T-2600BV
Precision Temperature Forcing System User and Maintenance Manual

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OVERVIEW OF THE T-2600BV PTFS

Introduction

Thermonics Inc., the acknowledged leader in semiconductor testing technology is proud to introduce the T-2600BV Bench-top Vortex Precision Temperature Forcing System (PTFS). A portable unit that is one of the most reliable systems available today.

About This Manual

The purpose of this manual is to enable you to make optimal use of the T-2600 PTFS, for temperature testing, by helping you to efficiently understand and effectively operate and maintain the system. Provided is information on the use of the system's main components which include the operator interface, the boom and arm, and remote control. Additional information, such as operator precautions and safety considerations is also provided.

The manual has two main parts - the *User Guide Module* and the *Maintenance Module*. The current chapter, which is within the User Guide Module, introduces the system's main features, its specifications and warranty. Additional sections of the User Guide discuss how to:

- Install the system: Connect the power and air sources and set up the interface to the tester.
- Operate the system: Use the operator interface and position the boom and arm.
- Establish remote communication: Use the RS-232C, IEEE-488.2 and Standard Interfaces.
- Maintain the system: Perform operator maintenance, cleaning and minor housekeeping.

The *Maintenance Module* provides information on preventive maintenance, calibration and trouble-shooting the system. (On printed versions the maintenance information is bound with these materials behind the tab labeled *Maintenance*. For versions on digital media, it is located in a separate PDF file.)

System Overview

Localized precision temperature forcing systems are typically used for hot and cold temperature testing of semiconductor, hybrid and other small components and assemblies in those application where tri-temperature component handlers are either unavailable or inappropriate due to the low volume nature of the application. The T-2600BV is a bench-top sized PTFS that retains many of the important features of our full-sized units. Typical applications of the T-2600BV may include research and development, product engineering, quality assurance or production test.

Features that make the T-2600BV a unique vehicle for the aforementioned are its small footprint, integrated support arm and the use of *Vortex Technology.* The benefits of these features are listed in the following table:

Feature	Benefit
Small footprint:	The system measures only 18 X 22 inches (46cm X 56cm), requiring very little floor space and allowing it to be easily placed on work benches or counter tops.
Integrated Support Arm:	Provides easy positioning and precise placement of the thermal test head over the Device Under Test (DUT). Assures excellent integration of the DUT with the air stream for effective temperature control.
Vortex Technology: (See the *Functional Theory* section of this manual for details on Vortex Technology)	Enables the system to reach cold temperatures without standard mechanical refrigeration or LN_2. Provides a lower cost of operation and fewer servicing issues.

Table 1 - 1, Features and Benefits

The features which the T-2600BV shares with Thermonics' other PTFS models include:

- Easy to adjust integrated support arm and thermal test head
- Standard, IEEE-488 and RS-232C remote interfaces
- Automatic temperature cycling
- DUT sense temperature control
- Password protection of system setups
- Reliable operation with high MTBF.

Figure 1 - 1, T-2600BV PTFS

Technical Support

Technical questions about the T-2600BV can be directed to Thermonics Customer Service department:

Thermonics Inc.
1288 Reamwood Ave
Sunnyvale, CA 94089-2233

Telephone: (408) 542-5900
FAX: (408) 542-5910
E-mail: info@thermonics.com
URL: www.thermonics.com

Training

Formal technical training is conducted at the Thermonics facility on a scheduled basis. One credit for training is provided with the purchase of each system. Credits are good for six months after delivery of the system. Training of additional personnel or on-site training can be arranged. The course covers the operating theory, maintenance and repair of the system. For additional information call, Thermonics Customer Service at the above contact number.

Spare Parts

Replacement parts for all electrical, mechanical and pneumatic components can be obtained directly from Thermonics Inc. Refer to the Maintenance Module for part numbers.

Repair and Service

Thermonics Inc. maintains a fully equipped repair center in Santa Clara, CA, U.S.A. The repair center provides warranty and non-warranty repairs and emergency spares support. For more information on repair and spare parts availability contact Thermonics' Customer Service Department.

User Repair

Important! All repairs to the system should be performed by qualified technical personnel Thermonics will aid in the repair or replacement of all components and assemblies as stated in the warranty, located on page 1 - 6.

You may contact Thermonics regarding service issues at the above contact information. Alternatively, you can E-mail the service department directly at:

service@thermonics.com

T-2600BV PTFS Specifications

The model T-2600 is designed to comply with the following specifications. The system has been factory tested to verify conformance.

FEATURES

- **Light, Compact, Portable**
- **Small Footprint**
- **Vortex Cooling**
- **Easy to Operate**
- **Lower Power Consumption**

GENERAL DESCRIPTION

Method of Cooling: Forced air with integrated vortex tube. No CFC based refrigerants are used.

Method of Heating: Forced air with in-line air heaters.

Operator Interface: Four-line, 80-character fluorescent display panel. Numeric keypad for data entry. Preset keys for setup data storage and retrieval.

Data Communications: Interfaces to ATE systems. Contains IEEE-488.2, RS-232C, and Standard Tester Interface. Software communication parameters are configurable to accommodate varying systems.

SYSTEM FEATURES

Temperature sensor: Device Under Test (DUT), K-type and T-Type thermocouples. Also, K-type thermocouple for air temperature.

Controller: Microprocessor-based PID (Proportional Integral Differential).

Fail safes: Snap-disc thermostats, air flow sensors and thermocouples.

PHYSICAL CHARACTERISTICS

	Height (in/cm)	Width (in/cm)	Depth (in/cm)	Weight (lbs/kgm)
T-2600	8/20	18/46	22/56	50/23

TEMPERATURE PERFORMANCE

	Range (°C)	Accuracy (°C)	Stability (°C)	Displayed Resolution (°C)	Transition[1] Time (sec)
T-2600	-30–225	±1.0	±0.3	0.1	15

[1]Transition time measured after system stabilization in cycle mode. Temperature set-points of +100C to -5C.

Maximum cold specifications are for room ambient temperature of 77°F (25°C), or lower, using 60Hz power. Cold temperature specifications are degraded 5°C for 50Hz operation. [1]Transition time is between +100°C and -40°C; air temperature measured at air output nozzle. Measured in temperature cycle mode after system stabilization with a 10-second soak time, or less, at each temperature.

ENVIRONMENTAL REQUIREMENTS

Ambient Temperature Range: 15°C to 26°C
Relative Humidity: 20 - 65%

POWER REQUIREMENTS

	Volts[1]	Hertz	Phases	Amps
T-2600	110–120	50/60	1Ø	20

[1]Note: Optional 200 to 240 volts available.

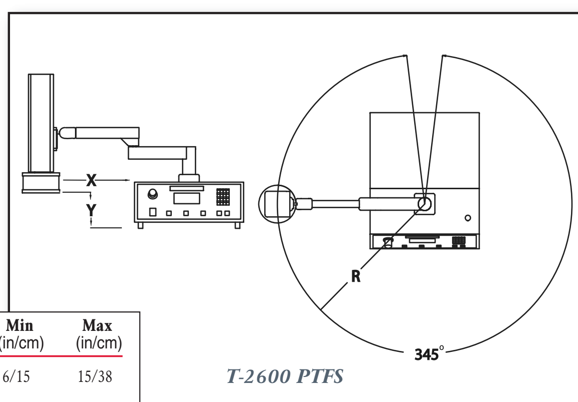
AIR INPUT REQUIREMENTS

Pressure: 80-110 PSIG (6.4 - 8.5 Kg/Cm^2)
Flow Rate: 15 SCFM (7.15 liters/sec)
Dew Point: Less than -40C at 90 PSIG (6.4 Kg/Cm^2)*
Quality: Clean air; free of oil, moisture and particles

*This can be achieved using Thermonics' T-ADF/BV air dryer.

AIR FLOW

T-2600 300 to 900SCFH (2.4 - 7.08 liters/sec) hot operation. 300SCFH cold.



	Min (in/cm)	Max (in/cm)
X	6/15	15/38
Y	0/0	12/30

T-2600 PTFS

Warranty

The T-2600BV Precision Temperature Forcing System has been manufactured according to high reliability and quality standards. The system is warranted to be free of manufacturing defects (materials and workmanship) for a period of one year from the date of shipment. If the system fails during this period of time, Thermonics will repair the unit free of charge (labor and materials) provided the following conditions have been met:

1. The system is installed, operated and maintained in accordance with the operating and maintenance specifications included with this equipment.

2. The system has not suffered accident, misuse, neglect, improper movement or storage.

3. The system has not been modified or repaired without prior written permission of Thermonics.

This warranty shall be considered void if the above conditions (1, 2 & 3) have not been met.

If a defect in the system does occur, the customer should take the following steps:

1. Contact Thermonics's Customer Service Department. Provide the service representative with model and serial number of the system and then describe the nature of the problem to the representative. You will be given information on corrective actions, shipping instructions, or the cost of repair for non-warranted items. Do not ship the system to Thermonics Service Center without prior authorization from a Thermonics Service Representative. Repair of the T-2600BV can generally be accomplished on site, and very rarely requires the return of the system.

2. Depending on the severity of the problem, and in order to speed the repair, the representative will give information on corrective actions that may include the following:

   a. On-site repair

   b. On-site repair by a Thermonics Service Representative

   c. Shipment of a subassembly to the Thermonics Service Center.

d. Shipment of the entire PTFS to Thermonics's Service Center

Prior to shipping the system, carefully pack the unit for shipment using the original containers and packing materials. If they are not available, use a strong container with several inches of shock absorbing material, or ship by padded van. Always contact Thermonics for detailed shipping instructions.

Thermonics will makes every effort to assist/perform any necessary repairs to enable the system to be running as quickly as possible.

UNPACKING AND INSTALLING THE T-2600BV

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UNPACKING AND INSTALLING THE T-2600BV

Introduction

This chapter describes the procedures for unpacking the T-2600BV and connecting the air and power sources. The instructions for setting up the system for operation can be found in the Chapter 3: *Operating the PTFS*.

Shipping Configuration

The PTFS is crated for shipping. After receiving the unit, inspect the container for freight damage. Note any damage. The unit is packed in a foam enclosure. Remove the foam and carefully unpack the T-2600BV and all associated accessories. Inspect all contents for discrepancies or damage. If any freight damage has occurred, contact both the shipper (the Freight Company) and Thermonics. We are not responsible for freight damage, but will work with you and the Freight Company to solve the problem in an efficient manner.

Connecting the Air and Power Sources

The PTFS requires a supply of compressed air and electrical power to function. Use the following instructions to connect the system to the air and power sources:

1. Connect the air source to the rear panel fitting labeled "GAS INPUT". Use a 3/8-inch OD (outer diameter) air supply line with a 1/4 inch ID (inner diameter).
2. Turn the power switch on the front panel to the "OFF" position.
3. Connect the power cord to a standard, grounded three-prong outlet.

The specific requirements for the gas and power are as follows:

Air:
90 to 120 PSIG (6.4 to 8.5 Kg/cm^2) compressed air with a minimum flow capability of 18 SCFM (8.6 liters/sec). The air supply should be industrial grade, free of oil and particles or excessive moisture. The dew point should be less than: *-85C at 90 PSIG (5.7 Kg/Cm^2).*

Note: If the source air does not meet these specifications, the optional air dryer should be installed. An air source that is too wet can cause frost or moisture problems, which can impair the functioning of the PTFS or contaminate devices during test by expelling moisture from the thermal test head. (See *appendix of this manual*.)

Power:
110VAC to 120VAC, single phase, 50/60 Hz, a 20A.

Note: 220VAC, single phase, 15A, 50/60 Hz is available as a system option.

a. Air Input Connector

b. Input Air Pressure Gauge

c. Circuit Breaker

d. Purge Air Flow Control

e. RS-232C Port

f. Standard Tester Interface Port

g. Foot Switch Port

h. IEEE-488 Port

Figure 2 - 1, T-2600 Rear Panel

OPERATING THE T-2600BV

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OPERATING THE T-2600BV

Introduction

This chapter describes how to operate the T-2600BV PTFS. It covers the following subject matter:

- Front and rear panel controls, indicators and interfaces
- Manipulation of the arm and thermal head
- Physical setup of the system for use in testing devices
- Configuration of the PTFS's operating and system parameters
- Manual operation of the T-2600BV
- Automatic Temperature Cycling
- Menus, messages and alerts that appear on the alphanumeric display

NOTE: This chapter covers operation of the PTFS from the front panel. Control of the system is also possible via remote interfaces such as IEEE-488 and RS-232C. See the Chapter 4: *Remote Operation*, for further details.

The T-2600 is a very flexible system that you can configure to operate in a variety of environments. How you set up the PTFS depends on the tests you wish to perform and the type of device you want to evaluate. The parameters you enter may be as simple as a single test temperature or as complex as a series of profiles with various test temperatures, soak times and temperature ramp rates. Reading this chapter provides you with an overview of the system's configuration items that you can access and modify for your specific testing requirements.

Front Panel Controls and Indicators

End user interaction with the PTFS primarily occurs using controls on the system's front panel. The front panel comprises the following elements:

- Main Power Switch
- EMO Switch
- Numeric Keypad

- Cycle Control Key
- Local/Remote Key
- Temperature Preset Keys (T1, T2, T3)
- Hot Air Flow Rate Adjust

See the adjacent illustration (Fig. 3 - 1) for the location of these items on the front panel. A brief description of the functions and uses of these controls appears below.

Main Power Switch

The main power switch turns the system on or off. When the switch is in the **on** position, it illuminates. Upon activation of the switch, the alphanumeric display panel illuminates and presents relevant text-based information related to system initialization. (This assumes power is available, the circuit breaker is in the *on* position and the EMO is not active.)

Alphanumeric Display

The display is a four line, 20-character fluorescent panel. The system presents status information, error messages, configuration items, menus and operator prompts as appropriate for end-user control of the PTFS. Use the *SET, ENT* and arrow keys on the numeric keypad to navigate through the menus that appear on the display panel.

EMO Switch

The emergency off switch (EMO) trips the circuit breaker and shuts off all power to the system at the rear panel. Activate it by pressing it down. It is primarily a safety feature - do not use it as an on/off switch. After activation, reset it by rotating it clockwise until it pops up into the non-activated position.

Numeric Keypad

The keypad enters numeric data into the system. The main body of the keypad contains the characters "*0*" through "*9*" (numerals) and the "." (Decimal point) and "-" (minus) keys. Additionally, the keypad contains the *ENT, SET* and "< >" (arrow) keys that you use to navigate through the menus, select menu items and store information.

Temperature Preset Keys

The system can store three pre-configured temperatures (presets) using the *T1*, *T2* and *T3* keys. The presets can include a single test temperature, ramp rate, soak time, and ATE setting.

Cycle Control Key

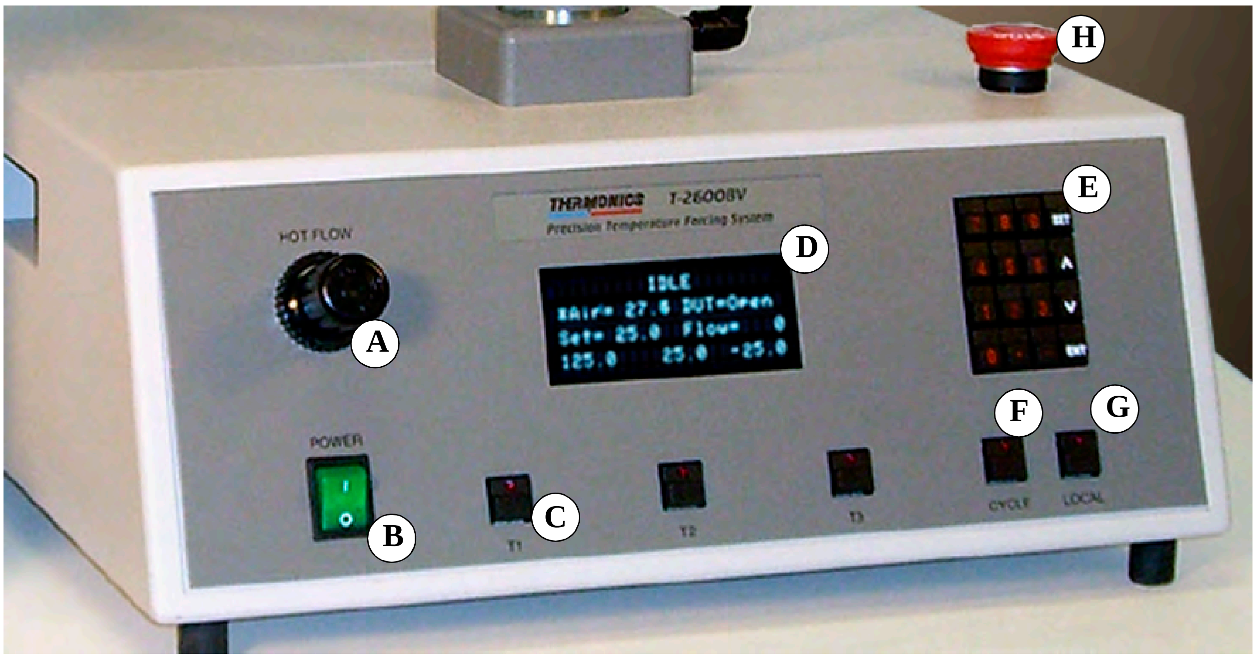
Use the cycle key to access the portion of the software where you set up cycle parameters and to activate temperature cycling. The cycle portion of the software enables you to set up a sequence of test profiles that automatically initiate in a continuous manner. As with a temperature preset (above), a test profile contains parameters such as a temperature setpoint, ramp rate, soak time and ATE setting.

Local/Remote Key

Toggles the system between remote communication and local operation. Remote communication includes the RS-232C and IEEE-488 communication protocols.

Air Flow Rate Adjust

Use this knob to adjust the rate of hot air flowing through the thermal head. The flow rate appears on the display panel in standard cubic feet per hour (scfh). Due to the nature of the vortex mechanism, cold airflow presents as unregulated, full-force air.



A	Hot Airflow Control
B	Main Power On/Off Switch
C	Temperature Preset Keys
D	Alphanumeric Display Panel
E	Alphanumeric Keypad
F	Cycle Control Key
G	Local/Remote Key
H	Emergency Off Switch (EMO)

Figure 3 - 1, Front Panel Controls and Indicators

Rear Panel Interfaces

The rear panel of the T-2600BV is the principal location where the PTFS interfaces to external resources. These include power and air sources and remote communication ports. The main elements of the rear panel are the:

- Circuit Breaker
- Input Air Pressure Gauge
- Gas Input Connector
- RS-232C Port
- IEEE-488 Port
- Foot Switch Port
- Tester I/O Port

Below is a brief description of these rear-panel features.

Circuit Breaker

20 ampere circuit breaker. Shunt trip with auxiliary switch. Trips when the EMO is active. **Note**: when the breaker is in the *off* position, 110VAC is still accessible at the rear panel. Unplug the system and use standard lockout tag-out procedures when servicing the system.

Input Air Pressure Gauge

This gauge displays the currently measured input air pressure. The input air specification is 90 to 120 PSIG. Flow rate of 15 SCFM (7.5 liters/sec). Dew point less than 10C at 90 PSIG.

Gas Input Connector

This is the location for connecting to the facility air source. The air input is a 1/4 inch NPT connector with a male quick disconnect fitting. (See chapter 2 for instructions on integrating your air source with the PTFS.)

RS-232C and IEEE-488 Ports

These ports enable the PTFS to communicate with computers, other machinery, and test equipment. The communication protocols available are RS-232C and IEEE-488.2 interfaces. Using these interfaces, the PTFS can be communicated with, statused, and controlled in various ways. Find further details the chapter: *Remote Interfacing*.

Foot Switch Connector

This connector enables use of a foot switch (Thermonics part number T-FSW) with the T-2600BV. This optional control device is available for any model PTFS that uses a pneumatic head lift. The switch provides hands-free operation of the system by enabling the end-user to toggle the position of the thermal head, relative to the DUT, by stepping on the pedal.

Tester I/O Port
This port enables the system to make use of start-test signals (STS) and end-of-test signals (EOT) for interfacing with automatic test equipment (ATE) systems.

Purge Air Adjust
Use this knob to regulate the flow rate of purge air.

Purge Air Connector
Connector for purge air source. Connect air hose for purge air here and direct to required location(s). Fitting is push-type quick connect for .25 inch (.635cm) OD hose.

a. Air Input Connector

b. Input Air Pressure Gauge

c. Circuit Breaker

d. Purge Air Flow Control

e. RS-232C Port

f. Standard Tester Interface Port

g. IEEE-488 Port

h. Purge Air Line Connector

i. Foot Switch

Figure 3 - 2, Rear Panel

Positioning the Arm and Thermal Head

The system has an adjustable arm and test head that enables you to direct the flow of temperature-controlled air to the DUT. The arm and head assembly is designed with several degrees of freedom that permit placement of the test head in various vertical and horizontal positions. You can further adjust the location of the thermal test head by extending or contracting the arm at the elbow or rotating the head at the wrist.

Control the vertical position (height) of the arm using the elbow clamp. To raise or lower the arm, loosen the elbow clamp and then pivot the arm up or down at the elbow. Reset the clamp when you achieve the desired height to ensure stable positioning.

Control the horizontal position (length) of the arm by rotating it at the elbow. First make sure that the test head is in a raised position, and then loosen the elbow or base clamp. Bend the arm inward toward the base to reduce the extended distance of the arm. Rotate the arm at the elbow away from the mast to extend the arm. Make sure to fully tighten the elbow clamp to hold the arm in the desired position. You can make further adjustments to the position of the arm using the clamp at the arm base.

Rotate the thermal test head at the wrist to adjust the vertical alignment of the head. Loosen the wrist clamp to position the head and then tighten in place.

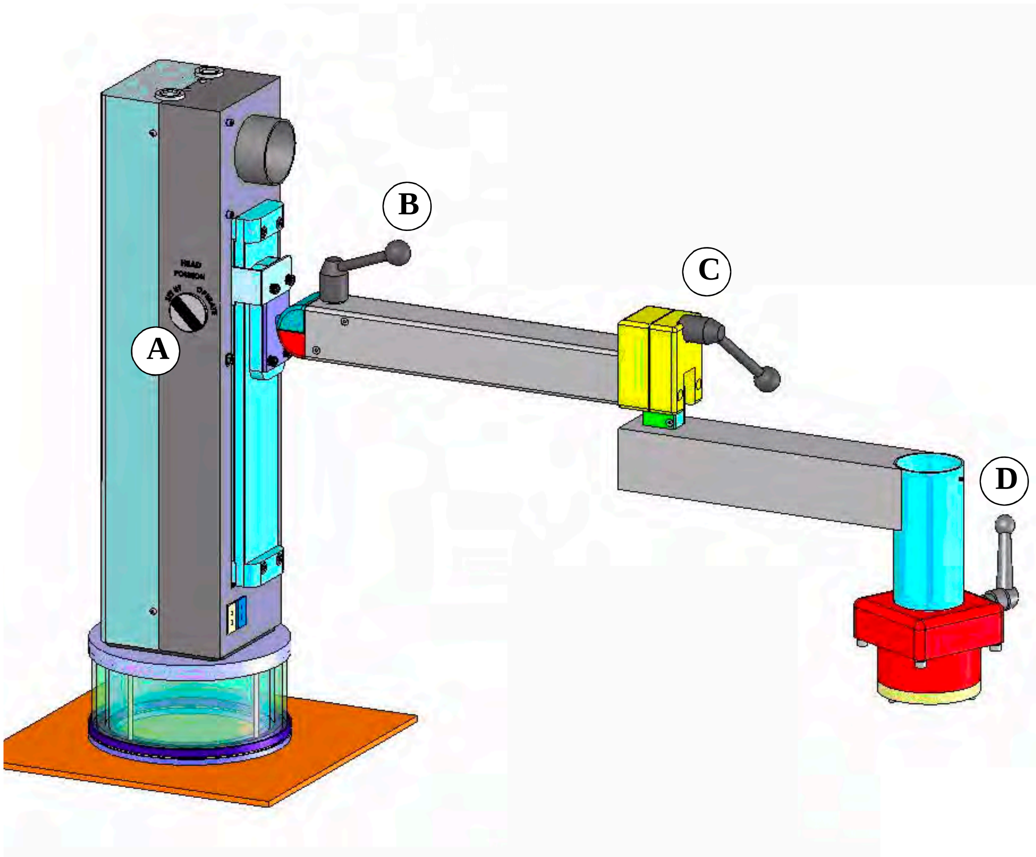
Raising or Lowering the Test Head

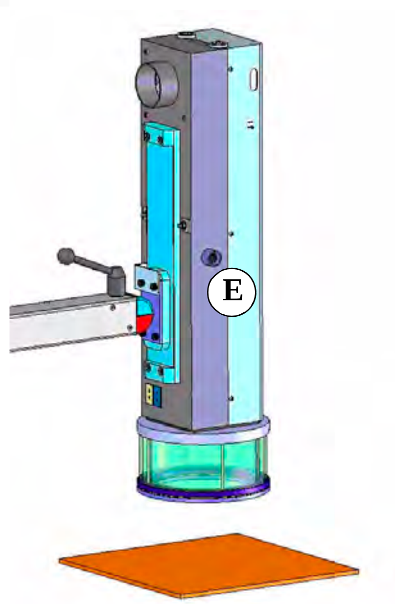
To raise or lower the thermal head, press the head up/down button located on the right side of the test head case. Pressing the button toggles the position of the test head up or down, relative to its current position using a pneumatic bearing.

Caution: make sure that your hands are clear of the rear test head bearing when changing the position of the head.

Alternative Methods for Changing Head Position

The thermal test head can be raised or lowered using other techniques as well. One technique is to use a footswitch pedal (Thermonics' part number T-FSW. See Foot switch connector, on page 3 - 4). Another technique is to make use of an automatic feature embedded in the system software. This feature controls the up/down status of the head at the end of an automatic temperature cycle. Use the Configuration Menus to set up this type of functioning. See Configuration Menu Parameters, on page 3 -16. Remote communication commands can also be used. See Chapter Remote Operation.





a. Head Position Mechanism (aka “Travel Force Wheel”)

b. Wrist Clamp

c. Elbow Clamp

d. Base Pivot Clamp

e. Head Up/Down Switch

Figure 3 - 3, Arm/Head Adjustments

Ensuring a Proper Seal of the Shroud

The shroud is the circular glass enclosure located at the bottom of the thermal head, which along with the thermal boot, enables the development of a uniform temperature environment. For effective testing, it is important to position the intersecting face of the shroud against the test site surface so that an "air-tight" environment is created. The head's feature for ensuring an adequate seal is the integrated head position mechanism.

Head Position Mechanism

The head position mechanism is a built-in thermal-head feature that ensures the physical adjustment of the thermal head position is adequate to produce a good seal of the shroud against the test site surface. It accomplishes this by making a small adjustment (overdrive) to the downward travel distance of the thermal head so that the shroud exerts increased physical pressure against surface (which is usually foam insulation). This adjustment is made during physical setup of the system via the two-position travel force wheel located on the side of the thermal test head.

Using the Head Position Mechanism

To make this adjustment begin with the head in the upward position by pressing the head up/down switch, located on the side of the thermal head. Turn the travel force wheel to the setup position (rotate left) and press the up/down switch again to lower the head. Adjust the head and arm position as appropriate to contact the surface of the glass shroud against the test site surface. The next time the head is raised, the travel force wheel will automatically return to the operating position - the system is now properly adjusted. (See detailed procedure in Appendix E - 1.)

Head Adjustment Procedure

1. Power on the system.
2. Raise the test head by pushing the Head Up/Down button.
3. Turn the Travel Force Wheel to the "Set Up" setting.
4. Press the Head Up/Down button again to drop the test head.
5. Loosen all three clamps on the arm.
6. Manually adjust the arm and test head to align the glass shroud against the test site at the desired location.
7. Adjust the test head to sit level on the test site by centering the bubble in the leveling indicator. Tighten the clamp to lock the test head into level position.
8. Tighten all the remaining clamps to hold the arm in place.
9. Push the Head Up/Down Button to raise the test head.
10. The Travel Force Wheel will automatically rotate to the "operate" setting. The head is now adjusted.

Physical Setup for Operation

Position the PTFS in a location with easy access to the required air and power sources. Make sure that the surface the T-2600BV rests on is stable and has room for the DUT socket fixture and test head.

Follow these guidelines:

1. *Connect the ac power*. Make sure that the power switch on the front panel is in the "off" position and the main circuit breaker on the rear panel is in the "on" position. The power cord is equipped with a standard 110VAC three-prong connector. (Note: optional systems can be ordered with different power ratings - so be sure you are aware of any system modifications.)

2. *Connect the air supply*: The air input line attaches to the 1/4 inch NPT gas fitting located on the rear panel. View the pressure gauge on the rear panel to verify that air pressure is within specification when air is flowing.

3. *Attach the Thermal Boot*: The PTFS is equipped with five boots that help integrate the temperature-controlled air with the device under test. The boot attaches to the air outlet nozzle on the thermal head. Choose the boot that has the appropriate dimensions for the device you wish to test.

4. *Connect the DUT sensor*: If needed, connect the DUT sensor to the system. Place the DUT sensor thermocouple bead between the device and the test socket. The thermocouple connectors are located on the thermal test head. Type T or K connectors are provided.

5. *Connect remote interfaces*: If remote operation of the system is desired, connect the appropriate interface cable for the ATE to the PTFS. The IEEE-488 and RS-232 connectors are located on the rear interface panel. (See Chapter 4, *Remote Operation* for more details.)

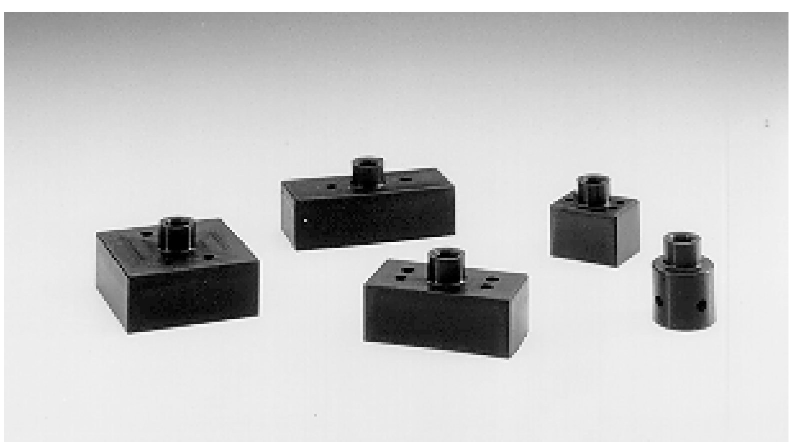


Figure 3 - 4, Thermal Boots

Note on Air Quality
To achieve best performance of the system, make sure the air quality requirements are met. Air saturated with oil, water vapor, or particles will cause degraded performance of the system. Inadequate air pressure will produce poor temperature transition performance.

Air	90 to 120 PSIG (6.4 to 8.5 Kg/cm^2) compressed air. Minimum flow capability of 18 SCFM (8.6 liters/sec).
Power	110VAC to 120VAC, single phase, 50/60 Hz, a 15A.

Table 3 - 1, Air and Power Requirements

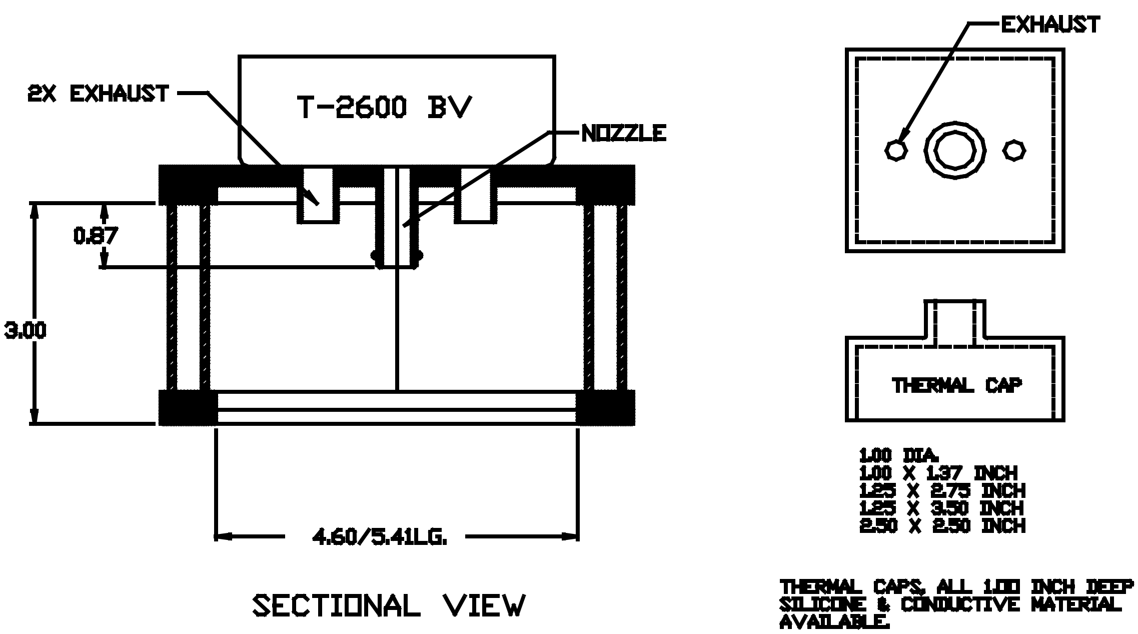


Figure 3 - 5, Thermal Fixture Dimensions

System Startup

Power up the system by toggling the power switch to the "on" position. Upon power up the display panel illuminates and the system performs a series of self-diagnostic tests. If it detects **no** errors, three screens present in sequence that display the system status. The first screen displays the current model type of the PTFS and the revision number and date of the control software (A). The second screen displays messages related to the initialization and status of relevant PTFS subsystems: processors, electronics, and firmware (B). The third and final start-up screen displays a summary of the system's current operating configuration and temperature control mode (C). The system is now in standby mode waiting for operator input.

If the system detect errors, a message displays on the panel. To re-test for the error, turn the system off and restart it. If the message returns, contact the system manager or review the error in the Maintenance portion of this manual.

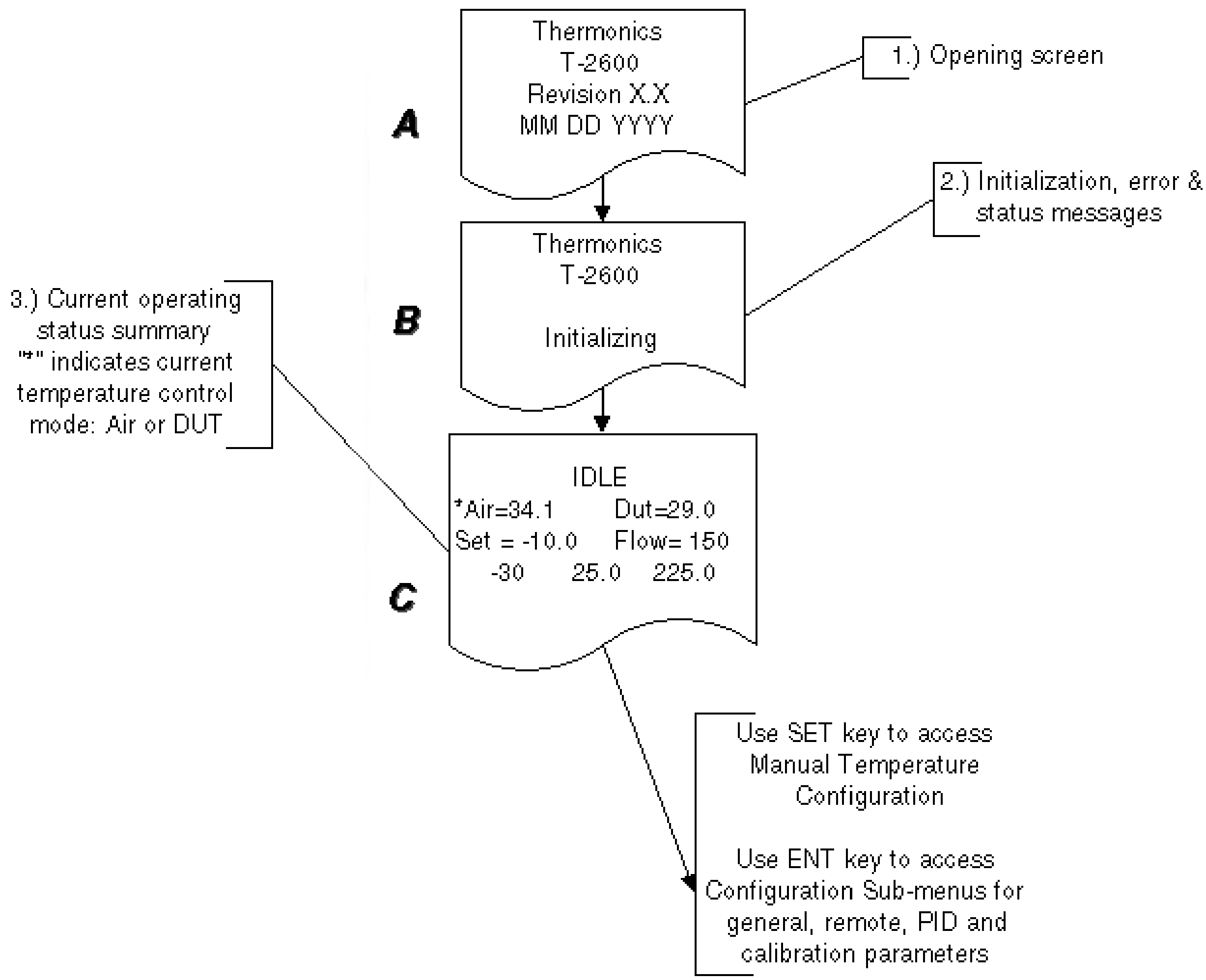


Figure 3 - 6, Start-up Screens

Overview of the Operator Interface

The operator interface presents on a four line, 20 character fluorescent panel. The panel displays status information, error messages, configuration items, menus and operator prompts as appropriate for end-user control of the PTFS. The primary screen that appears on the panel is the Main Status Screen. (See, Figure 3 - 1, Front Panel Controls and Indicators.)

Main Status Screen

The Main Status Screen (Screen 3 in adjacent illustration, Figure 3 - 6) appears on the display panel after proper initialization of the system. The information that presents on the screen summarizes the system's current operating status, the current temperature and flow rate, and various configuration parameters. The four lines of text-based information on the Main Status Screen provide the following specific information:

Line	Displayed information
1.	Messages that appear on this line relate to the current operating status of the system. The messages range from error conditions and alerts to temperature and cycle status messages.
2.	The real-time temperature reading of the fixture or DUT sensors. The "*" (asterisk) character denotes which sensor (Air or DUT) is currently in use for temperature control.
3.	The temperature setpoint the system is implementing and the current airflow rate.
4.	The manual temperature setpoints pre-configured for front panel keys T1, T2 and T3.

Table 3 - 2, Main Screen Information

Traversing, Selecting and Configuring Menu Items.

The Main Status Screen is the entry point to the system software (See diagram of the system software architecture on pages 3 - 14, 15) There are two main segments to the software that you can access from this screen, these are:

- *Manual control segment*: Where you enter manual temperature presets and temperature cycling parameters. To access the manual control segment press the **SET** key when the Main Status Screen is invoked. (See *Manual Operation of the PTFS*, for more details.)

- *System configuration segment*: Where you set up temperature control, operating, communication and calibration parameters. To access the system configuration portion of the software press the **ENT** key when at the Main Status Screen. (See *System Configuration*, below.)

In addition to accessing the main software segments from the Main Status Screen, the SET, ENT and < > arrow keys are used to navigate through the remaining system software submenus. In general, the keys function on all other screens as follows:

Key	Function
SET	Toggles or selects a menu item. Parameters are usually in the form of numeric ranges, yes/no toggles, or list items.
ENT	Enters numeric after it is input using the numeric keypad.
< >	Scrolls up and down an index of menus items.
Alternate key uses	Some keys have additional functions as follows: A second press of the ENT key exits you from the current menu up one level. Pressing the T2 key while in any submenu returns you to the Main Status Screen. Also, additional uses of the arrow keys are as a backspace key when entering numeric data or to increment the temperature of a preset by +/- 0.1 during operation.

