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Chapter 1: Overview

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1. Overview

1.1. Introduction

The Engineering Thermal Control (ETC) 2000 uses a conductive heat dissipation method for precise control of the temperature of a Device Under Test (DUT). The system also collects temperature and control data for engineering analysis.

1.1.1. Configurations

The ETC 2000 is designed for use in an engineering environment, and is available in two configurations:

- Stand-alone, with umbilicals connected to an environmental chamber mounted on the tester load board; in this configuration, DUTs are socketed manually.
- To perform thermal control for automatically-socketed DUTs, with umbilicals connected to a separate handler

The system, mounted in a wheeled frame, is small enough to be easily moved around an engineering lab and positioned relative to a tester or handler.

1.1.2. Operation

During operation, the ETC 2000 executes an operator-selected programmed profile. A profile is a series of test sequences, specifying thermal control mode, DUT type, and temperature set points and timing. Several methods of thermal control are available, differentiated by the feedback inputs and control logics used. Device Kit (DK) calibration data are stored on an identity chip in the kit; the system reads the calibration values and configures its application software accordingly.

The tester can receive Start of Test signals from the ETC 2000, and send Binning and End Of Test signals to it, so that thermal control can be coordinated with the appropriate test programs. Password protection is provided for a number of levels.

Figure 1-1 and Figure 1-2 show the orientation and general features of the ETC 2000.

NOTE:	Note that, in order to facilitate positioning of the system, the facilities and umbilical connections panels, and the monitor, may be installed on either side of the cart. The environmental chamber (shown in Figure 1-3) may also be right- or left-

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handed. All the photographs and side references used in these manuals show the configuration illustrated in Figure 1-1 and Figure 1-2.

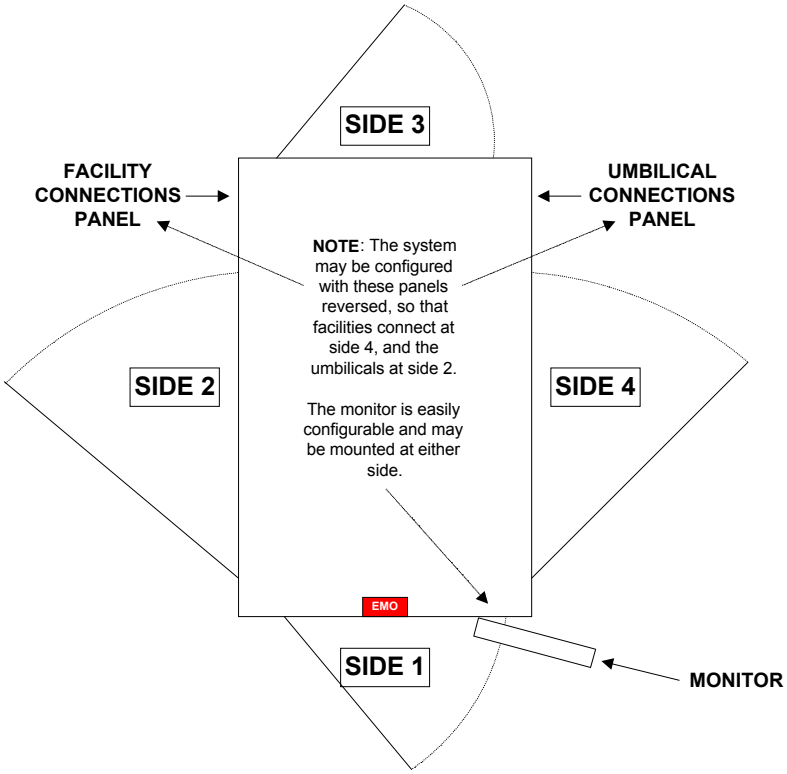


Figure 1-1. Plan View of ETC 2000 Showing Sides and Major Components



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Figure 1-2. General Views of ETC 2000

1.1.3. Key Features

Key features of the ETC 2000 include:

- Easy exchange of Device Kit (DK) allows rapid setup for test of different part types.
- Easy to program, operate, and maintain.
- PID-based digital thermal control.
- Offers an extensive range of test temperature set points (junction temperatures) from –10 degrees C to +150 degrees C, depending on the characteristics of the Thermal Unit (TU) and process fluid in use.
- Temperature resolution displayed in degrees C, to four decimal places.
- DK-based calibration function (with 'tooling identity' chip) automates system configuration to ensure accuracy of thermal control.
- When the system is used in its stand-alone configuration, the environmental chamber protects against condensation on the TU and DUT, regardless of test temperature. The TU and associated plumbing remain in a purged environment even when DUTs are being exchanged.
- Personal computer/system controller with multitasking operating system, and graphical user interface, controlled via keyboard and trackball.
- Flexible umbilicals permit easy connection to the environmental chamber, mounted to Tester Interface Unit (TIU), or to a separate handler.
- Casters and handles allow easy transport and positioning; a floor-lock brake prevents movement once the system is in position.

