Dehumidification System air pump is located inside the Chamber control cavity. The desiccant column is attached externally through the fittings labeled 'AIR IN' and 'AIR OUT' on the 'Side Interface Panel'.

To operate the Model 518 Dehumidification System:

1. Read the operating instructions for the Dehumidification System being used.

2. Adjust the set-point to a value below the ambient RH conditions.

3. Turn on the "RH" STANDBY switch on the front of the Model 518 control panel.

   This will not automatically apply power to the dehumidification system. Turning on the "RH" STANDBY switch only makes the dehumidification system *available* to the microprocessor controller.

   When the controller activates the outlet, the small red LED in the lower right corner of the RH display will illuminate.

4. The microprocessor will determine the amount of dehumidification needed to maintain the desired set-point in the enclosure.

   If less than the full output capacity of the dehumidification system is needed, the controller will provide pulses of power to the unit to limit the output. The dehumidification system will be turned on and off cyclically to obtain an average output lower than the full capacity of the dehumidification system, appropriate to maintain the desired set-point in the chamber.

   For best results, the Cycle Time 2 (CyC.2) should be set as short as possible. See the Dehumidification System instructions for cycle time recommendations.

   ETS Model 561 minimum cycle time is 2.0 seconds.
   ETS Model 578 minimum cycle time is 5.0 seconds.

3.3 Programming the Microprocessor Controller

3.3.1 Accessing the Programming Menu

1. To access the Controller Program Menu, press the "▲" and "▼" buttons simultaneously for three (3) seconds. The controller will enter the Menu on Level 1 in the "tunE" function. (If using the CalComm Computer Program, see the "CALCOMM" section of the Manual).

2. To scroll to different parameters within a Level, press the "▲" button to scroll right and the "▼" button to scroll left.

3. To change a parameter or change Levels, press and hold the "∗" button. Press the "▲" or "▼" buttons to change the parameter.

4. All factory-programmed values listed here are optimized for use with the ETS Model 561 Desiccant Dehumidification System and ETS Model 562 Ultrasonic Humidification System. Other systems may require different settings.

   If the Model 518 Chamber has different systems, the information programmed into the controller will be different. Information on the specific program is provided separately, if not, contact ETS.

5. To exit the menu press and hold "▲ ▼" for three seconds.

3.3.2 LEVL C (Level C)

Level C is only visible when the unit is fitted with the COMMS option (RS 485 computer interface card). Level C is responsible for the communication protocol for the unit when interfacing with a PC. The values in Level C must match the values on the computer screen to establish communication.

Addr – (2) Instrument Communication Address. This address may be changed to any number suitable to the user.

bAud – (9600) The baud rate should be set as high as possible.

dAtA – (18n1) *Do Not Change.* The data format should not change.

DbuG – (off) *Do Not Change.* Debugging is an advanced feature that will not be covered in this manual.

3.3.3 LEVL 1 (Level 1)

Level 1 is the programming level. The Proportional, Integral, and Derivative controls are adjusted here. The combination of PID values is virtually limitless. This allows the controller to be used in a wide variety of applications. However, this flexibility can also lead to confusion when programming the controller in the Model 518's limited mode of operation.

To avoid confusion, this section will discuss which parameters may be adjusted, which parameters should not be adjusted.

All Parameters are programmed at the ETS Factory to match the Operating Systems shipped with the Chamber. The programmed values will control the Chamber within specifications. For better control, the user may adjust the values. The values listed here are for standard chambers only. Non-standard units may have different values than those listed here.

The following settings are approximations that will allow any user to achieve good RH control at any set point (approximately ±2.0 %, depending on the specific conditions). However, as the user becomes familiar with each parameter and it's effect on RH control, the user will be able to program the unit to control within ever tightening tolerances. Control of ± 0.2% RH, or better, is achievable with this system.

tunE – (oFF) The Autotune function may be used to help determine the optimum operating conditions for a given set of operating systems and chamber volume. The Autotune operates using the Humidifier only. The Dehumidification System will be disabled during an auto tune. The 'Tune At Set Point' (**At.SP)** option is recommended with the Model 518.

Occasionally, the message 'Tune Fail' will appear in the microprocessor display after the unit attempts an autotune. The user will need to clear the 'Tune Fail' message and attempt another autotune. To clear the message, turn the Model 518 Main Power Switch 'Off' and then 'On' again. When power is re-applied, the message will no longer be displayed.

A 'Tune Fail' may be caused by many variables. However, performing multiple 'Tune' attempts will generally result in a successful 'Tune'.

bAnd – (10.0) Proportional Band for humidifier.

int.t – (0.5) Integral Time in minutes.

The integral time is responsible for calculating how much output should be coming from the humidifying and dehumidifying systems to maintain the desired conditions.

der.t – (2.0) Derivative Time in seconds.

The derivative time, in combination with the **dAC**, is responsible for keeping the environment moving toward the set-point, following a pre-determined curve (set by the **dAC** in combination with the **bAnd**). The curve is followed to help avoid set-point overshoots.

Shortening the derivative time will cause the controller to recover slowly from disturbances. Lengthening the derivative time may cause oscillations.

dAC – (1.0) *Recommended.* The **D**erivative **A**pproach **C**ontrol determines how quickly the unit will reach the set- point, without overshooting. The **dAC** creates a gently sloping, exponential curve that the system must follow when approaching the set-point. The smaller the number, the quicker the unit will allow the set-point to be reached. The **dAC** multiplied by the band determines where the beginning of the approach curve will be located. A larger **dAC** setting will cause the beginning of the **dAC** curve to be further away from the set point. The larger setting will control overshoots better, but will cause responses to disturbances to be slower.