Table 3 - 3, Front Panel Key Functions

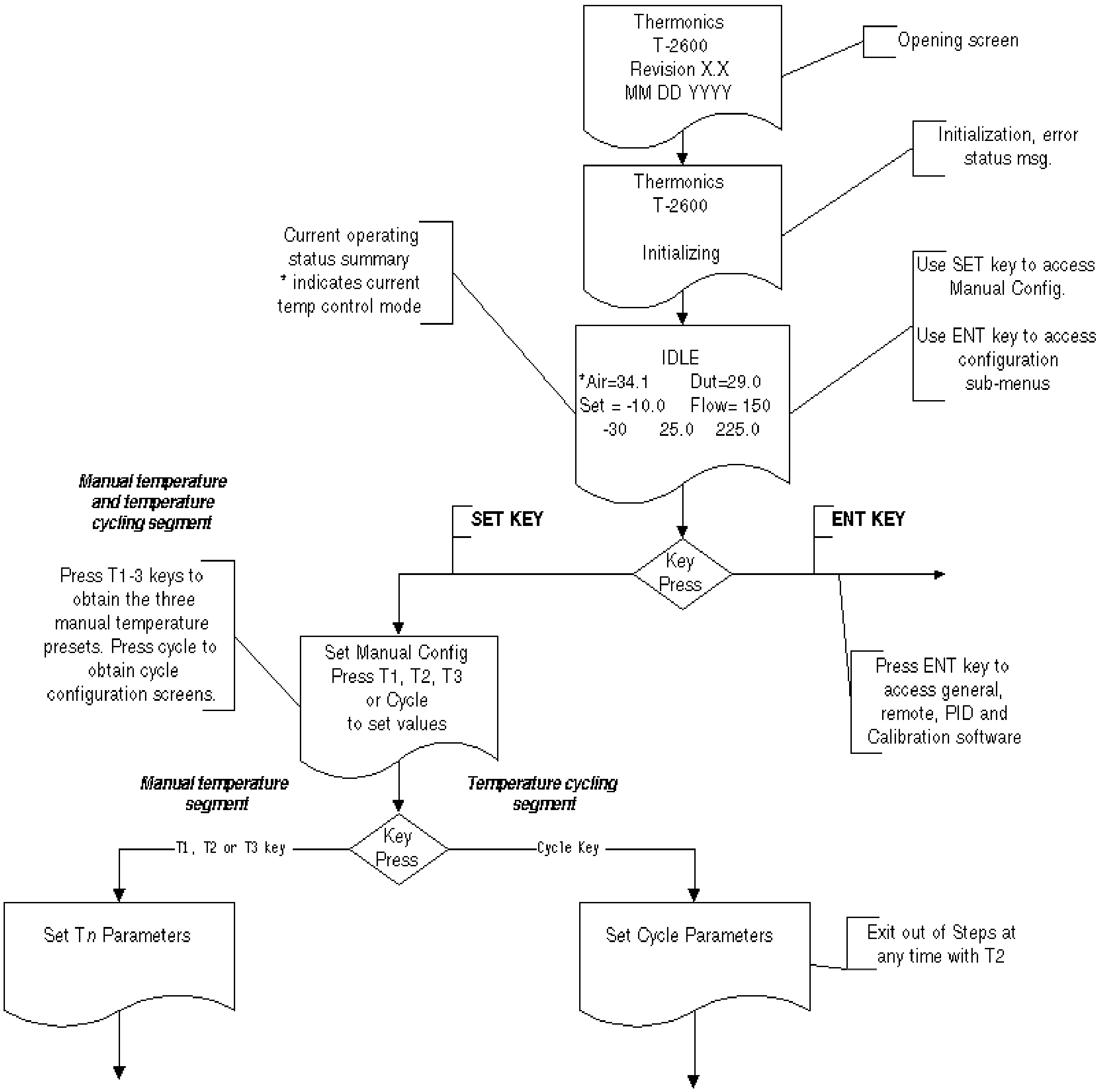


Figure 3 - 7, Software Flow: Panel 1 of 2

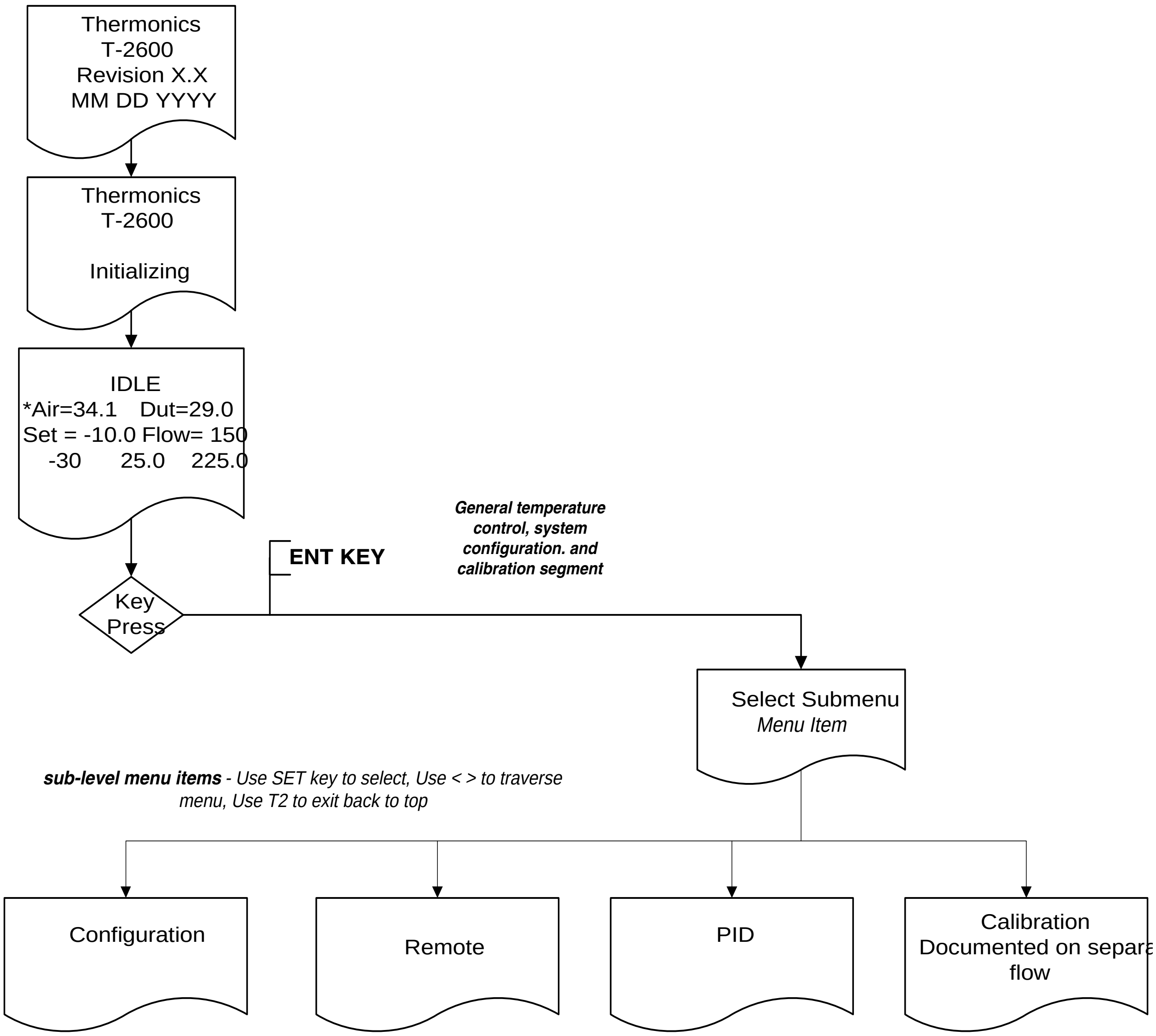


Figure 3 - 8, Software Flow: Panel 2 of 2

System Software Configuration

The system configuration software segment is where you enter parameters that control the functioning of the PTFS. Access this part of the control system by pressing **ENT** when the Main Status Screen is active. Four top-level menus are available. Use the arrow keys on the numeric keypad to cycle through the menu list. Use the **SET** key to select a specific menu item. The four main menu items available are:

1. ***Configuration*** - Where you set up a wide range of operating parameters related to how the system functions. These include parameters that affect the functioning of the test air temperature, thermocouple type, and the position of the thermal test head during temperature cycling.
2. ***Remote*** - Provides access to parameters that affect system communication. These include IEEE-488.2, RS-232C and test signals. Also located within this menu is the password protection feature.
3. ***PID*** - Accesses a series of menus that enable you to modify the specific parameters of the temperature control system. (The factory presets for these parameters should be sufficient for your temperature testing requirements. Modifying them is not recommended.)
4. ***Calibration*** - Provides access to a series of screens that guide you through the temperature and air calibration procedure.

Each parameter of the Configuration menu is discussed below. The System and Calibration menus are discussed in the chapters: *Remote Communication* and *Calibrating the PTFS* respectively.)

Configuration Menu Parameters

The items within the configuration menu have the following functions:

1. *Max Air Temp* - The maximum hot air temperature the device is exposed to during hot testing. Use it to ensure that the system does not force air at a temperature that may damage the test device.
2. *Hot/Cold Changeover* - Determines the temperature at which the system distinguishes between a hot and cold temperature.
3. *Head Down Air Delay* - The amount of time the system pauses before forcing air when the head moves to the down position.

4. *Soak Timer* - A yes/no toggle that affects the action of the soak timer. *Yes* means that if the system drifts out of temperature after the soak timer clock has started the count starts over again.

5. *Cool Down Air Temp* - Provides a burst of cool air to the test device before the thermal head lifts off it after a hot test. Ensures that the device is at a safe handling temperature. Use with Cool Down Air Time. (This feature activates when you press the head-lift button on the thermal head, or at the end of an automatic cycle if *head up at end of cycle* is selected.)

6. *Cool Down Air Time* - Specifies the amount of time a device is exposed to cool air after a hot test has terminated. A "0" (zero) in this field disables the cool-down feature.

7. *Warm Up Air Temp* - Provides a burst of warm air to the test device before the thermal head lifts off it after a cold test. Ensures that the device is at a safe handling temperature. Use with Warm Up Air Temp. (This feature activates when you press the head-lift button on the thermal head, or at the end of an automatic cycle if *head up at end of cycle* is selected.)

8. *Warm Up Air Time* - Specifies the amount of time a device is exposed to warm air after a cold test has terminated. A "0" (zero) in this field disables the warm-up feature.

9. *Start Cycle when Head Down* - A yes/no toggle that determines when the system begins forcing air. *Yes* indicates that the system will immediately begin a temperature cycle (forcing air) when the thermal test head moves to the down position. *No* requires you to press the CYCLE button to begin an automatic control cycle. (See *Automatic Temperature Cycling*, later in this chapter.)

10. *Head up at end of Cycle* - Yes/No toggle to determine if the thermal test head lifts when an EOT signal is received or when an automatic control cycle terminates.

11. *Temperature Stability Factor* - Use this field to modify the stability factor for a DUT. The stability factor scales the PID parameters used for temperature control based on the mass of the DUT.

12. *Temperature Window* - The number you enter in this field specifies the resolution window around the temperature setpoint at which the system is considered to be at temperature.

13. *Thermocouple Type* - A toggle where you select the type of thermocouple the system is using to sense the temperature. Choices are *T* and *K* type.

Changing a Configuration Item

Change or modify configuration items in the following manner:

1. With the Main Status Screen invoked, press **ENT** to access the system configuration software segment.
2. Use the arrow keys to scroll through the menus until *CONFIGURATION* displays.
3. Press the **SET** key to enter the Configuration Menu.
4. Use the < > keys (arrow keys) to scroll through the list of configurable items in either direction.
5. For menu items that require numeric input, use the numeric keypad followed by a press of the **ENT** key. Use the < > keys to move to the next menu.
6. If the menu item is a toggle or list item, use the **SET** key to scroll to the desired value (yes/no etc.). Use the < > keys to move to the next menu.

Example of a Configuration Change

The ensuing example illustrates the procedure for making configuration changes to the T-2600 PTFS in a step-by-step manner. For illustrative purposes, the system will be configured to do the following:

- Use a T-type thermocouple to monitor the device temperature.
- Ensure the device is at the test temperature for the required time interval by restarting the soak timer if it drifts out of the temperature range.
- Protect the device from extreme temperatures by setting the maximum hot air the system will output to 190C.

1. Beginning at the Main Status Screen, press the **ENT** key to access the system configuration menus.
2. Use the arrow keys to select *CONFIGURATION* from the menu list and then press the **SET** key to enter into the menu.
3. Use the < > keys to scroll through the configuration menu list to select *Thermocouple Type*. Use the **SET** key to toggle between *Type: K* and *Type: T.*
4. Now use the < > keys to scroll through the configuration menu list to *Restart Soak-timer?*. Use the **SET** key to toggle to *Restart*: *Yes*.

5. Use the < > keys to scroll through the menu list to *Max Air Temp*. Use the numeric keypad to enter *Temp = 190C*. Press the **ENT** key.

6. Press the **ENT** key twice more to return to the Main Status Screen.

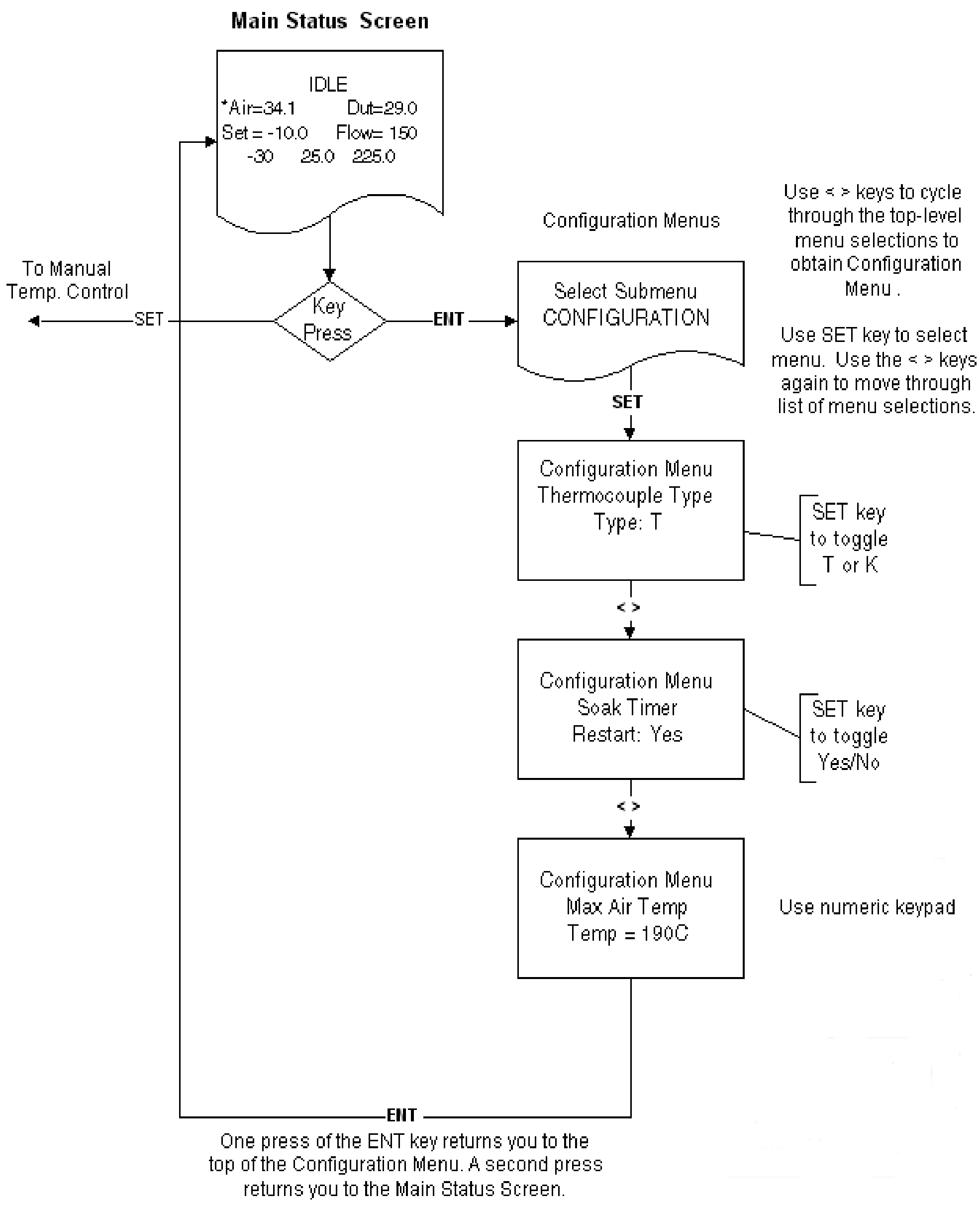


Figure 3 - 9, Example Configuration Change Flow

Operating Modes of the PTFS

You can operate the T-2600BV in three ways: manually, automatically and remotely. These operating modes function in the following manner:

1. ***Manual Operation*** - Provides full operator control of the system by pressing buttons on the front panel. Using this type of control, the system does not change state, from hot to cold for example, unless you press a button (*Tn* key, etc.) on the front panel. (See following section.)
2. ***Automatic Temperature Cycling*** - Controls the system in a pre-programmed manner, performing a series of tests automatically. You enter a sequence of test criteria, such as temperatures and soak times, which are then performed in a continuous manner. (See *Automatic Temperature Cycling*, later in this chapter.)
3. ***Remote Operation*** - Enables you to control the system from a remote computer or other type of test equipment. Uses the IEEE-488 and RS-232C communication protocols. (See chapter, *Remote Operation of the PTFS*.)

Manual Operation

Manual operation occurs when you press key T1, T2 or T3 on the front panel. Upon pressing the key, the system forces air at the temperature specified in the Manual Operation Setup menus. A second press of the key toggles the temperature controlled air off and returns you to the Main Status Screen. The arrow keys increment the temperature setpoint +/- 0.1 degrees during operation.

The Manual Operation Setup menus are where you determine the temperature setpoint. Additional configuration items that present within these menus are: soak time, ATE use, ramp rate, and the temperature control technique. The significance of these menu items is outlined below:

1. *Temperature* - The temperature setpoint to achieve during testing. Acceptable temperature parameters range from -30 to 225C.
2. *Temperature Control* - How the system controls the temperature. Choices are ***air*** or ***DUT***. To control the temperature based on the temperature of the air in the thermal head, select *air*. To control the temperature based on the device temperature, specify *DUT*. **Note**: when you set this parameter for any one key (T1, T2 or T3), it changes this parameter for all three temperature preset keys.
3. *Soak Time* - The amount of time the device is exposed to air of a specific temperature. Acceptable soak times range from zero to 9999 sec. (Note: the *Soaktimer Restart* parameter, located in the Configuration Menus, determines how the clock functions if the device drifts out of temperature. See *Configuration Menu Parameters*, on page 16.)
4. *ATE* - Controls issuance of a Start Test Signal when temperature is achieved. *Yes/No* toggle.

5. *Ramp Rate* - The rate at which the system achieves the specified test temperature. This parameter determines the number of degrees per minute of temperature change. Acceptable parameters range from zero to 9999 degrees per minute. Zero indicates the ramp feature is off and the system achieves temperature at its normal rate.

Setting Manual Operation Parameters

Set or modify manual operating parameters in the following manner:

1. With the Main Summary Screen invoked press the **SET** key. The Manual/Cycle menu appears.
2. Press one of the temperature preset keys (*T1*, *T2*, *or T3*) to enter the Manual Operation Setup menu. The menu for input of the manual temperature parameters appears.
3. Use the < > keys (arrow keys) to scroll through the list of configurable items in either direction.
4. For menu items that require numeric input, use the numeric keypad followed by a press of the **ENT** key. Use the < > keys to move to the next menu.
5. If the menu item is a toggle or list item, use the **SET** key to scroll to the desired value (yes/no etc.). Use the < > keys to move to the next menu.
6. When finished entering all of the parameters, press the **ENT** key, the data for the parameters is then stored and you return to the Manual Operation Setup menu. A second press of the **ENT** key returns you to the Main Status Screen.

Manual Operation Setup Example

This example illustrates the procedures for making changes to the manual control setup menus in a step-by-step manner. For illustrative purposes, the system will be configured to do the following when the T1 key is pressed:

- Provide a temperature of 125C.
- Use DUT sensor for temperature control.
- Achieve the test temperature at a specific rate of five degrees per minute.
- Soak the device at temperature for two minutes and then initiate the test.

Set up the system in the following manner. (A flow chart of the steps is provided.)

1. From the Main Status Screen, press the **SET** key to obtain the Manual Control Software Segment.
2. The top-level menu for manual control appears. Press the **T1** key to obtain the configuration menus for that specific key.
3. Now use the **< >** keys to obtain the temperature input screen. Use the numeric keypad to enter a setpoint of 125C. Input the value by pressing the **ENT** key.
4. Move to the temperature control screen using the **< >** keys. Toggle the sensor type to *DUT* using the **SET** key. The system will now use the DUT temperature for control.
5. Move to the ramp rate control screen, using the **< >** keys. Enter *5* using the numeric keypad, followed by a press of the **ENT** key. The system will now change temperature at 5 degrees per minute.
6. Move to the soak time screen. Enter *120* seconds using the numeric keypad, followed by **ENT**.
7. Lastly, use the **< >** keys to obtain the ATE screen. Use the **SET** key to toggle the selection to *YES*. The system will now issue a start test signal after the two-minute soak time has elapsed.

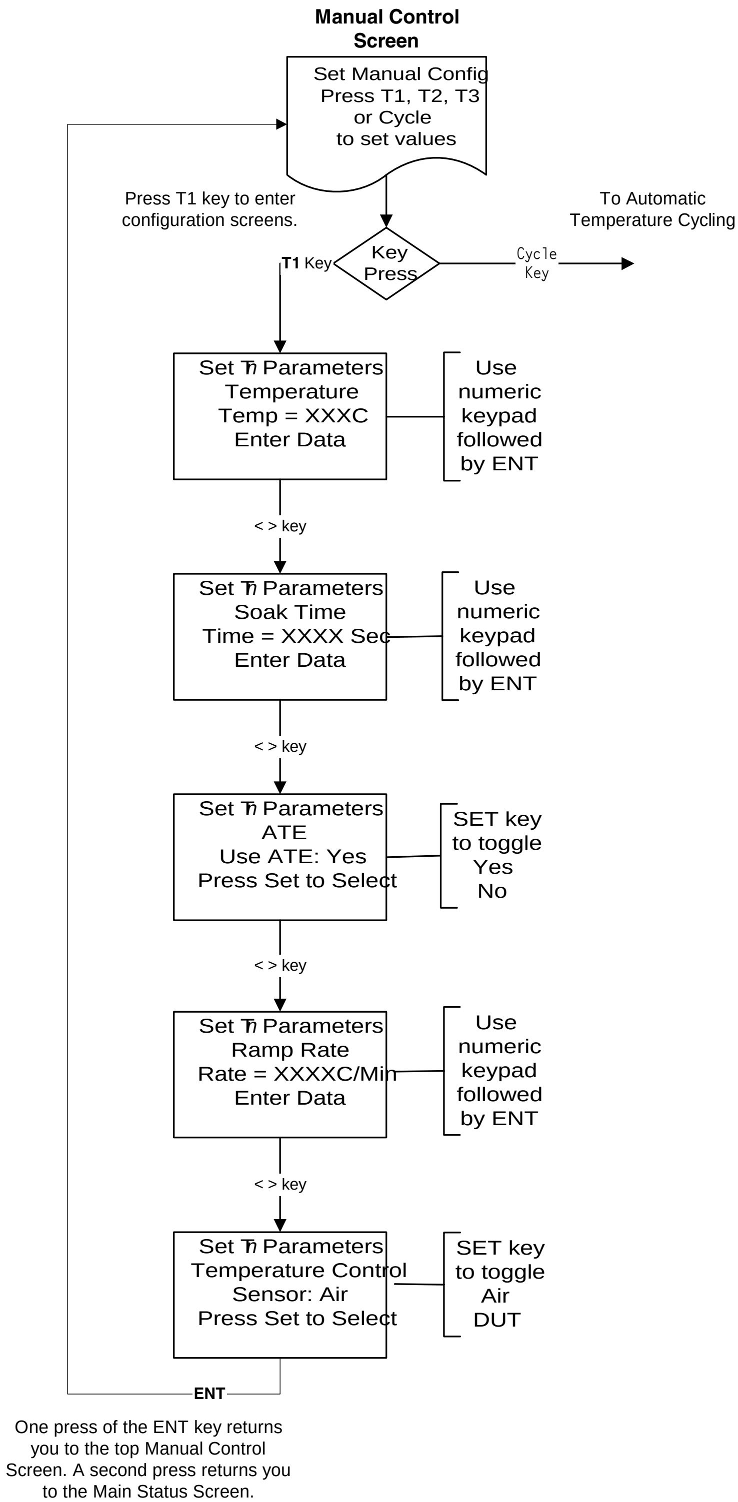


Figure 3 - 10, Example Manual Temperature Control Configuration Flow

Automatic Temperature Cycling

Temperature cycling enables the system to perform a sequence of tests automatically. It can be used to test individual components over a series of temperatures and to safely transition between temperature extremes that might be harmful to the test components. Up to 99 separate test temperatures with varying test criteria may be programmed and stored in the PTFS as *steps*. During an individual cycle, each step is invoked once in a sequential manner.

The system can be set up to cycle through each step continuously or between one and 999 times in sequence. When the system has finished the specified number of cycles it enters standby mode.

The data for the cycle is entered using the Temperature Cycling Setup menu, which contains the following elements:

1. *Number of Cycles* - The number of times each step is repeated in sequence. Can range from 0 to 999 times. A zero indicates continuous cycling.
2. *Temperature* - The temperature setpoint to achieve during a discrete step. Acceptable temperature parameters range from -30 to 225C.
3. *Soak Time* - The amount of time the device is exposed to air of a specific temperature during a step. Acceptable soak times range from zero to 9999 sec. (Note: the *Soaktimer Restart* parameter, located in the Configuration Menus, determines how the clock functions if the device drifts out of temperature. See *Configuration Menu Parameters*, earlier in this chapter.)
4. Use ATE? A yes/no toggle that determines if a start test signal is issued to the tester during a specific step. When *yes* is selected, the system waits for an EOT signal from the tester before moving to the next step in that cycle.
5. *Ramp Rate* - The rate at which the system achieves the specified test temperature during that step. This parameters determines the number of degrees per minute of temperature change. Acceptable parameters range from zero to 9999 degrees per minute. Zero indicates the ramp feature is off and the system achieves temperature at its normal rate.
6. *Last Step?* - A YES/NO toggle that you use to determine when you are finished entering step data (individual test sequences) into the system. As long as ***NO*** is selected, the system continues to prompt you for data to enter into a new step - incrementing the step count by one. When you have finished defining all required steps, select ***YES*** to end data entry and store the information.

Initiating Temperature Cycling

Activate temperature cycling by pressing the ***Cycle*** key on the front panel. The sequence of cycles that activate when you press the key is based on the parameters explained in the previous section.

Controlling Cycling by Thermal Head Position

You can set the system configuration parameters so that the position of the thermal head initiates the automatic temperature cycle. When the head lowers, the cycle will activate by itself without pressing the *CYCLE* key. Additionally, the head can be raised automatically at the end of the cycle. This style of functioning is set up in the Configuration Menus by selecting *yes* for both *Start cycle when head down* and *Head up at end of cycle*. (See "Configuration Menu Parameters" on page 16.)

Note: There are three ways to lower the thermal test head: 1.) Using the head up/down button located on the side of the head. 2.) Using the foot pedal switch (optional part T-FSW). 3.) Sending a remote command via a remote interface.

Entering Cycle Parameters

The software segment where you configure the cycle parameters has two basic parts. 1.) A screen where you determine the number of times to repeat each sequence of steps, which is the number of cycles. 2.) Data entry screens where you set up the specific parameters for each discrete step. Enter cycling parameters as follows:

1. Beginning at the Main Status Screen, press the **SET** key. The Manual/Cycle menu appears.
2. Press the **CYCLE** key on the front panel. The top-level menu for entering cycle parameters appears.
3. Enter the number of times you want the system cycle through each step. Use the numeric keypad to input the required number and then press the **ENT** key.
4. The temperature input screen appears. Use the numeric keypad to input the required temperature and then press the **ENT** key. Use the arrow keys to traverse the menus to enter the other parameters for that step (temperature, air sensor type, ramp rate, ATE and soak time.) Note: after entering the temperature, the system moves to the *Last Step?* screen, use the up arrow key to move to the screens for setting the other parameters.
5. To enter data for another step, set the *Last Step?* to *No* followed by **ENT**. To stop entering steps set the *Last Step* to *Yes*.
6. Note: If the *Last Step?* is set to *Yes*, pressing the **ENT** key returns to the top Manual/ Cycle menu.

Automatic Temperature Cycle Setup Example

This example illustrates the procedures for making changes to the cycle parameters setup menus in a step-by-step manner. For illustrative purposes, the system will be configured in a two-step cycle that activates when you press the ***CYCLE*** key. The cycle will repeat three times. The specific actions programmed into the system include:

- Test device at -20C using the air sensor.
- Test the device at + 125 using the air sensor.
- Do not issue a Start-Test-Signal when at temperature.
- Soak devices at each temperature for 1 minute.
- Perform the operation three times.

For the purposes of this example we will enter only one sequence. Assume the same steps are required to enter the second sequence.

1. From the Main Status Screen, press the **SET** key to obtain the Manual Control Software Segment.
2. Press the **CYCLE** key to obtain automatic the temperature cycling menus.
3. A screen appears where you set up the number of times to repeat each sequence (series of steps). Enter *3* using the numeric keypad followed by **ENT**.
4. Press the **ENT** key again to access the temperature setup screen. Use the numeric keypad to enter -20C, followed by pressing the **ENT** key. Move to the next field using the up < > key.
5. The temperature control screen appears. Set the temperature control parameter to air using the **SET** key. Move to the next screen using the up < > key.
6. The ramp rate screen appears. Enter a zero via the numeric keypad followed by a press of the **ENT** key. Move to the next screen using the up **< >** key.
7. The ATE screen appears. Use the **SET** key to toggle the selection to *no*. The system will not issue a start-test signal. Use the < > keys to move to the next screen.
8. The soak time screen appears. Enter a soak time of *60* seconds using the numeric keypad followed by **ENT**. Use the **< >** keys to move to the next screen.
9. The *Last Step?* screen appears. Use the **SET** key to toggle the answer to *no*. You will be taken to the top sequence screen where you enter the second sequence that includes a temperature of 125C. When finished entering the data for the second sequence answer *yes* to this screen to exit out of these menus.

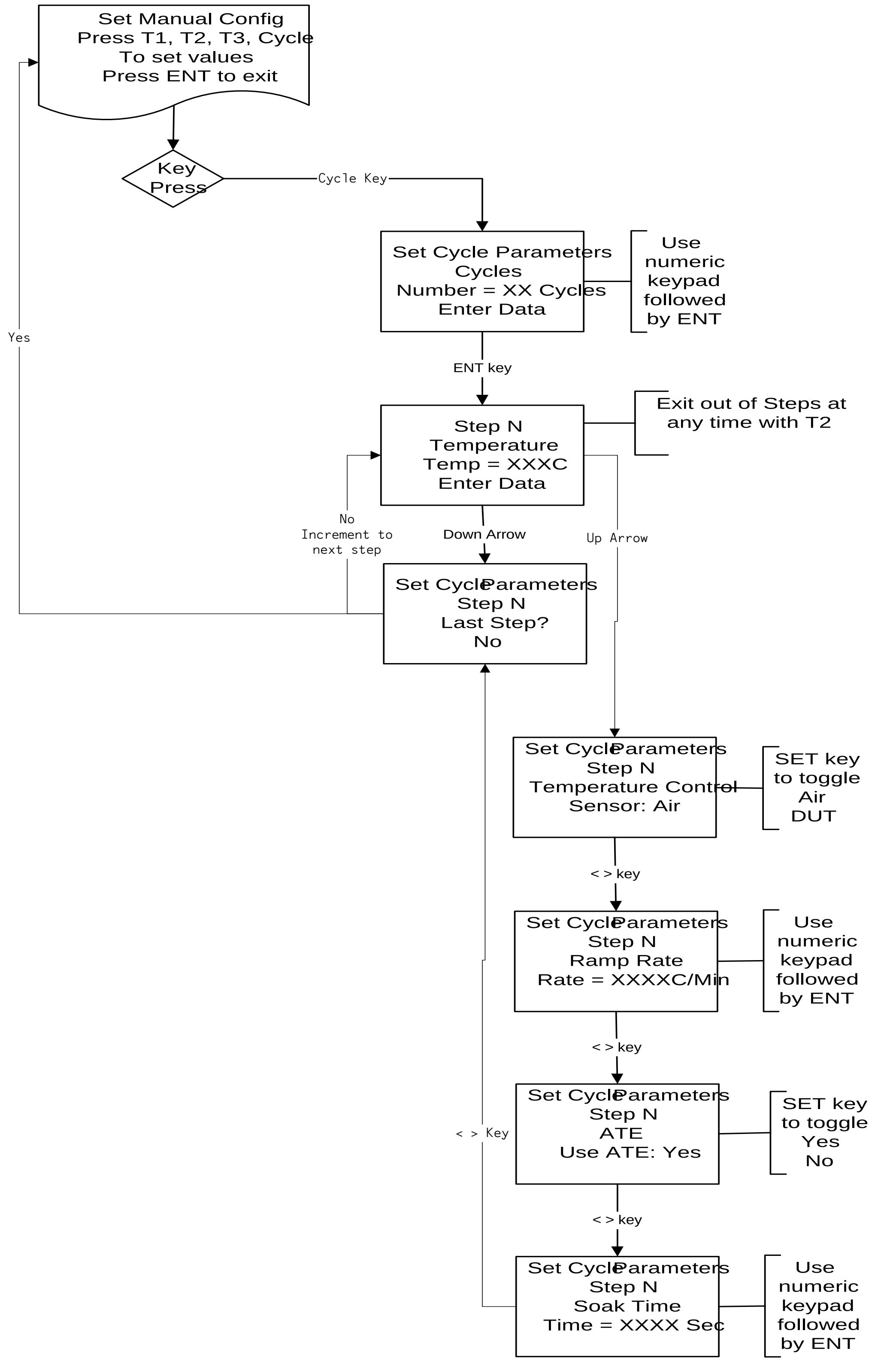


Figure 3 - 11, Example Automatic Temperature Cycle Configuration Flow

Password Protection

This feature prevents access to the configuration portion of the system software to prevent unauthorized changes. The specific menu items that are not accessible when the password feature is in use include the Configuration, Remote, PID and Calibration menus. The manual operation portion of the system remains available when a password is in use.

Entering or Changing A Password

You configure the password in the Remote section of the system software. To enter or change the password, access the Set Password submenu and then use the numeric keypad to enter the desired word (the password is a numeric sequence). After entering the password a confirmation screen verifies the input.

Note: if you forget the password you have entered, you can enter the default password. (Shown in the flowchart on the following page.)

Activating a Password

To activate the password protection feature, scroll to the activation screen and toggle it to *YES*, using the SET key. After you exit to the Main Status screen, you will not be able to change or modify configuration items without first entering a password. (See the Password Flow on the following page, Figure 3 - 12.)

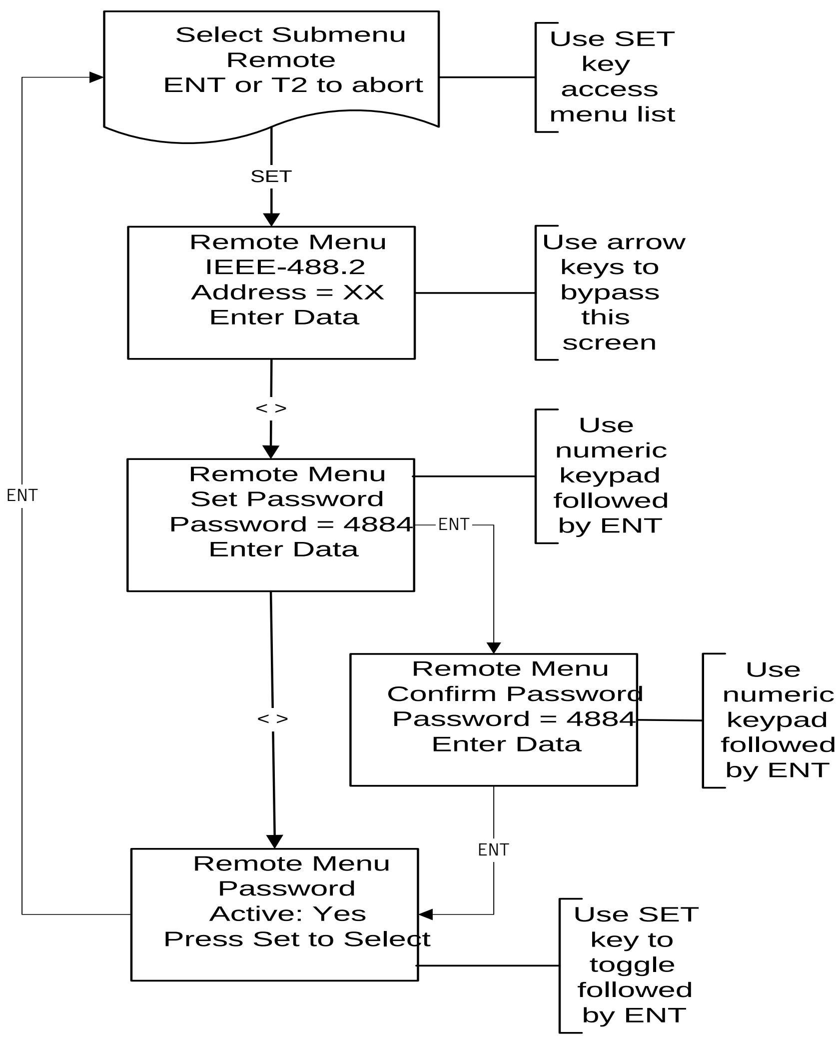


Figure 3 - 12, Password Flow

REMOTE OPERATION AND INTERFACING

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REMOTE OPERATION AND INTERFACING

INTRODUCTION

This chapter discusses the interfaces and procedures for remote operation, digital control, data retrieval, and tester interfacing using a remote computer or other test equipment. All normal operations of the PTFS can be remotely activated except power on/off.

The PTFS has three I/O interfaces:

- **RS-232C Serial Interface** - This is a bit-serial interface mainly used for communication between computers and peripheral equipment.
- **IEEE-488.2 Parallel Bus** - Provides an enhancement for IEEE-488. Defines specific codes, formats, protocols and common commands for use with the ANSI/IEEE Std. 488.1 -1987 bus structure.
- **Standard Tester Interface** - This is a parallel interface found to have industry-wide use. It makes use of a 24-pin architecture similar to the IEEE-488.1 bus connector.

THE RS-232C SERIAL INTERFACE

The EIA Standard RS-232C serial interface is a bit-serial interface that you use to transfer information between the T-2600BV PTFS and a computer or terminal. There are two ways to exercise the interface:

1. Use it to remotely operate the system via a pre-defined command set. (Note: commands are uniform for both R2-232C and IEEE-488.2.)
2. Use it to display diagnostic information on a standard terminal.

Data transmission rate, handshake mode, and data parity are programmed from the PTFS front panel via the Remote Setup Menu. The data format of the characters transmitted or received consists of 10 or 11 bits, depending on the transmission rate selected. Figure 4 - 1 shows the character-bit data format. Figure 4 - 2 displays the signal lines for the RS-232C DB-9 connector located on the rear panel of the PTFS.

Depending on the parameters setup, the RS-232C interface uses up to two data lines (one for each direction) and two handshake lines. All characters received by the PTFS are put into a buffer until they are interpreted. Handshaking protects characters from being lost if data is received faster than the PTFS can process it, or if the PTFS is sending data faster than the computer or terminal can receive it.

Handshaking

In RS-232C, two types of handshaking are implemented: hardware or software. Hardware handshaking uses the status of a signal line (high/low) to control the flow of data. Software handshaking uses control characters to administer the flow of data.

Hardware:

The **RTS** signal is normally at a logical high level, but the PTFS sets it to a logical low level whenever the buffer input is full. The **DTR** handshake line is used only if handshaking has been selected. The PTFS sends data out while the DTR is at a logically high level. No more data is sent if the line is held at a logical low level.

Software:

The **XON/XOFF** handshake is a software handshake using special control characters transmitted in both directions of the serial interface to start/stop transmission of data. The computer or terminal connected to the PTFS can stop transmission of data by sending the **XOFF** character to the PTFS when its buffer is full, and start it again by sending the **XON** character when the terminal's buffer has been emptied. The character for **XON** is "Ctrl Q" (17 Dec., 21 Oct., or 11 Hex.) and the character for XOFF is "Ctrl S" (19 Dec., 23 Oct., or 13 Hex.).

RS-232C Communication Parameters

Change the data transmission rate of the RS-232C interface and the serial interface parameters using the Remote Setup Menu. To access the menu, select ***REMOTE*** from the system configuration portion of the user interface. The menu contain parameters for the tester, IEEE-488.2 and RS-232C interfaces. The parameters that you are concerned with here, are labeled RS232 and include: Parity, handshake, echo and baud rate. (See Fig. 4 - 10 on page 4 - 27 to view menu tree.)

Parity: Used to ensure data is not lost. Can be none, odd or even.

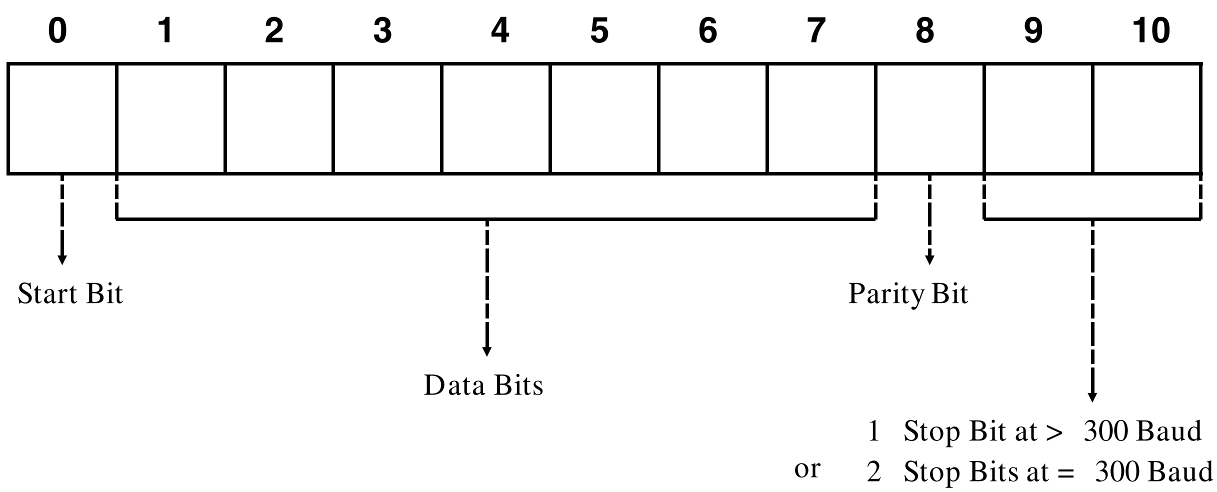
Handshake: None, hardware or software: None, DTR or XON respectively.