1.2. System Description

1.2.1. Thermal Unit

The Thermal Unit (TU) is the element of the Device Kit (DK) that directly contacts the DUT and provides conductive heat dissipation and socketing force. The TU consists of a heater/heat exchanger assembly, together with thermal feedback and overtemperature detection devices. Process fluid circulates through the heat exchanger to facilitate heat removal. The fluid is held at a constant temperature and flow rate. The heater modulates TU heat absorption to match the heat generated by the DUT.

Access to the face of the TU, for cleaning or other maintenance, is via tool-removable covers of the environmental chamber

1.2.2. Socketing Force

A pneumatically-actuated Device Kit automates the process of applying socketing pressure. The actuating mechanism is mounted in the environmental chamber. A software controlled electronic regulator mounted on the pneumatics panel controls the force applied by the actuator cylinder.

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1.2.3. Umbilical Connections

Three umbilicals -- two for process fluid, one for gas and electric connections -- run between the ETC 2000 and the environment chamber and tool within.

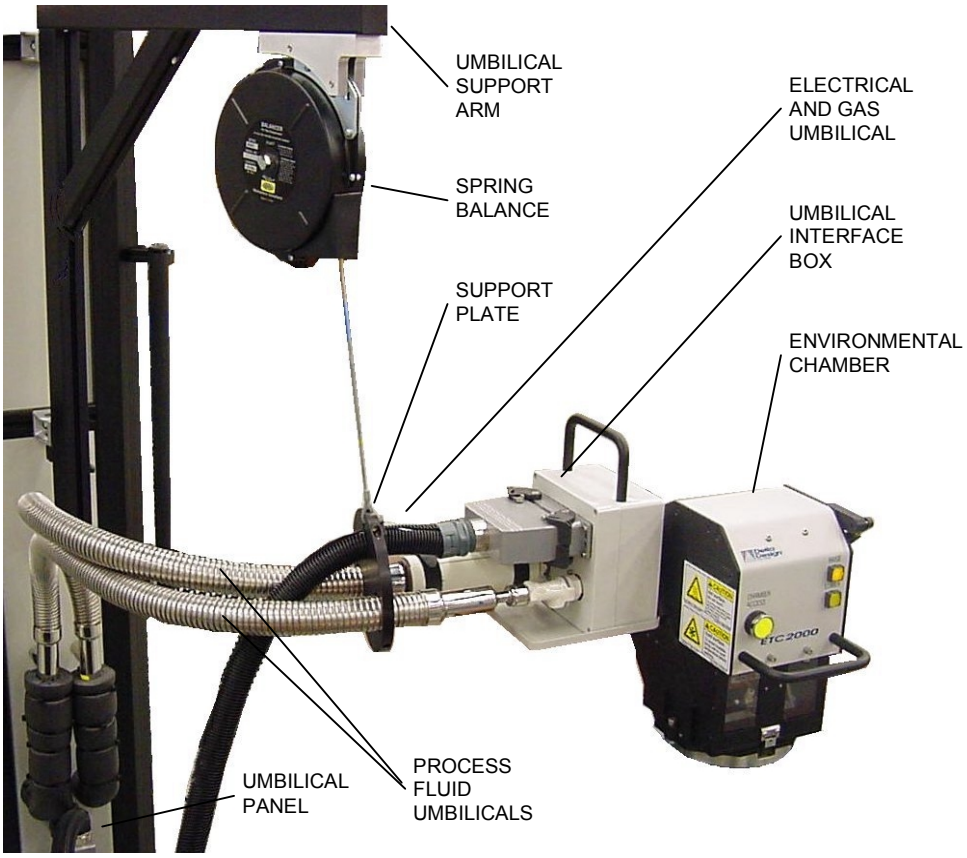


Figure 1-3. Umbilicals, Umbilical Support Mechanism and Environmental Chamber

The umbilicals comprise the following elements:

- Insulated supply and return tubes for the process fluid from the chiller.
- Purge air and helium supply tubes.
- Electrical cabling for the TU power supply, DUT RTD current source, DK safety RTD/s, and safety interlock mechanisms.