CYC.t – (1.0) *Recommended.* Cycle time means how often the unit can potentially be turned on and then off in succession. The ETS Model 562 and Model 572 Humidifiers may each be safely turned on and off once a second. **DO NOT DECREASE CYCLE TIME BELOW 1.0 SECOND when operating these systems.**

The shorter the cycle time, the greater the degree of precision that may be achieved with the controller.

If using any other humidification system, determine the minimum cycle time at which the unit can safely operate (consult the manufacturer's instructions for the unit).

oFSt – (0.0) *Do Not Change.* The Offset / Manual Reset control is only usable when the integral time (**int.t**) is turned off. Since the integral time is being used, the offset control may be ignored.

SP.LK – (oFF) Locks the set-point preventing unauthorized adjustment.

SP2 OPERATING PARAMETERS

The SP2 parameters can be configured in a variety of ways. In the Model 518 Humidity Controller, the SP2 parameters are used to tailor the Dehumidification System output for best RH control.

SET.2 – (0.0) Setpoint 2 allows the user to create a setpoint offset for the Dehumidification System. It is generally not used for the Desiccant Dehumidification System.

bnd.2 – (10.0) *Recommended.* Band 2 should generally be equal to **bAnd**. The heating and cooling system will work within the same proportional band, helping to prevent overlap in the system's operation. (i.e., the dehumidification system will have a tendency to stay 'off' when only humidification is needed and vice versa).

CyC.2 – (2.0) *Recommended.* Cycle time means how often the unit can potentially be turned on and then off in succession. The ETS Model 561 Dehumidifier may be safely turned on and off once a second but the pump will be excessively noisy. **DO NOT DECREASE THE CYCLE TIME BELOW 1.0 SECOND when operating this system.**

ETS Model 578 Self-Regenerating Dehumidification System solenoid valve **CyC.2** may be set as low as 0.5 second, but short times will accelerate valve wear. The recommended Cycle Time is 5.0 seconds. To extend the life of the internal solenoid valve, the cycle time may be increased but control may suffer.

If using any other dehumidification system, determine the minimum cycle time at which the unit can safely operate (consult the manufacturer's instructions for the unit).

NOTE: All functions in Level 2, 3, & 4 are "locked" and may not be altered unless "unlocked". See section 2.4.5 (Level 4).

3.3.4 LEVL 2 (Level 2)

Level 2 is the controller configuration level. The controller is capable of being configured in an unlimited number of ways. However, the parameters needed to control the Humidity Operating Systems, with the ETS Model 554 Humidity Sensor, are programmed and locked.

MANUAL CONTROL MODES

SP1.P – Read **SP1** output percentage power. (Read only).

hAnd – (off) SP1 Manual percentage power control.

For manual control, should a sensor fail, record typical **SP1.P** values beforehand.

PL.1 – (100) Set **SP1** power limit percentage, 100 to 0% of the duty cycle.

Limits maximum SP1 (humidifier) output power during warm-up and in proportional band.

PL.2 – (100) Set SP2 power limit percentage, 100 to 0% of the duty cycle.

Limits maximum SP2 (dehumidifier) output power during warm-up and in proportional band.

SP2 OPERATING MODES

SP2.A – (Cool) Main SP2 operating mode.

Must remain in "Cool" mode to properly operate the dehumidification system.

SP2.b – (nonE) Subsidary SP2 mode: latch/sequence. Non-linear dehumidify proportional band.

INPUT SELECTION AND RANGING

The following settings are used to calibrate the input of the unit for use with the ETS Model 554 RH Sensor.

diSP – (0.1) Select display resolution.

hi.SC – (100.0) Sets Sensor full scale. The sensor full scale is also the upper limit for the setpoint.

Lo.SC – (0.0) Sets Sensor minimum. The sensor minimum is also the lower limit for the sensor set point.

inPt – (Lin 1) Selects a Linear Input Voltage setting (0-50mV) for use with the ETS Model 554 Humidity Sensor & Sensor Interface PC Board (0-1VDC Input, 0-50mVDC Output).

unit – (rh) Selects process units. The process units can be changed independent of the calibration settings. In other words, changing the setting from "rh" to any other units will not affect the calibration settings, it will only change the units displayed.

3.3.5 LEVL 3 (Level 3)

Level 3 is the output configuration level. There are also features for calibration adjustment and performance data reading.

OUTPUT CONFIGURATION

SP1.d – (SSd1) *Do not change.* Assigns humidification control to the appropriate output.

SP2.d – (SSd2) *Do not change.* Assigns dehumidification control to the appropriate output.

SAFETY SETTINGS

Burn – (uP.SC) *Do Not Change.* Sensor burnout/break protection. This safety setting is not applicable for RH control, it is meant as a high temperature / low temperature cutoff for heating applications to protect the surroundings from damage due to sensor failure.

rEv.d – (1r.2d) *Do Not Change.* Select output modes: Direct/Reverse. Select Reverse for Humidification and Direct for Dehumidification.

rEv.l – (1n.2n) *Do Not Change.* Selects Microprocessor LED display mode. Normal mode is selected for each LED. In normal mode, the lower left (red) LED will light when the microprocessor calls for dehumidification and the upper left (green) LED will light when the microprocessor calls for humidification.

SPAn – (-60) *Do Not Change.* Changing the SPAn will affect unit calibration.

NOTE

The calibration settings (SPAn & ZEro) should not be altered. All calibration should be performed on the Model 554 Sensor (Temp. & RH) directly, or through the calibration potentiometers on the Model 518 'Sensor Interface Board'. The SPAN adjustment pot on the 'Sensor Interface Board' is far more accurate than this microprocessor setting.

ZEro – (0.0) *Do Not Change.* Zero sensor error, see SPAn.

NOTE

The Model 518 'Sensor Interface Board' includes an internal ZERO adjustment pot that is far more accurate than the microprocessor setting.

PERFORMANCE DATA

ChEK – (oFF) Select control accuracy monitor.

rEAD – (Var) Read control accuracy monitor.