Baud Rates: The various available baud rates range from 300 to 38400 baud.

ECHO ON: causes a prompt to appear on the remote terminal and echoes the keyboard strokes to the terminal.

Entering Remote Mode:

When using the RS-232C for remote operation, place the PTFS in the remote mode by sending the character "Ctrl R" (18 Dec., 22 Oct., 12 Hex.) to the PTFS. A remote screen appears on the T-2600BV display. Use "Ctrl L" (12 Dec., 14 Oct., 0c Hex.) to return the system to local control. The red LED on the *Local* key toggles on when the system is in remote mode, otherwise it is off.



1 start bit
7 data bits using ascii code characteristics
1 parity bit that can be programmed to constant low, even parity, or odd parity
1 stop bit at speeds higher than 300 baud
or
2 stop bits at 300 baud

Figure 4 - 1, Character Bit Data Format

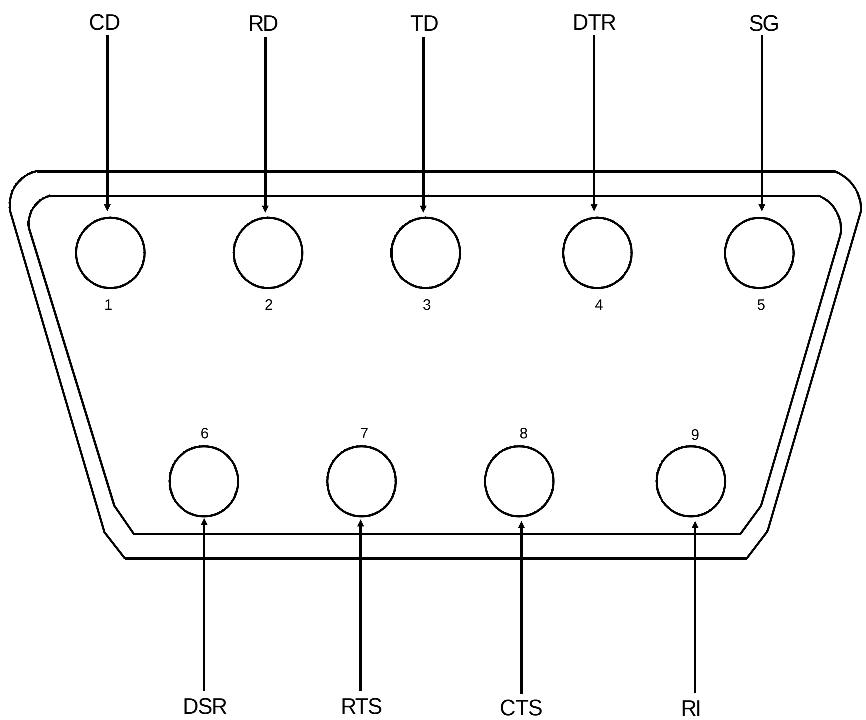


Figure 4 - 2, DB-9 RS-232C Serial Connector

Connecting the RS-232C Interface

Connect the cable from the computer or terminal to the DB-9 RS-232C I/O connector on the rear panel of the PTFS. The following, highlighted, connector pins are used for the RS-232C interface:

Pin#	Description	Signal	Direction*
1	Carrier Detect	CD	
2	Receive Data	RD	In
3	Transmit Data	TD	Out
4	Data Terminal Ready	DTR	Out
5	Signal Ground	SG	
6	Data Set Ready	DSR	In
7	Request To Send	RTS	Out
8	Clear To Send	CTS	In
9	Ring Indicator	RI	In

* From PTFS

Table 4 - 1, RS-232C Pin Assignments

Interface Example

The illustration below is an example of a simple five-wire interface between the PTFS and a computer or terminal using a hardware handshake. The computer has a DB-9 connector, as does the PTFS. Note that pins 2 and 3 on the connector cable must be swapped at one end to ensure that the appropriate connection between TD (Transmit Data) and RD (Receive Data).

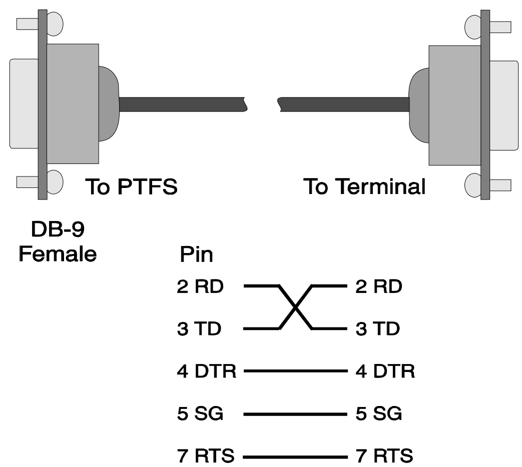


Figure 4 - 3, Serial Cable Configuration

The table, below, includes example parameters that you set in both the PTFS and Terminal software to establish communication via RS-232C.

RS232 Parameters	
Baud Rate	9600
Parity Bit	none
Handshake	none
Stop Bits	1
Data Bits	8
Echo	On

Table 4 - 2, Example Communication Parameters

The table below indicates the relationship of pin assignments between a DB-25 and DB-9 connector.

DB-25	DB-9	Signal		Description
1			x	Protective Ground
2	3	TD	I	Transmitted Data
3	2	RD	O	Received Data
4	7	RTS	1	Request to Send
5	8	CTS	O	Clear to Send
6	6	DSR	O	Data Set Ready
7	5	GND	X	Signal Ground
8	1	CD	O	Received Line Signal
9			X	Reserved for Data Set Testing
10			X	Reserved for Data Set Testing
11			X	Unassigned
12		SCF	O	Secondary Received Line Signal Detector
13		SCB	O	Secondary Clear to Send
14		SBA	I	Secondary Transmitted Data
15		DB	O	Transmission Signal Element Timing
16		SBB	O	Secondary Received Data
17		DD	O	Receiver Signal Element Timing
18			X	Unassigned
19		SCA	I	Secondary Request to Send
20	4	DTR	I	Data Terminal Ready
21		CG	O	Signal Quality Detector
22	9	RI	O	Ring Indicator
23		CH/CI	I/O	Data Signal Rate Selector
24		DA	I	Transmitted Signal Element Timing
25			X	Unassigned

Table 4 - 3, DB-9 to BD-25 Conversion Chart

RS-232C Remote Command Set

The following commands are implemented on the for the RS-232C interface. (Note: these are the same commands as for the IEEE-488.2) “!” indicates command. “?” indicates query. When issuing a command from a terminal with keyboard, type it and press the enter key. To use the query function of a command, follow it with a “?” with no space.

#	Command		Action	Input	Output
1	AIRFLOW	?	Reads the current air flow rate.	N/A	Flow rate in SCFH
2	AIRTEMP	?	Provides the current temperature reading of the air temperature sensor in the thermal test head.	N/A	Temperature in degrees C.
3	ATE1	!?	Set or reads use of the ATE for temperature preset T1.	1 = Use Tester, 0 = No Tester	1 = Use Tester, 0 = No Tester
4	ATE2	!?	Set or reads use of the ATE for temperature preset T2.	1 = Use Tester, 0 = No Tester	1 = Use Tester, 0 = No Tester
5	ATE3	!?	Set or reads use of the ATE for temperature preset T3.	1 = Use Tester, 0 = No Tester	1 = Use Tester, 0 = No Tester
6	COLDMODE		Sets or reads the current temperature control mode of refrigeration unit.	0 = normal (dual), 1 = vortex only, 2 = chiller only.	0 = normal (dual), 1 = vortex only, 2 = chiller only.
7	COOLTEMP	!?	Reads or sets the cool down temperature used at the end of a hot test.	-20 to + 30C	-20 to + 30C
8	COOLTIME	!?	Reads or sets the amount of time the device is exposed to the cool down temperature before the head lifts off the device.	0 to 120 Sec.	0 to 120 Sec.
9	DUT_K_TEMP	?	Provides the current temperature reading of the DUT temperature sensor using thermocouple type K.	N/A	-30 to 225C
10	DUT_T_TEMP	?	Provides the current temperature reading of the DUT temperature sensor using thermocouple type T.	N/A	-30 to 225C
11	ERROR	?	Queries the type of error specified by the T-2600BV Status Register.	N/A	14 bits related to the reason for the fatal error.
12	GOTEMP1	!?	Activates or queries the temperature parameter set up for the T1 key.	Go to T1 temp	0 for IDLE, 1 to 3 for which key (Tn) is selected

Table 4 - 4, RS-232 Remote Commands (Part 1 of 3)

#	Command		Action	Input	Output
13	GOTEMP2	!?	Activates or queries the temperature parameter set up for the T2 key.	Go to T2 temp	0 for IDLE, 1 to 3 for which key (Tn) is selected
14	GOTEMP3	!?	Activates or queries the temperature parameter set up for the T3 key.	Go to T3 temp	0 for IDLE, 1 to 3 for which key (Tn) is selected
15	HEAD	!?	Reads or set the up/down position of the thermal test head.	0 down position, 1 up	0 down position, 1 up
16	HEADDELAY	!?	Reads or determines the amount of time the system delays forcing air after the head moves down over the DUT.	4 to 30 seconds	4 to 30 seconds
17	HELP			N/A	N/A
18	IDLE		Puts the system in idle mode. No air or temperature	N/A	Returns 0 for idle. 1 to 3 for which temperature (T1-T3) is in use.
19	MAXTEMP		Determines the maximum air temperature the DUT is exposed to in DUT sense mode.	31 to 225C	31 to 225C
20	MINTEMP		Determines the minimum air temperature the DUT is exposed to in DUT sense mode.	-30 to 30.9C	-30 to 30.9C
21	RAMPRATE1		Determines the number of degrees/ minute the temperature (for T1) changes as it achieves the setpoint.	0 to 999 seconds	0 to 999 seconds
22	RAMPRATE2		Determines the number of degrees/ minute the temperature (for T2) changes as it achieves the setpoint.	0 to 999 seconds	0 to 999 seconds
23	RAMPRATE3		Determines the number of degrees/ minute the temperature (for T3) changes as it achieves the setpoint.	0 to 999 seconds	0 to 999 seconds
24	SETPOINT	?	Queries the current temperature setpoint.	N/A	-30 to + 225C
25	SFACTOR	!?	Reads or sets the stability factor for a DUT.	0 to 10000	0 to 10000
26	SOAK1	!?	Sets or returns the soak time for T1	0 - 999 seconds	0 - 999 seconds
27	SOAK2	!?	Sets or returns the soak time for T2	0 - 999 seconds	0 - 999 seconds
28	SOAK3	!?	Sets or returns the soak time for T3	0 - 999 seconds	0 - 999 seconds

Table 4 - 4, RS-232 Remote Commands (Part 2 of 3)

#	Command		Action	Input	Output
29	SOAKTIME	?	Queries the current soak time.	N/A	0 - 999 seconds
30	TCONTROL1	!?	Reads or sets the temperature control mode (T,K, air) for T1.	0 - 2 for Air, T DUT, K DUT	0 - 2 for Air, T DUT, K DUT
31	TCONTROL2	!?	Reads or sets the temperature control mode (T,K, air) for T2.	0 - 2 for Air, T DUT, K DUT	0 - 2 for Air, T DUT, K DUT
32	TCONTROL3	!?	Reads or sets the temperature control mode (T,K, air) for T3.	0 - 2 for Air, T DUT, K DUT	0 - 2 for Air, T DUT, K DUT
33	TDISPLAY		The currently displayed temp type	0 - 2 for Air, T DUT, K DUT	0 - 2 for Air, T DUT, K DUT
34	TEMP1	!?	Sets or reads temperature T1	-30 to 225C	-30 to 225C
35	TEMP2	!?	Sets or reads temperature T2	-30 to 225C	-30 to 225C
36	TEMP3	!?	Sets or reads temperature T3	-30 to 225C	-30 to 225C
37	TEMPTOL	!?	Reads or sets the resolution window around the setpoint when the system is considered at temperature.	1 to 15C	1 to 15C
38	TESTCLASS	?	Returns the last class issued by the ATE.	N/A	0 - 15 for class signals
39	WARMTEMP	!?	Reads or sets the warm up temperature used at the end of a cold test.	50 to 225C	50 to 225C
40	WARMTIME	!?	Reads or sets the amount of time the device is exposed to the warm up temperature before the head lifts off the device.	0 - 999 seconds	0 - 999 seconds

Table 4 - 4, RS-232 Remote Commands (Part 3 of 3)

IEEE-488.1 BUS STRUCTURE

The system uses IEEE-488.2 interface protocol, based on the 488.1 bus structure. The most recent version of IEEE standard (i.e., IEEE-488.2) is implemented, which uses a more refined set of device dependent messages. However, the following summary of the 488.1 bus structure is valid for 488.2. (See next section, *Use of the IEEE-488.2 Interface Protocol*.)

The IEEE-488.1 bus uses eight data lines and eight control lines to transfer digital data among a group of computers, measuring equipment, and other system components. Figure 4 - 4 shows the bus structure. For the physical specifications of the bus, see *IEEE Standard 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation*, published by the Institute of Electrical and Electronic Engineers, Inc.

A maximum of 15 devices can be connected to the bus at one time. Only one device can be the bus controller at any given time. The controller orders the rest of the devices to either send data (talk) on the bus or receive data (listen) on the bus. Each device on the bus has a unique address that the controller uses when administrating the bus. The device addresses have a range of 0 to 30, with 0 being the typical controller address. (See, *Setting IEEE-488.2 Parameters*, in next section.)

Devices on the IEEE-488.1 interface share signal lines in a party bus structure. Sixteen signal lines and eight data lines connect the devices in parallel. The bus signal lines have a positive polarity and use a low-true logic convention.

Information is transferred from device to device on the interface using eight bi-directional 8-bit data lines. All commands and messages sent on the bus conform to character strings using the ANSI X3.4-1977 ASCII 7-bit code.

Two types of data are transferred on the bus between the controller and the T-2600BV:

- remote control commands and set points from the controller to the PTFS,
- temperature measurement results and status messages from the PTFS to the controller.

Three byte transfer lines are used to control the transfer of information over the data bus from any talker (or controller) to any addressed listener.

The IEEE-488.1 bus standard connector, shown in Figure 4 - 5 is located on the rear panel of the PTFS. Standard IEEE-488.1 interconnection cable should be used for connecting the device to the bus.

Place the T-2600BV PTFS in remote operation by activating the REN (Remote Enable) line of the IEEE-488.1 bus and then sending a command to the PTFS. Return the PTFS to local operation by by sending the RTL (Return To Local) message on the IEEE-488.1 bus.

IEEE-488.1 Bus Interface Pin Assignments and Signal Descriptions

The following lists the interface connector pin-out and signal descriptions for the IEEE-488.1 bus.

in	Name	Description/Function
1	DI01	Data bit 1 (bi-directional)
2	DI02	Data bit 2 (bi-directional)
3	DI03	Data bit 3 (bi-directional)
4	DI04	Data bit 4 (bi-directional)
5	EOI	End or Identify - When ATN is true the controller use this line to perform a parallel poll. When ATN is false the EOI line is used by a sender to indicate the last byte of a data message.
6	DAV	Data Valid indicates the condition of the information on the data lines (DIO). Driven true by the source when the data is valid and settled and NRFD is sensed false.
7	NRFD	Not Ready-For-Data indicates the condition of readiness of devices to accept data. A receiver sets NRFD true to indicate that it is not ready to accept data. The line is set false when it (and any other participating acceptor) is ready to accept data.
8	NDAC	Not Data-Accepted Indicates that a device(s) has accepted data. The acceptor sets NDAC true to indicate it has not accepted data. It sets NDAC false when it (and all participating acceptors) accepts data from the DIO lines.
9	IFC	Interface-Clear signal is generated by the bus controller. It initializes the logic of the interface for all devices that are connected to the bus.
10	SRQ	Service-Request signal can be asserted by any device except the bus controller. It is sent by any device that requires service by the bus controller. During a serial poll SRQ will be turned off when the SRQ byte is read from the device.
11	ATN	Attention signal is generated by the bus controller. When the bus controller needs to send interface-command bytes to other items on the bus the ATN is sent.
12	SHIELD	Connects to the shield of interface cable

Table 4 - 5, Interface Pin Assignments

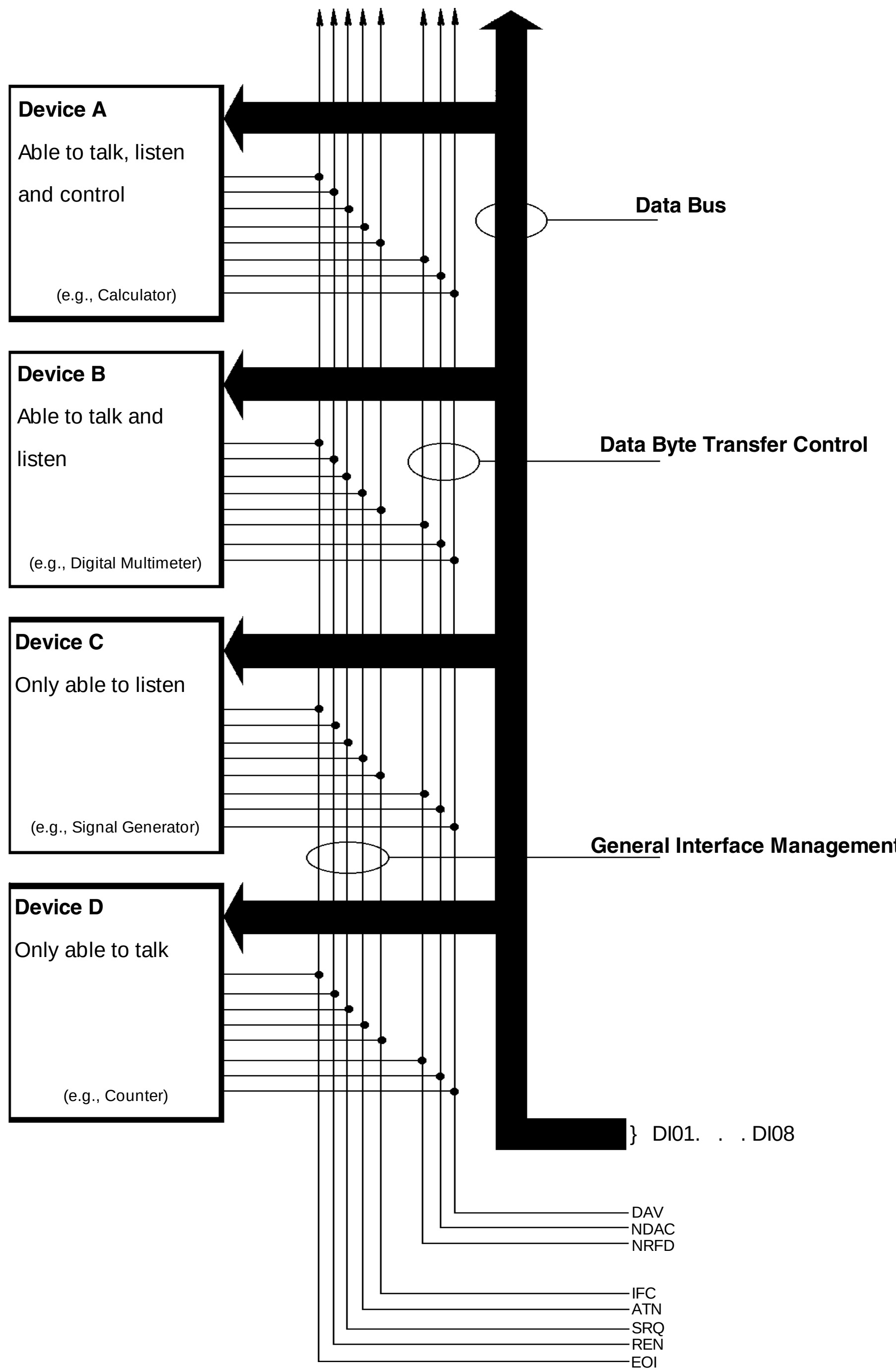


Figure 4 - 4, IEEE BUS Structure

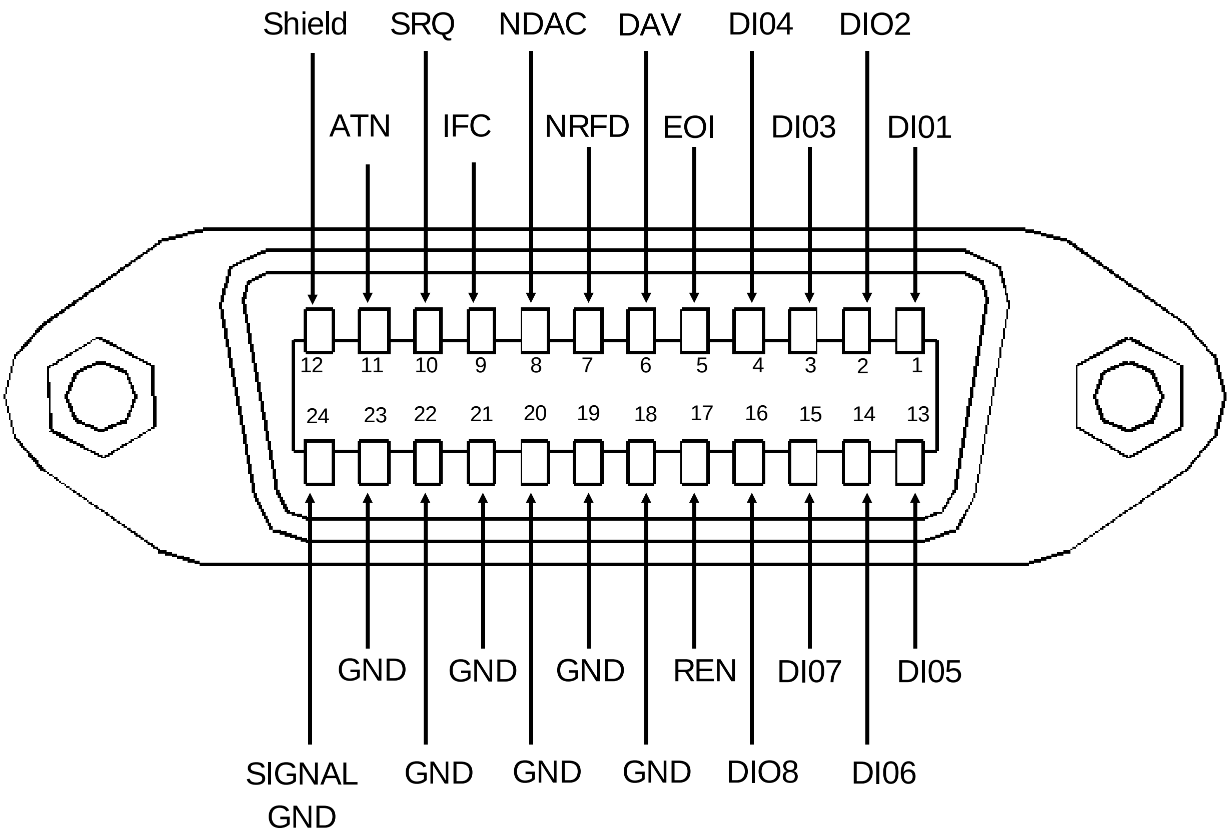


Figure 4 - 5, IEEE-488 Standard Connector

USE OF THE IEEE-488.2 INTERFACE PROTOCOL

This section provides a general overview of IEEE-488.2-1992. In addition, it presents the common commands and device dependent messages that have been implemented on the T-2600BV. For detailed information on the standard, see *IEEE Standard Codes, Formats, Protocols, and Common Commands for use with the IEEE Std 488.1-1987, IEEE Standard Digital Interface for Programmable Instrumentation* (Revision 1992, Published by the Institute of Electrical and Electronic Engineers, Inc. 345 East 47th Street, New York, NY 10017, U.S.A.). Details on the IEEE-488.1 Bus can be found in the previous section of this chapter.

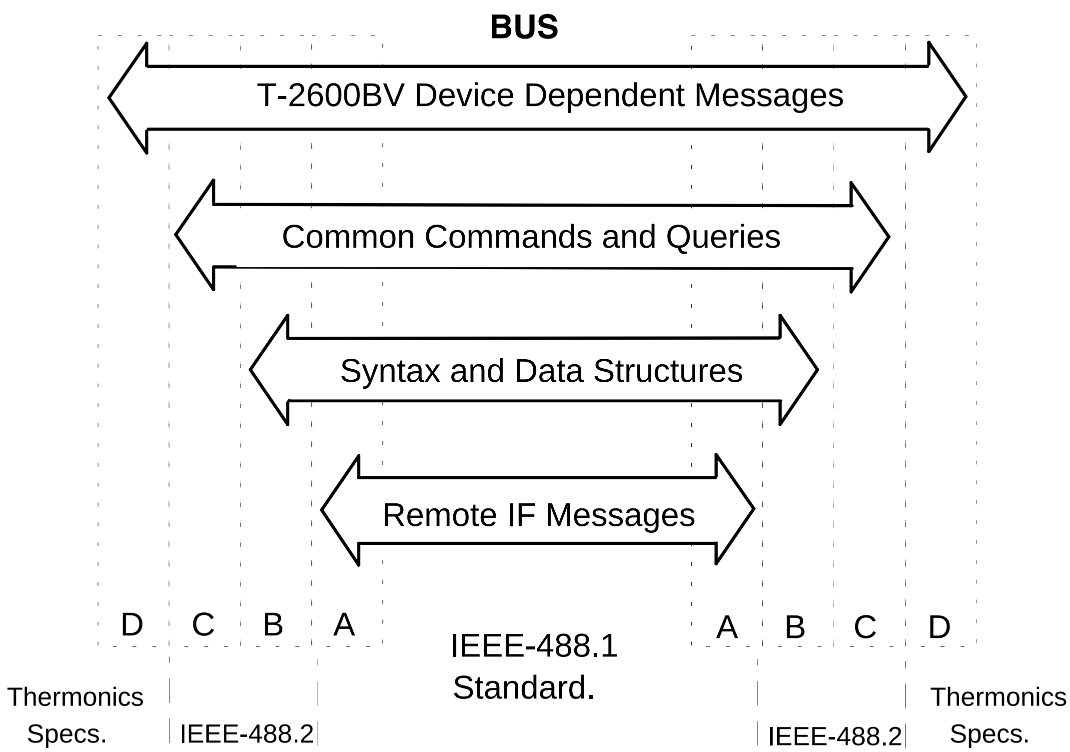
The IEEE-488.2 standard addresses many of the confusions that users encounter with 488.1 by providing a set of codes, data formats, message protocols and common commands for use with the IEEE-488.1. Specifically the standard provides:

- A minimum set of IEEE-488.1 interfacing capabilities
- Specific structures for data format and syntax
- Protocols for device messages
- Status reporting model
- Common command set

The interface, in theory, can be divided into several functional layers. Consider the diagram on the following page (Figure 4 - 6). The lowest layer (A) is the Remote Interface Messages layer, which is actually the IEEE-488.1 bus physical interface. This layer includes the mechanical connector, wiring, electrical signals and handshaking.

IEEE-488.2 is represented by the middle two layers (B,C) which consist of the Syntax and Data Structures and the Common Commands and Queries. The Syntax and Data structures layer defines how devices communicate data. The common commands provide uniform communication with other devices.

The last layer, the T-2600BV Device Dependent Messages Layer (D), represents the T-2600BV - specific messages that tell the PTFS which functions to perform. The messages are explained in a later section of this chapter.



Where:

Layer A represents Interface Functions
Layer B represents Message Communication Functions
Layer C represents Common System Functions
Layer D represents Device Functions

Figure 4 - 6, Interface Theory Diagram

Interface Capabilities

The minimum interface capability that a device must have is the ability to:

- Send Data
- Receive Data
- Request Service
- Respond to the Device Clear command.

In addition, it specifies the minimum capabilities that a device must have when it functions as controller, performs a Parallel Poll, or is operating locally or remotely.

NOTE: The T-2600BV is not setup to be the controller.

Data Formats

According to the standard, devices must accept a variety of coding and data formats so those new devices can communicate with older ones. Transmitted data, on the other hand, is held to a strict format. 488.2 specifies three sets of codes:

- ASCII 7-bit for alphanumeric
- Binary 8-bit integer
- Binary floating point

<u>ASCII 7-Bit Code</u>: Defines ANSI X3.4 -1977 ASCII 7-bit code as the common data code for device dependent messages.

<u>8-Bit Binary Integer</u>: Recommends a format for internal formats used to pass data between two devices with similar internal formats which eliminates the need to convert to and from ASCII. For binary integers:

- Data may contain as many 8-bit bytes as desired
- Most significant byte sent first
- Order of bits corresponds to the order of the bus data lines
- Most significant bit is DI01, least is DI08
- Data is right justified and in 2's complement notation

Binary Floating-Point: Recommends using IEEE Std 754-1985 to represent floating point numbers. Data received as Arbitrary Block Program Data. Sent as Definite Length Arbitrary Block Response Data.

Using these codes, it defines data formats for:

1. Decimal, Octal, and Hexadecimal numbers
2. Decimal Floating-Point numbers
3. Strings
4. Character Strings
5. Arbitrary Strings

Please see specification for details on data formats.

Decimal Numeric Program Data

The format for Decimal Numeric Program Data (NRf) is very flexible. A digit is defined as a single ASCII byte in the range of 48-57 decimal (ASCII 0-9). The following are examples of valid formats:

.123
1.23
12.3
+12.3
.123E -45
+123e +45
.123E +1
+12.3e -1
.0.123

Device Message Protocols

Message exchange protocols describe what to do when:

- Device receives multiple commands
- Incomplete commands
- Interrupted while processing a command

The protocol is implemented via the following operational states:

#	STATE	PURPOSE
1.	IDLE	Wait for messages
2.	READ	Read and execute messages
3.	QUERY	Store responses to be sent
4.	SEND	Send responses
5.	RESPONSE	Complete sending responses
6.	DONE	Finished sending responses
7.	DEADLOCK	Device cannot buffer more data
8.	UNTERMINATED	Device has tried to read an unterminated message
9.	INTERRUPTED	Device interrupted by a new message while sending a response

Table 4 - 6, Device Message Protocol States

Status Reporting Model

IEEE-488.2 defines a standard status reporting model enabling the controller to ask a device (in this case the T-2600BV) for its status. It uses the IEEE-488.1 status byte. The byte contains seven single-bit summary messages (from the Status Data Structures; usually registers or queues). IEEE-488.1 defined only the RQS bit in the status byte. 488.2 further defines the status byte by providing additional meanings for bits 4 and 5. In addition, it provides more commands that allow the user to access the status byte and associated data structures. The two newly defines bits are:

- ESB - Event Status Bit: The state of this bit determines whether or not a standard event has occurred.
- MAV - Message Available Bit: The state of this bit determines whether the output queue is empty. The bit is true whenever the T-2600BV (or some other device) has data available to output.

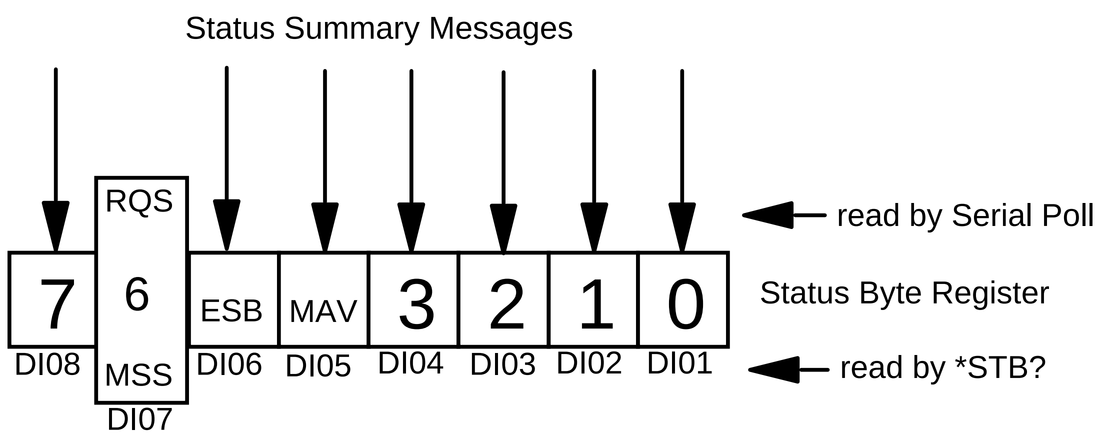


Figure 4 - 7, IEEE-488.2 Status Byte

Additional Definitions:

MSS: The Master Summary Status Bit indicates that the device has at least one reason to request service. It is not part of the Status Byte.

Serial Poll: Tells the Device to send the status byte. Bit six contains the RQS (Request For Service) bit. The Poll clears the RQS if it was set.

The commands on page 4 - 23 are used to monitor the status. See the IEEE-488.2 Status Model Diagram for details (Figure 4 - 8).

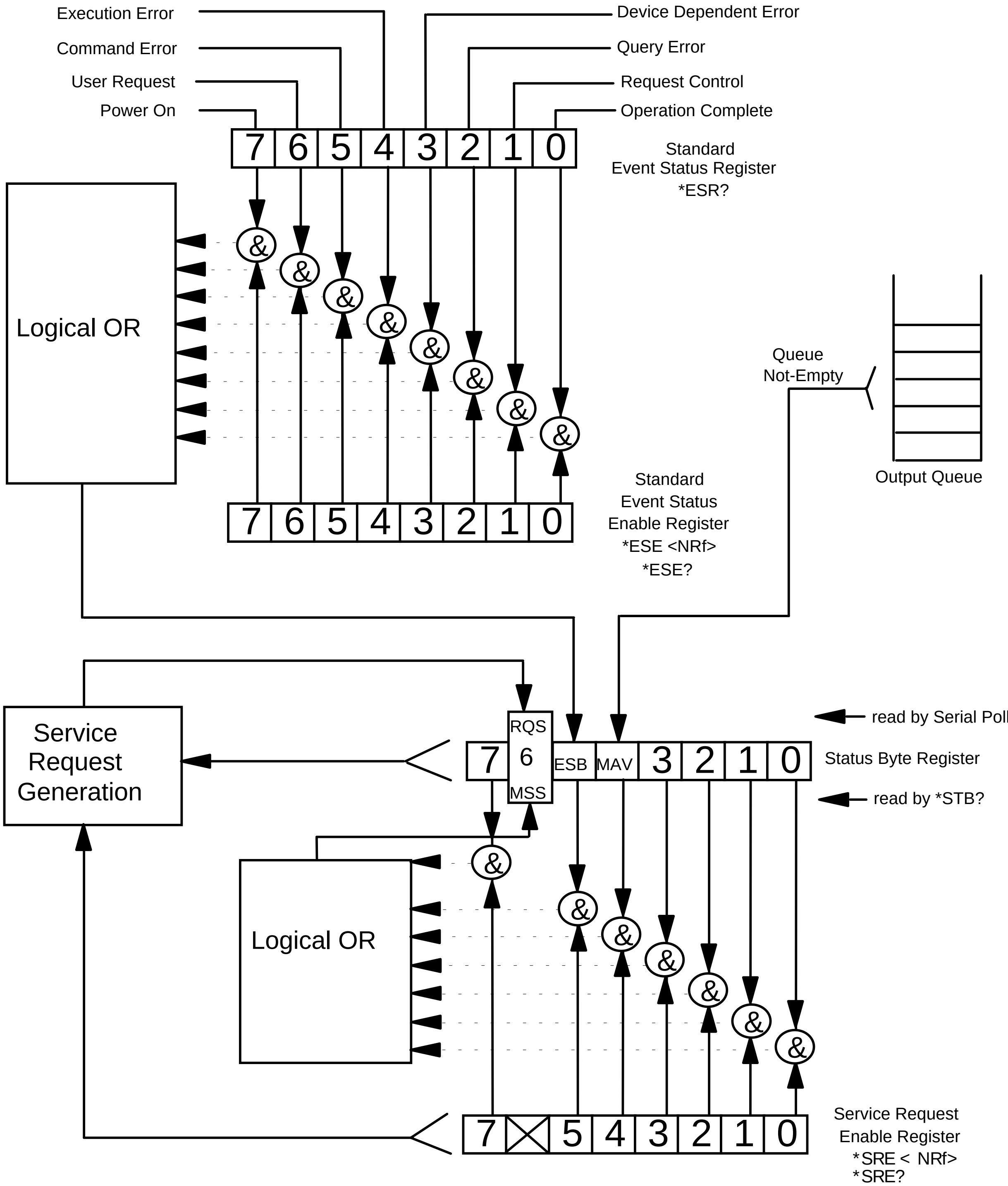


Figure 4 - 8, IEEE-488.2 Status Reporting Model

**ESR?*: Event Status Register Query, reads the contents of the Event Status Register and clears it.

ESE: Standard Event Status Enable Command. Sets the bits on the Standard Event Status Register.

**ESE?:* Event Status Enable Query reads the contents of the Standard Event Status Enable Register.

**STB?:* Status Byte Query, reads the Status Byte with MSS. Bit six represents MSS not RQS.

**SRE?:* Service Request Enable Query, reads the contents of the Service Request Enable Register.

T-2600BV Status Register Pair

The system, in compliance with the standard, provides a means of accessing the status of the PTFS via a pair of registers. These are:

- The T-2600BV Event Status Register (TESR)
- The T-2600BV Event Status Enable Register (TESER)

TESR is a read-only register of which only bits 0-3 are significant. It summarizes the T-2600BV status as follows:

BIT 0: Future Use.

BIT 1: Soak Time start.

BIT 2: Soak Time end.

BIT 3: EOT/Class received.

BITS 4 - 7: Future use.

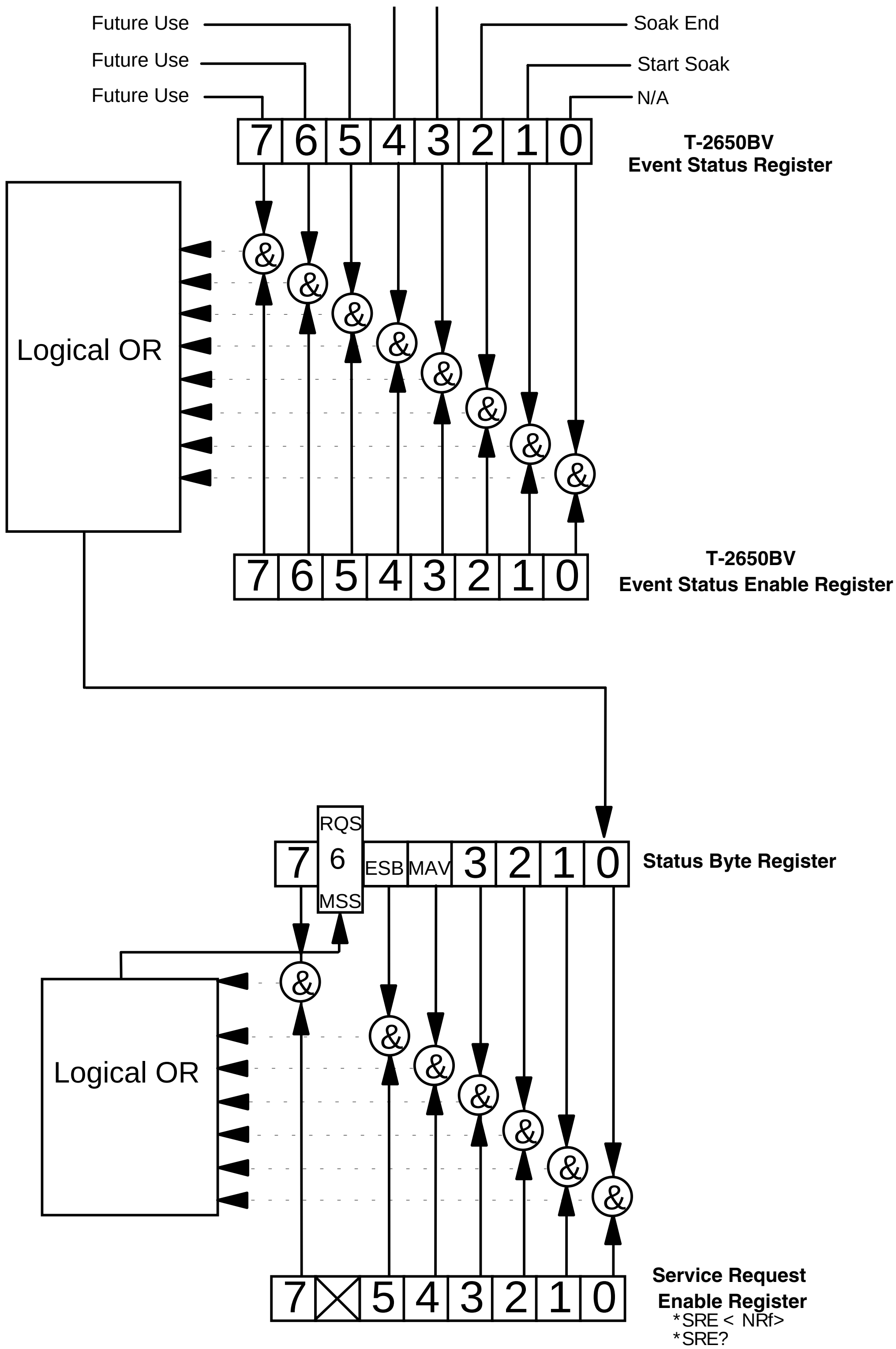


Figure 4 - 9, T-2600BV Status Register Pair

When an event occurs, that is deemed significant by the TESR and the corresponding TESER, bit 0 of the Status Byte Register is set to true. Three T-2600BV -specific commands have been implemented that enable acquisition of the status of these registers:

TESR?: Queries the state of the T-2600BV Event Status Register.

TESE: Sets the state of the T-2600BV Event Status Enable Register.

TESE?: Queries the state of the T-2600BV Event Status Enable Register.