The umbilicals are supported by a balance spring, which is suspended from an arm mounted at side 2 or 4 of the system (depending on umbilicals connection panel configuration). At the system end, the process fluid umbilicals are hard-plumbed; quick disconnects at the environmental chamber end are asymmetrical to ensure proper attachment.

The electrical/gas umbilical attaches to quick disconnect blocks on the ETC 2000 facilities panel and at the environmental chamber.

The umbilicals are described in more detail in Chapter 13 of the ETC 2000 *Maintenance Manual* (*Umbilicals and Environmental Chamber*, P/N 7003110013).

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1.2.4. Environmental Chamber

1.2.4.1. Features of the Environmental Chamber

The main operational features of the environmental chamber are indicated in Figure 1-4. The chamber pivots up for access to the socket, so that the DUT can be exchanged. The chamber base mounts to a socket adapter with a bayonet mount; an interlocked latch, which may be over-ridden using a tool, holds the chamber closed during use.

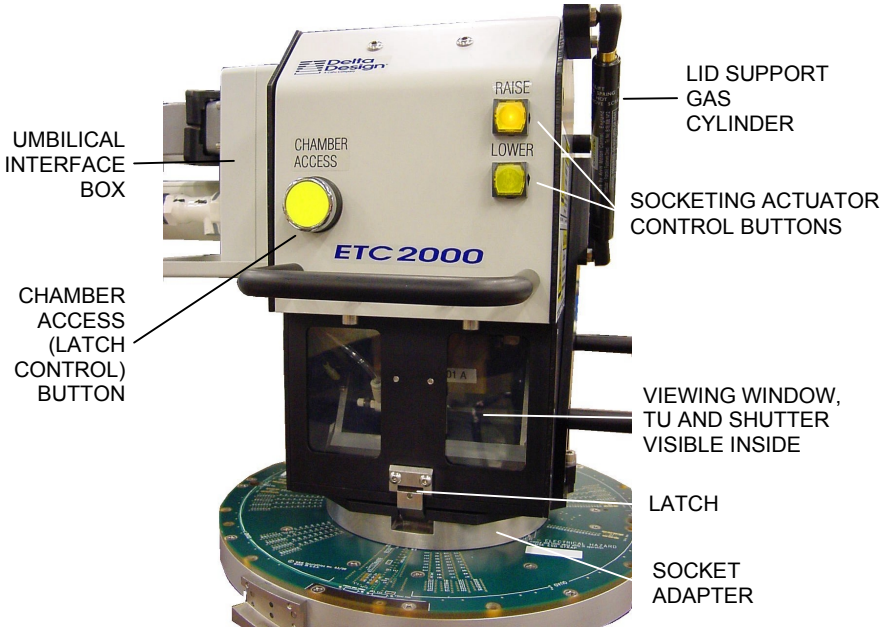


Figure 1-4. Environmental Chamber Mounted on Load Board

1.2.4.2. Helium Interface

Helium supplied through the gas/electrical umbilical is directed at the TU/DUT interface in order to make the thermal coupling more efficient.

1.2.4.3. Purge Control

The environmental chamber as a whole is purged with dry air, in order to prevent condensation or frosting at low test temperatures.

The environmental chamber may be pivoted up and out of the way to permit access to the socket, so that DUTs may be exchanged. A shutter mechanism in the chamber closes automatically when the actuating cylinder is retracted, sealing purge air in and excluding ambient air, even when the chamber is pivoted upward.

An air pressure gauge, flow meter, and other components of the pneumatic system, are mounted on the inside of the door at side 3 of the system.

1.2.5. Fluid Circulation Subsystem (FCS)

The Fluid Circulation Subsystem (FCS) moves fluid via the insulated supply and return umbilicals through the TU heat exchanger to provide, in effect, a controlled-temperature heat sink. An air-cooled refrigeration loop chills the process fluid in a heat exchanger. Once chilled, the fluid moves into a reservoir. From the reservoir, a pump moves the fluid through the system under positive pressure.

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The ETC 2000 chiller offers a wide range of process fluid temperatures, ranging from -40°C to +80°C. The temperature of the process fluid is set in the profile, and is kept well below test set-point. At low set points, the temperature differential is usually 40°C below the test set-point, though at low test set points it is not possible to sustain this differential (ΔT), and the difference may be higher at high set points. Fluid temperature is measured as the fluid leaves the evaporator in the chiller, and as it returns to the pump. The fluid is filtered on its way to the TU, and its flow rate measured as it returns to the pump.