TECH – (Ct A) Read Autotune cycle data. Using the Autotune function is not recommended.

VEr – software version

rSEt – (none) *Do Not Change.* If the unit is reset, all programmed information will be lost. Each parameter must be re-entered manually.

3.3.6 LEVL 4 (Level 4)

Level 4 is a "hidden" level. This allows "locked" functions to be inaccessible to any unauthorized user. Access to Level 4 is gained through "VEr" in Level 3. Press and hold "▲" and "▼" for ten seconds.

Enter Level 4 at "LoCK", release "▲" and "▼" together.

LoCK – (LEV.2) Select from three lock options.

LEV.3 – Locks Level 3 and 4 only – Technical Functions.

LEV.2 – Locks Levels 2, 3 and 4 only – Configuration and Technical Functions.

ALL – Locks all functions (unrestricted LEVL, VEr, dAtA, SP.LK)

Note: Locked functions and options may be read.

ProG – (Auto) Program mode auto-exit switch. Auto-exit returns display to normal if 60 seconds of key inactivity, select **StAy** to disable.

no.AL – (oFF) Disable SP2 alarm annunciator -AL-. Select **on** to disable -AL-.

diS.S – (dir) *Do Not Change.* Display sensitivity.

DEr.S – (0.1) *Do Not Change.* Derivative sensitivity.

3.4 CALCOMMS - Computer Interface (Optional)

CALCOMMS is a graphic Windows™ based software package designed for PC supervision of CAL 3300 Controllers. It offers the capability of remote adjustment, instrument configuration, cloning, saving and retrieving instrument settings to files together with logging and charting in real time. Communications uses the MODBUS® protocol via a fully isolated RS485 link.

To gain full benefit of CALCOMMS software, it is recommended that the PC be fitted with a Pentium processor (although a 486 will work) and is running WINDOWS 95 or Windows NT programs. A minimum of 16 MB RAM is recommended to run the program (slightly less is OK), together with enough free hard disc space to meet logging requirements.

Because the controllers are "stand alone" they do not need PC supervision for their normal function, and will continue to control the process unaffected by failure of any part of the communications loop.

When used with the Model 518 Chamber, the Temperature Microprocessor & Humidity Microprocessor COMM PORTS are wired together, in parallel. One RS-485 COMM PORT, common to both controllers, is located on the 'Side Interface Panel' of the Model 518 Chamber.

3.4.1 Set-up and Installation

(Refer to pp. 2 & 3 in the CALCOMMS Manual)

3.4.1.1 RS 485 COMM PORT

RS-485 is a half duplex serial communications link and is the standard most commonly used for industrial applications due to it's high noise immunity and multi-drop capability. It enables a PC to communicate with up to 32 instruments over distances of over 1200 meters, and requires the addition of an RS-485 interface card, or a separate RS-232/485 converter.

The RS-485 COMM PORT is a 9-pin subminiature-D female connector located on the 'Side Interface Panel'.

3.4.1.2 RS-232/485 Converter

The RS-232/485 Converter will not be needed if the computer is outfitted with an RS-485 interface card.

The converter is a 9-pin / 9-pin in-line style connector. The converter is gray and bears the label ' RS-232 TO RS-485 / Model 485SDD9R'.

3.4.1.3 Connections

1. Connect the supplied 9-pin male/female sub-D cable to the RS-485 COMM PORT on the 'Side Interface Panel'.

2. Connect the other end of the cable to the 'RS485' side of the RS-232/485 converter.

3. Connect the 'RS232' side of the converter into the appropriate Comm Port on the PC.

3.4.1.4 Software Installation

Software installation instructions can be found on pp. 9-11 of the CALCOMMS Manual.

The CALCOMMS Manual is separate from the CAL 3300 Users Manual, it is the manual with the color cover.

3.4.2 Operation

After installing the computer program and making the appropriate wiring connections to a PC, turn to p. 11 in the CALCOMMS Manual. This section is titled GETTING STARTED. Follow the directions to begin operating the program.

3.4.2.1 MODBUS Addresses

The MODBUS address is found in Level C. (See Section 2.4.1)

HUMIDITY controller address is set to **2** at the ETS factory (if equipped with RS 485 COMM PC Board).

3.4.2.2 Open Communications

Instructions for opening communication are found on p.13 of the CALCOMMS Manual.

3.4.3 Logging and Charting

Instructions for operating the Logging and Charting functions of the CALCOMMS program begin on p. 21 of the CALCOMMS Manual.

Section C
Temperature

4.0 HEATING OPERATING SYSTEMS

4.1 Heating System

The Model 518 Chamber contains two (2) 250 Watt Electric Heaters (500 Watts total). The heater is an integral part of the chamber, located inside the Chamber workspace. Since the heater is already installed, there is no additional set-up required.

After turning "ON" the "TEMP" STANDBY switch, the microprocessor temperature controller governs the operation of the Heating System.

1. The controller will determine the amount of heat needed to maintain the desired set-point. Power will be applied to the heater as a series of time proportioned pulses. **See Section 4.2 – Microprocessor Temperature Controller Operation** for details.

2. The electric heating element and indicator light are located on the Fan Panel (the heater is hidden from view). The Fan Panel is the white metal panel inside the Chamber workspace, on the rear wall.

3. The heater indicator light will illuminate to indicate when power is being applied to the heater. (The microprocessor LED's will illuminate at the same time.)

A thermal safety switch (also on the Fan Panel) is connected in series with the heater. Power to the heater will be cut off if the temperature within the chamber exceeds 135 °F. (58°) (The Acrylic Chamber will begin to melt at 150 °F)

4.2 Cooling Systems

The Model 518 Chamber includes the ETS Model 563 Liquid Carbon Dioxide Cooling System as a standard feature. Other cooling options include:

4.2.1 Model 563 Liquid CO_2 Cooling System

The Liquid CO_2 Cooling System is standard and is already installed onto the Model 518 Chamber. The Solenoid Control Valve is wired into the 'Relay PC Board', which is controlled by the microprocessor temperature controller. All the user needs to do is connect the Transfer Hose to the appropriate liquid CO_2 cylinder with dip tube.(**NOTE: CO_2 gas will not work**)

The ETS Model 563 Gas Cooling System enables the temperature within the Model 518 Chamber to be reduced below ambient.