Common Command Set

488.2 details a list of common commands that provide uniform communications with devices. Commands are grouped by the function they perform.

#	Command Group	Functions
1.	System Data	Store or retrieve information about devices - descriptions and options.
2.	Internal Operations	Internal operation commands: resetting, testing, calibrating.
3.	Status & Event	Commands that control status and structure of a device.
4.	Synchronization	Synchronous operation of devices.
5.	Parallel Poll	How devices respond to parallel poll.
6.	Device Trigger	Commands that control trigger or how device responds to trigger.
7.	Controller	Commands to pass control between devices.
8.	Auto Configure	Setting device addresses in system.
9.	Macros	Commands to define new commands.
10.	Stored Settings	Save and store the state of the device.

Table 4 - 7, Common Command Set

The following Common Commands and Queries have been implemented on the T-2600BV:

#	Mnemonic	Name	Command Group	Description
1.	*CLS	Clear Status Command	3	Clears the status data structure and status register summarized in the status byte.
2.	*ESE	Standard Event Status	3	Sets the Standard Event Status Enable Register bits.
3.	*ESE?	Status Event Status Enable Query	3	Reads the contents of the Standard Event Status Enable Register. T-2600BV sends the contents in integer format.
4.	*ESR?	Standard Event Status Register Query	3	Reads the contents of the Standard Event Status Register and clears it. Returns integer which converted to binary represents the contents of the individual bits of the register.
5.	*OPC	Operation Complete	4	Tells the T-2600BV to set bit 0 in the Standard Event Status Register after completing all pending operations.
6.	*OPC?	Operation Complete Query	4	Tells the T-2600BV to place an ASCII 1 in the output queue when finished with all pending operations.
7.	*PSC	Power On Status Clear Command	3	Controls the automatic power-on clearing of the Service Request Enable Register and the Parallel Poll Enable Register.
8.	*PSC?	Power On Status Clear Query	3	Reads the status of the power-on- true.
9.	*RST	Reset Command	2	Resets the T-2600BV
10.	*SRE	Service Request Enable	3	Sets the Service Request Enable Register. Determines which bits in the status byte will cause a Service Request from the T-2600BV.
11.	*SRE?	Service Request Enable Query	3	Reads the contents of the SRE Register. The T-2600BV returns the data as an integer in the range of 0 to 63 or 128 to 191.
12.	*STB?	Status Byte Query	3	Reads the Status Byte with the Master Summary Status bit. T-2600BV responds with an integer in the rang 0 to 255. The bits represent the contents of the Status Byte.

Table 4 - 8, Common Commands and Queries (Part 1 of 2)

#	Mnemonic	Name	Command Group	Description
13.	*TST?	Self Test Query	2	Causes the T-2600BV to perform an internal self test and report any error conditions.
14.	*WAI	Wait To Continue	4	Makes the T-2600BV wait until all the previous commands or queries complete. It then executes the commands that follow WAI.
15.	*TRG	Trigger Command	6	Performs same function as Group Executive Trigger defined by IEEE-488.1.

Table 4 - 8, Common Commands and Queries (Part 2 of 2)

ATE Connection Modes

There are two basic models for integrating the T-2600BV and the ATE for use with IEEE-488.2. The standard format is to chain the PTFS to the tester and the IEEE-488.2 controller using only the IEEE BUS. The other, less common, format is to link the PTFS to the tester using the Standard Tester Interface with a separate connection to the IEEE BUS. These formats are referred to as ATE Disabled and ATE Enabled, respectively. (See illustration. For details on the Standard Tester Interface, see next section of this chapter.)

ATE Disabled

In the ATE Disabled mode, the PTFS generates an SRQ at the end of the soak time. When the Controller detects the SRQ, it reads the T-2600BV Event Status Byte to determine if the Soak End Bit (bit 2) is set. If so, the controller issues an appropriate command to the tester to start testing, and waits for a reply. When the reply is received by the controller from the tester, the PTFS is commanded to move to the next appropriate temperature or operation. In this case, the ATE is disabled because the T-2600BV is out of the loop, and the Class Signal returned by the tester provides no information that the T-2600BV requires. The PTFS is merely used as another biasing element for the tested part.

Another way to perform the same function is to poll the T-2600BV Event Status Register until bit 2 is set, and then go to the next appropriate operation. See diagram on following page.

ATE Enabled

In this model, the PTFS is connected to the tester via the Standard Tester Interface. A separate connection is made from the PTFS to the controller via IEEE. The SRQ is generated when an EOT or Class result is sent from the ATE to the PTFS (bit 3 of the T-2600BV Event Status Register). The Controller can then issue the TESTCLASS? query to obtain the result. Alternatively, the Controller could poll bit 3 until it is set, and then issue the query. See diagram on page 4 - 28.

Assigning the IEEE-488.2 Address

Change the address parameter using the Remote Menu. Access it by selecting REMOTE from the Configuration portion of the user interface. Valid addresses range from 1 to 30. See menu tree on following page.

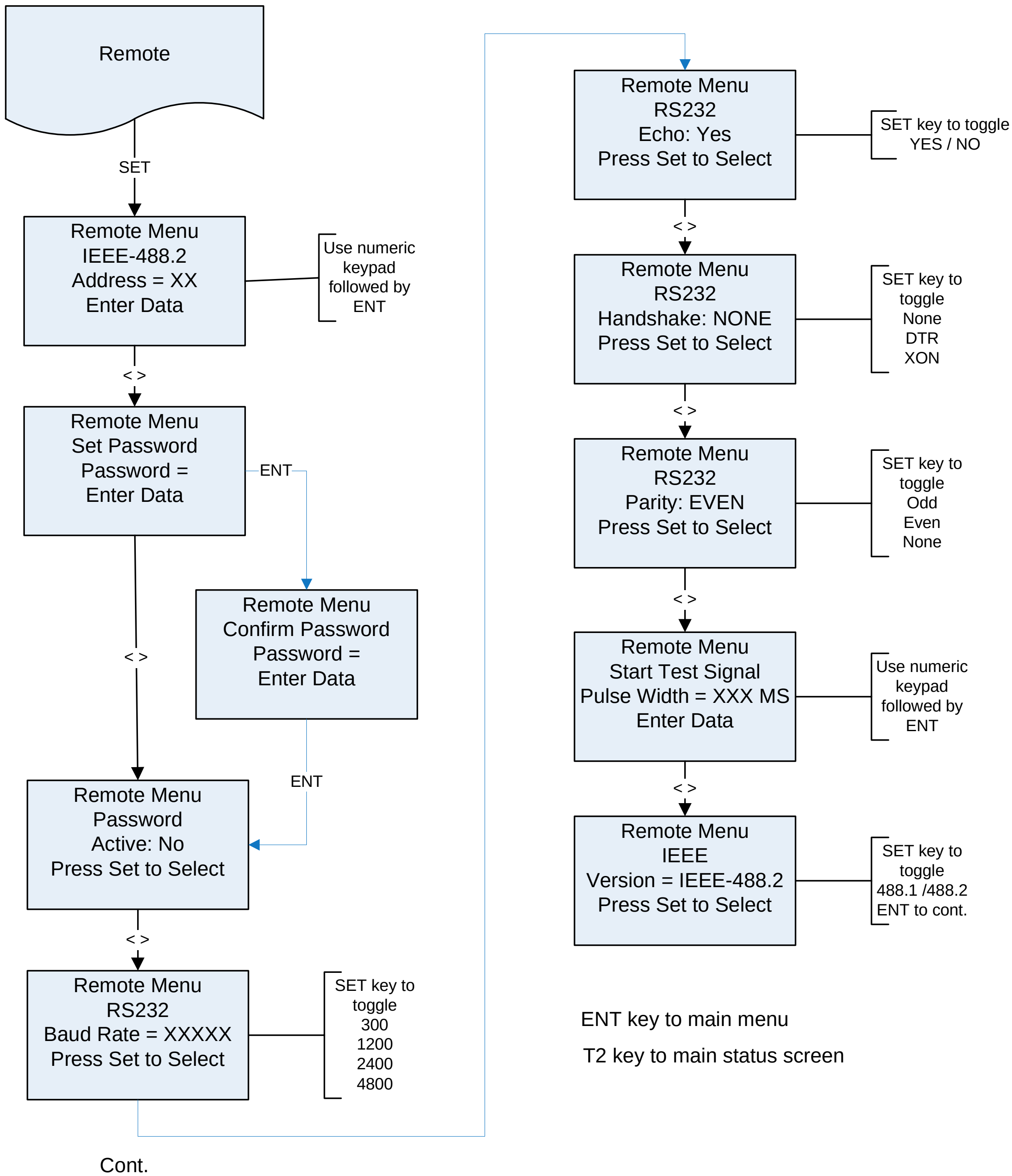


Figure 4 - 10, Remote Menu Tree

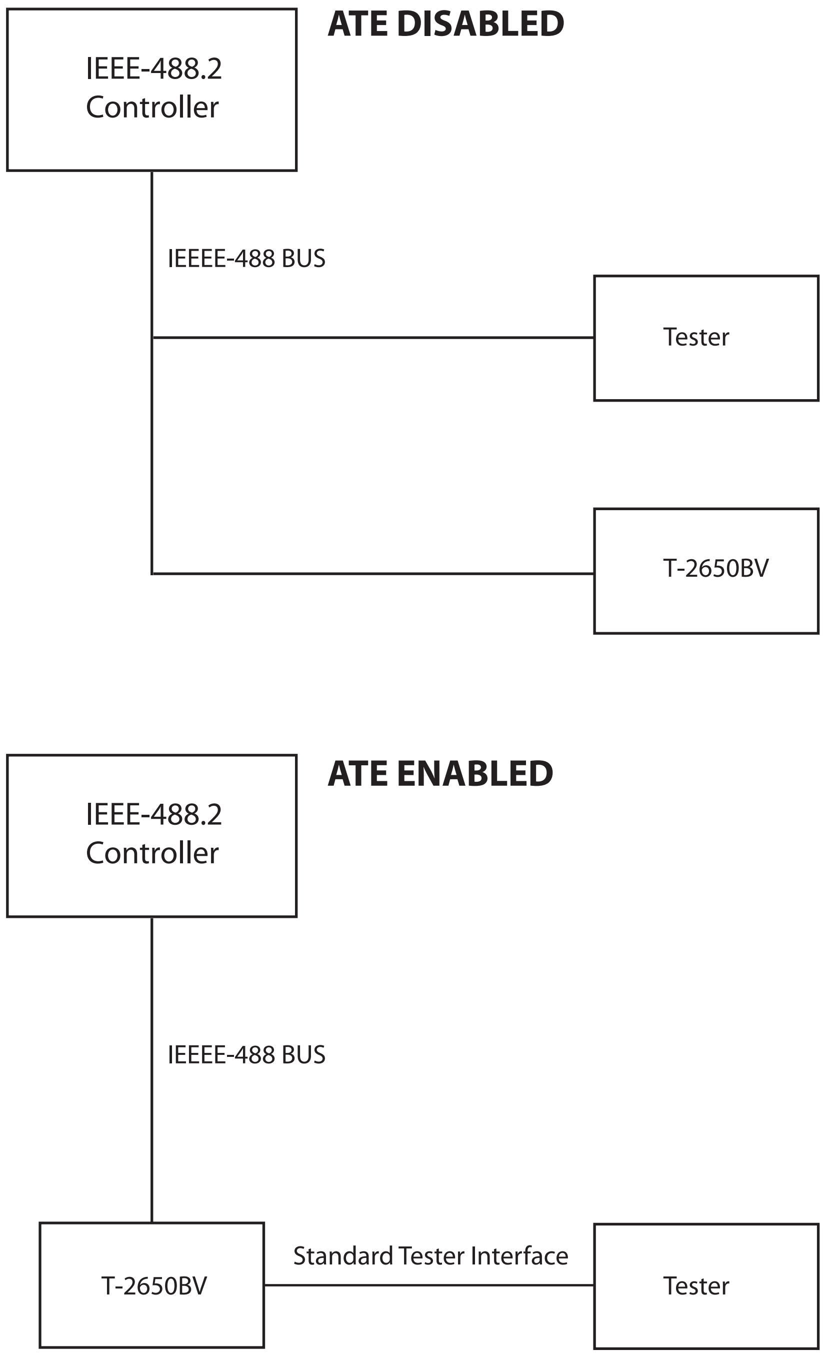


Figure 4 - 11, ATE Connection Modes

IEEE-488 Remote Command Set

The following commands (device dependent messages) are implemented on the for the IEEE-488.2 interface. (Note: these are the same commands as for the RS-232C) “!” indicates command. “?” indicates query. When issuing a command from a terminal with keyboard, type it and press the enter key. To use the query function of a command, follow it with a “?” with no space.

#	Command		Action	Input	Output
1	AIRFLOW	?	Reads the current air flow rate.	N/A	Flow rate in SCFH
2	AIRTEMP	?	Provides the current temperature reading of the air temperature sensor in the thermal test head.	N/A	Temperature in degrees C.
3	ATE1	!?	Set or reads use of the ATE for temperature preset T1.	1 = Use Tester, 0 = No Tester	1 = Use Tester, 0 = No Tester
4	ATE2	!?	Set or reads use of the ATE for temperature preset T2.	1 = Use Tester, 0 = No Tester	1 = Use Tester, 0 = No Tester
5	ATE3	!?	Set or reads use of the ATE for temperature preset T3.	1 = Use Tester, 0 = No Tester	1 = Use Tester, 0 = No Tester
6	COLDMODE		Sets or reads the current temperature control mode of refrigeration unit.	0 = normal (dual), 1 = vortex only, 2 = chiller only.	0 = normal (dual), 1 = vortex only, 2 = chiller only.
7	COOLTEMP	!?	Reads or sets the cool down temperature used at the end of a hot test.	-20 to + 30C	-20 to + 30C
8	COOLTIME	!?	Reads or sets the amount of time the device is exposed to the cool down temperature before the head lifts off the device.	0 to 120 Sec.	0 to 120 Sec.
9	DUT_K_TEMP	?	Provides the current temperature reading of the DUT temperature sensor using thermocouple type K.	N/A	-30 to 225C
10	DUT_T_TEMP	?	Provides the current temperature reading of the DUT temperature sensor using thermocouple type T.	N/A	-30 to 225C
11	ERROR	?	Queries the type of error specified by the T-2600BV Status Register.	N/A	14 bits related to the reason for the fatal error.
12	GOTEMP1	!?	Activates or queries the temperature parameter set up for the T1 key.	Go to T1 temp	0 for IDLE, 1 to 3 for which key (Tn) is selected

Table 4 - 9, IEEE Remote Commands (Part 1 of 3)

#	Command		Action	Input	Output
13	GOTEMP2	!?	Activates or queries the temperature parameter set up for the T2 key.	Go to T2 temp	0 for IDLE, 1 to 3 for which key (Tn) is selected
14	GOTEMP3	!?	Activates or queries the temperature parameter set up for the T3 key.	Go to T3 temp	0 for IDLE, 1 to 3 for which key (Tn) is selected
15	HEAD	!?	Reads or set the up/down position of the thermal test head.	0 down position, 1 up	0 down position, 1 up
16	HEADDELAY	!?	Reads or determines the amount of time the system delays forcing air after the head moves down over the DUT.	4 to 30 seconds	4 to 30 seconds
17	HELP			N/A	N/A
18	IDLE		Puts the system in idle mode. No air or temperature	N/A	Returns 0 for idle. 1 to 3 for which temperature (T1-T3) is in use.
19	MAXTEMP		Determines the maximum air temperature the DUT is exposed to in DUT sense mode.	31 to 225C	31 to 225C
20	MINTEMP		Determines the minimum air temperature the DUT is exposed to in DUT sense mode.	-30 to 30.9C	-30 to 30.9C
21	RAMPRATE1		Determines the number of degrees/ minute the temperature (for T1) changes as it achieves the setpoint.	0 to 999 seconds	0 to 999 seconds
22	RAMPRATE2		Determines the number of degrees/ minute the temperature (for T2) changes as it achieves the setpoint.	0 to 999 seconds	0 to 999 seconds
23	RAMPRATE3		Determines the number of degrees/ minute the temperature (for T3) changes as it achieves the setpoint.	0 to 999 seconds	0 to 999 seconds
24	SETPOINT	?	Queries the current temperature setpoint.	N/A	-30 to + 225C
25	SFACTOR	!?	Reads or sets the stability factor for a DUT.	0 to 10000	0 to 10000
26	SOAK1	!?	Sets or returns the soak time for T1	0 - 999 seconds	0 - 999 seconds
27	SOAK2	!?	Sets or returns the soak time for T2	0 - 999 seconds	0 - 999 seconds
28	SOAK3	!?	Sets or returns the soak time for T3	0 - 999 seconds	0 - 999 seconds

Table 4 - 9, IEEE Remote Commands (Part 2 of 3)

#	Command		Action	Input	Output
29	SOAKTIME	?	Queries the current soak time.	N/A	0 - 999 seconds
30	TCONTROL1	!?	Reads or sets the temperature control mode (T,K, air) for T1.	0 - 2 for Air, T DUT, K DUT	0 - 2 for Air, T DUT, K DUT
31	TCONTROL2	!?	Reads or sets the temperature control mode (T,K, air) for T2.	0 - 2 for Air, T DUT, K DUT	0 - 2 for Air, T DUT, K DUT
32	TCONTROL3	!?	Reads or sets the temperature control mode (T,K, air) for T3.	0 - 2 for Air, T DUT, K DUT	0 - 2 for Air, T DUT, K DUT
33	TDISPLAY	?	The currently displayed temp type	0 - 2 for Air, T DUT, K DUT	0 - 2 for Air, T DUT, K DUT
34	TEMP1	!?	Sets or reads temperature T1	-30 to 225C	-30 to 225C
35	TEMP2	!?	Sets or reads temperature T2	-30 to 225C	-30 to 225C
36	TEMP3	!?	Sets or reads temperature T3	-30 to 225C	-30 to 225C
37	TEMPTOL	!?	Reads or sets the resolution window around the setpoint when the system is considered at temperature.	1 to 15C	1 to 15C
38	TESTCLASS	?	Returns the last class issued by the ATE.	N/A	0 - 15 for class signals
39	WARMTEMP	!?	Reads or sets the warm up temperature used at the end of a cold test.	50 to 225C	50 to 225C
40	WARMTIME	!?	Reads or sets the amount of time the device is exposed to the warm up temperature before the head lifts off the device.	0 - 999 seconds	0 - 999 seconds

Table 4 - 9, IEEE Remote Commands (Part 3 of 3)

USE OF THE STANDARD INTERFACE

Standard Tester Interface is a parallel interface found to have industry-wide use. This version of the interface makes use of a 15 pin architecture. See Figure 4 - 12, Standard Tester Interface Connector.

Standard Tester Interface Parameters

The EOT signal can be set to active high or low. Active high and active low settings change the way the voltage that is used to send signals between the PTFS and the tester functions. Typically the voltage is +5 volts. In an active high selection, the PTFS/tester expects the line voltage to be zero, therefore, when a 10 millisecond pulse of +5 volts is sensed, it is assumed by the PTFS or tester that a signal has been sent. Conversely, in an active low state, the line voltage is held at +5 volts and a signal is sensed if the line voltage drops to zero for 10 milliseconds. The use of active high or low settings is based on the needs and output signal type of the tester.

The class signals generated by the tester are sent to the PTFS on sixteen fixed data lines. The configuration of these lines is shown in the next section. See Figure 4 - 13, for tester interface diagram.

Start Test Pulse Width

The Start Test Pulse Width selection of the Remote Menu is used to determine the length of the pulse generated by the T-2600BV after it has reached temperature and the soak time has elapsed (start-test-signal). Valid values range from 10 to 999 milliseconds.

NOTE:
In IEEE-488.2 a start test signal is generated if USE ATE is set to YES in the Manual Control screens. The GOTEMP(N) command will issue the start-test-signal for a particular setting of the Manual Control Screen.

Standard Interface Pin Assignments and Signal Descriptions

The following lists the pin assignments and class signal data lines of the Standard Parallel Interface:

Pin #	Line Assignment
1.	NA
2.	NA
3.	NA
4.	Start Test -
5.	GND
6.	EOT -
7.	NA
8.	NA
9.	NA
10.	NA
11.	VCC
12.	Start Test +
13.	NA
14.	EOT +
15.	NA

Table 4 - 10, Pin Assignments

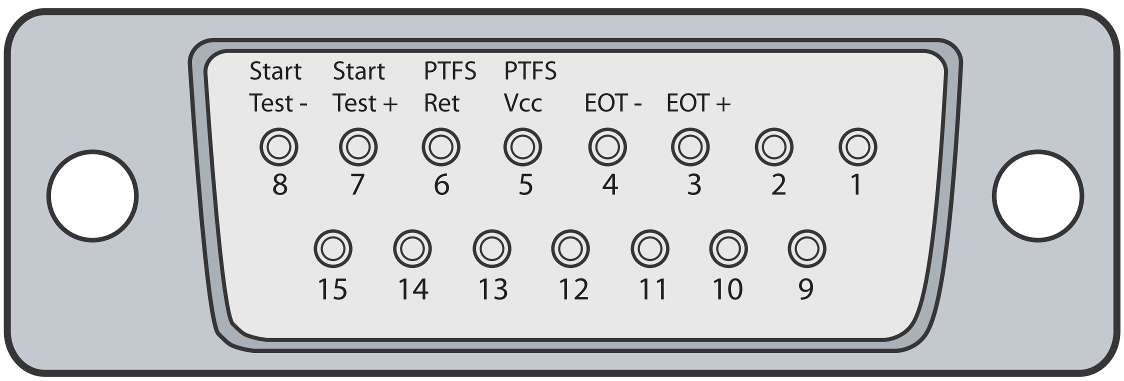


Figure 4 - 12, Front View Standard Tester Interface Connector

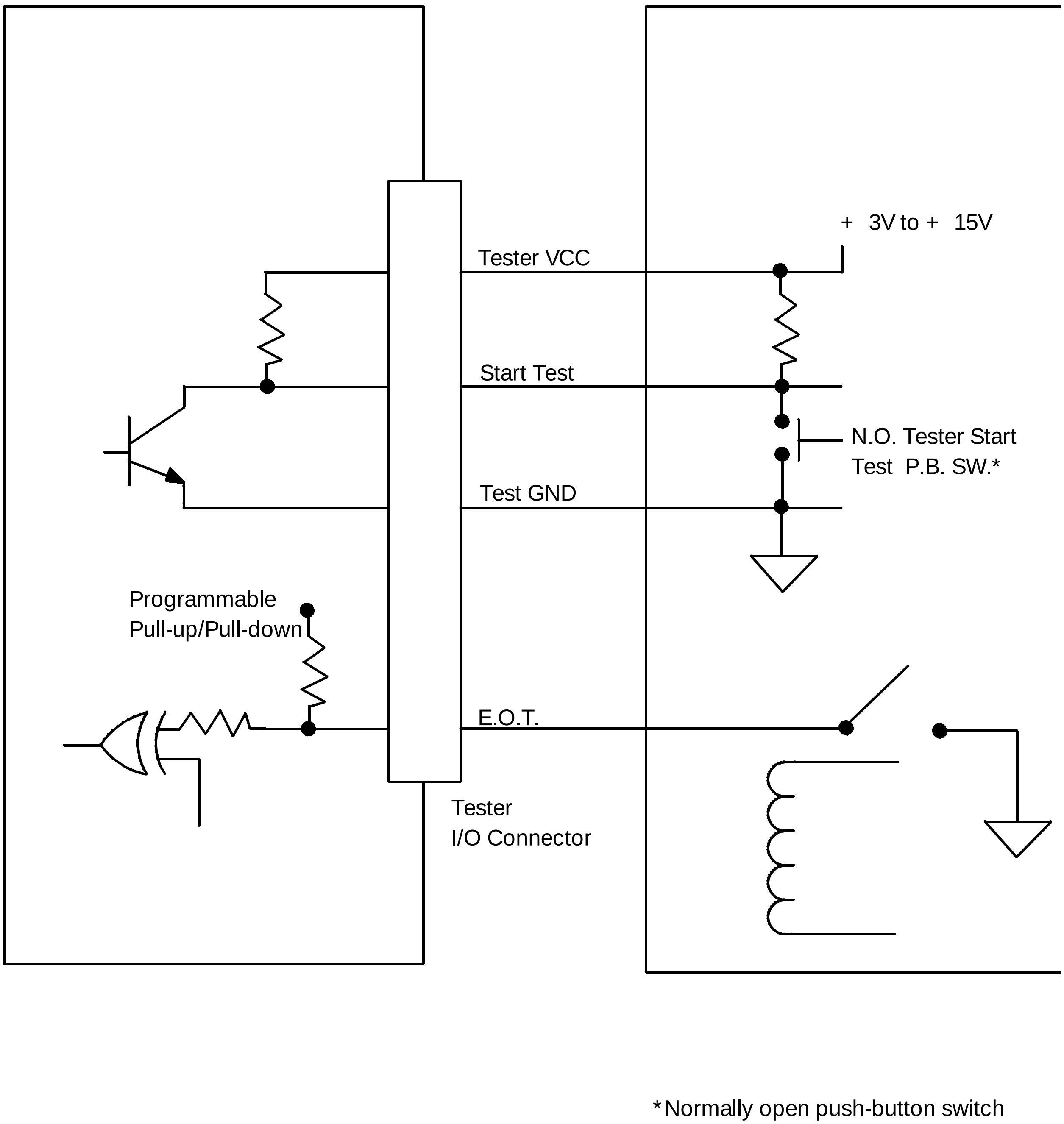


Figure 4 - 13, Tester Interface Diagram

OPERATOR MAINTENANCE AND INSPECTION

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OPERATOR MAINTENANCE AND INSPECTION

GENERAL

The Thermonics T-2600BV Precision Temperature Forcing System (PTFS) is designed and manufactured to the highest quality specifications in order to endure the hardships of frequent and prolonged use associated with most manufacturing environments. To maintain the superior level of performance, and the High Mean Time between Failure (MTBF) engineered into the system, a minimum of routine maintenance should be performed on a regular basis. Performance of these procedures will guard against major repair expenses resulting from neglect, and is a good way to protect company investments.

The procedures outlined here are those that can be performed by the operator, and primarily involve inspection and cleaning. The instructions for more sophisticated maintenance, of the type usually performed by a technician, can be found in the T-2600BV Maintenance Module.

CAUTION:

Procedures that involve removal and replacement of electrical or mechanical components must always be performed by a qualified technician who is fully aware of the operation of the PTFS, and of the dangers associated with electrical and mechanical devices.

Cleaning Materials

The T-2600BV is a very sturdy piece of equipment; however, it should be cleaned with the proper types of cleaning materials to prevent damage to its appearance or functioning. Mild household soap is the preferred cleaning solution. Methanol also may be used. Abrasive cleaners and chemicals such as acetone, benzene, and carbon tetrachloride should never be used.

Periodic Inspection

To keep the system running properly, it is best to perform periodic inspections of all moving parts, gauges, lamps and LEDs, for wear, play, fit, functioning or cleanliness. Examples of items to inspect are:

- Input pressure gauge for operability

- Thermal Fixture motion (up/down)
- Support arm motion up/down in/out
- Arm rotation
- Brakes/clamps
- Fan filter (cleanliness)

OPERATOR INTERFACE

Avoid spraying large amounts of cleaning fluid on the operator interface panel. When cleaning the surface of the display panel, do not to spray the screen directly with the cleaning solution because a fluid build-up around the edges of the display may cause a problem. It is best to dampen the cleaning cloth with the spray and then use it to wipe off the screen.

EXTERIOR PANELS

Remove loose dust and grime from the outside panels of the PTFS with a soft cloth or brush. A mild soap solution may be used on these surfaces.

SUPPORT ARM AND THERMAL TEST HEAD

Periodically inspect the Support Arm and Thermal Test Head for proper functioning. Make sure that the horizontal and vertical motion of the arm is smooth, and that the complete range of motion occurs. Also, make sure that the brakes/clamps are functioning properly. Test the Thermal Fixture for up/down motion.

SYSTEM FAN

Clean the air filter on the system fan located inside the control unit. Perform this task whenever excessive dust has accumulated on the filter. Remove the snap-on filter cover, and then clean the filter with compressed air, or replace it if necessary.

AIR DRYER

When using the T-2600 in conjunction with an air dryer such as the T-ADF, it is important to ensure that airflow to the unit is not restricted. Inspect the input air filter for accumulations of water and oil. Discharge any contamination found. If large amounts of contaminants are found, the membrane filter may be being contaminated causing a frost problem. Details for air dryer maintenance may be found in the instructions that arrived with the air dryer.

INTERNAL CONTROL UNIT

The internal control electronics of the PTFS are analogous to any sophisticated computer equipment and are sensitive to corrosive gasses, dust, high humidity and temperature extremes. Because dust is hard to avoid, you should inspect the internal PC boards periodically for a build-up. Noticeable build-ups of dust should be removed with a vacuum cleaner and a brush-tipped adapter.

Make sure the unit is disconnected from the power source and observe static precautions. Lock-out, tag-out as appropriate.

T-2600BV FUNCTIONAL THEORY

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T-2600BV FUNCTIONAL THEORY

This chapter discusses various topics related to the functioning and design of the T-2600BV. Its purpose is to provide an overview of the theoretical background and principles on which the system is based.

Typical Uses of the PTFS

The PTFS is most commonly used for direct testing of semiconductor components at temperature extremes while they are on an auto-tester performance board. This permits measurement of all electrical parameters (ac or dynamic and dc) without adding the long test leads that are common for a conventional oven. Examples of applications of the PTFS are:

- Engineering evaluation, device validation, or characterization of components.
- Incoming inspection.
- Production testing of small lots.
- Quality assurance testing and failure analysis.
- Testing printed circuit boards, wafers, or modules at temperature.

System Overview

The PTFS heats or cools test devices with a stream of temperature controlled air. It directs air to the DUT by an insulated output hose that integrates with a thermal test head. Heaters, located in the test head, provide the warm air and a jointly located vortex tube provides the cold temperature source. The test device is typically placed in a thermal fixture that aids in maintaining temperature of the device by insulating it from the environment.

When testing devices, the air must be free of oil, moisture and particles. If the source air is moist, you must install an air dryer. The moisture removal process permits the air to be chilled to a lower temperature and prevents the development of frost or moisture that could inhibit airflow.

The air dryer (if installed) intercepts the source air. The air then flows through a series of regulators and flow-metering devices that automatically control the flow through a drying procedure. It then passes through the output hose through which it is integrated with the PTFS.

Ambient temperature purge air may be used to prevent frost and moisture from building up on the thermal fixtures and surrounding test components. The purge air adapter is located on the rear panel of the system. During cold operation you may direct the purge air to these locations: a.) to the inside of the junction of the shroud and thermal fixture. b.) to exposed surfaces adjacent to the test socket. c.) to the purge path of a custom test fixture that is used.

Various configurations of sensors permit the PTFS to monitor the temperature of the DUT. T or K-type thermocouple sensors may be used. A temperature control algorithm, within the temperature control portion of the system software, provides extremely accurate temperature control. (US Patent # 5,205,132)

A 20 character, (four line, vacuum fluorescent, dot matrix style display) continuously informs the operator of the system status via menus, messages, temperature information, and operating parameters that display during use. Numeric values or menu selections are entered and/or navigated using keys on the front panel.

Functional Overview

A firmware program is implemented by the CPU (80188) to monitor and control all of the functional states the PTFS may obtain. Upon startup, the system checks for specific inputs from internal sensors. If a sensor detects an error condition, it generates a fail-safe causing the system to enter a neutral inoperative state. Otherwise, the system enters a standby mode and waits for input from the front panel or through a remote interface.

The following messages display during startup:

Message	Interpretation
Thermonics T-2600 Revision X.X MM DD YY	The specific model. System software revision.
Thermonics T-2600 Initializing	Testing of internal system sensors, initialization of sub-processes.
IDLE *Air = 25.1 DUT= 29.0 Set=10.0 Flow=0 10.0 25.0 175.0	The main status screen is the final screen that appears on startup. The screen summarizes the system operating status, temperature and airflow.

Table 6 - 1, Start-up Messages

When properly initialized, the system displays the Main Status Screen at the end of the routine.

Using Air to Determine Device Temperature

Temperature-controlled air has many characteristics that make it a superior medium for testing devices at temperature. The two most important of these are its speed and accuracy. Other test systems that rely on slow moving ambient air or conduction of temperature through hot or cold surfaces are less efficient. The airstream's efficiency is a result of:

- Quickly submerging the device in a stream of air of a specific temperature.
- Accurately forcing the device to the desired temperature with minimal modulation around the setpoint.
- Testing the devices or modules directly at the tester socket: soaking its leads and the socket in the stream of air.

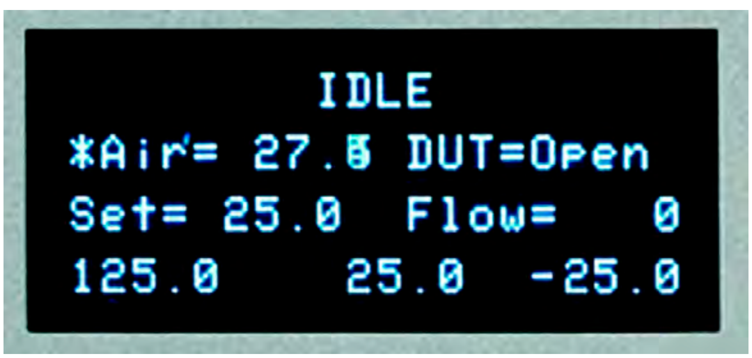

Figure 6 - 1, Main Status Screen

Thermocouple Options

The temperature of the forced air or of the DUT is measured using thermocouples. Thermocouples are temperature-registering devices that are made up of dissimilar metals joined at each end. One junction is placed where the test temperature is measured; such as in the air stream or at the DUT, and the other is kept at a reference temperature. A voltage (EMF) is generated that is linearly proportional to the temperature of the junction. The system software uses this information to determine the temperature for use in temperature control.

The T-2600BV is capable of using two types of thermocouples: type T and type K.

Type	Temp. Range	EMF (mV)
T	-200 to 350C	-5.602 to 17.816
K	-200 to 1250C	-5.973 to 50.633

Table 6 - 2, Thermocouple Options

Thermocouple Signal Enhancement

The system contains electronic circuitry designed to eliminate noise generated by high-frequency environments. Experienced as unstable or drifting temperatures, noise can make control and accuracy of some systems difficult; particularly in DUT sense mode. When the thermocouple is grounded or connected to a conductive surface, such as device packaged in a metal enclosure, the noise problem can be a difficult one.

The noise-reduction circuitry enhances the signal by isolating the common mode noise from the differential signal, and rejecting the noise via a charge capacitor switch. Low-pass filtering techniques are used to enhance the desired frequency response characteristics of the thermocouple signal with a low-noise precision operational amplifier. In addition, the differential thermocouple input is altered into single-ended output.

Thermal Time Constant and Soak Time

The thermal time constant of a device is a measure of the time it takes for a device to approach the temperature of its environment. When a device is placed in a thermal environment, such as the enclosure on T-2600BV Thermal Test Head, the temperature of the device approaches the temperature of the environment (the temperature of the air in the thermal enclosure) following an exponential curve.

Many factors contribute to the amount of time that is required for a device to reach and stabilize at a given temperature, affecting the shape and character of the response curve. These include the material the device is made from, its size, the air temperature and flow rate, the properties of the thermal fixture, and the accuracy of the control technique. Key factors that are affected are the

offset and ***transition time***. The *offset* is the number of degrees of temperature overdrive required to bring a device to temperature rapidly. The *transition time* is the amount of time required for the device to change temperature. The T-2600BV has several type/sizes of thermal boots available to help optimize the integration of the temperature controlled air and the DUT, which can reduce both the *offset* and *transition times*.

The amount of time required by the device to become stable at temperature before testing can begin is the ***soak time***. The *soak time* is typically determined and programmed into the system before testing begins to assure accuracy and repeatability of test results. The best way to determine the *soak time* is to directly measure the thermal response of the component. This can be implemented in several ways depending on the characteristics and requirements of the test item. Techniques for determining soak time include:

- Replace the DUT with an RTD (temperature dependent resistor) that is packaged similarly to the device to be tested and measure the RTD's response.
- Measure the substrate diode characteristic of an integrated circuit.
- Measure the temperature inside the device by implanting a thermocouple in a hollow cavity sealed with RTV.

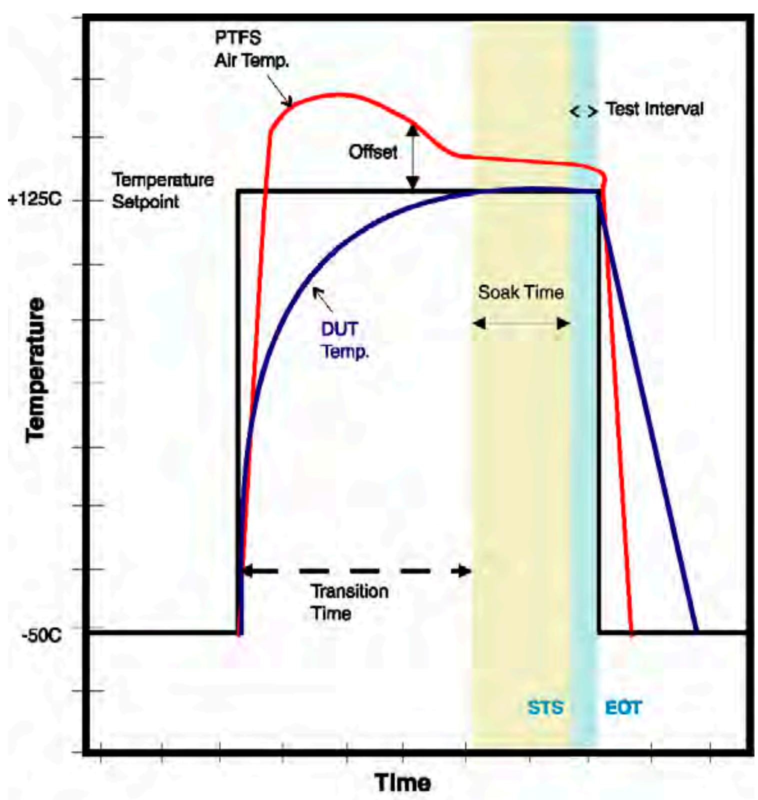

Figure 6 - 2, Thermal Time Constant Example

Computer Control Unit

The PTFS is control unit comprises the following boards: Temperature Control Board, Heater Control Board, and power supply.

Board	Function
Temperature Control Board	80188 microprocessor, memory, 16 bit A/D input, 14 bit A/D input, digital I/O, serial, parallel I/O, IEEE-488 and thermocouple termination.
Heater Control Board	AC switches, ammeter sensing, 24 V control relay, bar graph display, and optical isolation.
Power Supply	Provides the following outputs: pin 1 = + 12V pin 2 = -12V pin 3 = + 24V pin 6,7 = + 5V pin 5,4 = return

Table 6 - 3, Board Functions

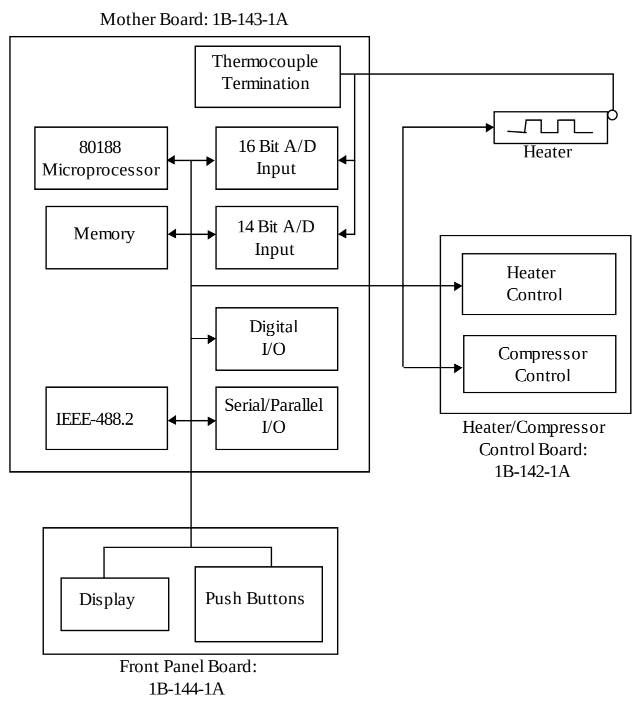

Figure 6 - 3, Control Unit Block Diagram

Air Flow Control

Compressed air is connected to the rear panel of the PTFS. From this input, it splits into separate paths for the hot air and cold air and pneumatic head-lift systems. (See adjacent Air Flow Block Diagram.). A series of venturis, regulators and solenoid valves control the flow of air through the pneumatic system.

When the systems forces hot air, the solenoid valve for the hot air path is opened. The cold air valve is closed and the exhaust for the venturi valve is closed. Conversely when cold air is in use, the hot air path is closed, and the cold air and vortex exhaust solenoids are open.

Hot air takes the following path:

- The venturi measures the air flow rate
- A manual flow control valve controls the flow rate. (This valve is operated from the front panel.)
- A solenoid valve controls the air's access to the hot pathway.
- The hot heater in the test head provides the temperature source.

Cold air takes the following path:

- The venturi measures the flow rate (Same venturi used for hot path.)
- A solenoid valve controls access to the cold pathway.
- A cold air heater controls the temperature of the air.
- The vortex tube in the thermal head provides the cold air source.
- A solenoid valve controls the exhaust air form the vortex tube. This prevents hot air from exhausting through the vortex tube.

Note: the cold air path uses full force air; therefore, the flow rate is not manually regulated.

The pneumatic system takes the following path:

The air passes through a flow regulator to a solenoid valve. When the solenoid valve is activated, the pneumatic lift raises or lowers the thermal head. A separate manual pressure regulator adjusts the speed of response of the pneumatic head lift.