For a more detailed account of the FCS, please refer to Chapter 12 of the ETC 2000 Maintenance Manual, *Fluid Circulation and Purge Subsystems* (P/N 7002210012).

1.2.6. Electronics Rack

The front of the electronics rack (see Figure 1-5) is accessible from side 1 of the ETC 2000. It includes the following:

- **System Controls Panel**

  The EMO button is mounted at the center of this panel. To the left is an overtemperature relay reset button, and to the right System and HVPS ON/OFF buttons.

- **Power Supplies**

  A high-voltage power supply, used to drive the TU, is mounted in the rack . A low-voltage power supply, with outputs of +24, +15, +5 and -15 VDC, is mounted in the AC enclosure behind the door at system side 3.

- **Thermal Control Chassis**

  The thermal control system may be configured with a linear or a switch-mode amplifier to supply power to the thermal control system.

  In either configuration, the chassis includes:

  - A backplane interconnect board.
  - Cabling.
  - Power summing or APECS power summing board.

  When configured with a the **linear mode amplifier**, the chassis contains the following components

  - Power amplifier pre-amp board/heat sink assembly. This receives commands from the RT board and 250VDC power from HVPS, and drives the TU heater.

  For **switch-mode amplifier** systems, the chassis contains these components:

  - Amplifiers and amplifier mother board
  - Low Voltage Power Supply
  - PFC power supplies

- **System Controller**

  A Pentium™-based Single Board Computer (SBC) running a Windows NT™ operating system controls all system functions and central communications. Video and Ethernet facilities are integral to the SBC. The system includes hard, floppy and CD-ROM drives.

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The system controller also includes the National Instruments™ Real Time board, the functions of which are detailed immediately below.

Other components include a system DAQ board, a GPIB board and a RocketPort serial interface. The system DAQ collects temperature-related data, as well as fluid flow rate and air pressure from the regulator on the pneumatics panel. It also includes 6 user-configurable inputs. The GPIB is used for tester communication.

The system controller is described in more detail in Chapter 8 of the ETC 2000 Maintenance Manual (*Electrical System and System Controller*, P/N 7003110008).

1.2.7. RT Board

The RT board is a microprocessor-based device which handles thermal control, receiving profile information from the SBC and outputting commands to the thermal control chassis. It receives feedback in parallel with the system DAQ.

The RT board accepts the test set point from the system controller and controls the power supplied to the TU heater. The RT board also receives DUT power information (either directly from the tester power supplies, or from the ETC 2000 power summing board, or from APECS [version 1 or 2] -- the Active Power Summing External Current Sensor) for use during Power Following mode. In Direct Temperature Feedback mode the board receives information from the RTD/s or thermal diodes on the DUT itself.

The RT board can only enable thermal control (the HVPS and amplifier/s) when the system conforms to the following state:

- The overtemperature module is not tripped.
- The environmental chamber and DK are in a safe state for operation.
- The flow sensors detect correct movement of process fluid in the plumbing loop.

1.2.8. I/O System

The ETC 2000 has, in effect, two I/O systems. One, handled by the RT board, is transparent to the user. The system DAQ board deals with the following:

- The UP and DOWN buttons on the environmental chamber
- The air cylinder which moves the TU up and down
- The status light
- The helium valve
- The purge valve (when system is configured to use purge)

1.2.9. Safety

For a full account of the ETC 2000 safety systems, refer to Chapter 2 of this manual, *Safety Hazards and Precautions* (P/N 7003100002).



WARNING: ***When the EMO is pressed, power remains on the line side of the K1 relay and in the EMO circuit.***

Electrical interlocks and an Emergency Machine Off (EMO) button provide the means to manage emergency situations efficiently. If the EMO button (see Figure 1-5) is pressed, power is removed from the machine immediately.

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1.2.10. Operator Interface

The system is operated through an interface accessible from either a sitting or a standing position. Figure 1-5 shows the elements of the interface for a linear amplifier-based system.