1. The System utilizes Liquid CO_2* (Carbon Dioxide) as the cooling medium.

   CO_2 is user supplied. 50lb. CO_2 tanks are readily available from local bottled gas companies.

   ***Liquid CO_2* with a *DIP Tube* must be specified. The DIP Tube allows liquid to be siphoned from the bottom of the tank. CO_2 Gas (without DIP Tube) will not provide cooling with this system.**

2. The CO_2 is allowed to evaporate (expand from a liquid to a gas) within the chamber.

3. The phase change of the CO_2 produces a large cooling effect. (The temperature *directly in front of* the nozzle will be near -100 °F.)

4. The microprocessor temperature controller will monitor the chamber temperature and proportionally control the solenoid valve to provide the appropriate amount of cooling to maintain the desired set-point.

4.2.1.1 Cooling System Accessories

1. Liquid CO_2 Transfer Hose

   A. 4’ long with Braided Stainless Steel Safety Shield.
   B. Brass High Pressure Fitting for mating to Liquid CO_2 tank.
   C. Brass Quick Disconnect (female) for mating to Valve Input.

2. Cooling Nozzle Cleaning Tool

4.2.1.2 Liquid CO_2 Tank Connections

1. Secure the CO_2 cylinder to a wall using an approved securing belt or clamp.

2. Failure to secure the cylinder to a wall or other suitable stationary object may result in serious injury to personnel should CO_2 cylinder fall over.

3. The CO_2 cylinder contains liquid carbon dioxide under extremely high pressure (800-1000 psi). Care must be exercised at all times when working with this cylinder. The manual valve on top of the cylinder should be closed (fully clockwise) when the cooling system is not in use.

4. Although CO_2 is non-toxic, it can cause asphyxiation if not used in areas with adequate ventilation. The Model 518 Chamber is equipped with a Chamber Vent (1" White Hose Barb located in the middle of the Black Panel on the right side of the Chamber). The spent CO_2 gas will escape from the Chamber Vent and dissipate into the room atmosphere. To vent the gas outside of the room or building, connect an appropriate length of 1" ID tubing to the Vent Hose Barb. The open end of the tubing should be exhausted outside the working environment.

5. Connect the Transfer Hose to the CO_2 Tank and Valve.

   A. Connect the Female Quick Disconnect fitting to the Male Quick Disconnect fitting. Pull back on the collar of the female fitting and place it onto the male fitting, release the collar. These fittings should mate to form a leak-free seal.

   B. Connect the other end of the transfer hose (Large Brass Fitting) to the CO_2 Cylinder. Tighten the fitting onto the tank using a wrench.

4.2.1.3 Operation

The user does not have to do anything else to operate the system. Total operation will be under the control of the microprocessor temperature controller.

The temperature controller is a PID microprocessor with a time proportioned AC voltage output. Refer to **Section 5.2**, **Microprocessor Temperature Controller Operation**, for a full description of operation.

The user should periodically monitor the status of the CO_2 cylinder. The user should also periodically monitor the cooling performance of the system to check for an exhausted CO_2 tank.

4.2.1.4 Changing CO_2 Tank

Before disconnecting any fittings or attempting to change the tank, all of the CO_2 must be vented from the system. Venting the CO_2 will relieve any pressure in the system. **Failure to bleed the system may result in injury!!** To bleed the pressure from the line:

1. Turn "ON" the Cooling Valve. Turn on the "TEMP" STANDBY switch on the front panel and adjust the set-point several degrees below the temperature inside the chamber. Wait for the Cool Valve to turn "ON".

2. While the Cool Valve is open, turn off the manual valve on top of the CO_2 tank. This will shut off the CO_2 supply to the system

The CO_2 will bleed out of the cooling nozzle, into the chamber. When all the CO_2 is out of the system, the flow of gas from the nozzle will stop.

3. Using a wrench, disconnect the Transfer Hose (loosen the large brass fitting) from the CO_2 tank.

4. Replace the empty tank with a fresh Liquid CO_2 tank. Then, using a wrench, reconnect the transfer hose.

5. Turn "OFF" the "COOL" switch on the front panel. This will close the Cool Valve.

6. After the system is turned "OFF", open the manual valve on top of the CO_2 cylinder.

   The Transfer Hose and Cool Valve will now be pressurized. If any leaks occur, close the manual valve on top of the CO_2 cylinder and tighten any fittings that are leaking. Open the manual valve and recheck for leaks.

4.2.1.5 Specifications and Performance

1. Cooling Capacity:

   The Model 563 CO_2 Gas Cooling System, when used in the ETS Model 518 Chamber with a full 50 lb. CO_2 tank, will provide cooling to at least 32 °F (0 °C). The total CO_2 consumption rate for the system depends upon the temperature that is being maintained.

   The following chart shows the approximate consumption rate for the system at different temperatures, assuming a full 50lb. CO_2 tank and room ambient temperature of 72 °F (23 °C).

Temperature Set-point (°F)	Time (approx.) to empty CO_2 tank.
62 °F (16.7 °C)	6 hours
52 °F (11.1 °C)	3 hours
42 °F (5.6 °C)	2 hours
32 °F (0 °C)	1 hour

NOTE

<u>These consumption rates are for maintaining the above temperatures. When lowering the temperature from room ambient to the set-point temperature, the consumption rate will be higher. The consumption rate will be as shown once the set-point temperature is reached.</u>

2. To lower the CO_2 consumption rate and extend the operating time per tank, insulation should be added to the chamber. Adding insulation will reduce heat loss and aid in stabilizing the chamber temperature (especially at very low temperatures).