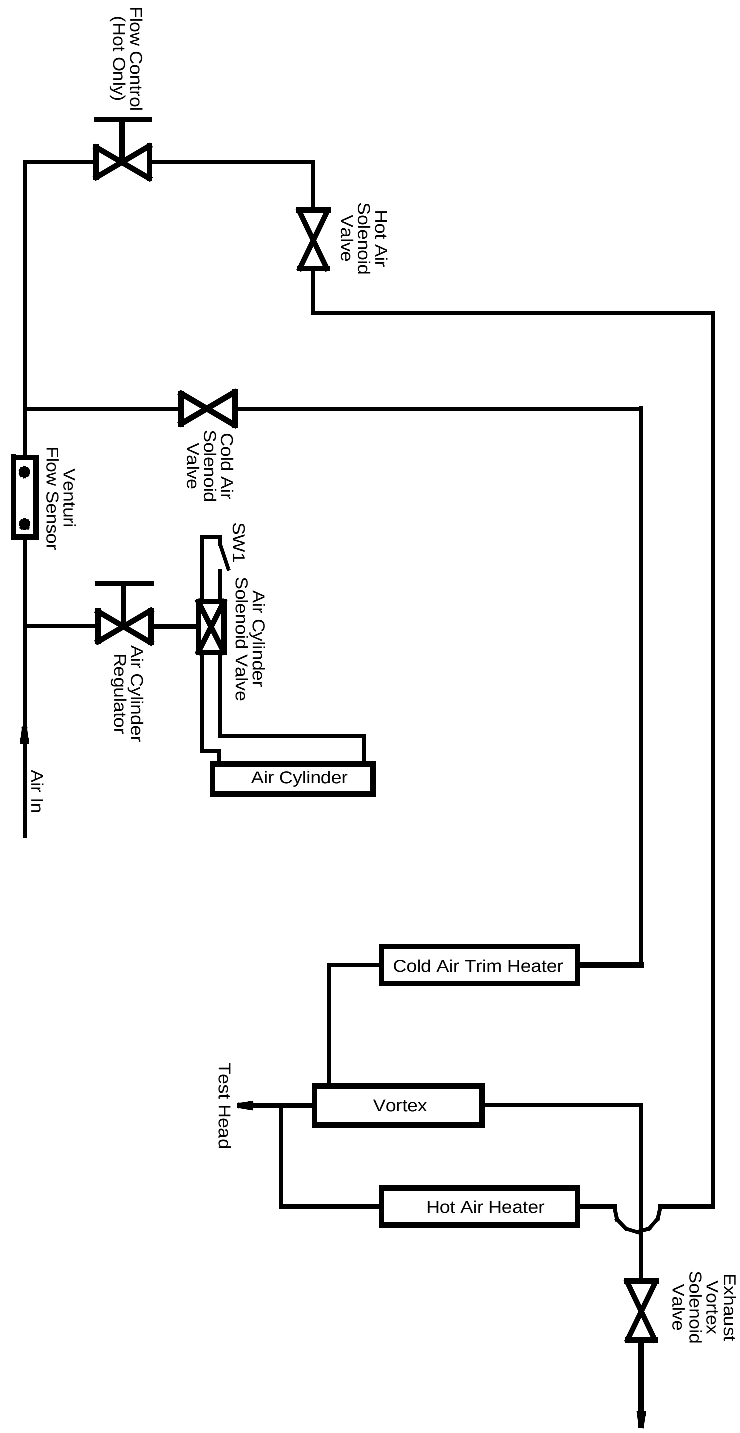

Figure 6 - 4, Air Flow Block Diagram

Vortex Technology

The vortex tube is the source of cold air for the T-2600 PTFS. Vortex tubes function using subtle physical principles of compressed air. The diagram below exhibits some of the main features of a generic vortex tube design. The tubes used by the T-2600BV have been optimized for use in the specified temperature range of this product.

The compressed air enters the tube at the vortex chamber and expands to a very high velocity. Because the hot air outlet is larger than the outlet for the cold air, the air tends in the direction of the hot air outlet, which is where the control valve is located. The air is spinning (vortex) and stays close to the wall of the tube. The control valve is set so that only a fraction of the air can escape. This forces the air back down the center of the tube in a tight inner vortex toward the cold exit.

The outer stream gets hot, and the inner one cold because of an exchange of energy between them. The energy exchange takes place in an unusual manner because the vortex is a "*forced vortex*." In this unusual type of vortex, the angular velocity of the air is held constant, therefore, the linear speed of the of the air decreases as it moves towards the smaller (cold) exit. Because the kinetic energy is proportional to the square of the linear velocity, the air exiting the cold tube dissipates less kinetic energy than the outer vortex. The "extra energy" exits the system via the outer core to which it is transmitted in the form of heat. The temperature drop of the inner air stream is greater than the temperature gain of the hot air stream because the mass flow rate of the hot air stream is larger than that of cold air.

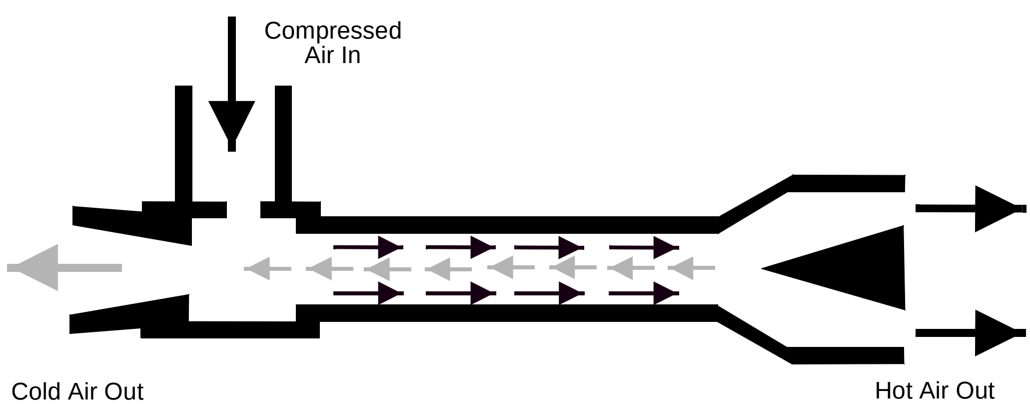

Figure 6 - 5, Vortex Tube

Fail-Safes

The PTFS protects the heaters from overheating with sensors and snap-disk thermostats. The control system measures the temperature of the heaters using thermocouples. A Venturi measures the airflow. To protect the heaters from overheating, the system turns the heat off if the air temperature is too high or if the airflow is too low. The snap-disk thermostats activate to turn off all power to the heaters if the heater case temperature becomes too high.

SAFETY

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SAFETY

Overview

Thermonics furnishes this information to enhance the safe use and servicing of this product. However, Thermonics **does not** assume any responsibility for the operator or service technicians' safety practices. The user or service technician is responsible for the implementation of safe and sane operating habits when using this equipment. All personnel who perform service on this product must understand the dangers of working on electrical and mechanical equipment and take precautions to protect themselves and others against possible bodily injury, damage to equipment or facilities.

Electrical System

This system contains circuits that are capable of large currents at 110 volts ac or higher. Read this section before servicing the system.

- High voltages are used by some subsystems. Areas that contain high voltages are marked with warning labels that read: ***WARNING High Voltage***. Use extreme caution when working on or near these areas.
- Never service or maintain any area of the system without first understanding the related circuits and voltages.
- Service panels should only be accessed by qualified technicians.
- Remove all jewelry such as rings or watches before performing any electrical troubleshooting.
- Remember the ***One Hand in Pocket Rule*** when working with high voltages.
- Never lean on frame or metal surfaces.
- Always work with a partner.
- When using probes or meters, make sure they are rated for the power that is being measured.
- Always disconnect the air line when servicing the pneumatic system.
- Wear safety glasses at all times.

WARNING!: 110 VAC is present is the chassis and rear enclosure with the machine power switch off. `Note: Optional systems may be configured with 20VAC.`

Emergency Off Switch (EMO)

The emergency off switch is a large, round, red switch located on the upper-right-hand side of the front panel. Use the EMO (emergency machine off) switch to remove power from the system in an emergency. To secure the EMO function, press the switch.

NOTE: The EMO function trips the main circuit breaker. To reactivate the system, set the circuit breaker to the “ON” position.

WARNING!: When the EMO is engaged, 110VAC is present at main circuit breaker. The main circuit breaker must be switched off, locked out, and the power cord disconnected before servicing.

Electronic Enclosures

The system is designed to minimize the probability of electric shock during maintenance, repair, modification, calibration and adjustment. Energized circuits, components, or terminal strips are enclosed with covers that require a tool to remove. In addition, hazardous areas are clearly marked with tags that read: ***DANGER HIGH VOLTAGE.***

Areas of the system that have active line voltages present when the system is switched off (using the main power switch, not the EMO) are: the main terminal strip, the On/Off switch, the EMO switch, transformers, line filters, and the circuit breaker. (Note: all items are located inside the chassis which has a screw-on cover.)

Lock Out Tag Out

If service is required to the electrical system:

1. Remove power to the system by shutting of the main circuit breaker.
2. Disconnect the main power cord from the wall socket.
3. Attach a tag listing the individuals authorized to reconnect the main power cord.

Electrical Task Hazards

Classification of electrical task hazards as defined by SEMIS2-93:

Type 1: Equipment is fully de-energized (electrically “cold”)

Type 2: Equipment is energized. Live circuits are covered or insulated. Work is performed at a remote location to preclude electric shock.

Type 3: Equipment is energized. Live circuits are exposed and accidental contact is possible. Potential exposures are **less** than 30 volts RMS, 42 volts peak, 240 volt-amps, 20 Joules, or radio frequency (rf) is present.

Type 4: Equipment is energized. Live circuits are exposed and accidental contact is possible. Potential exposures are **greater** than 30 volts RMS, 42 volts peak, 240 volt-amps, 20 Joules, or radio frequency (rf) is present.

Type 5: Equipment is energized and measurements and adjustments require physical entry into the equipment, or equipment configuration will not allow the use of clamp-on probes.

Listed below are all the electrical tasks that are classified as type 3 or higher:

Power Supply Checkout: The power supply checkout procedure is classified as a **Type 4** Electrical Task Hazard. Potential exposure to voltages greater than 30 volts RMS is possible. This procedure must be performed by a qualified technician.

Moving Parts

Parts that move inside the system are covered with cages or panels to prevent injury when the system is operating. Proper precautions should be observed when these subsystems are active and protective coverings have been removed. The following external components of the system are capable of moving when the system is powered up:

- Thermal Fixture (up/down)
- Support Arm (up/down - via mechanical crank)

Damage to Equipment

- Never forcibly move the boom with the brakes/clamps engaged.
- Move the system using the handles on the d body of the system, do not lift the system using the boom.

- Make sure that the input line voltage is correct; particularly so if a step-up or step-down transformer is installed.
- Always use clean, dry facility air.

Powering Up After Servicing

A qualified service technician must test and qualify the system for safety conformance, subsequent to service or repairs, prior to releasing it for normal use.

Prior to Applying Power:

1. Verify the input power. Make sure that it is 110 to 120VAC and correctly connected to the rear panel connector labeled AC INPUT.
2. Verify that the facility air (CDA), used for pneumatic operation and temperature transference, is between 80 to 100 psi. A gage is located on the air input connector panel. Adjust if necessary. Clean, dry air must be used.
3. Verify that the cover to the card-cage is securely replaced.

After Applying Power:

1. Test the EMO (Emergency Machine Off) button. Power to the system should be removed, and the main circuit breaker activated, when the button is depressed. Restart the system by setting the main circuit breaker, located on the rear panel, to the ON position.
2. Observe the operation of the system, the Start-up screens should appear with no warning messages or alerts active.

Installation

Observe the following safety precautions when installing the system:

- Personnel must receive proper training on safety procedures for the temperature-test environment. Do not operate the system without prior safety training. Appropriate safety equipment and medical treatment information must be available.
- All facility supply lines must be clearly labeled. All power cables and plumbing should be routed to prevent damage to the lines or individuals.

DISPLAYS AND CONTROLS

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DISPLAYS, CONTROLS AND INTERFACES

GENERAL

This section of the manual provides information to familiarize the maintenance technician with the operational controls and interfaces of the T-2600BV. Items covered include the front panel controls and indicators, the rear panel interface connectors, and the support arm and thermal fixture adjustment.

FRONT PANEL CONTROLS AND INDICATORS

The T-2600BV front panel consists of ten primary controls and indicators. The following information describes their primary functions and how they are actuated. (See Figure 8 - 1, for an illustration of the front panel.)

Emergency Stop Button (EMO)

The emergency stop button immediately stops the system by tripping the circuit breaker via a special input. **Note**: when activated power remains supplied to the rear pane. When servicing the unit, disengage the power and lock-out tag out as appropriate.

Display Panel

The T-2600BV front panel displays pertinent system operation information via a four line, 80 character alphanumeric display. Types of information that displays are system operation status, error messages, and programmable menu features.

Numeric Key Pad

The numeric key pad is used to enter numeric data for the various programmable menu options. The SET, ENT, < > (arrow) keys are used to navigate the menu items. Numeric data is entered using the number keys.

Main Power Switch

The POWER switch applies power to the T-2600BV power supply board from the rear panel circuit breaker and fuses. The **ON** position is indicated by green illumination.

Temperature Select Push-Buttons (x 3)

Three temperature select push-buttons allow the operator to force temperature controlled air to programmable set-points. The push-buttons are labeled T1, T2, T3. A red LED on each button indicates the switch that is currently activated. These switches illuminate when selected either manually or by remote operation.

Cycle Key

When the CYCLE push-button is pressed, it activates the programmable cycle routine. A red LED on the switch indicates that the cycle routine is active. The cycle mode may be deactivated by pressing the CYCLE push-button, raising the test head, pressing the T2 push-button or sending a command via a remote interface.

Local/Remote Key

The red LED on the LOCAL key is illuminated whenever the unit is in a remote mode of operation. When the LOCAL push-button is pressed, it deactivates remote operation placing the unit in local mode. The T-2600BV remote mode is activated via RS-232C or IEEE-488 interfaces.

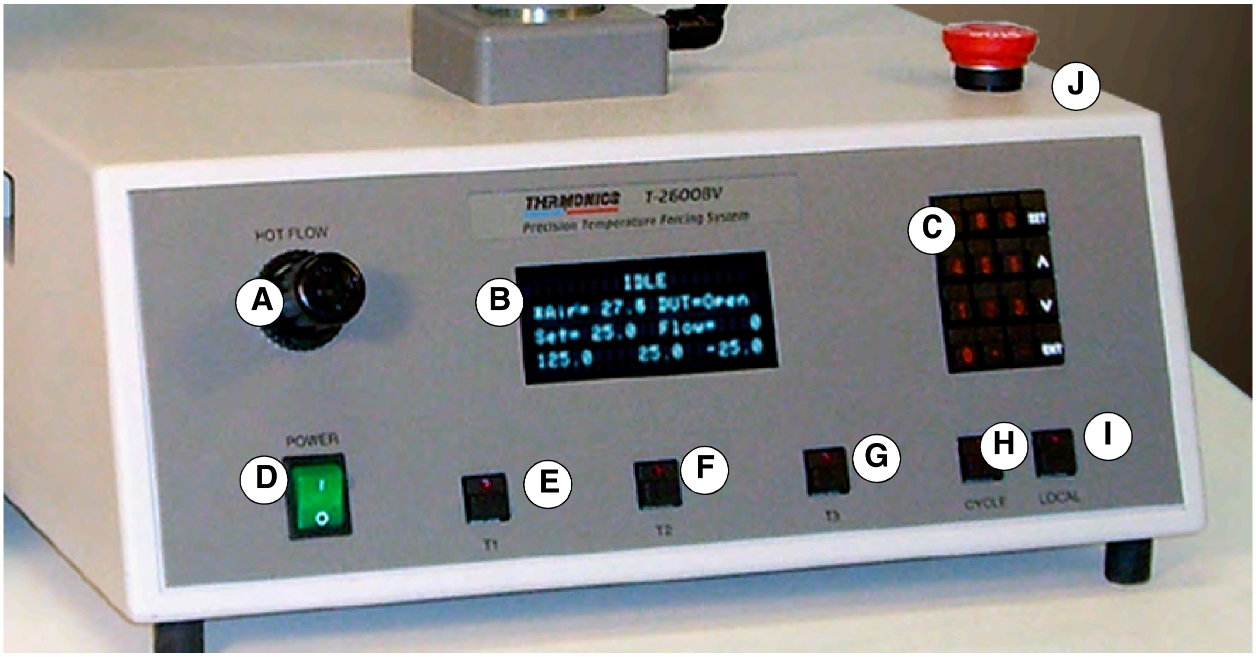
Hot Air Flow Regulator

Hot air flow regulation is controlled by the HOT flow regulator. The HOT flow regulator controls the air flow for temperatures of 30C or greater.

Head Up/Down Force Control

Controls the amount of air delivered to the air bearing on the thermal test head. An increase in air pressure controls both the rate of ascent and descent of the head, and the amount of pressure the shroud exerts on the service below. This adjustment interacts with the head position adjustment to facilitate an effective seal between the glass shroud and the surface below it.

Note: On current models the *Head Up/Down Force Control* is a regulator located inside the chassis, just behind the front panel.



A. Hot Flow Control

B. Display Panel

C. Numeric Keypad

D. Main Power Switch

E. Temperature Preset Key

F. Temperature Preset Key

G. Temperature Preset Key

H. Cycle Key

I. Local/Remote Key

J. Emergency Stop

Figure 8 - 1, T-2600BV Front Panel Controls

REAR PANEL INTERFACE CONNECTORS

The rear panel of the system contains all of the input connectors for system communications, power, and pneumatics. A table of Thermonics part numbers for replacement of these items can be found in the *Appendix***.**

Circuit Breaker

20 Ampere Circuit Breaker. Shunt trip with auxiliary switch. Power is 110VAC to 120VAC, single phase, 50/60 hertz. (Note: optional system configurations may use 208 - 240VAC)

Air Inlet

The air inlet is comprised of a 1/4” NPT connector and a male quick disconnect. Thermonics part number for this item is P2-181.

Input Pressure Gauge

Displays the amount of air pressure supplied to the air system.

Purge Air Flow Regulator

Purge air prevents frost and moisture from forming on the shroud and bezel area of the thermal test head enclosure. Use this control to increase the flow of purge air if frost begins to form.

Ports

The rear panel provides interfaces that enable the system to communicate with other machines and test equipment through cables. The tester I/O, RS-232C, and IEEE-488 connectors enable two-way communication with and control by external devices. See Chapter: *Remote Operation and Interfacing.* The following connectors are found on the rear panel.:

Tester I/O:

24-pin female connector. Provides a standard handler interface.

RS-232C I/0

9-pin male connector. Standard RS-232C interface protocols are supported.

IEEE-488 BUS

24-pin female connector. Enables use of IEEE-488.2 interfaces.

Foot Control

15-pin female connector (also called head control). Enables foot operation of the thermal fixture up/down motion.

Purge Air Line Connector

A quick disconnect fitting is provided for access to purge air.

Note: A table providing information on the part numbers and mates for these connectors can be found in the ***Appendix***: C - 1

A. Input Pressure Gauge
B. Air Input Connector
C. Circuit Breaker
D. Purge Air Regulator
E. Purge Air Connector
F. RS-232C Port
G. Standard Tester Interface Port
H. IEEE-488 Port
I. Foot Switch Port

Figure 8 - 2, Rear Panel Interfaces

THE SUPPORT ARM AND THERMAL TEST HEAD

This assembly is comprised of the arm and thermal test head.

Support Arm

The arm has three mechanical adjustments that control its position.

Wrist Adjustment Clamp

This brake restricts the position of the wrist near the thermal fixture. It allows the head to be rotated around a bearing into a variety of positions.

Elbow Clamp

The elbow brake restricts the motion/position of the forearm. The arm can be extended or contracted between 11 and 24 inches.

Arm Base Clamp

The arm base clamp restricts/sets the rotational position of the entire arm assembly. When unclamped the arm is free to pivot up to 345 degrees around its base.

Thermal Test Head

The thermal head has an up/down control, two thermocouple inputs jacks and head positioning mechanisms.

Head Up/Down Button

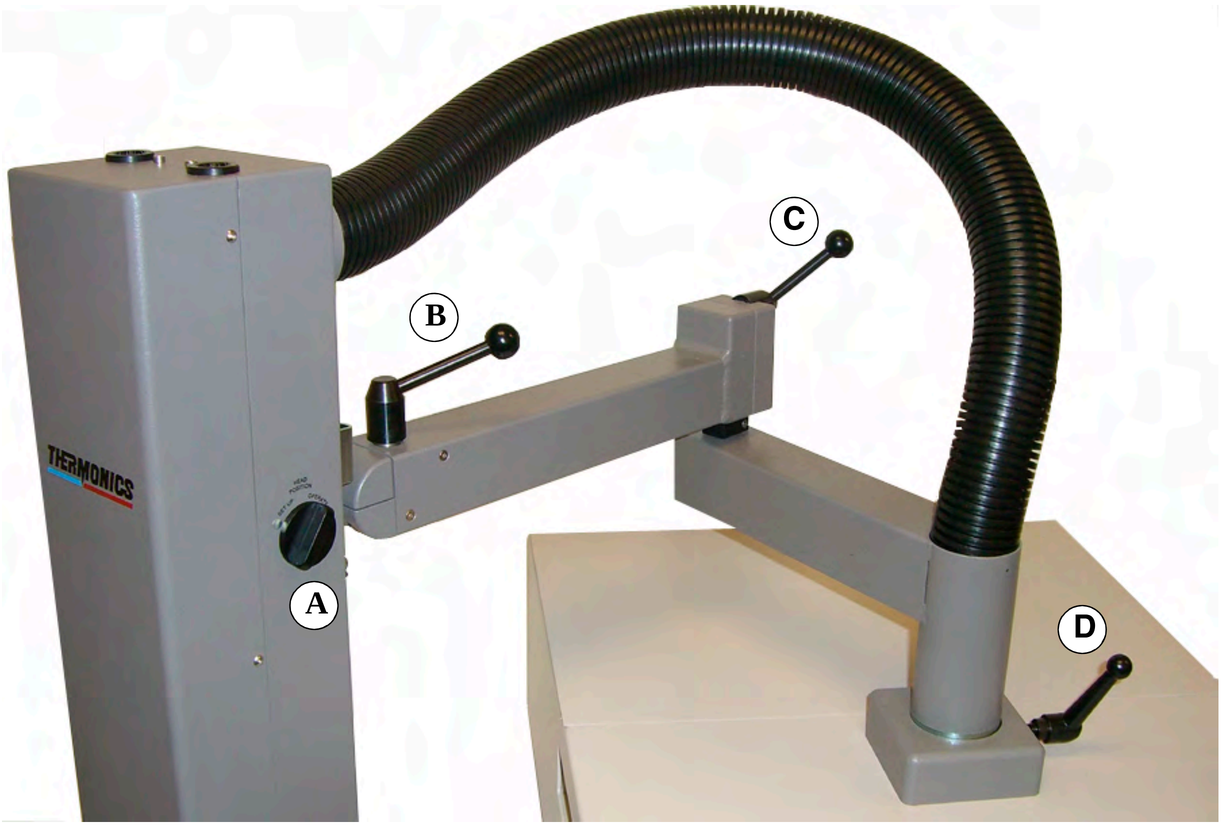
The small read button is used to alternately raise and lower the thermal fixture. (Not shown)

Thermocouple Access Ports

As a convenience, the two types of DUT sensors can be plugged into receptacles on the side of the thermal fixture. The blue receptacle is for the T-DUT thermocouple and the yellow if for the K-DUT thermocouple.

Head Position Mechanism

The head position mechanism provides an adjustment to the vertical position of the head that ensures a firm seal between the shroud and the foam insulating material surrounding the DUT. See Chapter *Operating the T-2600BV* for details on the use of this feature.



A. Head Position Adjustment

B. Wrist Clamp

C. Elbow Clamp

D. Arm Base Clamp

Figure 8 - 3, Arm and Thermal Fixture Position Adjustments

CALIBRATING THE T-2600BV

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CALIBRATING THE T-2600BV

Introduction

This chapter describes the procedures used to calibrate the T-2600BV PTFS. The specific calibration methods covered are:

- Hot air flow rate.
- Manual calibration of the air temperature sensor.
- Manual calibration of the DUT sensor.
- Millivolt source calibration of the air or DUT sensors.

NOTE: The recommended interval for calibration is every six months.

About Calibration

The calibration process serves to adjust and standardize the air flow rate and temperature measurement systems of the T-2600BV. The sensors that you can calibrate are the air flow rate sensor for the hot air path, the fixture air temperature sensor, and the DUT temperature sensors. The DUT sensor may use either T or K-type thermocouples.

The basic procedure for calibration is to measure the actual airflow rate or temperature using a known external standard. The values read by the standard are then entered into the system and used by the control software to ensure accurate display and control.

Use a mechanical flow meter as the external standard for airflow calibration. For air temperature calibration, you can use either an electronic temperature meter or a millivolt source.

The system software contains a series of screens that guide you the calibration process. To access the calibration top-level menu select *CALIBRATION* from the configuration portion of the system software.

Air Flow Rate Calibration

Periodic airflow rate calibration is essential to ensure proper functioning of the T-2600BV. Calibrate the airflow rate by using a flow rate meter, which measures the rate in SCFH. The flow rate that you calibrate is for the hot air path only. Cold air, on this particular model, always uses full-force air because of the requirements of the vortex system.

You calibrate the airflow rate by connecting the flow meter to the output air nozzle on the thermal test head. (See Figure 9 - 1.) The system will force air at two different flow levels (low and high) and then ask you to enter the readings from the meter.

At any point in the process, you can halt the calibration procedure without making any changes to the airflow control system by pressing the T2 key. Alternatively, a screen appears at the end of the process that allows you to disregard (not save) the calibration.

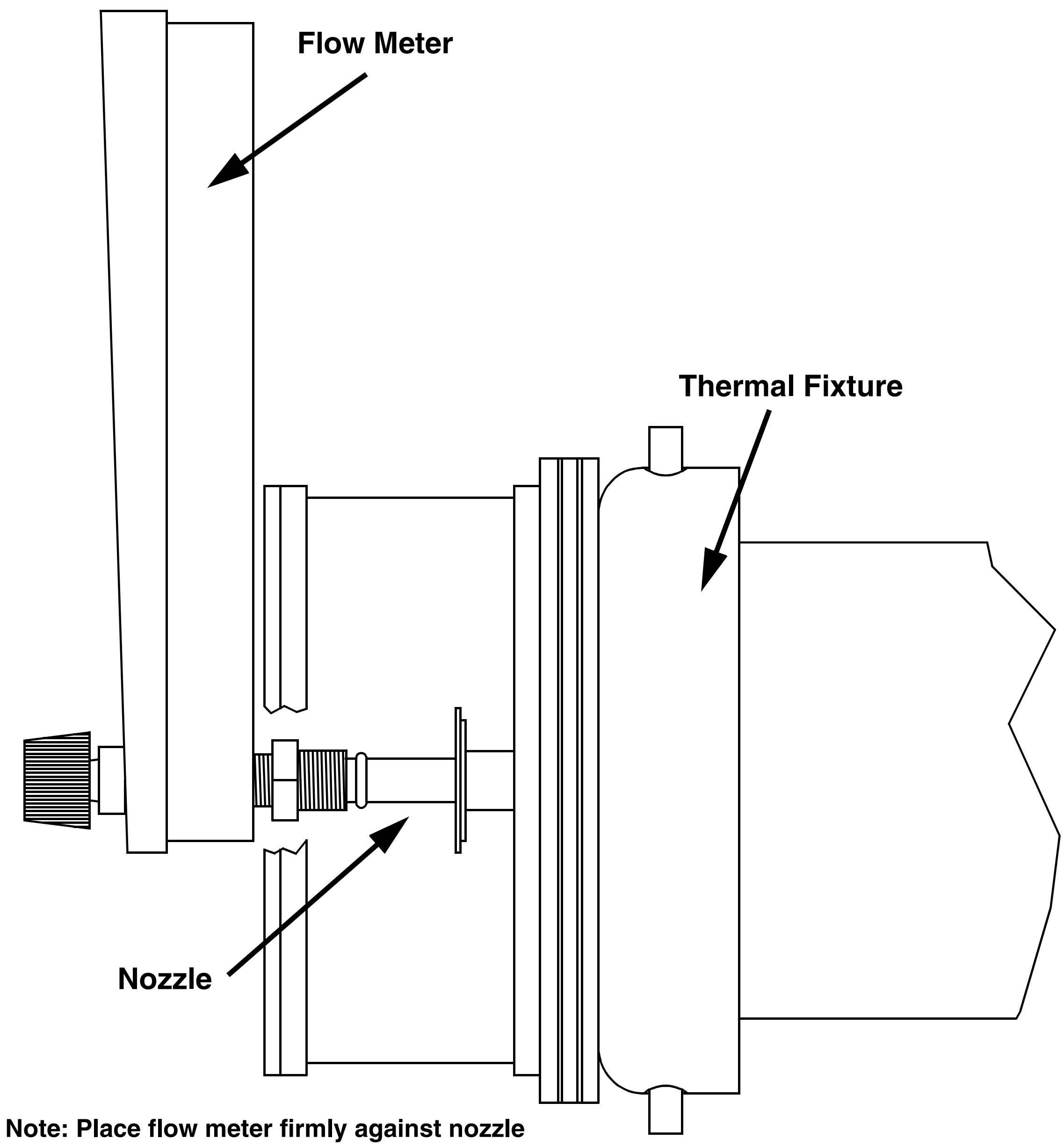


Figure 9 - 1, Placement of Air Flow Meter

Flow Calibration set up

Begin the flow calibration procedure as follows:

a. Start the system and allow it to power up completely. The Main Status Screen displays.

b. Adjust the thermal test head to a horizontal position so that the output air nozzle is easy to access with the flow meter.

c. Follow the procedures in the next section.

Flow Calibration Procedure

1. From the Main Status Screen, access the calibration portion of the system software by pressing the *ENT* key. Use the < > keys to scroll to the Calibration selection. Enter the menu by pressing the *SET* key.
2. Three choices are now available: *Temperature*, *Hot Air Flow Rate and Restore Defaults*. Use the < > keys to display *Hot Air Flow Rate* (if not already displayed). Use the *SET* key to enter the Hot Air Flow Rate calibration submenus.
3. A screen appears that supplies the instructions for connecting the flow meter and the instructions for an appropriate low flow setting. Use the flow rate adjustment knob on the front panel to adjust the flow to within the specified range (150 - 200). Press the *SET* key to move to the next screen.
4. This screen contains the data entry field for the measurement obtained by the external flow meter. Enter the value registered by the external meter using the numeric keypad. Press the *ENT* key to input the data.
5. The system now repeats the above procedure (step 5) for the high flow rate settings.
6. When finished entering the data for the high flow reading, a screen appears that allows you to accept the new air flow calibration values or to exit without saving them. Use the *ENT* key to accept the displayed slope and offset. Use the *SET* key to exit without saving.
7. After you accept the calibration by pressing the *ENT* key, *CALIBRATION COMPLETE* appears on the display panel. Further presses of the *ENT* key at this point exits you out of the menus.

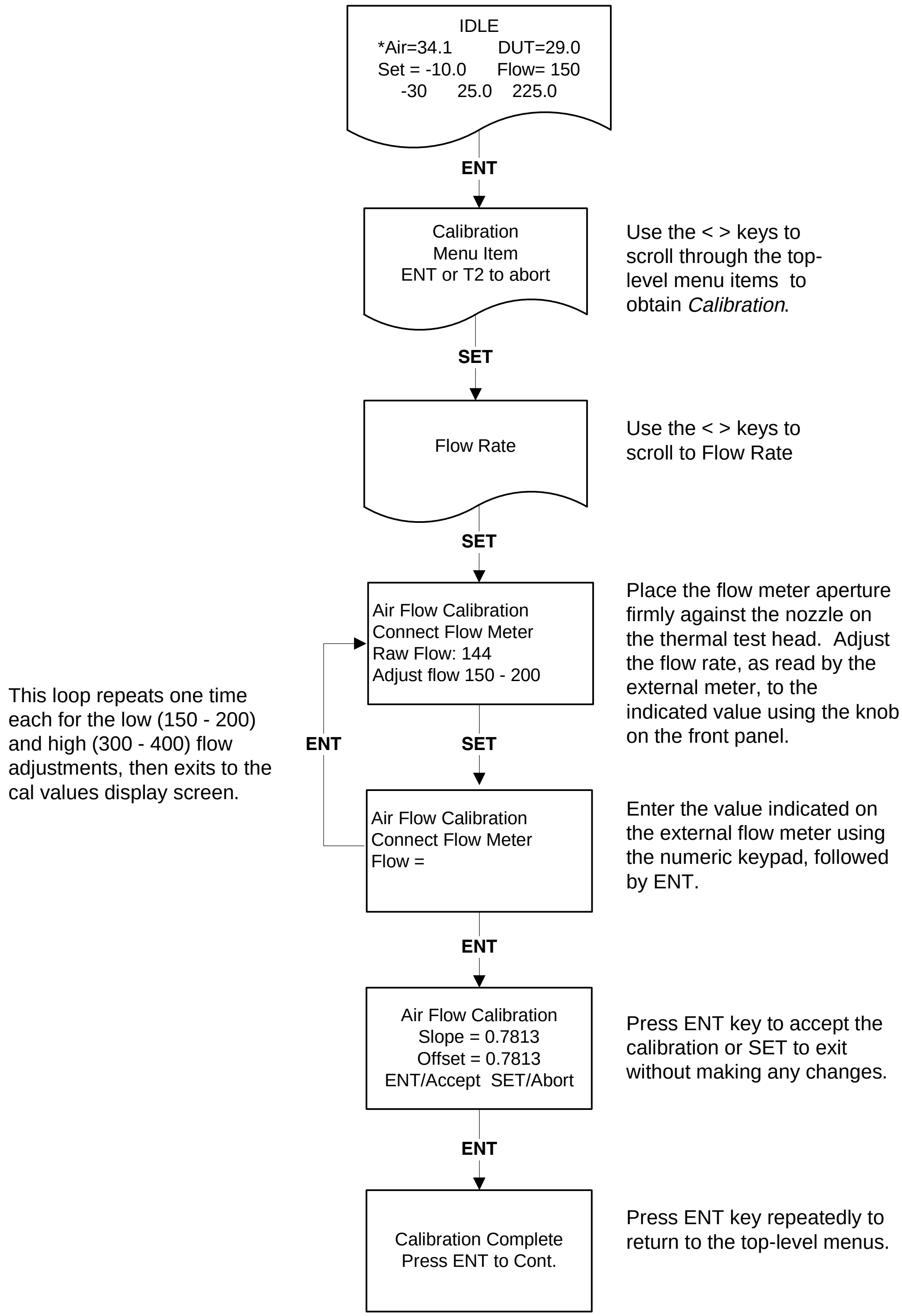


Figure 9 - 2, Air Rate Calibration Flow

Temperature Calibration

The temperature calibration procedure ensures the accuracy of the thermal fixture air and DUT sensors. The temperature calibration process scales the temperature reading of the system such that it agrees with a secondary standard. The secondary standard can be a temperature meter or a millivolt source.

Calibration is facilitated by a series of screens that enable you to set the temperatures for the calibration. The system automatically obtains the set points and asks you to enter the reading from the external temperature meter at the appropriate times. (See flow) At the end of the procedure, the system presents the slope and offset values obtained for that calibration. To accept the displayed values press the *ENT* key. To reject the values, press the *SET* key.

At any point in the calibration process, you can halt the procedure without making any changes to the temperature measurement system by pressing the *T2* key.

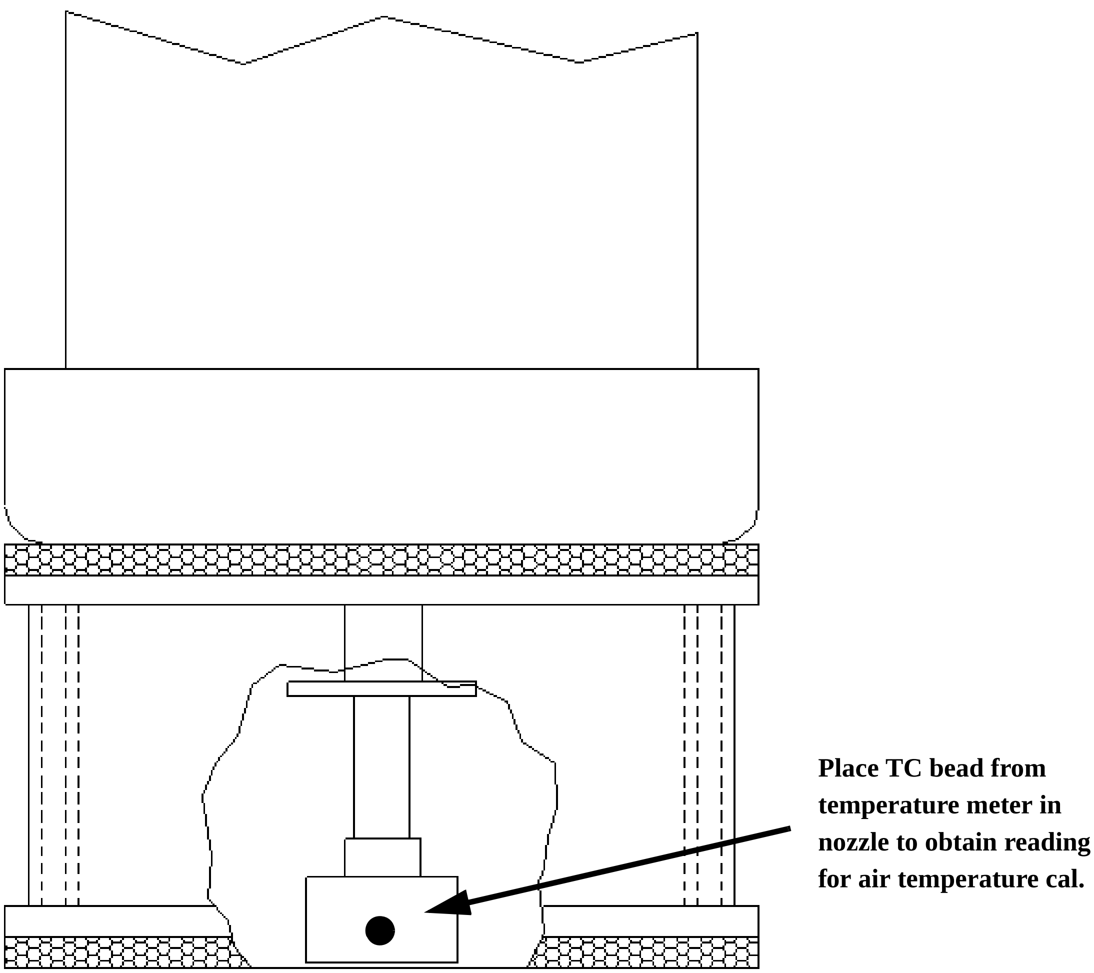


Figure 9 - 3, Placement of Secondary Standard

Thermal Fixture Calibration Setup

To perform the procedure, place an NBS traceable thermocouple in the output air nozzle of the thermal fixture. Connect the TC to the temperature meter and then follow the procedures in the calibration menus. (See the adjacent illustration, Figure 9 - 3, for placement of the thermocouple bead.)

Thermal Fixture Sensor Calibration Procedure

Use the procedure below to calibrate the air temperature sensor in the Thermal Test Head.

1. Physically prepare the system for calibration by placing the thermocouple for the temperature meter in an appropriate location.
2. Access the *Calibration* menus.
3. Select *Temperature* from the sub-menus.
4. Determine the type of calibration by selecting *Temp Meter.*
5. Press the *T3* key to select Air. (Fixture sensor). The other choices T1 and T2 are for selecting the type of DUT sensor to calibrate: T or K, respectively.
6. Enter the hot and cold temperature setpoints. Use the numeric keypad to enter the values, followed by *ENT*. Use the < > keys to move between the hot and cold input screens.
7. The system will stabilize at the cold setpoint and then prompt you for the reading from the meter. It will then do the same for the hot setpoint.
8. Enter the temperature meter readings when prompted.
9. After entering the reading for the hot temperature, the newly calculated slope and offset display. Press the *ENT* key to accept the calibration. Press the *SET* key to reject the calibration.

The flows on the following pages provide a detailed overview of the temperature calibration process.