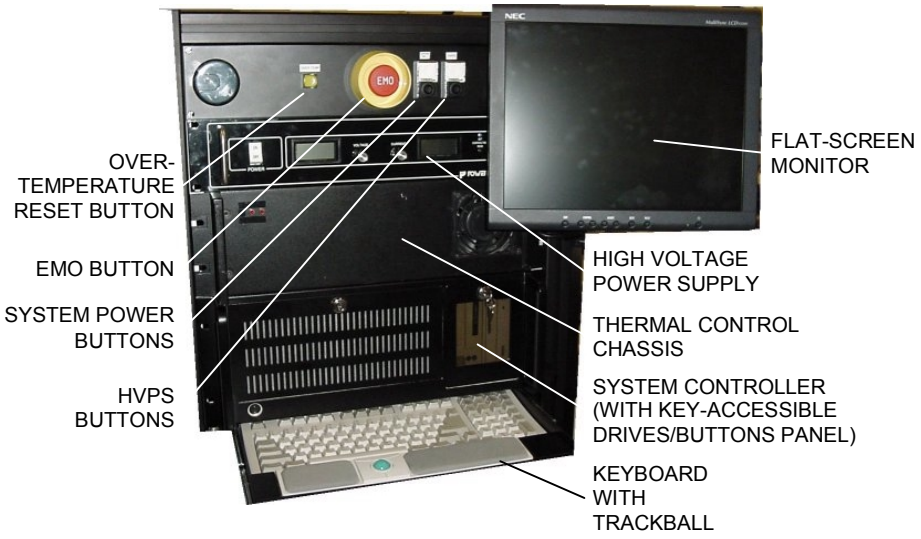


Figure 1-5. ETC 2000 Operator Interface (Linear Amplifier)

The components of the switch-mode amplifier system (Figure 1-6) are essentially the same, apart from the absence of the separate HVPS.

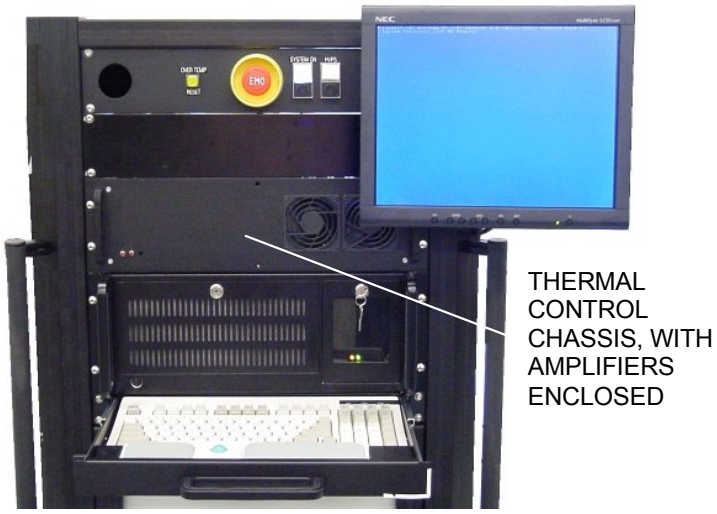


Figure 1-6. ETC 2000 Operator Interface (Switch-Mode Amplifiers)

The interface station includes the following:

- EMO (Emergency Machine Off) button
- Flat-panel LCD monitor, mounted near the top of the system frame; may be mounted on either side of side 1
- Standard 101-key keyboard with integrated trackball, stored in a drawer in the electronics rack
- System Power ON/OFF switch
- HVPS (thermal control) ON/OFF switch

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- Overtemperature relay reset button

1.2.11. System Cart

All of the system's components, with the exception of the operator interface, umbilical and DK interface, are packaged into a wheeled cart.

1.2.11.1. Doors

Doors at sides 1, 2 and 4 give access to the chiller. At side three, the door accesses the back of the electronics rack and to the pneumatic components (which are mounted on the inner surface of the door) and the AC enclosure and the chiller's control display. All doors are key-accessible, hinged and removable for ease of maintenance.

1.2.11.2. Movement

Rubberized handles at each corner of the system, together with swiveling casters, permit the ETC 2000 to be positioned easily. Once the cart is in position, a foot-actuated brake holds it in place; the system may be pivoted about the brake for exact positioning.

1.2.11.3. Cooling

A cooling fan, mounted in the top surface of the system cart, extracts air from the electronics enclosure.

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1.3. Theory of Operation

The ETC 2000's sole function is to maintain a set temperature or a series of set temperatures in a DUT while it is tested.

1.3.1. Profile and Sequence Description

A profile includes a DUT-specific series of test sequences, and pointers to configuration files, in which the correct parameters for the Thermal Control Subsystem are set. The same configuration files may be used by a number of different profiles.

Each sequence includes information about TU and chiller set point temperatures, as well as ramp, soak and test times. A profile allows the tester to run its tests while the DUT is controlled to a series of different temperatures.