4.2.1.6 Maintenance and Troubleshooting

The Model 563 Liquid CO_2 Cooling System should provide years of trouble free service. Other than changing CO_2 tanks when depleted, very little servicing is required.

Before performing any service, the pressurized CO_2 must be bled from the system. See section 4.2.1.4.

1. Clearing a clogged Cooling Nozzle.

   Occasionally, the Cooling Nozzle may become clogged due to impurities in the CO_2, small pieces of dirt or small pieces of Teflon sealing tape breaking free and lodging in the nozzle.

   Item #2, the Cooling Nozzle Cleaning Tool is provided to help clear such blockages. If the nozzle is extremely clogged, it may be necessary to completely remove the nozzle, clear the orifice, and reinstall it.

2. If the system is not producing a cooling effect after clearing the nozzle, make sure the CO_2 tank is full and the manual valve is fully open.

3. If the valve does not fully close when the system is turned “OFF”, a small piece of dirt, etc. may have lodged in the valve seal. The valve may be taken apart to inspect the seal.

4. Remove AC Power from the unit.

5. Remove the solenoid from the valve stem.

6. Using a wrench, carefully unscrew the valve stem from the upper portion of the valve body.

7. The stem contains a plunger with a round, red seal on the top. Make sure the seal is clean and free of debris. Also check the valve internally for obstructions.

8. After cleaning, carefully replace the Valve Stem and Solenoid.

9. For help with any other problems please contact ETS.

5.0 MICROPROCESSOR TEMPERATURE CONTROLLER

5.1 System Description

The microprocessor temperature controller, with Model 554 RTD Temperature Sensor is capable of controlling the temperature in the Model 518 Chamber by supplying a proportionally controlled power output to the Heating System and/or Cooling System.

The controller provides low voltage (6 VDC) control signals to the HEAT and COOL solid state relays, located on the 'RELAY' PC board. When the low voltage signal is applied to the relay 'Input', the 'Output' of the relay 'closes' and allows AC Power to flow to the connected device.

When the "TEMP" STANDBY switch on the front panel is in the 'OFF' ('0') position, AC power is manually disconnected from the control relays and no heating or cooling may take place until the switch is placed in the 'ON' ('I') position.

All devices in the Model 518 are connected through screw terminals on the 'Relay PC Board'. All relays and screw terminals are labeled.

5.2 Temperature Controller Operation

5.2.1 Set-Point Adjust

1. Press and hold the "∗" button. The letters '°C' or '°F' (depending on set-up) will appear followed by the current set-point value. While holding the "∗" button, the current set point value and '°C' or '°F' will alternately appear in the microprocessor display.

2. To adjust the set point higher, press the "▲" button. To adjust the set point lower, press the "▼" button.

3. Release the "∗" button.

5.2.2 Heating System

To operate the Model 518 Heating System:

1. Adjust the Temperature set-point to a value above the ambient temperature.

2. Turn on the "TEMP" STANDBY switch on the front of the Control Panel.

This will not automatically apply power to the heaters. Turning on the "TEMP" STANDBY switch only makes the heaters *available* to the microprocessor controller.

When the microprocessor activates the heaters, the small green LED in the upper left corner of the Temperature display will illuminate. The red neon light on the 'Fan Panel' will also illuminate to indicate that the heaters are receiving power.

3. The controller will determine the amount of heating needed to maintain the desired set-point in the enclosure.

   If less than the full output capacity of the heater is needed, the controller will provide pulses of power to the unit to limit the output. The heater will be turned on and off cyclically to obtain an average temperature output lower than the full capacity of the heater, appropriate to maintain the desired set-point in the chamber.

   For best results, the Cycle Time (CyC.t) should be set as short as possible. The minimum cycle time for the 500 Watt Heater in the Model 518 Chamber is 1.0 second. Shorter times may damage the Controller.

5.2.3 Cooling System

The Model 563 Liquid Carbon Dioxide Cooling System may be disabled if it is not needed or if not connected to a gas tank. In ***LEVEL 2*** *of the Programming Menu, adjust* ***SP1.P*** *from* ***'Cool'*** *to* ***'nonE'.*** *This will manually disable only the cooling system and prevent the solenoid valve from 'clicking' on and off unnecessarily. The Heating System will be unaffected.*

To operate the Model 518 Cooling System:

1. Adjust the set-point to a value below the ambient temperature.

2. Turn on the "TEMP" STANDBY switch on the front of the Control Panel.

   This will not automatically apply power to the cooling system. Turning on the "TEMP" STANDBY switch only makes the cooling system the *available* to microprocessor controller.

   When the controller activates the cooling system, the small red LED in the lower right corner of the Temperature display will illuminate.

3. The microprocessor will determine the amount of cooling needed to maintain the desired set-point in the enclosure.

If less than the full output capacity of the cooling system is needed, the controller will provide pulses of power to the unit to limit the output. The cooling system will be turned on and off cyclically to obtain an average output lower than the full capacity of the cooling system, appropriate to maintain the desired set-point in the enclosure.

For best results, the Cycle Time 2 (CyC.2) for the Model 563 Gas Cooling System should be set as short as possible.

The ETS Model 563 minimum cycle time is 1.0 seconds (3.0 recommended).

5.3 Programming the Microprocessor Controller

5.3.1 Accessing the Programming Menu

1. To access the Controller Program Menu, press the "▲" and "▼" buttons simultaneously for three (3) seconds. The controller will enter the Menu on Level 1 in the "tunE" function. (If using the CalComm Computer Program, refer to the "CALCOMM" section of the Manual).

2. To scroll to different parameters within a Level, press the "▲" button to scroll right and the "▼" button to scroll left.