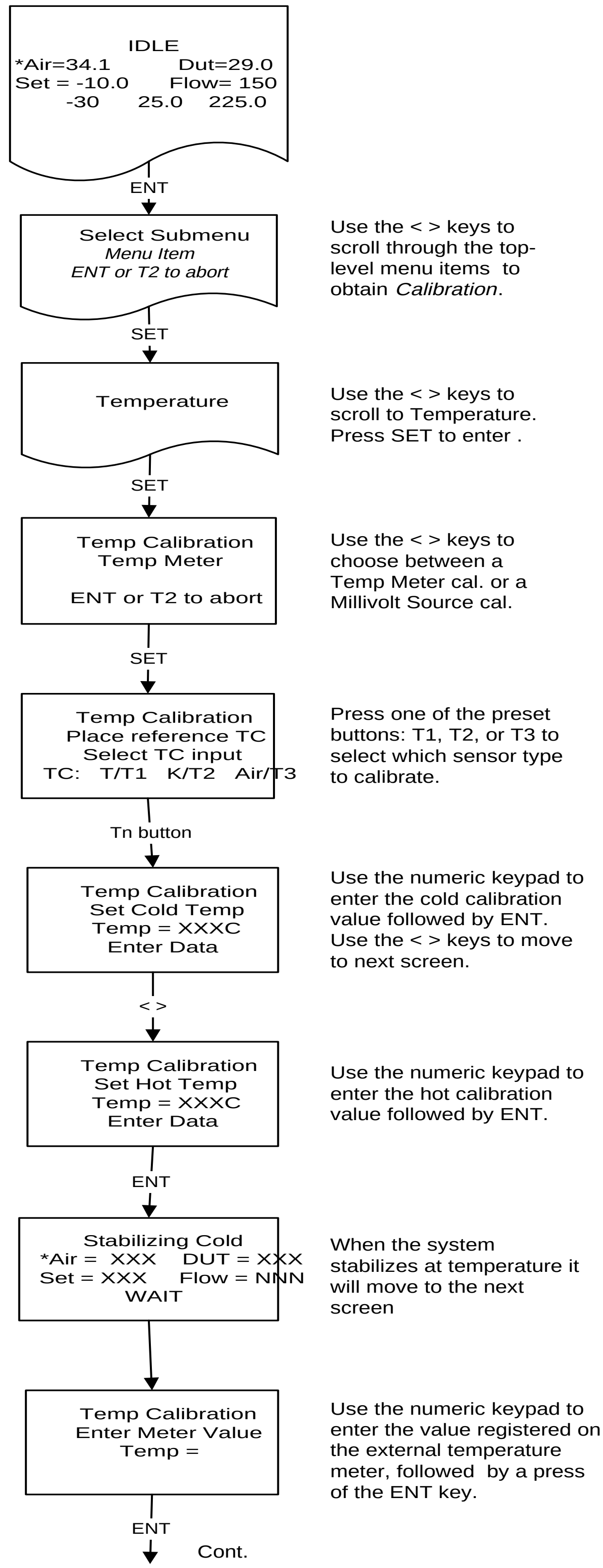
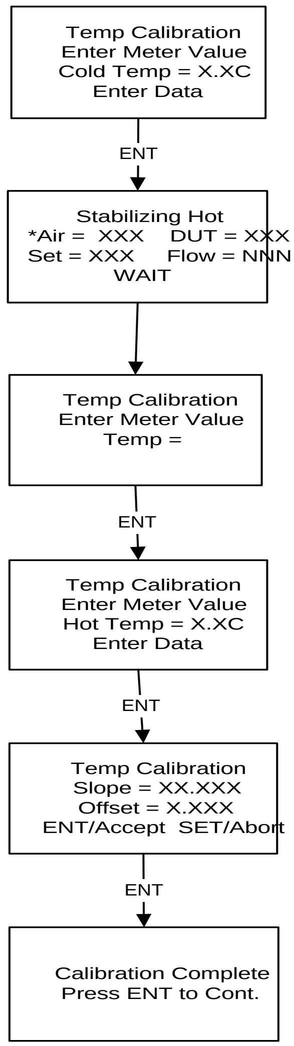


Figure 9 - 4, Temperature Calibration Flow (1 of 2)



Press the ENT key to begin the hot temperature calibration.

The system then repeats the procedure for the Hot temperature setpoint.

Use the numeric keypad to enter the value registered on the external temperature meter, followed by a press of the ENT key.

Press the ENT key to accept the calibration. Press the SET key to reject the calibration.

Figure 9 - 5, Temperature Calibration Flow (2 of 2)

DUT Calibration Set Up

DUT calibration requires the use of an external temperature-registering device such as an NBS-traceable thermocouple and temperature meter. You enter readings from the meter at various times in the process.

For an effective calibration, co-locate the thermocouple beads of the DUT sensor and the thermocouple of the temperature meter. It is best to attach the thermocouples to the underside of a representative test device using thermal tape. (See illustration.)

DUT Sensor Calibration Procedure

1. Physically prepare the system for calibration by placing the thermocouple for the temperature meter in an appropriate location. (As described in previous section.)
2. Access the Calibration menus.
3. Select *Temperature* from the sub-menus.
4. Determine the type of calibration by selecting *Temp Meter*. Other choices are millivolt source or restore defaults.
5. Press the *T1* or *T2* key to select the desired DUT sensor (T or K-type). The other choice T3 is for air.
6. Enter the hot and cold temperature setpoints. Use the numeric keypad to enter the values, followed by *ENT*. Use the < > keys to move between the hot and cold input screens.
7. The system will stabilize at the cold setpoint and the prompt you for the reading from the meter. It will then do the same for the hot setpoint.
8. Enter the temperature meter readings when prompted.
9. After entering the reading for the hot temperature the newly calculated slope and offset display. Press the *ENT* key to accept the calibration. Press the *SET* key to reject the calibration.

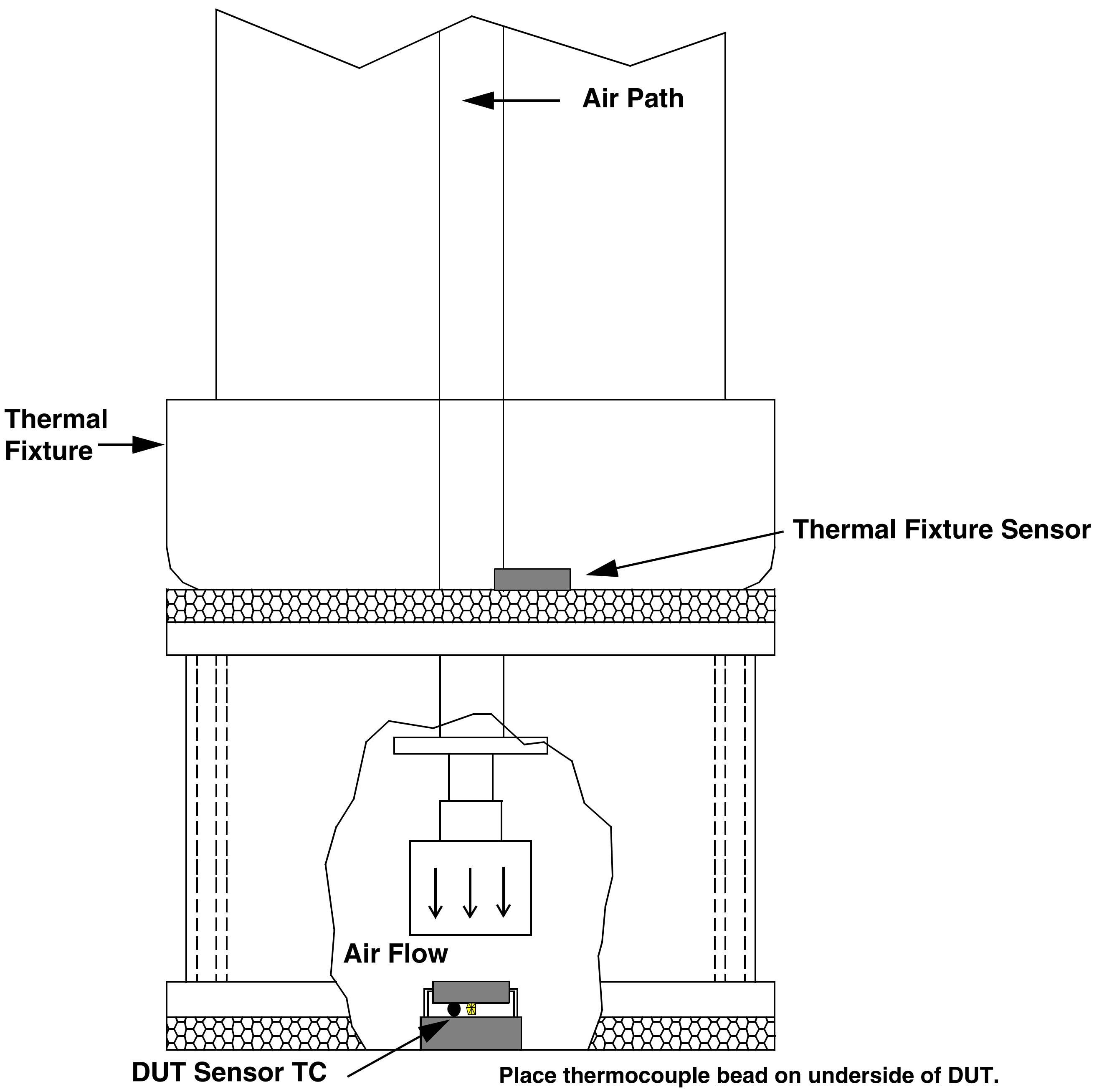


Figure 9 - 6, Placement of Secondary Standard for DUT Cal.

Calibrating Temperature with a Millivolt Source

An external millivolt source is capable of generating voltages equivalent to those a thermocouple generates at specific calibration setpoints. It provides an accurate reference voltage that the internal metering system uses to adjust the temperature scaling. The advantage of using a millivolt source is that it is a fast way to calibrate the system.

Use the millivolt source in place of an external thermocouple. When the system requires input from the outside reference, adjust the millivolt source until the temperature meter displays the desired calibration setpoint(s).

Millivolt Source Calibration Setup

To calibrate the DUT sensors, plug the millivolt source into the DUT thermocouple receptacles located on the side of the thermal test head. To calibrate the air temperature sensor located inside the thermal fixture, plug the source into junction J5 on the temperature control board. (See Illustration.)

Millivolt Source Calibration Procedure

The following procedure describes the step you follow to perform a millivolt calibration of the air temperature sensor. The same basic steps are followed when peforming an MV calibration of the DUT sensor. The main difference between the procedures is where you connect MV source (see previous section.)

1. Physically prepare the system for calibration by placing the thermocouple extension for the millivolt source in the appropriate TC receptacle. (As described in previous section.)
2. Access the Calibration menus.
3. Select *Temperature* from the sub-menus.
4. Determine the type of calibration by selecting *Millivolt Source*.
5. Press the *T3* key to select *Air.* (Fixture sensor). The other choices T1 and T2 are for selecting the type of DUT sensor to calibrate T or K, respectively.
6. When prompted, adjust the millivolt source to the specified temperature. Use the numeric keypad to enter the values, followed by *ENT.*
7. After entering the reading for the hot temperature the newly calculated slope and offset display. Press the *ENT* key to accept the calibration. Press the *SET* key to reject the calibration.

Restoring Default Temperature Calibration Values

The system enables you to restore the default calibration values for temperature control. These are the factory settings for the slope and offset. Do not restore the defaults unless it is apparent that calibration process is not ensuring accurate control.

To restore the airflow calibration values, access the calibration menus and select Restore Defaults within the temperature calibration submenus. (See adjacent flow.)

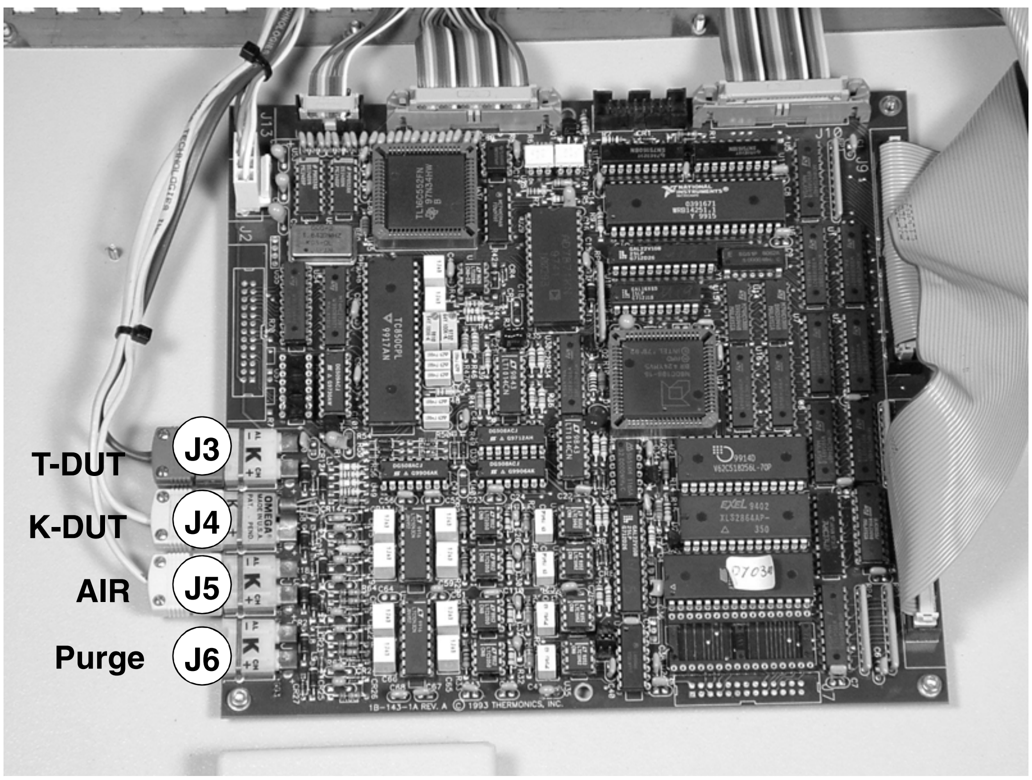


Figure 9 - 7, Termination for Millivolt Source Air Cal.

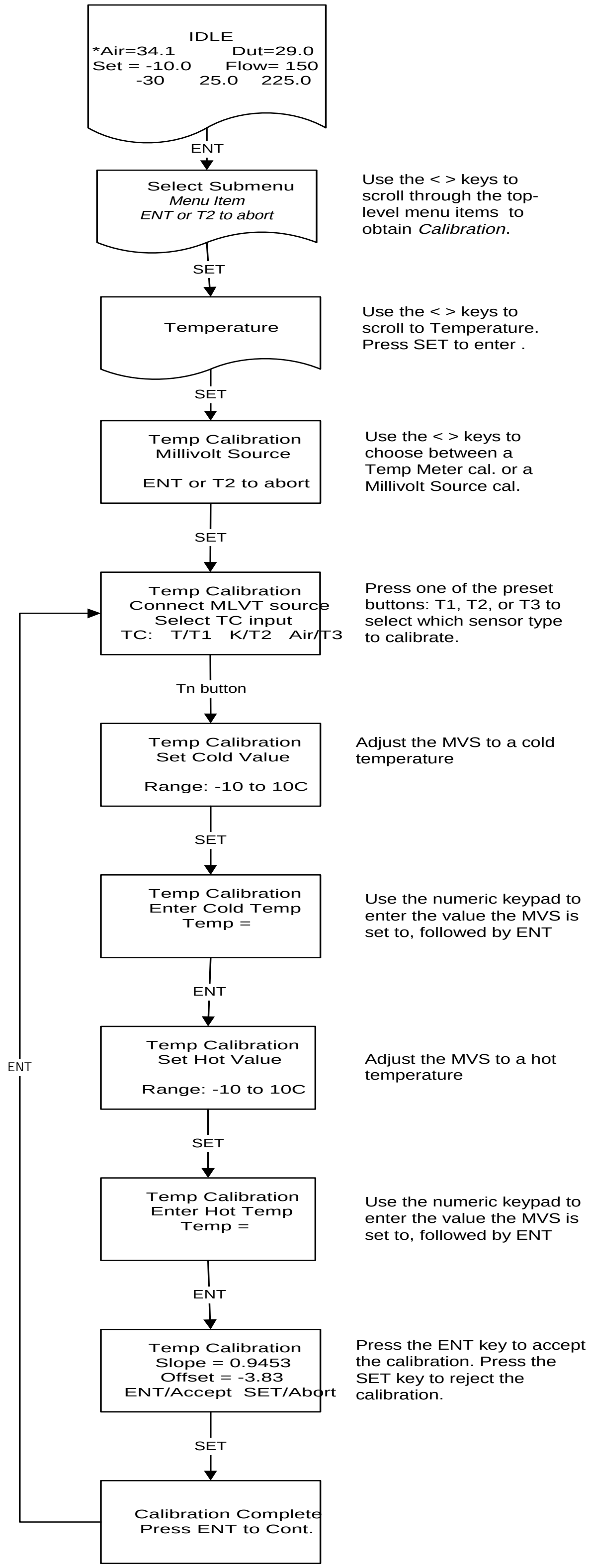


Figure 9 - 8, Millivolt Source Calibration Flow

Restoring Default Calibration Values for AirFlow

The system enables you to restore the default calibration values for airflow and temperature calibrations. The restored values are the factory settings for the slopes and offsets for each type of calibration. Do not restore the defaults unless it is apparent that calibration process is not ensuring accurate control, or the system has become so far out of range that calibration in not working.

To restore the airflow calibration values, access the calibration menus and select *Restore Defaults* from the top level menus using the SET key. Use the < > keys to cycle through the list of calibration types until the one you want to restore is displayed. Press the SET key to restore that specific calibration.

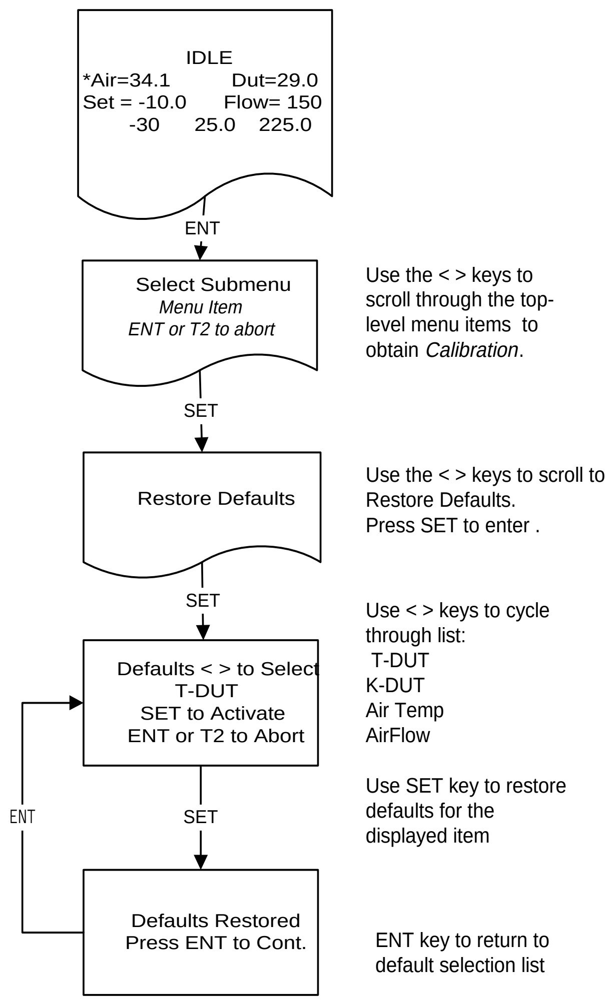


Figure 9 - 9, Restoring Default Calibrations Flow

CORRECTIVE MAINTENANCE

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CORRECTIVE MAINTENANCE

General

This section of the manual contains diagnostic and repair procedures for system failures that may occur in the field. Its purpose is to aid in the diagnosis and repair of problems to the board level. The maintenance philosophy adopted by Thermonics is that bad boards or subassemblies are to be entirely replaced. Repairs to PC boards or components are done at your own risk.

This chapter is organized by symptom. The procedures for diagnosis and repair of a particular problem can be found in the section associated with the symptom. In general, there will be an error message associated with the condition.

Because there may be multiple causes and symptoms associated with a given problem, this section is best used as a check list to systematically effect repairs through the process of elimination. Once the probable cause is isolated, follow the repair procedures in sequence until the system is again operational.

Internal Diagnostics

The T-2600's intelligent operating system continuously monitors sensors that provide data on the system's internal states. When the operating system detects an error condition, a fail-safe is generated. During a fail-safe, the system enters stand-by mode and a relevant message(s) is presented on the display panel.

Fail Safes

The self-monitoring circuitry is capable of generating a fail-safe when one of the following events occurs:

- AC switch is shorted
- AC switch is open
- Thermocouple open
- Thermocouple Safety Board activated

Error Messages and Alerts

When a fail-safe is exercised, specific messages appear. The message may be accompanied by an additional relevant instruction such as *Call Maintenance,* or *Turn Off Power.* (Please do so.)

#	Message	Interpretation
1.	Call Maintenance	This message appears in conjunction with any messages that denote the system requires service.
2.	Turn Off Power	This message occurs in conjunction with any message that indicates a serious malfunction.
3.	Heater Snap-Disk Open	Thermocouple Safety Board activated.
4.	J3, TC Open!	Thermocouple is reading an open condition. System is not sensing presence of TC.
5.	Heater Open/K1 Short	Monitoring circuitry has activated a fail-safe. TC may not be connected to junction or may be bad.
6.	AC Switch K1 Open!	Monitoring circuitry has activated a fail-safe. AC switch may be bad.
7.	AC Switch K2 Open!	Monitoring circuitry has activated a fail-safe. AC switch may be bad

Table 10 - 1, Error Messages

System Won't Power Up

No power to the system is indicated by failure of any subsystem to activate. The most obvious symptom is a blank display panel, including no illumination of the main on/off switch. In addition, you will not hear the system fan operating. If this is the case, the best diagnostic strategy is to trace through the system until you find the location where power stops transmitting. Proceed as follows:

1. Make sure that the front panel switch is in the OFF position.
2. Check the power source. Make sure that 110 Vac is supplied to the wall socket.
3. Make sure that the power cord is good. That is, transmitting power.
4. Check the fuse located on the rear panel.
5. Make sure that the circuit breaker is in the ON position

6. Check for power at the main terminal strip (4R-099-1A). The readings at pins 1 and 2 should be 110 Vac. If no power is found the problem lies between the wall and the power strip. If power is found, at these pins, the problem lies between the terminal strip and the power supply. Proceed as follows:

   a. Turn the main power switch to the ON position.

   b. Check pins 3, 4, & 5 and 6, 7 & 8 on the main terminal strip. If no power, check the AC relay. If bad, see *AC Switch Replacement*.

   c. If power is transmitted through the relay, check the power supply as outlined in *Power Supply checkout*.

Front Panel Display Not Operational

The first items to check when the front panel is not functioning are the fuses and the circuit breaker, as in the above procedure. Then follow these steps:

1. Check the power cord to ensure the system is receiving power.

2. Check the ribbon cable connected to the front panel

3. Check the power switch to see if power is transmitted in the “on” position, and it is illuminated. If it is, proceed as follows. If it is not illuminated, see *System Will Not Power Up,* above.

Power Supply Checkout

If the system is receiving power and the display is not functioning, the power supply may be bad. The most obvious symptom will be an illuminated power switch and a blank display panel. Perform the power-supply checkout as follows:

1. Check the fuse on the power supply board. With the power to the system off, the fuse should read as open. If bad replace with 0.75 Amp fuse.

2. Check the input power to the supply, it should be 110 Vac.

3. Check the power supply voltages at connector P2. Remove connector P17 at junction P2, located on the power supply board. The voltages measured on the pins should read as follows:

   1. +12 Vdc
   2. +2 Vdc
   3. -12 Vdc
   4. -12 Vdc

5. + 24 Vdc
6. +24 Vdc
7. COM
8. COM
9. + 5Vdc
10. + 5Vdc

If the power supply is bad, a new one can be ordered from Thermonics, part number B1-006.

Not Controlling at Setpoint

If the system is not getting hot or cold, the source of the problem should be detected by the system and generate an error message. For example, if something is wrong with the heater control circuit, you will get a message about an AC switch being open or shorted.

Check the system to make sure that it is not having a heater problem. You can observe the operation of the heater at K1 on the Heater/Compressor control board, by watching LED D1. It is on when the heater is activated. See *Cold Checkout Procedure* for information on determining the chiller status.

If all systems are operating correctly, lack of control is due to a calibration or temperature control parameter (PID) problem. See *Calibration Checkout Procedure.*

System Out of Calibration

If the readings obtained in the procedure outlined below indicate an out of calibration condition, recalibrate the system as described in the chapter: *Calibrating the T-2600*.

Calibration Check-out

Set a cold temperature to -15°C. Set a hot temperature to 125°C. Proceed as follows:

1. Select the cold temperature from the front panel.
2. Wait 15 minutes. Measure the temperature at the nozzle using an external temperature meter. The temperature should be -10°C to -15°C.
3. Activate the hot temperature.
4. Wait 10 minutes and measure the temperature at the nozzle, using and external temperature meter. The temperature should be 120°C - 125°C.

Thermocouple Open

Thermocouples are used to monitor the temperature of various sites throughout the system. The thermocouples terminate at the temperature control board at junctions J3, J4, and J5. Each junction is assigned as follows:

Junction	Location of TC
J3	T-DUT Sensor
J4	K-DUT Sensor
J5	Air sensor in thermal test head.

Table 10 - 2, Thermocouple Junctions

When a thermocouple is detected as open, a messages appears. The specific message that appears is dependent on when the TC is detected as open such as:

- During initialization.
- When attempting to force a specific temperature
- When the system is idle

See table 10 - 1 for a list of error messages.

When one of the messages appears, the thermocouple must be checked for continuity. To do so, use an Ohmmeter and be sure to check both the thermocouple and any thermocouple extensions it may be connected with. If the thermocouple is bad, replace it. New thermocouples and/or thermocouple extensions can be obtained from Thermonics.

If the thermocouple is good, the message may be due to a bad temperature control board. The board must be replaced. New boards can also be ordered from Thermonics. (IB-143-1A)

System Won't Go Cold

Typical problems that prevent cold operation of the system are:

- System out of calibration
- System frozen
- Flow rate not high enough

- Problem with the vortex tube

If the system is not achieving cold temperatures, first check the system for obvious setup errors such as improper power, compressed air input pressure and flow rate. Also, check the software for set up discrepancies such as type of DUT sensor used etc. After ensuring the system is set up properly, check the following:

1. Check the calibration with a secondary standard. (See below)
2. Check the flow rate, it should be 450 to 500 SCFH. If out of spec, check for blockages of the cold air path. (See Vortex Checkout, below).
3. Check the room temperature. It should be below 78F (26C).

Cold checkout Procedure

1. Set the cold temperature to -15C. Let the system force air for about ten minutes. Determine the maximum cold reading.
2. The system should have a temperature reading below -10C. If there is a discrepancy between the external and displayed temperatures, go to step three, below.
3. Ensure the calibration. Measure the temperature at the external nozzle and compare it to the displayed value. If system is out of calibration, perform the calibration checkout procedure.
4. If the system still does not perform properly, check out the vortex tube.

Vortex Checkout Procedure

If the vortex tube does not appear to be working, check for these problems:

1. *Loose cold cap or cold muffler.* A loose cold cap or muffler will cause poor performance.
2. *Input Pressure*. Low input pressure to the system will alter its performance. Measure the pressure of the compressed air. Restrictions in the compressed air supply line can cause pressure drops that deteriorate performance.
3. *Input air temperature*. A vortex tube provides a temperature drop from the source air. If the source air is too warm, the drop in temperature provided by the vortex tube may not be adequate.

4. *Continuous operation at cold*. If the vortex tube is operated continuously for an extended period, the cold end may freeze blocking airflow. If this happens, turn the system off for a few minutes to allow the tube to thaw. Check the supply air to make sure that it is clean and dry. If not, install an air dryer.

5. *Back pressure*. The performance of the tube will deteriorate if the exhaust is restricted causing back pressure. Make sure that the exhaust air is not restricted.

No AirFlow Through Systems

The air path comprises two main segments:

1. the hot air path

2. the cold air path

A series of pressure regulators, valves and solenoids direct the air within the pathways. When air enters the system it is directed, as required, to either the hot or cold path via the solenoid valves.

Typically, a blocked flow condition is caused by ice located somewhere in the pathway. This is caused by using air that is not dry enough. The fix to let the system thaw out for a few minutes and then run warm air through it. Use of Thermonics air dryer system (T-ADFBV) can help prevent this type of problem.

Additional sources of air flow restriction can be a bad air solenoid. If there is no air flow, first make sure you have supplied air to the rear panel. The input pressure should be 90 to 110 PSI. Then follow the procedure below:

Airflow Diagnostic Procedure

1. Turn the system's power off and then on again using the main power switch located on the front panel.

2. Allow the system to run through the start up screens. This requires about one minute.

3. Check for air flow, check out the air flow pathway.

4. Check the air pressure gauge on the rear panel. If air is present at the rear panel, then you know the blockage is further downstream.

5. Check the hot air flow control valve and the air solenoids.

Solenoid Checkout Procedure

There are two 2-way pilot operated solenoid valves used in the air pathways. One each for the hot and cold portions of the pathway. Check the solenoids as follows:

1. *Faulty Control Circuit*: Check the electrical control system by energizing the solenoid. A metallic click signifies the solenoid is operating. Absence of the click indicates a loss of power supply.
2. Check for loose or blown out fuses, open-circuit or grounded coil, broken lead wires, and terminals or splice conditions.
3. *Burned out coil*: Check for open-circuit coils. Replace valve coil as necessary.
4. Low Voltage: Check the voltage across the coil's leads. Voltage must be at least 85% of the operating specification which is 115V.

Air Solenoid Replacement

An ineffective solenoid is easily repaired by replacing the coil assembly. New solenoids can be ordered from Thermonics. Part # P1-007.

It is best to leave the valve body in place and swap the coil assembly from the new solenoid with the old one. Replace as follows:

1. Remove the old coil assembly from the bad solenoid by loosening the two bracket screws and lifting it off. The coil assembly includes the: diaphragm, pilot seat, core assembly, core tube etc. When complete, only the valve body should remain. (See Fig. Figure 10 - 1)
2. Remove the new coil assembly from the replacement valve by again loosening the bracket screws. Reinstall it to the valve body and tighten in place. Take care not to allow the coil assembly to fall apart while installing. An illustrated parts breakdown is provided.

NOTE: Torque bracket screws to 20 inch-pounds (2.3 Newton meters). Tighten screws evenly to insure proper compression of the diaphragm assembly - because it also serves as a gasket.

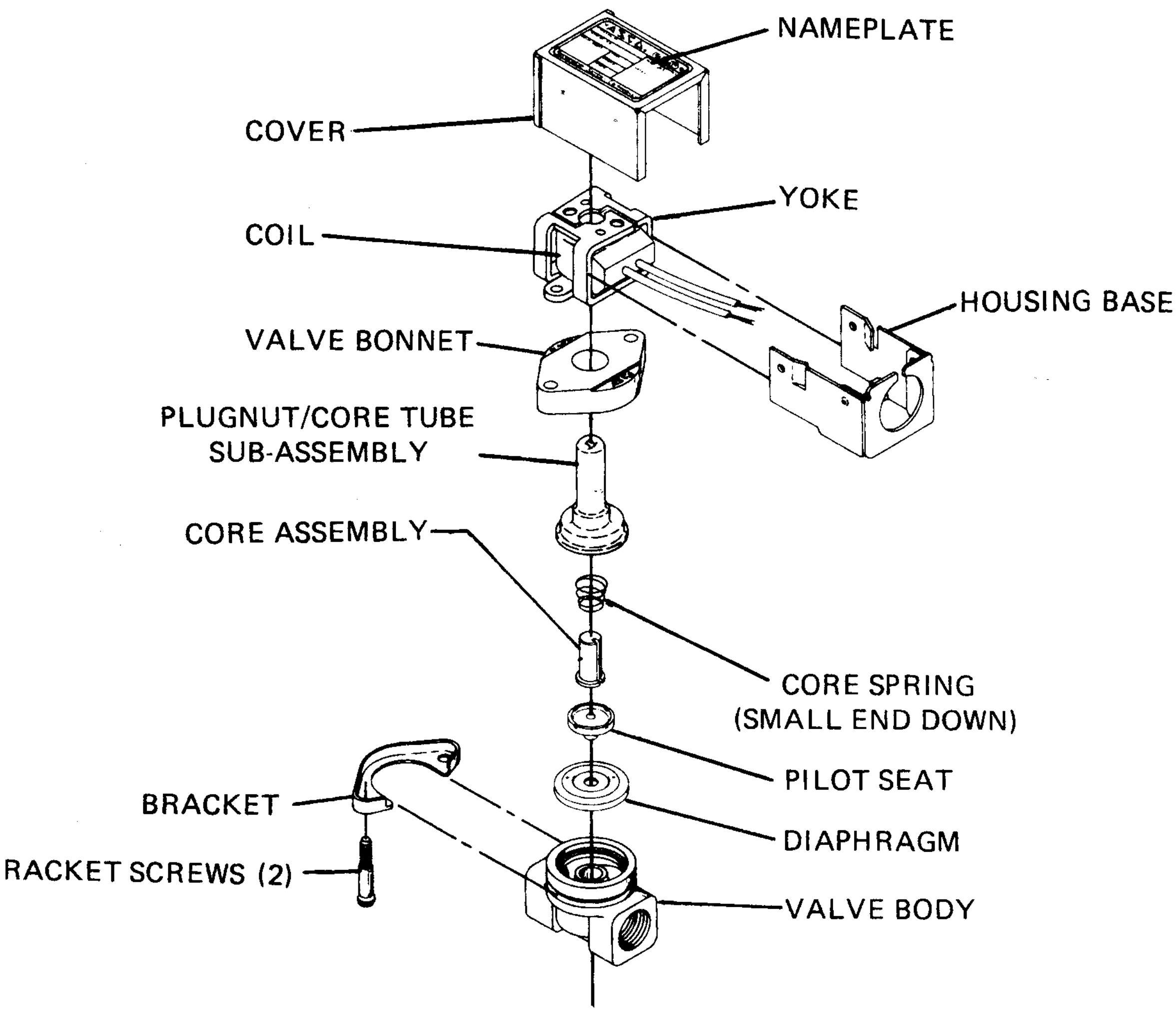

Figure 10 - 1, Solenoid

The System won't Go Hot

The system may not be going hot for several reasons.

- No air flow
- Loose connection on Temperature Control Board.
- Malfunctioning Temperature Control Board
- Non-functional heater relay
- Broken heater
- Tripped Thermocouple Safety Board

If the system is not going hot, an error message will usually appear on the display panel and/or the error condition will be evidenced by the LED's status of the Thermocouple Safety Board. To check out the heaters, use the procedures outlined below. If the heater is indeed bad, follow the instructions in the section Heater Replacement, below.

Thermocouple Safety Board

The thermocouple safety board is a fault control mechanism that monitors the status of the heater located in the thermal test head. It's purpose is to prevent over-heat conditions that could damage the heater itself or the device under test. While the status of the LEDs are indicative of an error condition, the board itself is not a diagnostic tool per se. You must still trace through the system to determine the cause of the error such as no airflow etc.

The LEDs of the Thermocouple Safety Board can be viewed on the side of the thermal test head. For model T-2600BV, the significance of the lights is shown below:

LED	Color	On Status	Indication
4	Red	N/A	
3	Red	N/A	
2	Red	Heater Input over temp.	Temperature greater than 82C detected at heater input. (Quartz tube case.)
1	Red	Heater core over temp	Temperature greater than 250C detected in heater’s output at nozzle.
0	Green	Operating Status OK	No fault detected

Table 10 - 3, Thermocouple Safety Board LEDs

Note: the inputs from the board are channeled through the snap-disk inputs, so you may get a snap-disk error message when the board trips, though this board has supplanted the use of snap disks.

Heater Check-Out Procedure

The primary means of checking the heater status is a simple resistance measurement. Follow this procedure:

1. Check all wiring an connections to heater.
2. Check the heater resistance with an Ohm meter. See Table below.
3. Replace heater if values differ more than 10%.

	Power	Heater	Ohms
Standard Unit	120VAC	1250W	11.5
Optional Unit	220VAC	1250W	37

Table 10 - 4, Heater Resistance

Heater Replacement

Heaters are contained in an insulated housing which includes a cover, base plate and a retaining bracket. Replacing the heater involves a complete swap-out of this housing. To replace the housing, follow these steps:

1. Turn the system off. Disengage the power and lock out/tag out as appropriate.
2. Remove the glass shroud, bezel and thermal test head cover.
3. Disconnect all pneumatic and electrical inputs to the heater housing. This includes the hot air input, thermocouples, ground and heater power connectors.
4. Remove insulation from the vortex tube.
5. Disconnect the vortex tube from the heater housing at the vortex/heater interface
6. Remove the four screws that hold the base-plate to the thermal test head assembly.

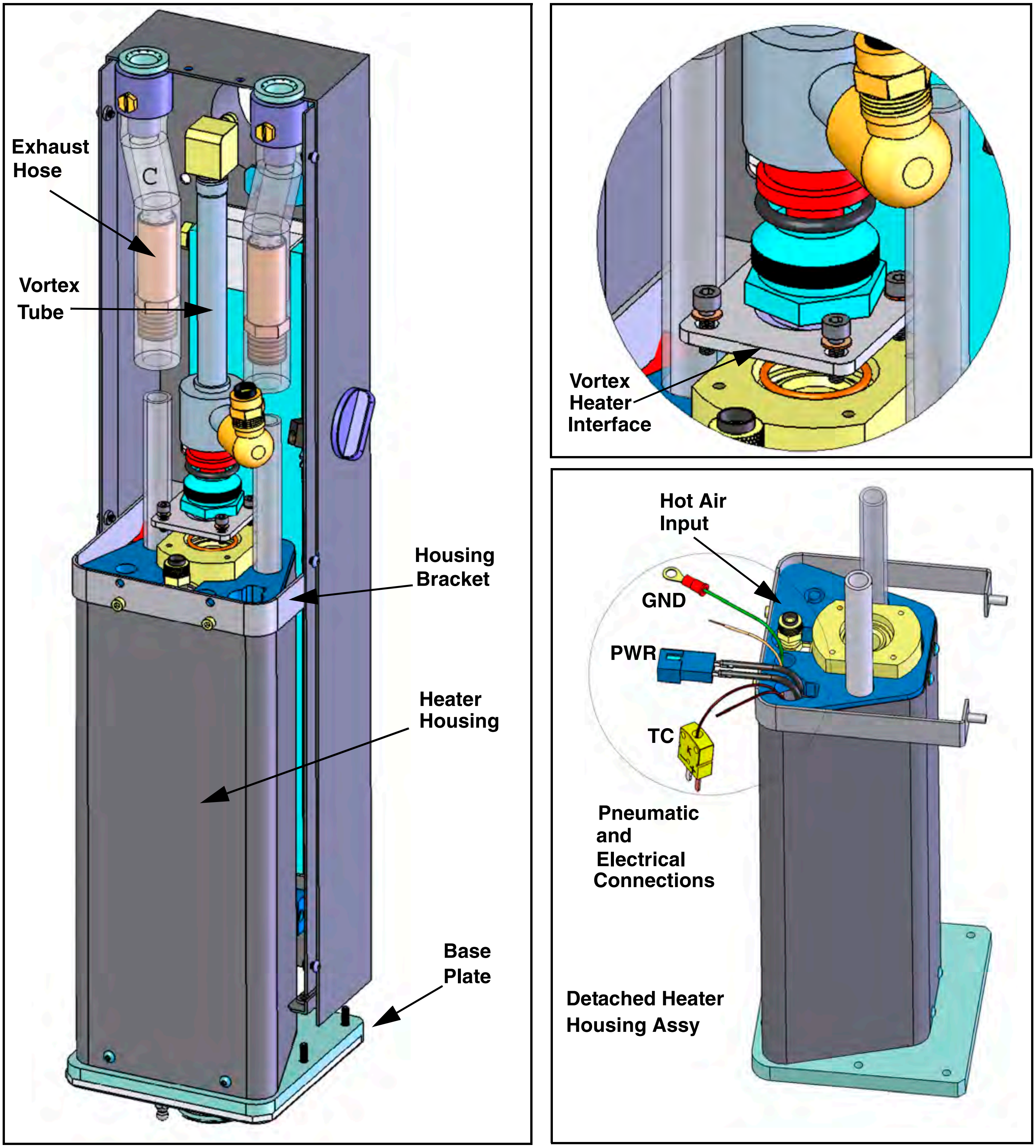

Figure 10 - 2, Thermal Test Head - Inside View

7. Remove the two screws that hold the retaining bracket to the rear of the thermal test head.

8. Disconnect the exhaust hoses.

9. Remove heater housing assembly.

10. Replace new housing assembly in reverse order as above.

AC Switch Open or Shorted

AC Switch Checkout

With the power to the system off. Check the AC switch with an Ohmmeter. The switch does not have to be removed from the board. Measure across pins 1 and 2. The reading obtained should be approximately 4M Ohm (AC side). Next, measure across pins 3 and 4 (DC side). The measurement obtained should be 3 K Ohm. If the readings are out of specification, replace the switch.

AC Switch Replacement

1. Turn power and circuit breaker to the off position.

2. Disconnect all cable connectors from Heater/Compressor Control Board. (J1, J2, J6, J8 and J9.)

3. Remove connectors (spade lugs) from AC switch in positions 1 and 2. You may want to label these to return to correct positions.

4. Remove the magnets holding the wire loops to the transformers (ammeters) in positions T2 and T3. (These remove by pushing towards rear panel of machine.)