1.3.1.1. Graphic Representation of a Profile

Figure 1-7 shows the elements of a simple profile. The profile in this case consists of a series of two sequences, punctuated by Start Of Test (SOT) signals sent to the tester, and End Of Test (EOT) signals received from it. The x-axis represents time, and the y-axis represents DUT temperature. The first test sequence is preceded by a soak period, during which the DUT is ramped and held at the test set point temperature before the SOT signal is sent. The second test sequence begins as soon as the ramp sequence is complete. The profile concludes once the ETC 2000 has returned the DUT to a safe, or ambient, temperature.

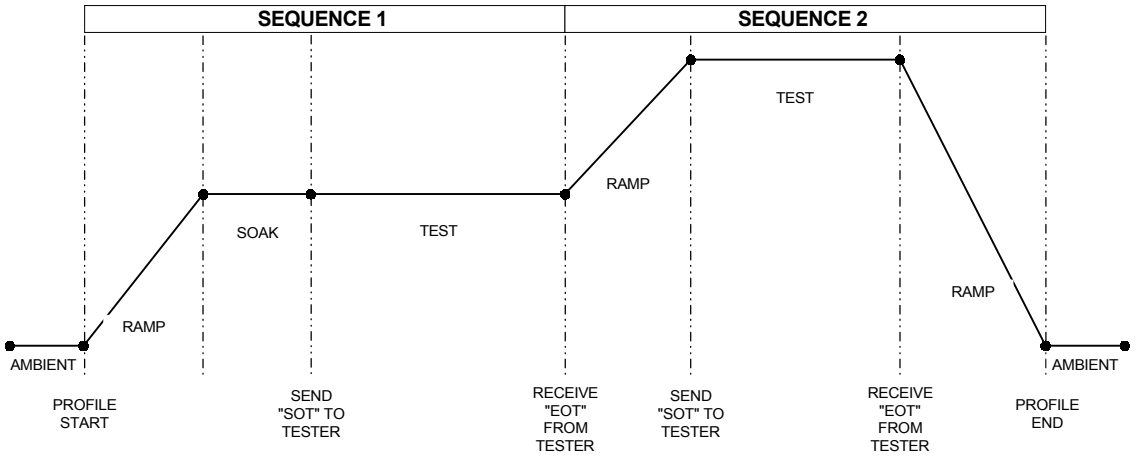


Figure 1-7. Outline of a Sample Profile

1.3.2. Operator Controls

The operator interface allows the operator to communicate with, and receive information from, the ETC 2000's subsystems. These functions are described in more detail in Chapters 3 (*Operation, Maintenance and Calibration Screens*, P/N 7003100003) and 4 (*Operating Procedures*, P/N 7003100004) of this manual.

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1.3.3. Thermal Control Modes

The ETC 2000 uses the following methods of analog PID (closed-loop) thermal control:

- **Heater Temperature Feedback (HTF)**

  The heater temperature is controlled to be constant at the set point; the DUT temperature varies slightly relative to this temperature.

- **DUT Temperature Feedback (DTF)**

  Signals from a temperature measuring device in the DUT are used as feedback to control the TU heater and keep the DUT's temperature constant.

- **Power Following Based on HTF (PF-HTF)**

  The ETC 2000 predicts temperature changes in the DUT by reading the HTF signal, in order to damp or offset changes in DUT temperature.

- **Power Following Based on DTF (PF-DTF)**

  The ETC 2000 predicts temperature changes in the DUT by reading the DTF signal, in order to damp or offset changes in DUT temperature.

Finally, **Simple** (or "off") mode uses the Heat Exchanger assembly as a large heat sink, with the process fluid assisting with heat removal. In Simple mode, the heater is not switched on, and there is no temperature feedback. To select Simple mode, Thermal Mode should be set to OFF in the profile setup screen.

1.4. Basic Operating Sequence

The operating steps listed below are a generic account of running a profile on the ETC 2000 from tooling change and system start-up through data export and system shutdown. For a more detailed account of these procedures, refer to Chapters 3 and 4 of this manual, *Operation, Maintenance and Calibration Screens* (P/N 7003100003) and *Operating Procedures* (P/N 7003100004).

NOTE:	This procedure assumes that the system is in its stand-alone configuration, and that an appropriate DK is mounted in the environment chamber.



CAUTION:	**Before operating the system, read Chapter 2 of this manual, *Safety Hazards and Precautions* (P/N 7003100002).**

1. Roll the ETC 2000 over to the tester.
2. Position the cart and engage the floor-lock brake.
3. Change the TIU (load board) to the one appropriate for the DUT to be tested.
4. Mount the socket interface on the TIU, and the environmental chamber on the interface.
5. Connect the umbilicals to the environmental chamber, if necessary adjusting the orientation of the ETC 2000 system cart to facilitate operator access to the environmental chamber/TIU and the operator interface.
6. Turn ETC 2000 system power on by pressing the System Power ON button on the system controls panel.
7. After the system software has initialized, log to the system.