3. To change a parameter or change Levels, press and hold the "∗" button. Press the "▲" or "▼" buttons to change the parameter.

4. All factory-programmed values listed here are optimized for use with the ETS Model 563 Liquid Carbon Dioxide Cooling System and the ETS Model 564 500-Watt Heating System. Other systems may require different settings.

   If the Model 518 Chamber has different systems, the information programmed into the controllers will be different. Information on the specific program is provided separately, if not, contact ETS.

5. To exit the menu press and hold "▲ ▼" for three seconds.

5.3.2 LEVL C (Level C)

Level C is only visible when the controller is fitted with the COMMS option (RS 485 computer interface card). Level C is responsible for the communication protocol for the unit when interfacing with a PC. The values in Level C must match the values on the computer screen to establish communication.

Addr – (1) Instrument Communication Address. This address may be changed to any number suitable to the user.

bAud – (9600) The baud rate should be set as high as possible.

dAtA – (18n1) *Do Not Change.* The data format should not change.

DbuG – (off) *Do Not Change.* Debugging is an advanced feature that will not be covered in this manual.

5.3.3 LEVL 1 (Level 1)

Level 1 is the programming level. The Proportional, Integral, and Derivative controls are adjusted here. The combination of PID values is virtually limitless. This allows the controller to be used in a wide variety of applications. However, this flexibility can also lead to confusion when programming the controllers in the Model 518's limited mode of operation.

To avoid confusion, this section will discuss which parameters may be adjusted and which parameters should not be adjusted.

All Parameters are programmed at the ETS Factory to match the Operating Systems shipped with the Chamber. The programmed values will control the chamber within specifications. For tighter control, the user may want to adjust the values. The values listed here are for standard chambers only. Non-standard units may have different values than those listed here.

The following settings are approximations that will allow any user to achieve good temperature control at any set-point (approximately ±1.0°C, depending on the specific conditions). However, as the user becomes familiar with each parameter and it's effect on temperature control, the user will be able to program the unit to control within ever tightening tolerances. Control of ± 0.2 °C, or better, is achievable with this system.

tunE – (oFF) The Autotune function may be used to help determine the optimum operating conditions for a given set of operating systems and chamber volume. The Autotune operates using the heater only. The cooling system will be disabled during an auto tune. The 'Tune At Setpoint' (**At.SP)** option is recommended with the Model 518 Chamber.

Occasionally, the message 'Tune Fail' will appear in the microprocessor display after the unit attempts an autotune. The user will need to clear the 'Tune Fail' message and attempt another autotune. To clear the message, turn the Model 532 Main Power Switch 'Off' and then 'On' again. When power is re-applied, the message will no longer be displayed.

bAnd – (1.0) Proportional Band for the heaters.

int.t – (4.1) Integral Time in minutes.

The integral time is responsible for calculating how much output should be coming from the heating and cooling Systems to maintain the desired conditions.

der.t – (14.0) Derivative Time in seconds.

The derivative time, in combination with the **dAC**, is responsible for keeping the environment moving toward the set-point, following a pre-determined curve (set by the **dAC** in combination with the **bAnd**). The curve is followed to help avoid set-point overshoots.

Shortening the derivative time will cause the controller to recover slowly from disturbances. Lengthening the derivative time may cause oscillations.

dAC – (1.0) *Recommended.* The **D**erivative **A**pproach **C**ontrol determines how quickly the unit will reach the set- point, without overshooting. The **dAC** creates a gently sloping, exponential curve that the system must follow when approaching the set-point. The smaller the number, the quicker the unit will allow the set-point to be reached. The **dAC** multiplied by the band determines where the beginning of the approach curve will be located. A larger **dAC** setting will cause the beginning of the **dAC** curve to be further away from the set point. The larger setting will control overshoots better, but will cause responses to disturbances to be slower.

CYC.t – (1.0) *Recommended.* Cycle time means how often the unit can potentially be turned on and then off in succession. The ETS 500 Watt heater may be safely turned on and off once a second. **DO NOT DECREASE CYCLE TIME BELOW 1.0 SECOND when operating this system.**

The shorter the cycle time, the greater the degree of precision that may be achieved with the controller.

If using any other heating system, determine the minimum cycle time at which the unit can safely operate (slightly shorter cycle times may be used for smaller heaters).

oFSt – (0.0) *Do Not Change.* The Offset / Manual Reset control is only usable when the integral time (**int.t**) is turned off. Since the integral time is being used, the offset control may be ignored.

SP.LK – (oFF) Locks the set-point preventing unauthorized adjustment.

SP2 OPERATING PARAMETERS

The SP2 parameters can be configured in a variety of ways. In the Model 518 temperature controller, the SP2 parameters are used to tailor the cooling system output for best temperature control.

The SP2 parameters are all shown in °C.

SET.2 – (0.0) Setpoint 2 allows the user to create a setpoint offset for the cooling system. It is generally not used for the Gas Cooling System. When a thermoelectric cooler or refrigerated cooling system is used, this setting may be increased or decreased to determine the point at which the cooling system will activate. (These systems are operated in On/Off mode instead of within a proportional band.)

bnd.2 – (1.0) Band 2 should generally be equal to **bAnd**. The heating and cooling system will work within the same proportional band, helping to prevent overlap in the system's operation. (i.e., the cooling system will have a tendency to stay 'off' when only heating is needed and vice versa).

When a thermoelectric cooler or refrigerated cooling system is used, this setting may be increased or decreased to determine the point at which the cooling system will activate. (These systems are operated in On/Off mode instead of within a proportional band.)