5. Remove the five bolts that hold the board to the standoffs. The board can now be removed from the system.

6. Remove the bolts in position 3 and 4 of the AC Switch and remove switch.

7. Install the new switch and re-assemble in reverse order as above.

WIRING DIAGRAMS

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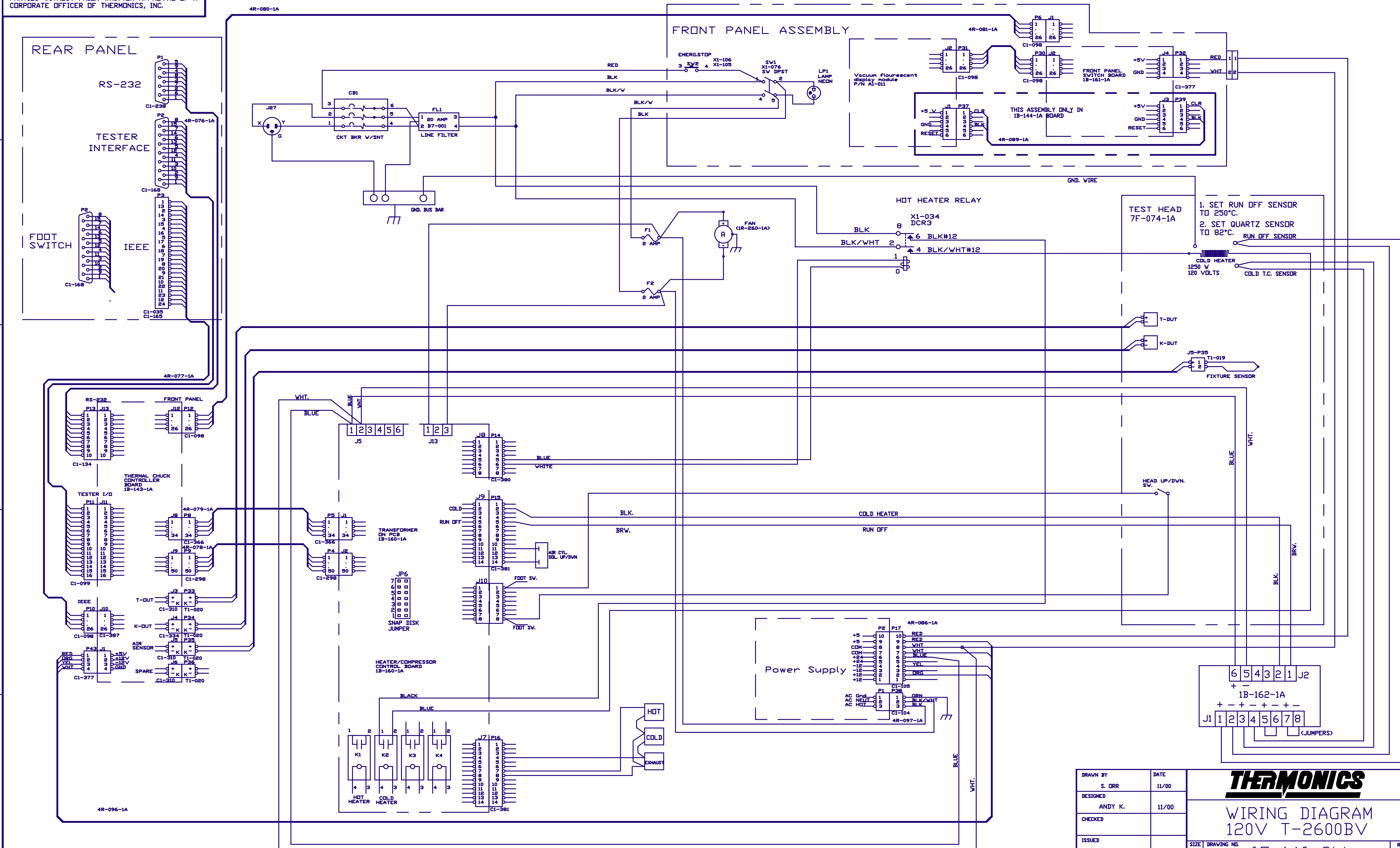
REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
ALL	A	MODIFIED FROM 6F-140-1W (PRODUCTION)	02/28/07	
ALL	B	WITH TC LED BD. 6F-707-3A & 1B-160-1A BD.	06/09/09	G. KUFIS



NOTES : (UNLESS OTHERWISE SPECIFIED)

DRAWN BY	S. ORR	DATE	11/00
DESIGNED	ANDY K.		11/00
CHECKED			
ISSUED			
CUSTOMER			

THERMONICS

WIRING DIAGRAM 120V T-2600BV

SIZE: D | DRAWING NO.: 6F-140-2W | REV.: B

SCALE: NONE | SHEET 1 OF 1

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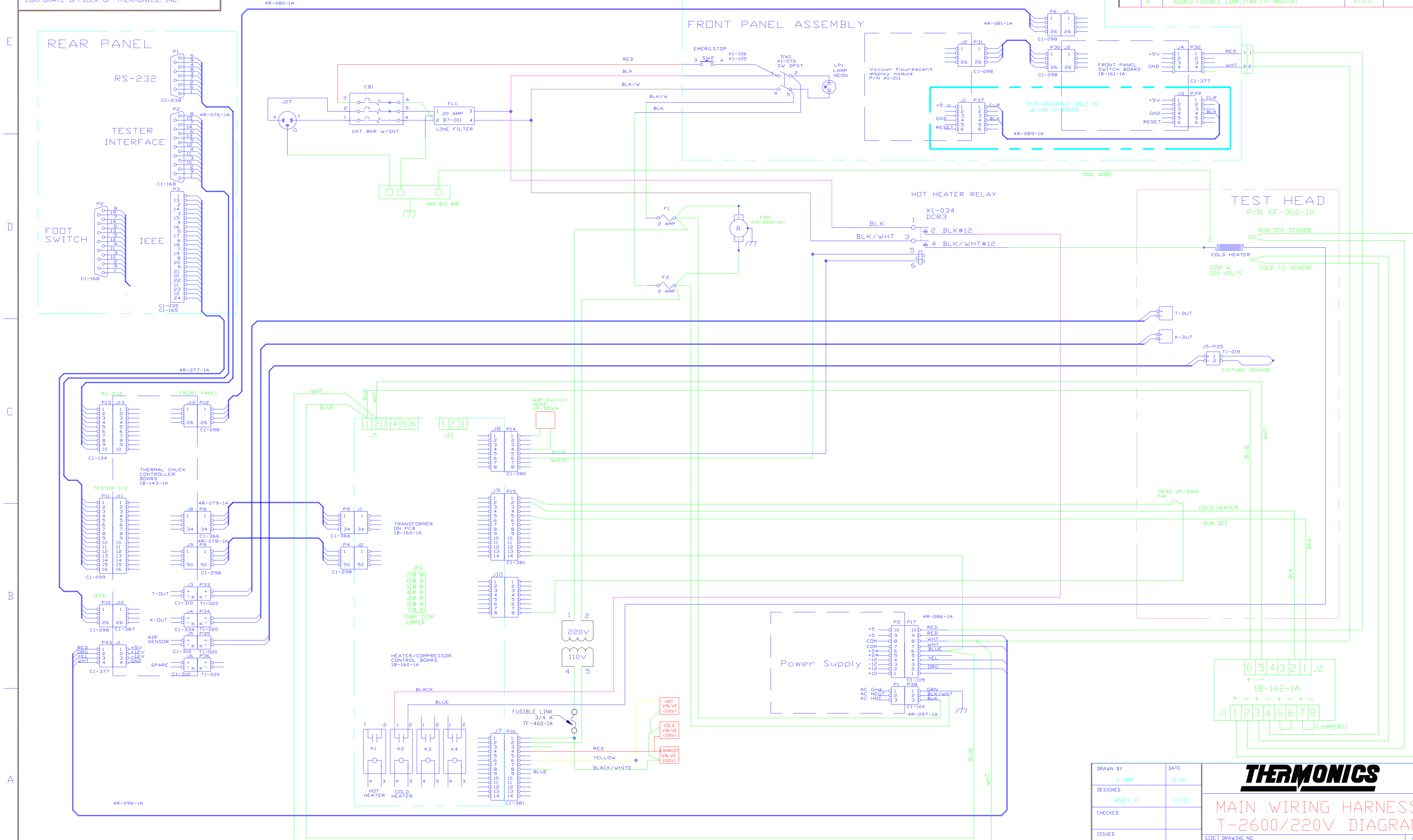
REVISIONS

ZONE	REV.	DESCRIPTION	DATE	APPROVED
ALL	X1	ECN # 3574 CONVERT FROM 110V TO 220V	11/06/03	
ALL	A	WITH TC LED BD. 6F-707-3A	06/09/09	G. KUFIS
	B	ADDED FUSIBLE LINK,3/4A (7F-460-1A)	2/1/11	



NOTES : (UNLESS OTHERWISE SPECIFIED)

DRAWN BY	DATE
S. ORR	11/00
DESIGNED	
ANDY K.	11/00
CHECKED	
ISSUED	
CUSTOMER	

THERMONICS

MAIN WIRING HARNESS T-2600/220V DIAGRAM

SIZE: D DRAWING NO. 6F-406-1W REV. B

SCALE: NONE SHEET 1 OF 1

ILLUSTRATED PARTS BREAKDOWN

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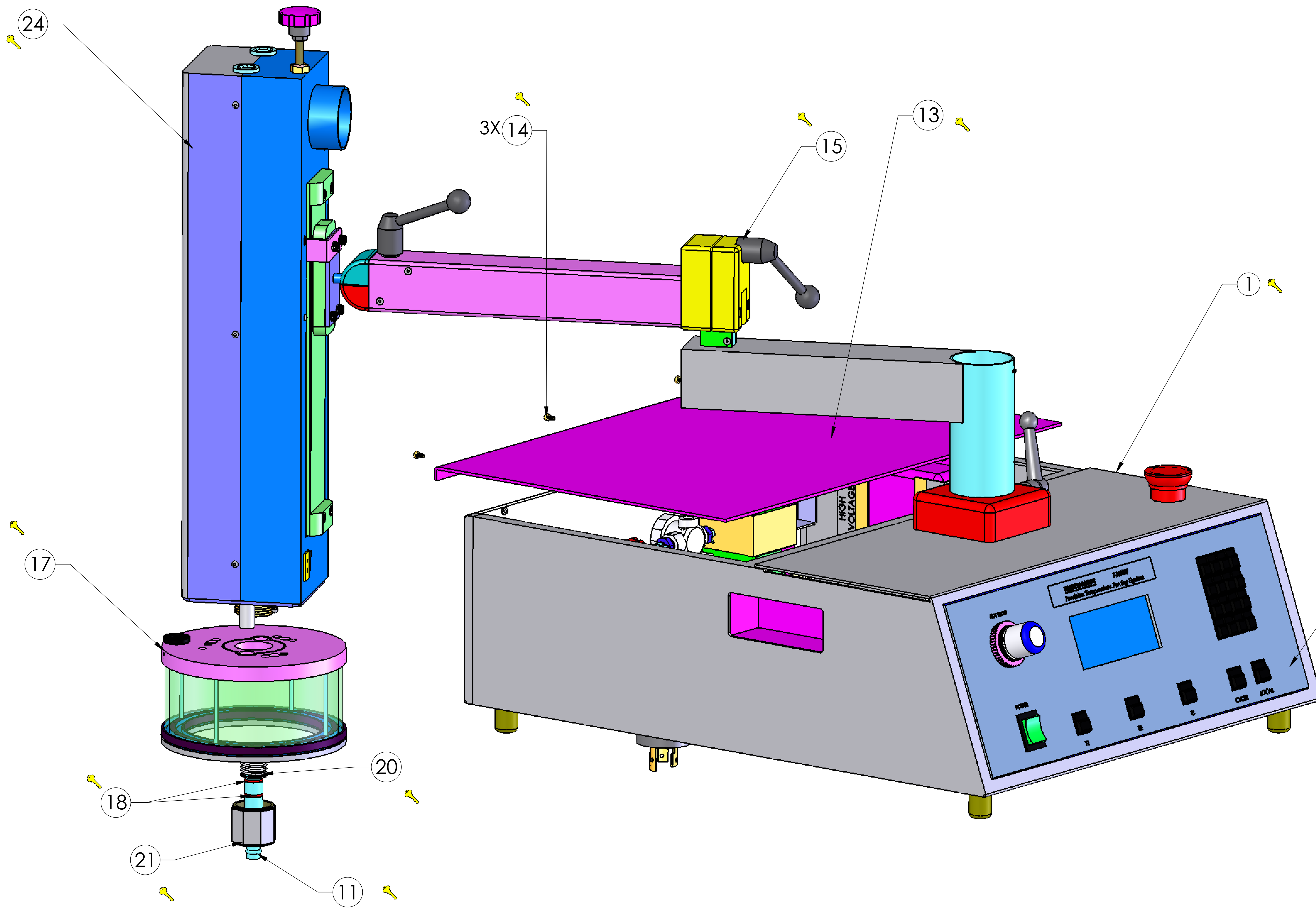
REVISIONS

REV.	DESCRIPTION	DATE	APPROVED



PARTS LIST

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS DECIMALS ANGLES .XX ± .02 .XXX ± .010	DRAWN BY G. KUFIS	DATE 10/21/05	THERMONICS
MATERIAL SEE B/M	DESIGNED		TOP FRAME 220V, T-2600BV
FINISH NO FINISH	CHECKED		SIZE D
DO NOT SCALE DRAWING	ISSUED		DWG. NO. 6F-405-1A
	CUSTOMER		REV. X1
			SCALE
			SHEET 1 OF 1

NEXT ASSY	USED ON
APPLICATION	

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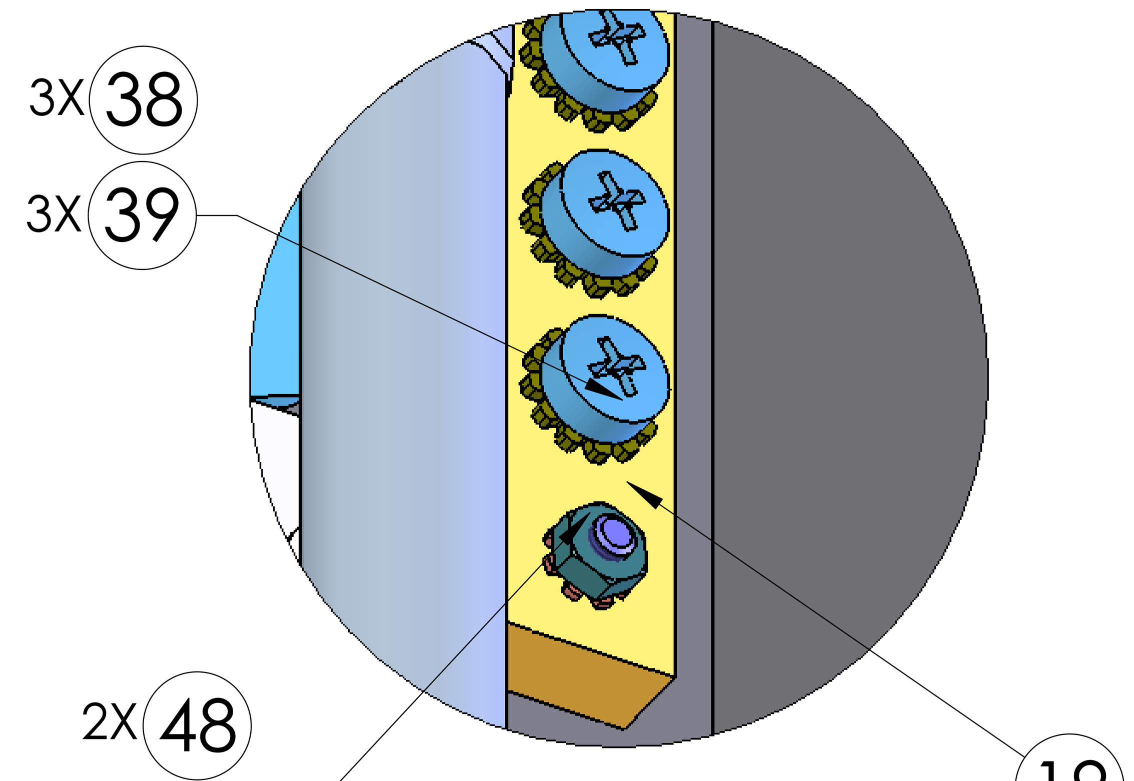
REVISIONS

ZONE	REV.	DESCRIPTION	DATE	SHEET #
-	A	RELEASE TO PRODUCTION	03/24/09	2 OF 3



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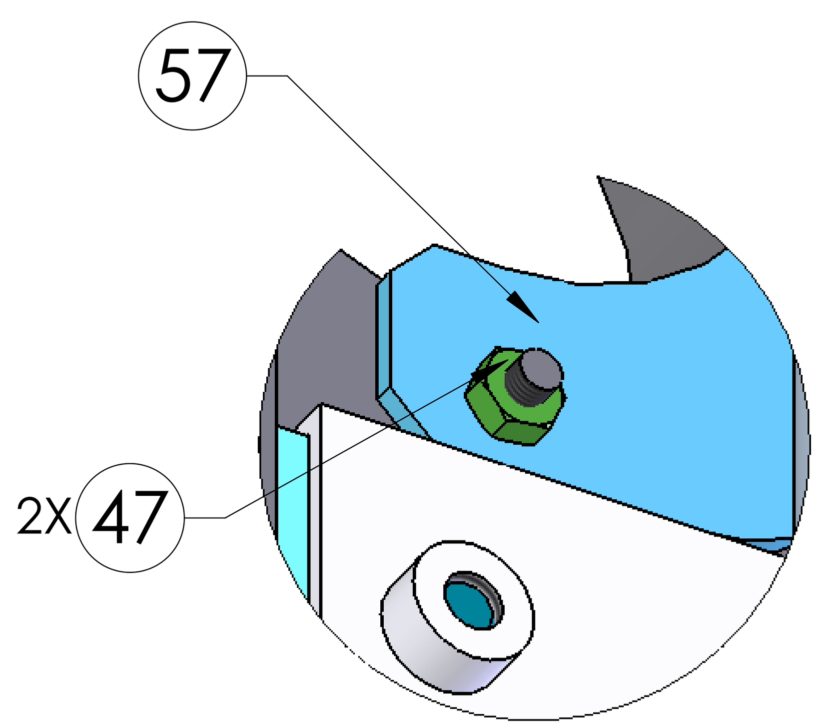

DETAIL O
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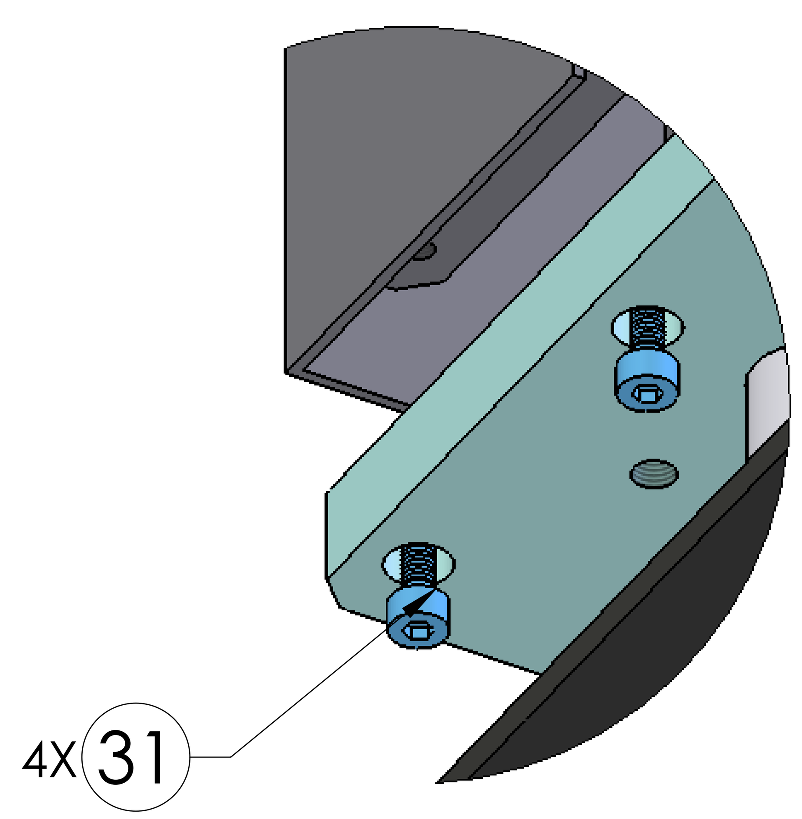

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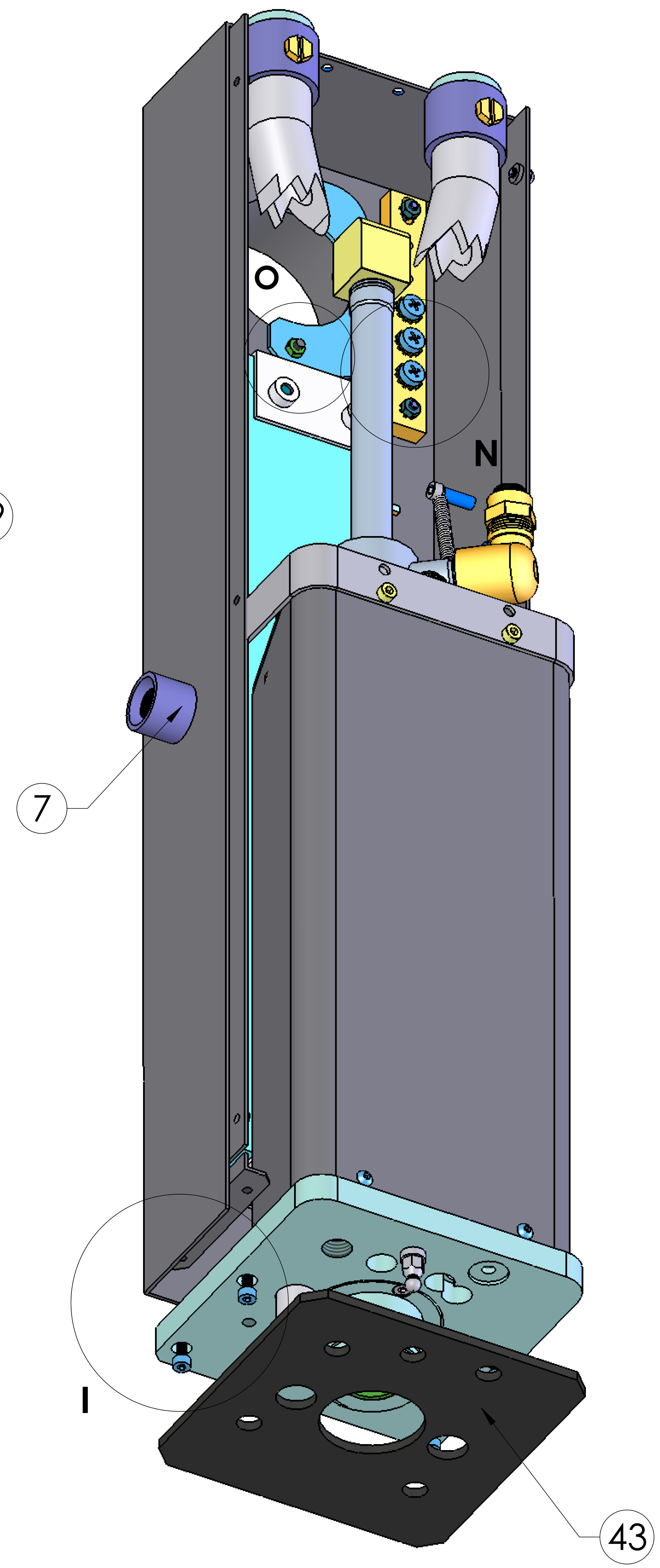

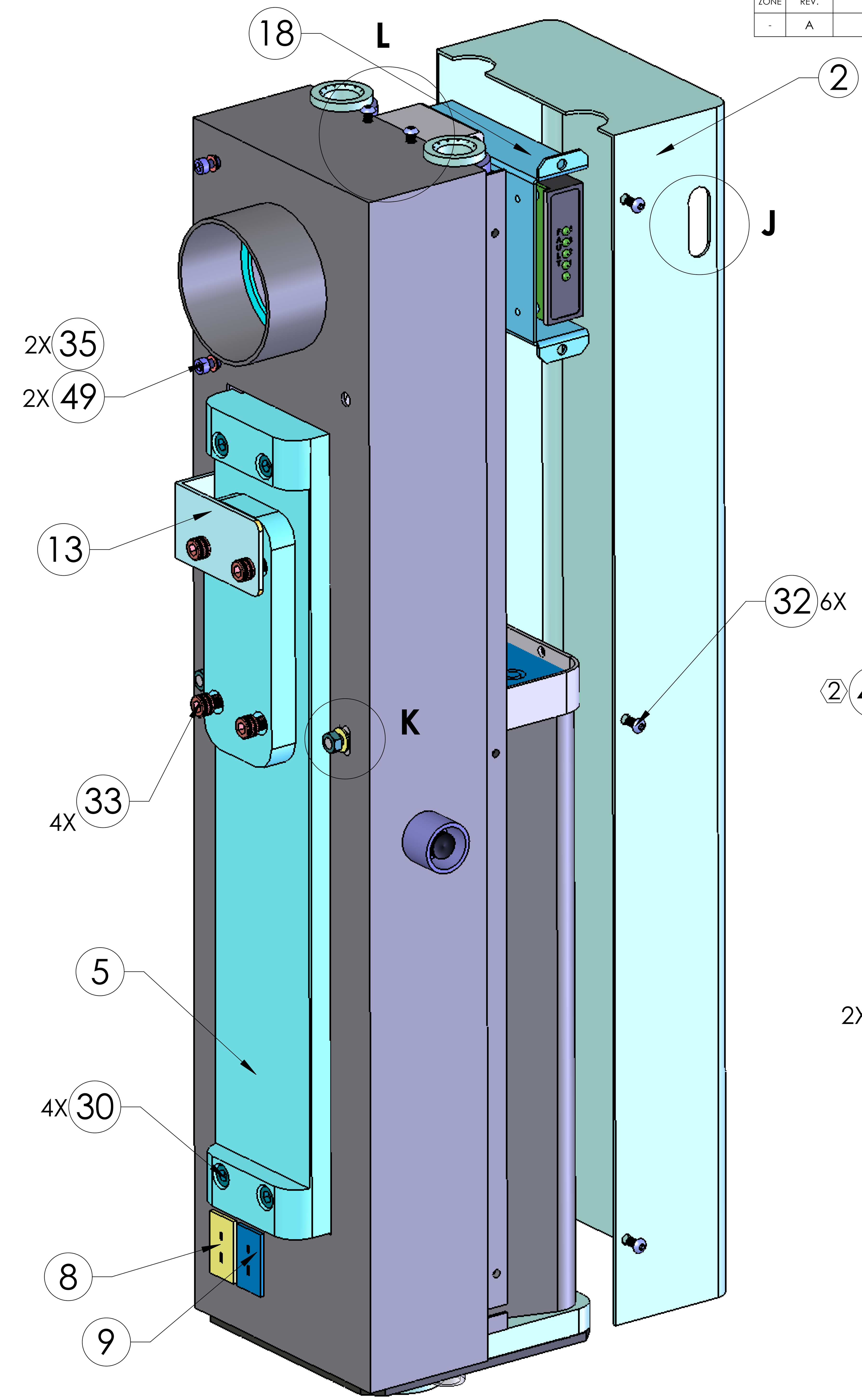

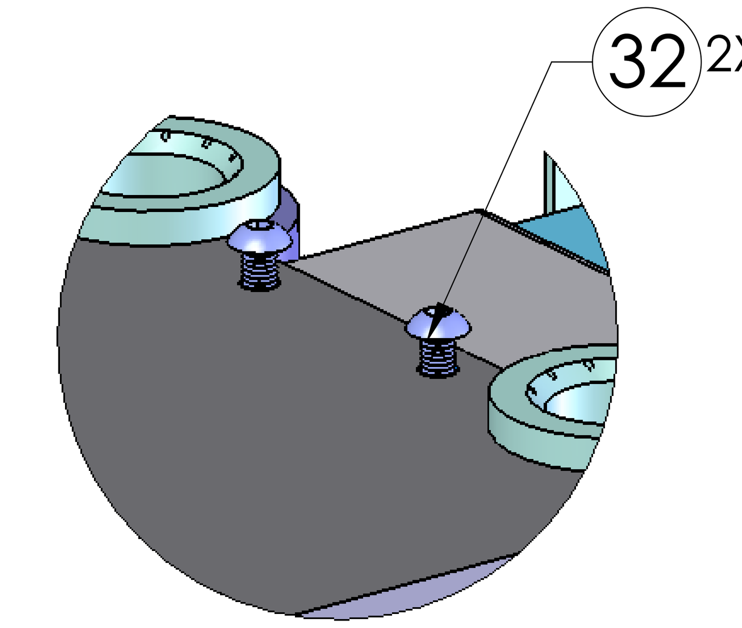

DETAIL L
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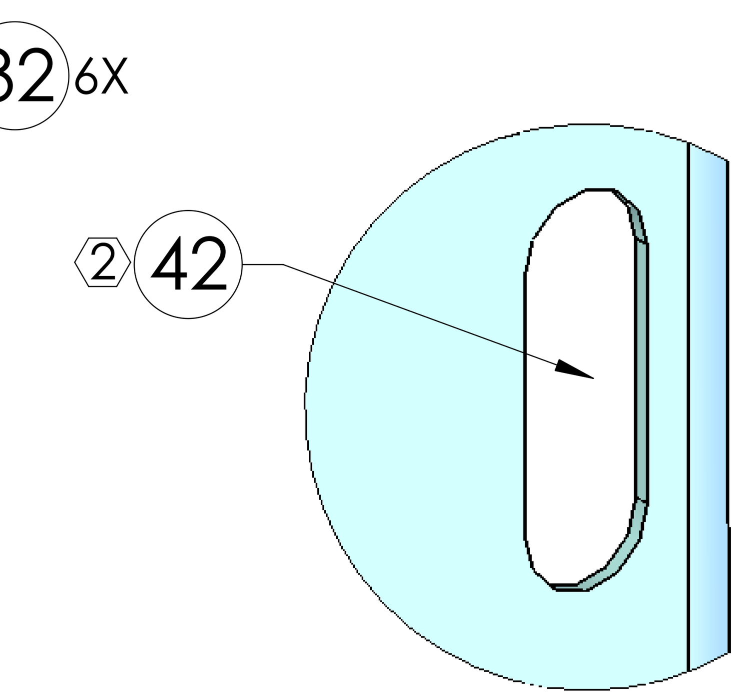

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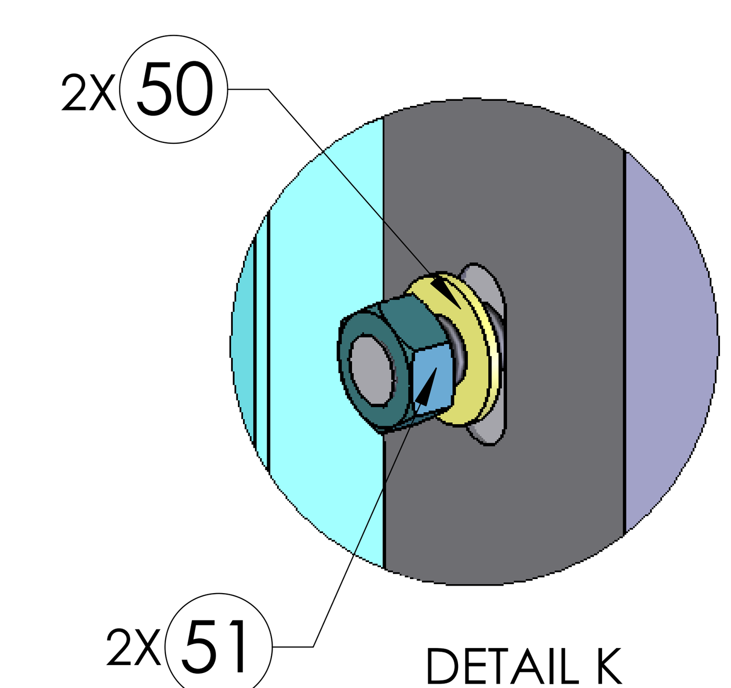

DETAIL K
SCALE 2 : 0.75

3. ITEMS 28, 29 NOT SHOWN FOR CLARITY. SEE SHEET 3 OF 3 FOR ITEMS 40, 41, 52, 53, 54, 55, 56.
2 APPLY LOCTITE TO THE TWO SHORT THREADED STUDS ON THE FARSIDE OF THE WALL TO MOUNT THE ITEM 42 LENS LABEL.
1. A TUBE IS OMITTED FROM THE ABOVE VIEW TO CREATE A VIEW TO THE ITEM 19 GROUNDING PLATE.
NOTES

PARTS LIST

NEXT ASSY | USED ON
APPLICATION

UNLESS OTHERWISE SPECIFIED DIMENSIONS ARE IN INCHES TOLERANCES ARE: FRACTIONS ±1/32 DECIMALS .XX ±.01 .XXX ±.005 ANGLES ±1°

MATERIAL: SEE B.O.M.

FINISH: NO FINISH

DO NOT SCALE DRAWING

DRAWN BY: G. KUFIS | DATE: 03/10/09
DESIGNED
CHECKED
ISSUED
CUSTOMER

THERMONICS

HTR ENCL W/QUARTZ 220V T-2600

SIZE: D | DWG. NO. 6F-966-1A | REV. A

SCALE | SHEET 2 OF 3

APPENDICES

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ERROR MESSAGES

Error messages are generated when the system detects a condition that could affect proper operation. Specific actions to perform for these errors can be found in the T-2600BV Maintenance Module.

#	Message	Interpretation
1.	Call Maintenance	This message appears in conjunction with any messages that denote the system requires service.
2.	Turn Off Power	This message occurs in conjunction with any message that indicates a serious malfunction.
3.	Heater Snap-Disk Open	Heater snap disk has opened. Usually due to an over-temperature condition.
4.	J3, HX TC Open!	Heat exchanger thermocouple is reading an open condition. System is not sensing presence of TC.
5.	Heater Open/K1 Short	Monitoring circuitry has activated a fail-safe. TC may not be connected to junction or may be bad.
6.	AC Switch K1 Open!	Monitoring circuitry has activated a fail-safe. AC switch may be bad.
7.	AC Switch K2 Open!	Monitoring circuitry has activated a fail-safe. AC switch may be bad

Note: Heater Snap-Disk Open indicates that thermocouple safety board is activated. Snap disks are not used.

TEMPERATURE CALIBRATION

Overview

This document discusses important concepts related to the procedures used to calibrate Thermonics' precision temperature forcing systems (PTFS). It provides an overview of commonly used calibration methods. In addition, it provides a discussion of the various factors that can affect the accuracy and reliability of calibrations and the advantages of storing multiple calibrations.

Calibration Overview

The calibration process serves to systematically adjust and standardize the temperature measurement system of the PTFS. Typically, the process involves a comparison between the temperature measured by the PTFS and an external standard. The PTFS temperature metering is adjusted to match the external temperature standard.

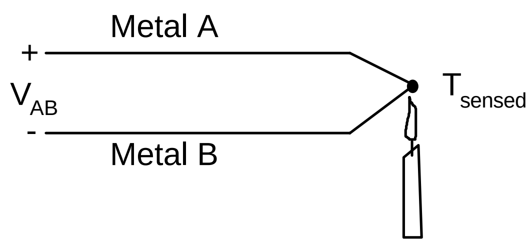
In more specific terms, calibration is an adjustment of the scaling of the temperature measurement system. It adjusts for any offset or change in gain between how the system measures a temperature and how a standardized external measurement instrument measures the same temperature. By taking sample measurements at diverse setpoints (such as -55C and +125C) a scaling adjustment can be entered into the system, which will accommodate for a wide range of temperatures.

PTFS Temperature Measurement

Several pertinent issues related to how the PTFS monitors and controls a temperature setpoint must be understood to obtain an accurate assessment of the complexity of temperature measurement systems. These issues are: how a thermocouple (TC) works, thermocouple voltage vs. temperature, cold junction compensation, thermocouple isolation, and the importance of traceability and accuracy of temperature calibration.

Thermocouples

The PTFS measures the temperature of the air stream or the DUT (device under test) using thermocouples. Thermocouples are temperature sensing devices that are made of dissimilar metals that form a junction that produces a voltage as a function of temperature. A voltage (EMF - Electro-motive Force) is generated that is proportional to the difference in the temperature of the junctions. Because the properties of most thermocouples are known, a specific voltage can be translated as a specific temperature. See following illustration:

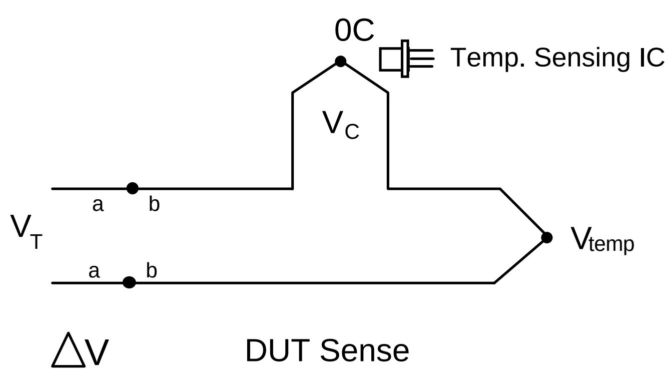


$V_{AB} = f T$; where T is the sensed temperature.

The system software converts V_{AB} to a temperature reading by using a look-up table.

Cold Junction Compensation

One of the challenges of accurately measuring the response of a thermocouple is created by the measurement system itself. Whenever there is a junction of dissimilar metals, such as between a thermocouple and voltage measurement system, an EMF is generated that is in opposition to the EMF generated by the thermocouple junction from which the desired reading is to be obtained. The result is a skewed reading that is proportional to the difference in temperature between the desired thermocouple junction and the junction with the voltage measurement system.



$V_{temp} = V_T - V_C$

$T = f(V_{temp})$

To compensate for this, Thermonics has added an additional thermocouple to the loop. This is commonly referred to as a cold junction or ice-point compensation (See above diagram). It has two benefits. Firstly, the additional thermocouple creates a junction with the PTFS using similar metals, hence no opposing EMF's are generated. Secondly, it provides a reference point from which a software compensation can be made so that an accurate EMF can be determined. The adjusted EMF is used in a look-up table to determine the temperature.

Look-Up Table

Because of the variations in the voltages measured on the thermocouple the relationship between a temperature and a specific voltage is not linear. As a result, the calculation required by the system can be very computer intensive and is performed much faster using a look-up table. A specific voltage is translated as a specific temperature. If a reading is between values in the table, interpolation is used to determine the temperature.

Thermocouple Isolation

Sometimes, it can be difficult to obtain accurate readings from the thermocouple used to monitor and control the DUT. This is particularly true in noisy, high-frequency environmental conditions. The result is an unstable temperature response of the DUT. The random and unpredictable fluctuations of the thermocouple signal mask the desired information content making control of the system less effective. This is particularly true when the thermocouple is grounded, or when connected to a conductive surface such as a device enclosed in a metal can.

Thermonics has developed a technique for attenuating the noise problem. The technique consists of filtering the incoming DUT signals so that more accurate control is obtained. This is accomplished by isolating the common mode noise from the differential signal. In addition, low-pass filtering enhances the desired frequency response characteristics of the signal.

The Importance of Traceability and Accuracy

One of the important goals of the calibration is to provide a systematic and standardized technique of assuring accurate temperature performance that is recognized as valid by the test community at large. Most importantly, the calibration technique must provide repeatability and traceability as defined by ANSI (American National Standards Institute) traceability standards. These goals are easily accommodated by using a an instrument that is pre-calibrated to an industry or known standard, commonly referred to as a secondary standard.

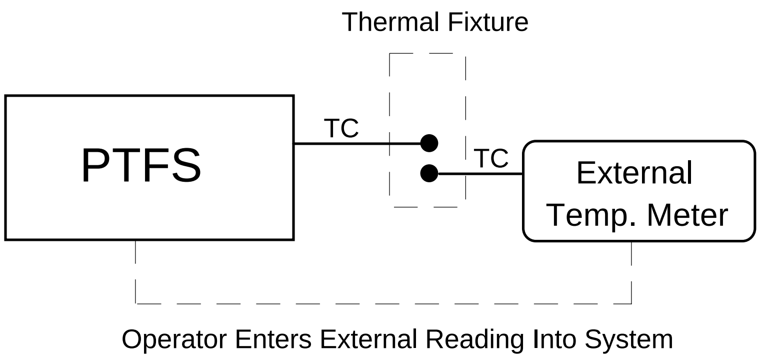
The thermocouple sensors that can be calibrated include the fixture air temperature sensor and the DUT temperature sensor. DUT temperature sensors may be either T-type or K-type. Temperature calibrations can be stored separately and recalled for use in specific testing situations.

Methods of Temperature Calibration

Several temperature measuring instruments are commonly used for calibration. These are an external temperature measurement meter, an external millivolt source and the RTD (Resistor, Temperature Dependent). These instruments can provide for an adequate calibration of the PTFS; though each technique has its own inherent strengths and limitations.

External Temperature Meters

The temperature meter is used in conjunction with a thermocouple to gain an independent reading of the air or DUT temperature. The readings from the meter are entered into the system and used to adjust the temperature scaling by recalculating the offset and slope.



This procedure requires that the systems' refrigeration unit is ready for operation and the system has achieved temperature stability. Total calibration time is about twenty minutes.

Using an external temperature meter for calibration is an extremely accurate way to calibrate the PTFS because it provides a calibration that accounts for all of the extraneous factors that can affect temperature performance. When these factors are not accounted for, such as when calibrating with a millivolt source, the calibration can be inaccurate. These factors are:

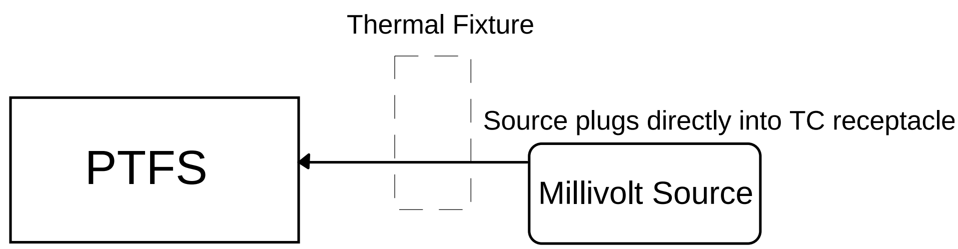
Air Flow Rate

The flow of air affects the thermal characteristics of the thermal fixture. Using an external temperature registering device allows calibration to be performed with air flowing, enabling any necessary compensation to occur. This is particularly important when calibrating the air temperature measurement to the sensed air temperature close to the DUT.

Test Sensor Location
Accurate calibration requires the thermocouple from the external standard is placed in close proximity to the thermocouple from the PTFS. The advantage of using an external meter is that the thermocouple from the meter can be placed within 50 mils of the system thermocouple assuring accurate results.