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NOTE:	When data collection is enabled, it is important to stop collecting data after the profile is run. The volume of data collected is such that the hard drive will become full and prevent the system from running.

8. Select an appropriate profile, editing as necessary to ensure that the correct configuration data are used.
9. Press the HVPS ON button on the system controls panel.
10. Press the UP button on the environmental chamber.
11. Press the latch release button on the chamber.
12. Pivot the chamber up off the socket.
13. Insert the DUT into the socket.
14. Push the chamber down to latch it on the socket interface.
15. Press the DOWN button on the chamber.
16. At the operator interface, start the profile by clicking the Run button with the cursor.
17. Once the profile is complete, press the UP button. The button will flash until the DUT has been brought to a safe temperature, and then the TU will be raised and the button will be lit solid.
18. Repeat the process from step 11.

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Chapter 2: Safety Hazards and Precautions

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2. Safety Hazards and Precautions

2.1. Introduction

This chapter outlines the safety guidelines and precautions that should be followed to avoid personal injury to the operator or damage to the machine.

The ETC 2000 has been evaluated against SEMI S2-93A Safety Guidelines for Semiconductor Manufacturing Equipment, as well as SEMI S8-95 Safety Guidelines for Ergonomic/Human Factors Engineering of Semiconductor Manufacturing Equipment.

2.2. Warnings, Cautions, and Notes

The safety signal words which appear throughout this manual are in accordance with ANSI Z535 safety standards and are described below: The icons used comply with IEC 417 and ISO 3684.



DANGER:	***Items displayed in this style indicate hazardous situations which, if not avoided, will result in death or serious injury. The accompanying graphic (left) illustrates the type or types of hazards.***



WARNING:	***Items displayed in this style indicate potentially hazardous situations which, if not avoided, can result in death or serious injury. The accompanying graphic illustrates the type or types of hazards.***



CAUTION:	**Items displayed in this style indicate potentially hazardous situations which, if not avoided, can result in minor or moderate injury or equipment damage. This signal word may also be used to alert against unsafe practices. The accompanying graphic is the standard Caution symbol.**

NOTE:	Items displayed in this style indicate additional or optional information related to items written directly above or below. Notes are not accompanied by a graphic.

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2.3. Hazard Labeling

The ETC 2000 bears a variety of labels warning of personnel hazards. These labels, and their locations, are detailed in this section.

NOTE:	The chiller and the High Voltage Power Supply have their own hazard labels for voltage and thermal hazards.

2.3.1. Hazardous Voltage Warning Label

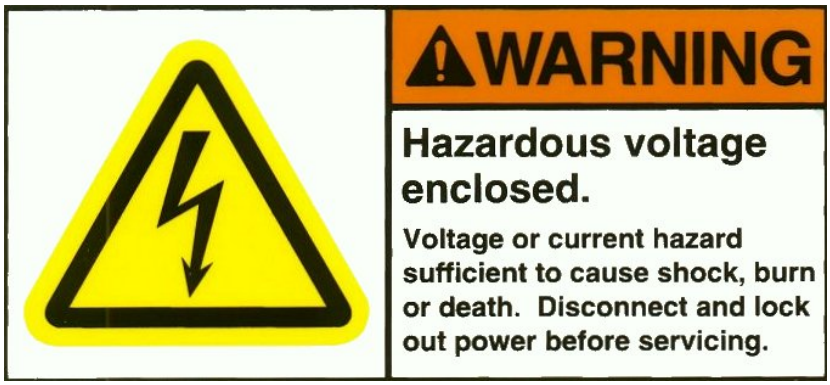


Figure 2-1. Hazardous Voltage Warning Label

The warning label shown in Figure 2-1 appears in two places on the ETC 2000:

- AC box door
- AC line filter
- Top cover of thermal control (amplifier) chassis

2.3.2. Hot Surface Caution Label



Figure 2-2. Hot Surface Caution Label

One hot surface caution label appears on each side of the environmental chamber.

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2.3.3. Cold Surface Caution Label



Figure 2-3. Cold Surface Caution Label

One cold surface caution label appears on each side of the environmental chamber.

2.3.4. Hot/Cold Surface Hazard Label



Figure 2-4. Umbilical Panel Hazard Warning Label

A label like the one shown in Figure 2-4 appears on the umbilical panel (at side 2 or 4 of the system, depending on configuration), next to the process fluid umbilical connections.