CyC.2 – (3.0) *Recommended.* Cycle time means how often the unit can potentially be turned on and then off in succession. 3.0 SECONDS is the recommended cycle time for the ETS Model 563 Cooling System to achieve good control and extended valve life. The ETS Model 563 solenoid valve **CyC.2** may be set as low as 0.5 second, but short times will accelerate valve wear. **DO NOT DECREASE THE CyC.2 BELOW 0.5 SECOND when operating this system.** The cycle time may be increased above 3.0 seconds to extend valve life but control may suffer. If using any other cooling system determine the minimum cycle time at which the unit can safely operate (consult the manufacturer's instructions for the unit).

NOTE: All functions in Level 2, 3, & 4 may be "locked" so that they may not be altered unless "unlocked". See section 4.4.5 (Level 4).

5.3.4 LEVL 2 (Level 2)

Level 2 is the controller configuration level. The controller is capable of being configured in an unlimited number of ways. However, the parameters needed to control the temperature operating systems, with the ETS Model 554 Temperature Sensor, are programmed and locked.

MANUAL CONTROL MODES

SP1.P – Read **SP1** output percentage power. (Read only).

hAnd – (off) SP1 Manual percentage power control.

For manual control, should a sensor fail, record typical **SP1.P** values beforehand.

PL.1 – (100) Set **SP1** power limit percentage, 100 to 0% of the duty cycle. Limits maximum **SP1** (heater) output power during warm-up and in proportional band.

PL.2 – (100) Set **SP2** power limit percentage, 100 to 0% of the duty cycle.

Limits maximum **SP2** (cooling) output power during warm-up and in proportional band.

SP2 OPERATING MODES

SP2.A – (Cool) Main **SP2** operating mode.

Must remain in "Cool" mode properly to operate the cooling system.

If use of the Model 563 Liquid Carbon Dioxide System is not needed, it is recommended that **SP2.A** be set as **'nonE'**. The output to the cool valve will be disabled and will not 'click' on and off unnecessarily.

SP2.b – (nonE) Subsidiary **SP2** mode: latch/sequence. Non-linear dehumidify proportional band.

INPUT SELECTION AND RANGING

°C to °F conversion - *A total of 4 settings must be modified to change scales. These include **hi.SC**, **lo.SC** , **unit** and **ZEro** (See Level 3). For these settings there will be two sets of values in parenthesis. The first one is the °C setting, the second is the °F setting.*

diSP – (0.1) Select display resolution.

hi.SC – (100), (212.0) Sets Sensor full scale. The sensor full scale is also the upper limit for the setpoint.

Lo.SC – (0.0), (32.0) Sets Sensor minimum. The sensor minimum is also the lower limit for the sensor set point.

inPt – (Lin1) Selects a Linear Input Voltage setting (0-50mV) for use with the ETS Model 554 RTD Temperature Sensor & Sensor Interface PC Board (0-1VDC Input, 0-50mVDC Output).

unit – (°C), (°F) Selects process units. The process units can be changed independent of the calibration settings. In other words, changing the setting from °C to °F or any other units will not affect the calibration settings, it will only change the units displayed.

5.3.5 LEVL 3 (Level 3)

Level 3 is the output configuration level. There are also features for calibration adjustment and performance data reading.

OUTPUT CONFIGURATION

SP1.d – (SSd1) *Do not change.* Assigns heating control to the appropriate output.

SP2.d – (SSd2) *Do not change.* Assigns cooling control to the appropriate output.

SAFETY SETTINGS

Burn – (uP.SC) *Do Not Change.* Sensor burnout/break protection. This safety setting will protect a system if the sensor quits working. All systems will be shut down if the temperature rises above the hi.SC setting.

rEv.d – (1r.2d) *Do Not Change.* Select output modes: Direct/Reverse. Select Reverse for Heating and Direct for Cooling.

rEv.l – (1n.2n) *Do Not Change.* Selects Temperature LED display mode. Normal mode is selected for each LED. In normal mode, the lower left (red) LED will light when the microprocessor calls for the cooling system and the upper left (green) LED will light when the microprocessor calls for the heating system.

SPAn – (-60) *Do Not Change.* Changing the SPAn will affect unit calibration.

NOTE

The calibration settings (SPAn & ZEro) should not be altered. All calibration should be performed on the Model 554 Sensor (Temp. & RH) directly, or through the calibration potentiometers on the Model 518 'Sensor Interface Board'. The SPAN adjustment pot on the 'Sensor Interface Board' is far more accurate than the microprocessor setting.

ZEro – (0.0), (32.0) Zero sensor error, see SPAn.

NOTE

The Model 518 'Sensor Interface Board' includes an internal ZERO adjustment pot that is far more accurate than the microprocessor setting.

PERFORMANCE DATA

ChEK – (oFF) Select control accuracy monitor.

rEAD – (Var) Read control accuracy monitor.

TECH – (Ct A) Read Autotune cycle data. Using the Autotune function is not recommended with the temperature controller

VEr – software version

rSEt – (none) *Do Not Change.* If the unit is reset, all programmed information will be lost. Each parameter must be re-entered manually.

5.3.6 LEVL 4 (Level 4)

Level 4 is a "hidden" level. This allows "locked" functions to be inaccessible to any unauthorized user. Access to Level 4 is gained through "VEr" in Level 3. Press and hold "▲" and "▼" for ten seconds.

Enter Level 4 at "LoCK", release "▲" and "▼" together.

LoCK – (LEV.2) Select from three lock options.

LEV.3 – Locks Level 3 and 4 only – Technical Functions.

LEV.2 – Locks Levels 2, 3 and 4 only – Configuration and Technical Functions.

ALL – Locks all functions (unrestricted LEVL, VEr, dAtA, SP.LK)

Note: Locked functions and options may be read.

ProG – (Auto) Program mode auto-exit switch. Auto-exit returns display to normal after 60 seconds of key inactivity, select **StAy** to disable.

no.AL – (oFF) Disable SP2 alarm annunciator -AL-. Select **on** to disable -AL-.

diS.S – (dir) *Do Not Change.* Display sensitivity.