Long-Term Consistency of Thermal Characteristics
The only extraneous factor that affects the long-term consistency of the calibration is the aging of electronic components. The effect of the aging process is minimal.

External Millivolt Sources
A millivolt source is plugged into the thermocouple receptacle in place of the thermocouple. When the system requires input from the thermocouple it is supplied by the source.

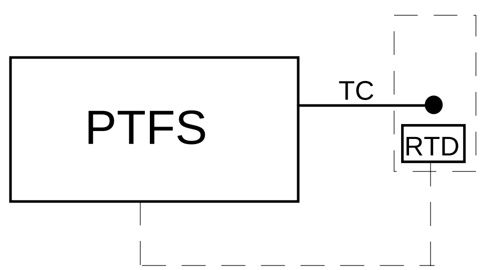


Millivolt Source Replaces Thermocouple

An external millivolt source is capable of generating voltages equivalent to those a thermocouple generates at the calibration setpoints. It provides a very accurate voltage reference the internal metering system uses to adjust temperature scaling. The advantage of using an external millivolt source is that it is a fast way to calibrate the system. It has the limitation, however, of not really assuring the calibration for the entire system in a global sense, because it does not accommodate for air flow, test sensor location, or thermocouple variations. If the PTFS existed in the best of all possible worlds, where no outside influences other than temperature were at play, then this technique would be sufficient.

Thermonics' RTD
An RTD is typically used as the standard during automatic calibration procedures.

The RTD series of dual-in-line temperature calibration devices permits accurate temperature calibration of the PTFS by providing a secondary standard that measures the cavity temperature of a semiconductor package. Under test conditions in a thermal fixture, an RTD chip will attain the same temperature as a semiconductor chip in a similar package prior to application of power. By substituting the RTD 1000 chip for the device to be tested an accurate calibration for an item of a particular mass can be performed. The temperature versus resistance response of the RTD 1000 is approximately 3.75 ohms/C and the resistance at 0.0C is 1000 ohms. The RTD can also aid in determination of soak times.



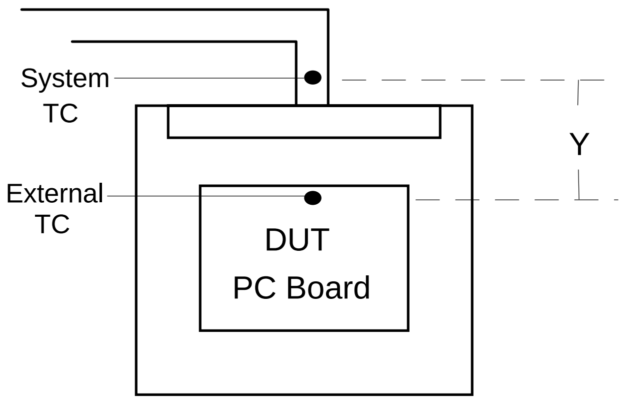
RTD is Used for Auto-Calibration

The RTD can confidently be used as secondary standard because it can be easily monitored for accuracy. Using a temperature meter and ohm meter, the response of the RTD can be evaluated if any questions arises as to its accuracy.

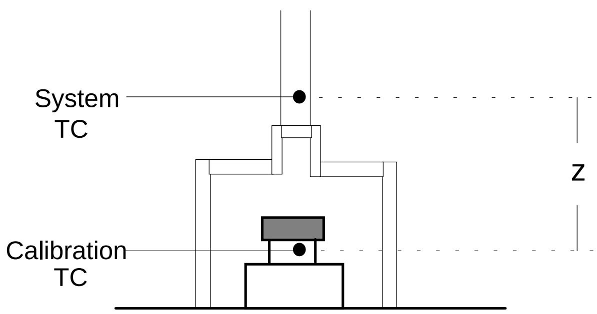
The recommended method of temperature measurement is to ground one terminal of the RTD and force 1.0 ma of current into the other terminal and read the voltage (V) on that terminal. The temperature can then be found by measuring the resistance of the RTD and using a resistance vs. temperature table to determine the actual temperature.

Advantages of Storing Multiple Calibrations

Thermonics' precision temperature forcing systems make provisions for storing multiple calibrations. The advantage of being able to store multiple calibrations is that you can assure accuracy for varying system applications. This includes using different or alternative thermal fixtures and compensation for the position of the test device. This makes it possible to set an air temperature that will be the temperature of the device under test.



In a large thermal fixture, an adjustment can be made for the offset between how the system air temperature TC registers a temperature and the actual temperature of the PC board.



In like manner, an adjustment can be made for the offset between how the system air temperature TC registers a temperature and the actual temperature of the underside of the DUT.

Conclusions

Temperature calibration of the PTFS is a way of insuring that the systems' internal temperature measurement system is accurate. Several calibration methods for precision temperature forcing systems are commonly used. Of these, use of a calibrated, external temperature meter provides a reliable and comprehensive calibration technique. Additionally, use of and RTD is a good way to calibrate temperature readings. The ability to store multiple calibrations provides a means of calibrating the system for specific applications.

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REAR PANEL CONNECTOR LIST

The following table lists the systems' main connectors and their mates. Most interfaces are located on the rear panel. The thermocouple connectors are located on the Thermal Test Head.

#	Connector	Thermonics Part #	# Pins	Type	Mate
1.	IEEE-488	C1-035	24	FEMALE	Blue Ribbon, male, 24-pin, ribbon connector
2.	RS-232C	C1-238	9	MALE	Standard, female, 9-pin, D, connector
3.	TESTER	C1-035	24	FEMALE	Blue Ribbon, male, 24-pin, ribbon connector
4.	FOOT CONTROL	C1-319	15	FEMALE	Male, subminiature, D, 15-pin
5.	PRINTER	C1-266	25	FEMALE	Male, subminiature, D, 25-pin
6.	TEMP SENSOR (T)	T1-026	2	FEMALE	Standard, male, T-type, connector
7.	TEMP SENSOR (K)	T1-019	2	FEMALE	Standard, male, K-type, connector
8.	HEATERS	C1-014	5	FEMALE	Standard, 5-pin, male, Molex connector

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T-ADF/BV AIR DRYER

This document provides information on the T-ADF/BV air dryer. It contains the following sections:

- Background
- Theory of Operation
- Assembly
- Installation
- Maintenance

Background

Thermonics' T-ADF/BV membrane air dryer removes excess moisture, oil, particles and other contaminants form the source air supplied to the PTFS. Drying and cleaning of the air prepares it for use in temperature testing by lowering the dew point and eliminating sources of moisture and other types of contamination of the DUT. Additionally, drying the air prevents the formation of frost or ice in the air pathways of the PTFS that can hinder the flow of air. The T-ADF/BV air dryer provides a dew point of -40C at 80 PSI (or 7 CFM).

Note: The air input to the air dryer should have a dew point no higher than +10C and be free of oil.

⚠**CAUTION**: The T-ADF is designed for use with compressed air and is **not** for use with any other gasses or fluids. Using the system with a different gas may be dangerous or cause damage to the system.

Theory of Operation

The main components of the T-ADF/BV are the two input air filters and the membrane filter. The first step, in the process of creating dry air, is to pass the air through the coalescing and water separator filters. The coalescing filter uses coalescing elements to remove small particles and oil. The water separator spins the air using centrifugal force to remove most of the moisture. Both filters make use of an auto-drain feature to remove collected contaminants.

The membrane portion of the dryer works in a simple manner. The (by now) partially dry air flows through a bundle of tube-shaped membranes. The water vapor passes through the membrane walls and the dry air passes out of the filter for use downstream in the PTFS.

Assembly

The unit arrives assembled and ready for installation. All that is required is for you to integrate the air dryer with your air source. Some modification of your source air input line might be necessary. See next section.

Installation

The system is very easy to install. Position the air dryer on a flat surface, near the PTFS. Make sure to orient the unit horizontally to ensure proper functioning of the floats in the input air filters.

The T-ADF/BV is provided with and air output hose that has a female quick disconnect on one end, and a male connector on the other (Thermonics part number: PS-234). To integrate your source air with the dryer, you need to plumb the air input hose with the appropriate female quick disconnect. Alternatively, you could replace the male connector on the T-ADF unit with a compatible connector for a .25 NPT threaded hole.

Proceed as follows:

1.) Place the air dryer in a convenient location adjacent to the PTFS.

2.) Connect the input air line from the facilities air to the air dryer.

3.) Connect the output air line from the T-ADF to the input air connector on the backside of the T-2600BV.

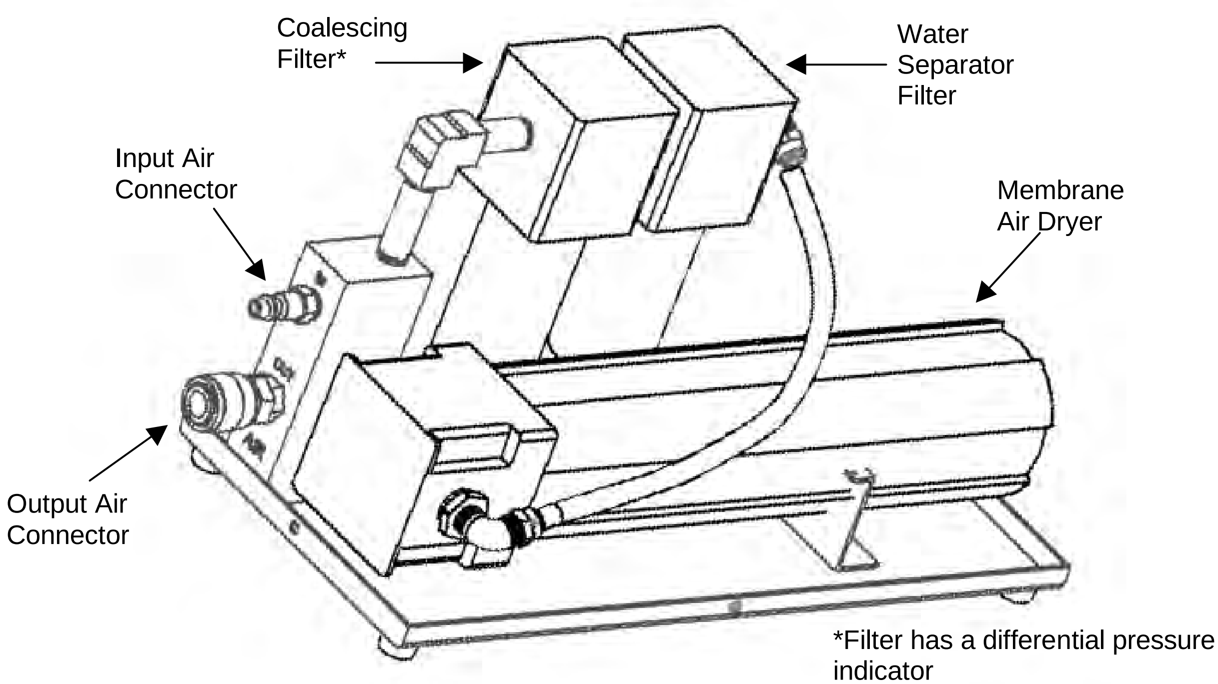


Fig. 1, Inside View T-ADF/BV

Maintenance

The scheduled maintenance interval for the two input air filters is every six months. The membrane filter requires no servicing as long as long as it is it is functioning properly (Note next paragraph.).

There are many variables in an air system, so it is difficult to predict the life of any particular component. With proper maintenance of the upstream filtration, the membrane module should give several years of dependable performance. During its lifetime, a gradual decrease in performance will occur, as well as a gradual increase in pressure drop. When this is noticed, the first thing to do is check the upstream filters (coalescing and water separator). Clean or replace any elements as necessary. If the dryer performance does not improve, it is time to replace the membrane module. (Filter replacement parts can be ordered from Thermonics, see parts list at end of this document.)

⚠**CAUTION**: Depressurize system before attempting service.

Input Air Filters

The two input air filters are a water separator and a coalescing filter. The maintenance instructions are found below.

Coalescing Filter Element

When the differential pressure indicator is RED, it indicates that the filter element requires servicing. Proceed as follows:

1.) Depressurize the unit.

2.) Remove the bowl/bowl guard assembly by pushing up on the bowl assembly and turning clockwise. Clean the inside of bowl using a clean, dry cloth. Inspect the plastic bowl for damage or crazing and replace if necessary.

3.) Remove the filter element by turning the element clockwise.

4.) Insert a new filter element and O-ring seal and reassemble in reverse order as above.

Note: Do not touch the exterior foam cover of the element. Use the plastic bag the element is shipped in to hold the element and install into the body.

5.) To clean the automatic float drain, remove the drain nut and drain. DO NOT DISASSEMBLE the drain. Clean the unit in warm, soapy water and blow dry with compressed air.

6.) Before returning the unit to service, insure that all seals have been reinstalled or replaced and the bowl is locked into position with the drain properly secured.

Note: if the differential pressure indicator no longer functions, it must be replaced.

Note: In the event that the drain knob is over-rotated, it may become disengaged from the drain stem. In such a case, pull down on both the knob and the stem while rotating to the right to re-engage.

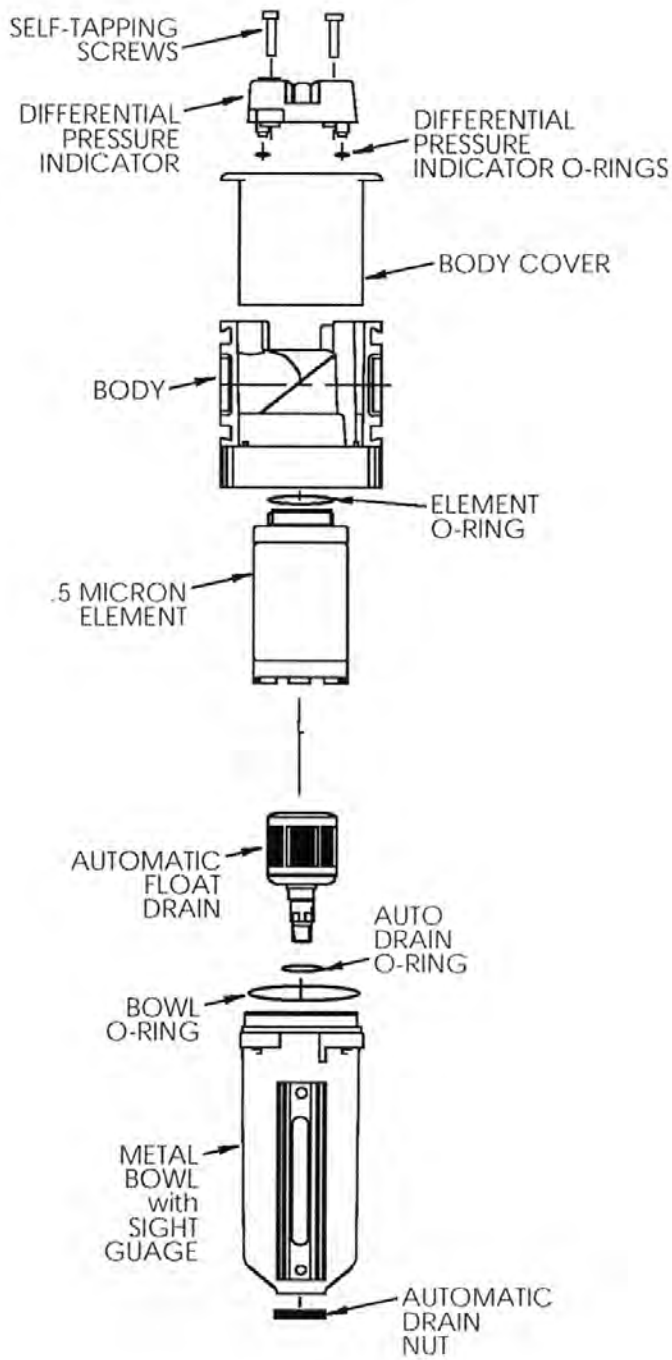


Fig. 2, Coalescing Filter

Water Separator Filter Element

1.) Depressurize the unit.

2.) Remove the bowl/bowl guard assembly by pushing up on the bowl assembly and turning clockwise. Clean the inside of bowl using a clean, dry cloth. Inspect the plastic bowl for damage or crazing and replace if necessary.

3.) Remove the filter element by turning the retainer counterclockwise. Remove filter and discard.

4.) Insert a new filter element and reassemble in reverse order as above.

5.) To clean the automatic float drain, remove the drain nut and drain. DO NOT DISASSEMBLE the drain. Clean the unit in warm, soapy water and blow dry with compressed air.

6.) Before returning the unit to service, insure that all seals have been reinstalled or replaced and bowl is locked into position with the drain properly secured.

Note: In the event that the drain knob is over-rotated, it may become disengaged from the drain stem. In such a case, pull down on both the knob and the stem while rotating to the right to re-engage.

Membrane Module

The bowl assembly is a bayonet mount with a safety locking detent. To remove the bowl, push straight up on the bowl, then rotate counterclockwise (as viewed from below the bowl.) The bowl and membrane module is then separated from the casting body by lowering down until clear of the body. The membrane module is then removed as outlined below.

1.) Depressurize the unit.

2.) An adapter is secured to the bowl by 4 (ea.) M5 x 0.8 x 20 button socket head cap screws. Remove the screws to allow separation of the adapter from the bowl. The adapter is sealed by an O-ring to the I.D. of the bowl, so turning or twisting the adapter may facilitate removal. After the adapter is separated from the bowl, the membrane module is remove as follows:

3.) To replace bottom plate O-ring, and to facilitate replacement of the lower module of the bowl O-ring, carefully remove the internal retaining ring, using an appropriate tool. Use a long wooden dowel or a hammer handle to tap the bottom plate out of the bowl from the inside. The lower O-ring can bow be replaced.

⚠**CAUTION**: When reinstalling the bottom plate, the internal retaining ring MUST BE securely seated in its mating groove in the bowl, below the bottom plate. Failure to do so could cause air pressure to blow the bottom plate off the bowl - which could cause serious injury.

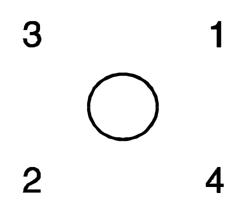
4.) Remove the membrane module from the bowl by pulling the module straight out of the top of the bowl. There are O-rings sealing the outside diameter for the module to the I.D. of the bowl. Turning or twisting the module while pulling upward may facilitate removal.

5.) To install a new membrane module, place a light film of grease on the O.D. of the plastic end caps of the module, being careful not to contaminate the ends of the module with the grease.

6.) Insert the module into the bowl with a turning or twisting motion, taking care not to damage the O-rings that seal the module to the bowl. Do not grasp the center tube of the membrane with any tool that may damage or deform the tube.

Note: When properly installed, the module bottoms out again the bowl bottom plate.

7.) Reinstall the bowl to the body adapter by twisting in the adapter and aligning the four screw holes. Reinstall the four M5 x 0.8 x 20 button socket head cap screws. Initially hand tighten the screws to snug in an even pattern, then tighten the screws to 3-5 ft-lbs., using this sequence:



8.) The bowl assembly can then be re-installed into the casting body by inserting the bowl straight up into the body and then rotating it clockwise (view from below).

Note: It is recommended that you replace all O-rings in the unit at the same time that you replace the membrane module. When servicing the unit, take care not to damage the rings.

Thermonics Part List

Part Number	Description
P5-057	Membrane Air Dryer
P5-058	Water Separator Filter
P5-059	Coalescing Filter

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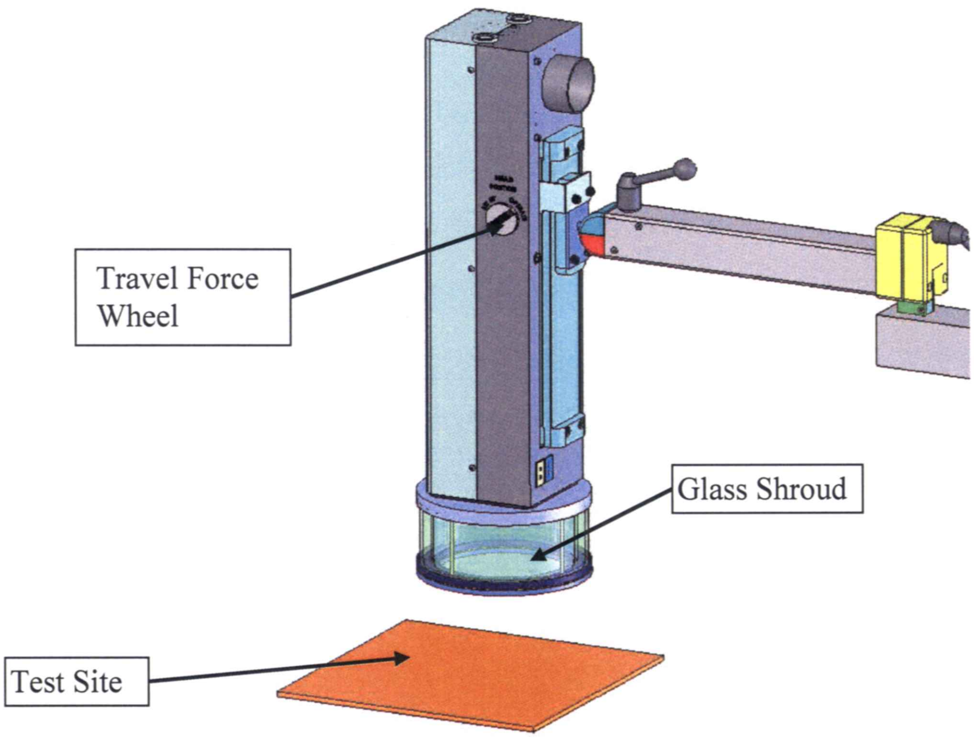
Setup of the Thermal Test Head: Sealing the Glass Shroud to the Test Pad for Thermonics Models T-2820, T-2800, T-2650BV, and T-2600BV



Purpose of the Travel Force Wheel:

The function of the wheel is to push the test head onto the test site with additional force. The wheel creates the force by making the test head overcompensate for the normal travel distance down. The purpose of exacting the additional travel distance down is to seal the test environment for the prevention of air leaks.

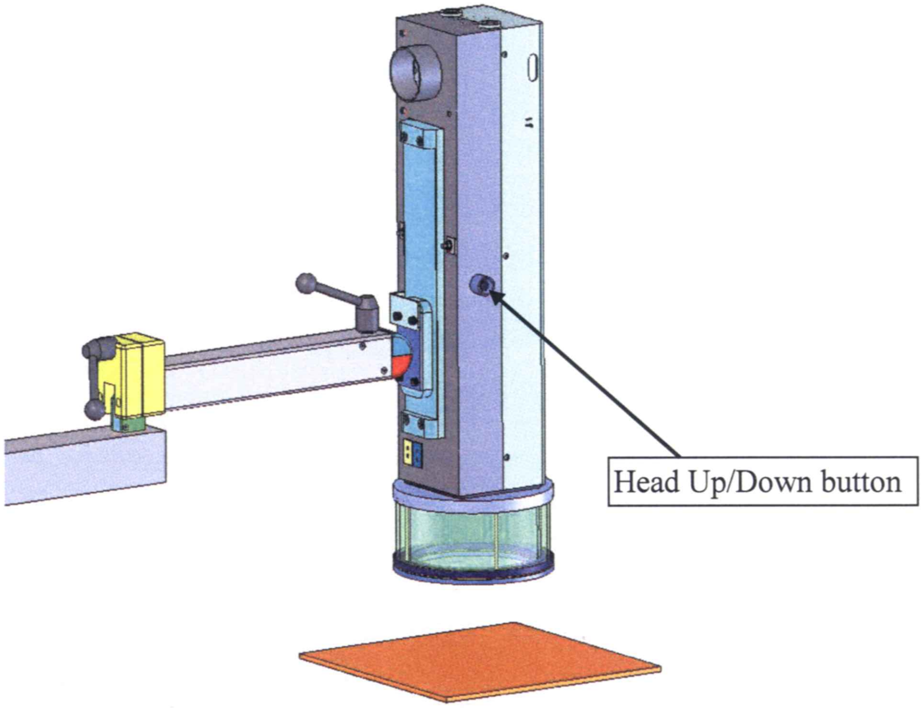
The procedure starts by pressing the head up/down button to raise the head before switching the wheel into the "set up" position. The "set up" position restricts the travel distance down during the first pressurized lowering of the head. After lowering the head, the system operator manually adjusts the arm and head to contact the glass shroud against the test site.

Then, the system operator pushes the head up/down button again to raise the head. The wheel automatically switches into the "operation" setting. The "operation" setting causes the test head to travel a farther distance down on the next lowering. It is this farther travel distance down that forces the shroud to create an "air-tight" testing environment.

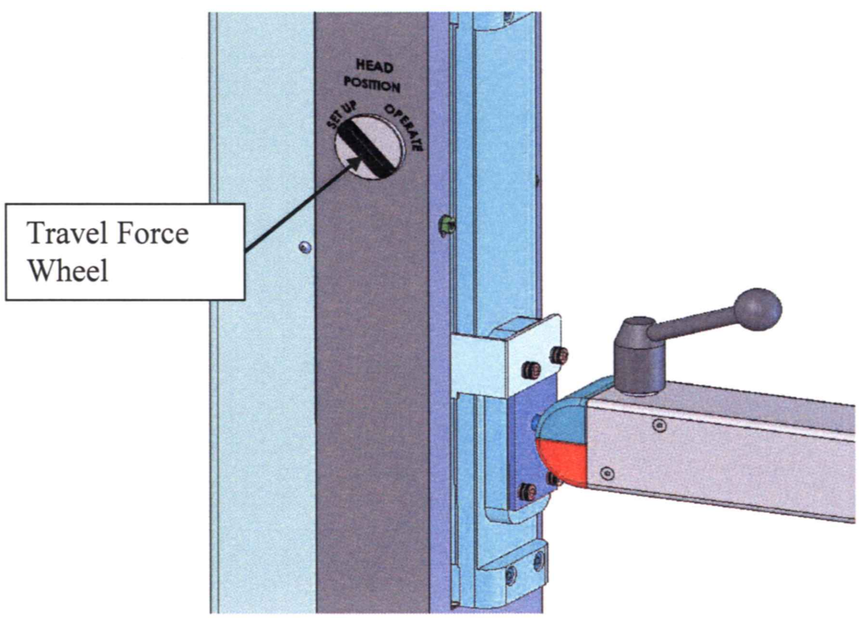
How to Create Travel Force from the Test Head

1. Power on the system.

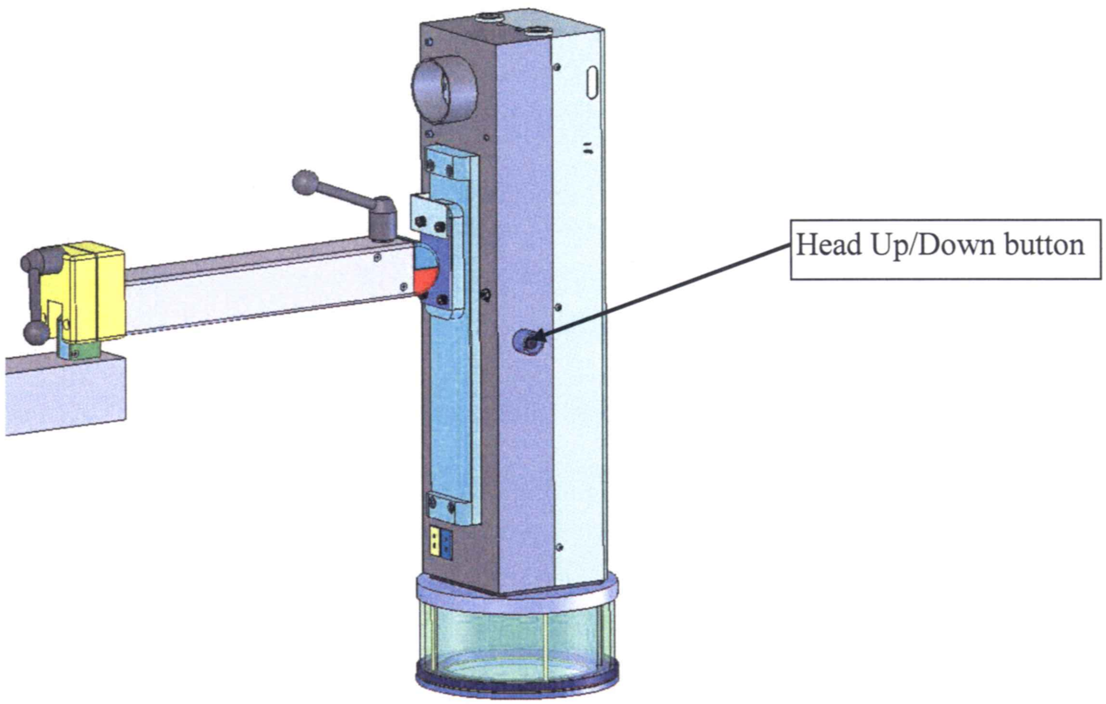
2. Raise the test head by pushing the Head Up/Down button.



3. Turn the Travel Force Wheel to the "Set Up" setting.

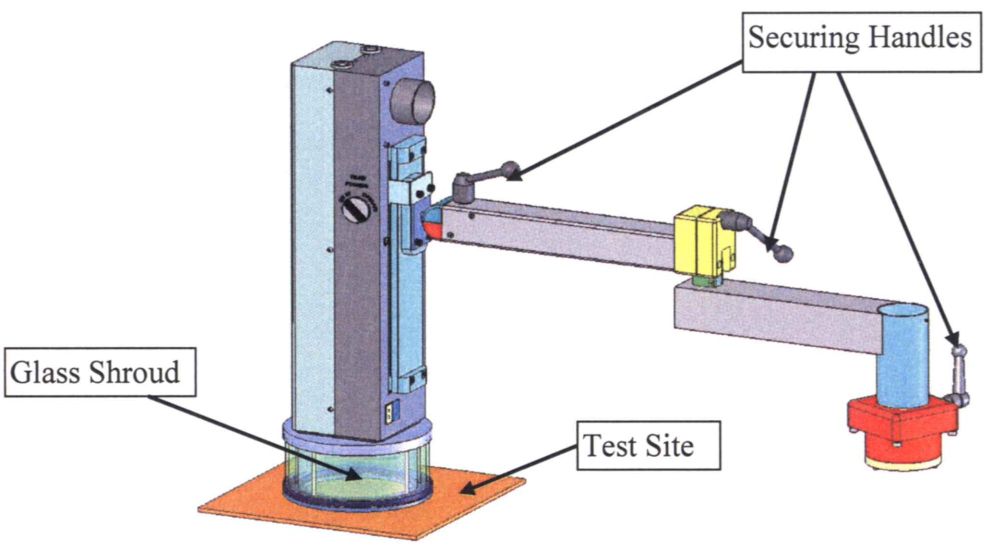


4. Press the Head Up/Down button to drop the test head.

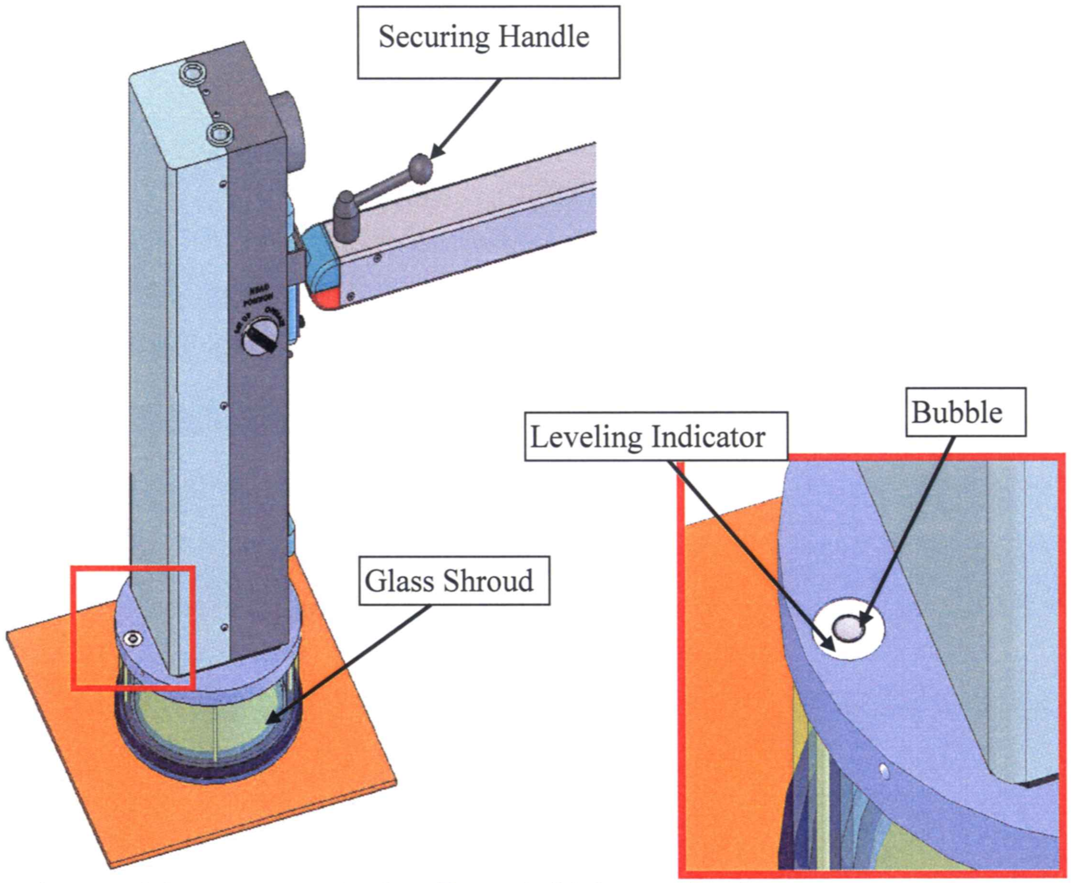


5. Loosen all three securing handles on the arm.

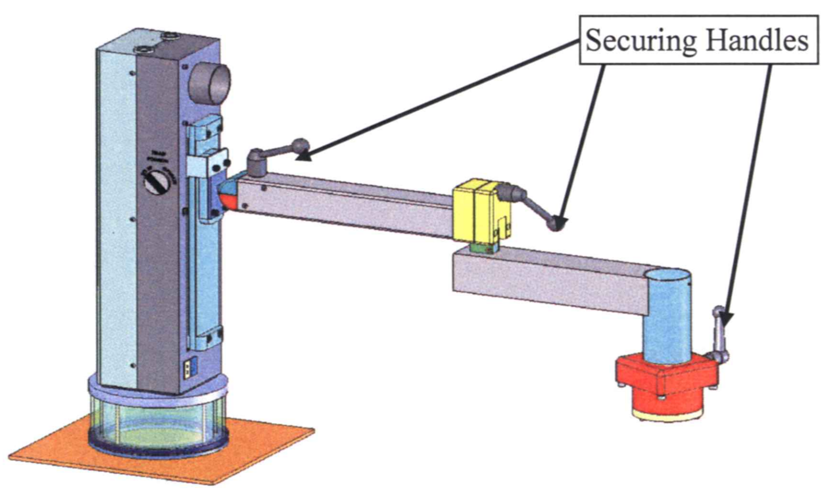
6. Manually adjust the arm and test head to align the glass shroud against the test site at the desired location.



7. Manually adjust the test head to sit level on the test site by centering the bubble in the leveling indicator. Tighten the securing handle to lock the test head into level position.

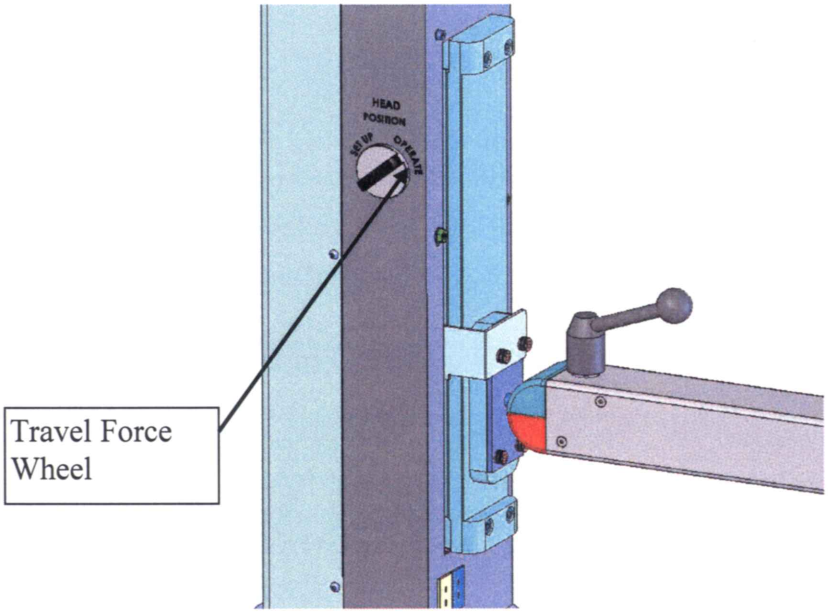


8. Tighten the remaining two securing handles to hold the arm in place.
Note: All securing handles must be thoroughly tight.

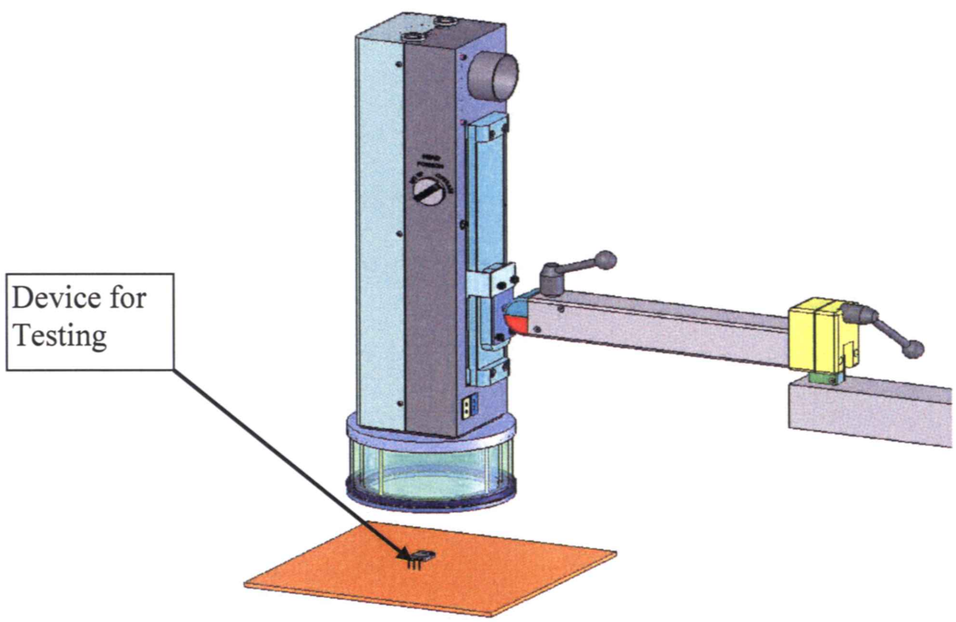


9. Push the Head Up/Down Button to raise the test head. Do not move the test arm or head.

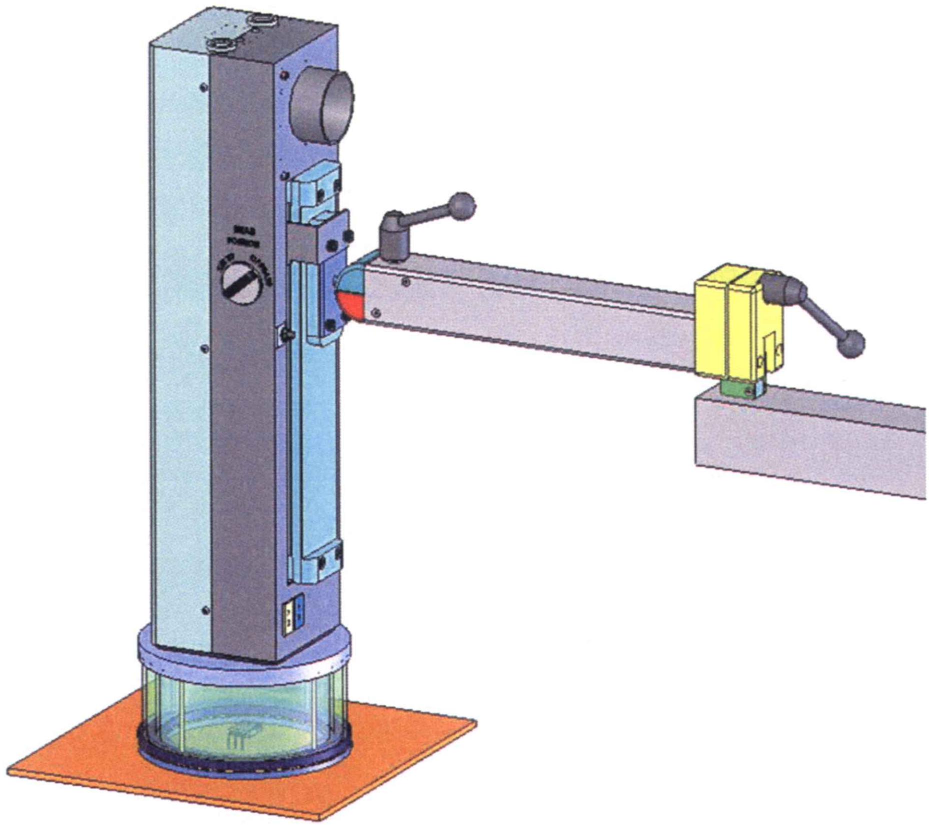
10. The Travel Force Wheel will automatically turn to the "operate" setting.



11. Insert the device for testing and any accessories onto the test site.



12. Push the Head Up/Down button to automatically drop the test head onto the test site with the additional force.



13. System is ready for operation.

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