DEr.S – (0.1) *Do Not Change.* Derivative sensitivity.

5.4 CALCOMMS - Computer Interface

CALCOMMS is a graphic Windows™ based software package designed for PC supervision of CAL 3300 Controllers. It offers the capability of remote adjustment, instrument configuration, cloning, saving and retrieving instrument settings to files together with logging and charting in real time. Communications uses the MODBUS® protocol via a fully isolated RS485 link.

To gain full benefit of CALCOMMS software, it is recommended that the PC is fitted with a Pentium processor (although a 486 will work) and is running WINDOWS 95 or Windows NT programs. A minimum of 16 MB RAM is recommended to run the program (slightly less is OK), together with enough free hard disc space to meet logging requirements.

Because the controllers are "stand alone" they do not need PC supervision for their normal function, and will continue to control the process unaffected by failure of any part of the communications loop.

When used with the Model 518 Chamber, the Temperature & Humidity Microprocessor COMM PORTS are wired together, in parallel. One RS-485 COMM PORT, common to both controllers, is located on the Side Interface Panel.

5.4.1 Set-up and Installation

(See Pp. 2 & 3 in the CALCOMMS Manual)

5.4.1.1 RS 485 COMM PORT

RS-485 is a half duplex serial communications link and is the standard most commonly used for industrial applications due to it's high noise immunity and multi-drop capability. It enables a PC to communicate with up to 32 instruments over distances of over 1200 meters, and requires the addition of an RS-485 interface card, or a separate RS-232/485 converter.

The RS-485 COMM PORT is a 9-pin subminiature-D female connector located on the 'Side Interface Panel'.

5.4.1.2 RS-232/485 Converter

The RS-232/485 Converter will not be needed if the computer is outfitted with an RS-485 interface card.

The converter is a 9-pin / 9-pin in-line style connector. The converter is gray and bears the label ' RS-232 TO RS-485 / Model 485SDD9R'.

5.4.1.2 Connections

1. Connect the supplied 9-pin male/female subminiature-D cable to the RS-485 COMM PORT on the 'Side Interface Panel'.

2. Connect the other end of the cable to the 'RS485' side of the RS-232/485 converter.

3. Connect the 'RS232' side of the converter into the appropriate Comm Port on the PC.

5.4.1.4 Software Installation

Software installation instructions can be found on pp. 9-11 of the CALCOMMS Manual.

The CALCOMMS Manual is separate from the CAL 3300 Users Manual. It is the manual with the color cover.

5.4.2 Operation

After installing the computer program and making the appropriate wiring connections to a PC, turn to p.11 in the CALCOMMS Manual. This section is titled GETTING STARTED, follow the directions to begin operating the program.

5.4.2.1 MODBUS Addresses

The MODBUS address is found in Level C. (See Section 2.4.1)

TEMPERATURE controller address is set to **1** at the ETS factory (if equipped with RS 485 COMM PC Board).

5.4.2.2 Open Communications

Instructions for opening communication are found on p.13 of the CALCOMMS Manual.

5.4.3 Logging and Charting

Instructions for operating the Logging and Charting functions of the CALCOMMS program begin on P. 21 of the CALCOMMS Manual.

6.0 WARRANTY

Electro-Tech Systems, Inc. warrants its equipment, accessories and parts of its manufacture to be and remain free from defects in material and workmanship for a period of one (1) year from date of invoice and will, at the discretion of Seller, either replace or repair without charge, F.O.B. Glenside, similar equipment or a similar part to replace any equipment or part of its manufacture which, within the above stated time, is proved to have been defective at the time it was sold. All equipment claimed defective must be returned properly identified to the Seller (or presented to one of its agents for inspection). This warranty only applies to equipment operated in accordance with Seller's operating instructions.

Seller's warranty with respect to those parts of the equipment which are purchased from other manufacturers shall be subject only to that manufacturer's warranty.

The Seller's liability hereunder is expressly limited to repairing or replacing any parts of the equipment manufactured by the manufacturer and found to have been defective. The Seller shall not be liable for damage resulting or claimed to result from any cause whatsoever.

This warranty becomes null and void should the equipment, or any part thereof, be abused or modified by the customer of if used in any application other than that for which it was intended. This warranty to replace or repair is the only warranty, either expressed or implied or provided by law, and is in lieu of all other warranties and the Seller denies any other promise, guarantee, or warranty with respect to the equipment or accessories and, in particular, as to its or their suitability for the purposes of the buyer or its or their performance, either quantitatively or qualitatively or as to the products which it may produce and the buyer is expected to expressly waive rights to any warranty other than that stated herein.

ETS must be notified before any equipment is returned for repair. ETS will issue an RMA (Return Material Authorization) number for return of equipment.

Equipment should be shipped prepaid and insured in the original packaging. If the original packaging is not available, the equipment must be packed in a sufficiently large box (or boxes if applicable) of double wall construction with substantial packing around all sides. The RMA number, description of the problem along with the contact name and telephone number must be included in formal paperwork and enclosed with the instrument. Round trip freight and related charges are the owner’s responsibility.

WARNING

WOODEN CRATES MUST NOT BE USED. PACKAGING OF DELICATE INSTRUMENTS IN WOODEN CRATES SUBSTANTIALLY INCREASES THE CONTENT’S SUSCEPTIBILITY TO SHOCK DAMAGE. DO NOT PLACE INSTRUMENTS OR ACCESSORIES INSIDE OTHER INSTRUMENTS OR CHAMBERS. ELECTRO-TECH SYSTEMS, INC. WILL NOT ASSUME RESPONSIBILITY FOR ADDITIONAL COST OF REPAIR DUE TO DAMAGE INCURRED DURING SHIPMENT AS A RESULT OF POOR PACKAGING.

CONTROLLED ENVIRONMENT CHAMBER

Model 518C

Operating Manual

11/14/02