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2.4. Machine Orientation and OIS Panel Layout

To facilitate orientation, the sides of the ETC 2000 are numbered. The front of the electronics enclosure faces Side 1; Sides 2 through 4 (see Figure 2-5) are defined counting clockwise from Side 1, when the machine is viewed from above.

Note that, depending on the system configuration, the umbilicals and facilities panels may be mounted in reverse, compared to Figure 2-5; the monitor may be at the right or the left of side 1.

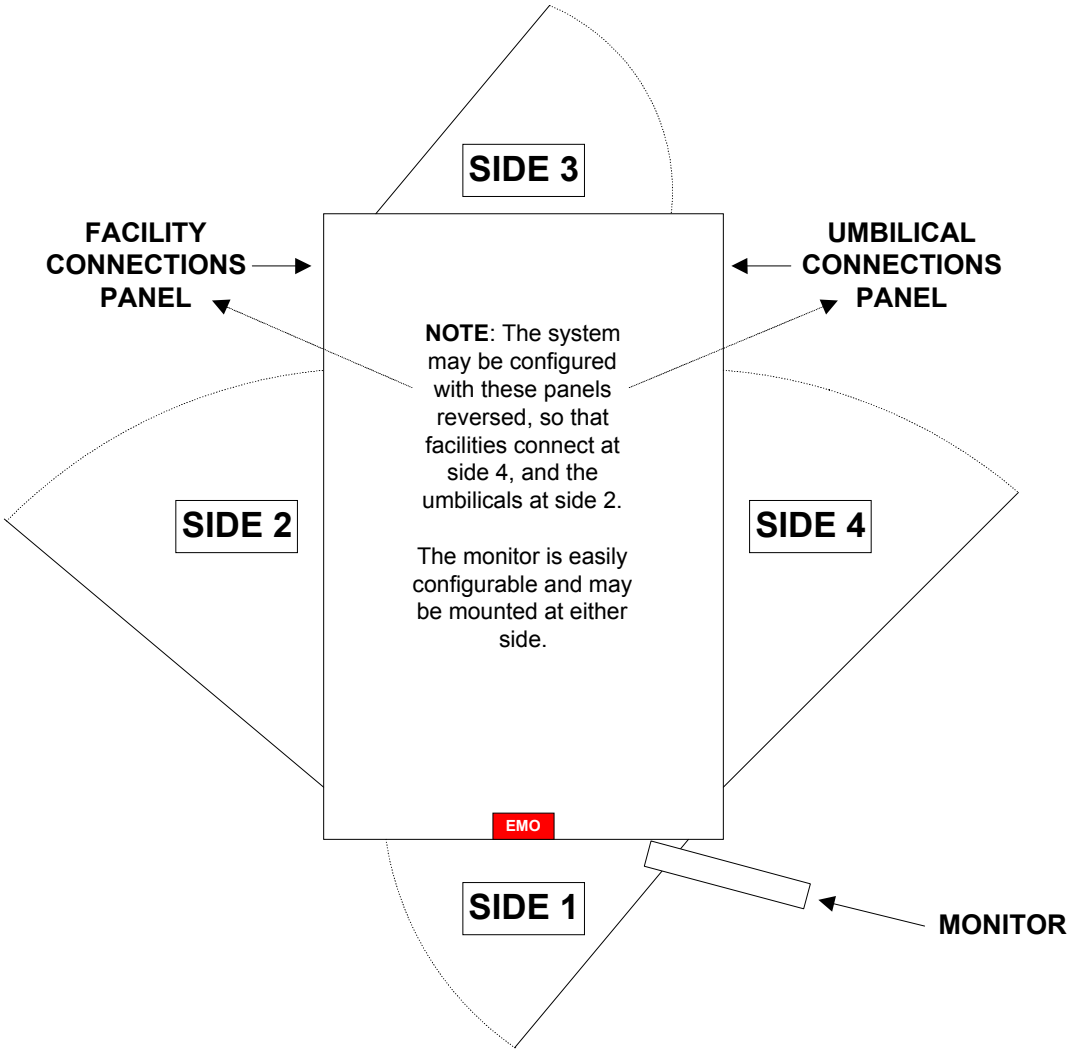


Figure 2-5. ETC 2000: Definition of Sides

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The components of the ETC 2000 operator interface are shown in Figure 2-6. This figure shows the system in its linear amplifier configuration; the switch-mode amplifier configuration does not have a separate high voltage power supply.

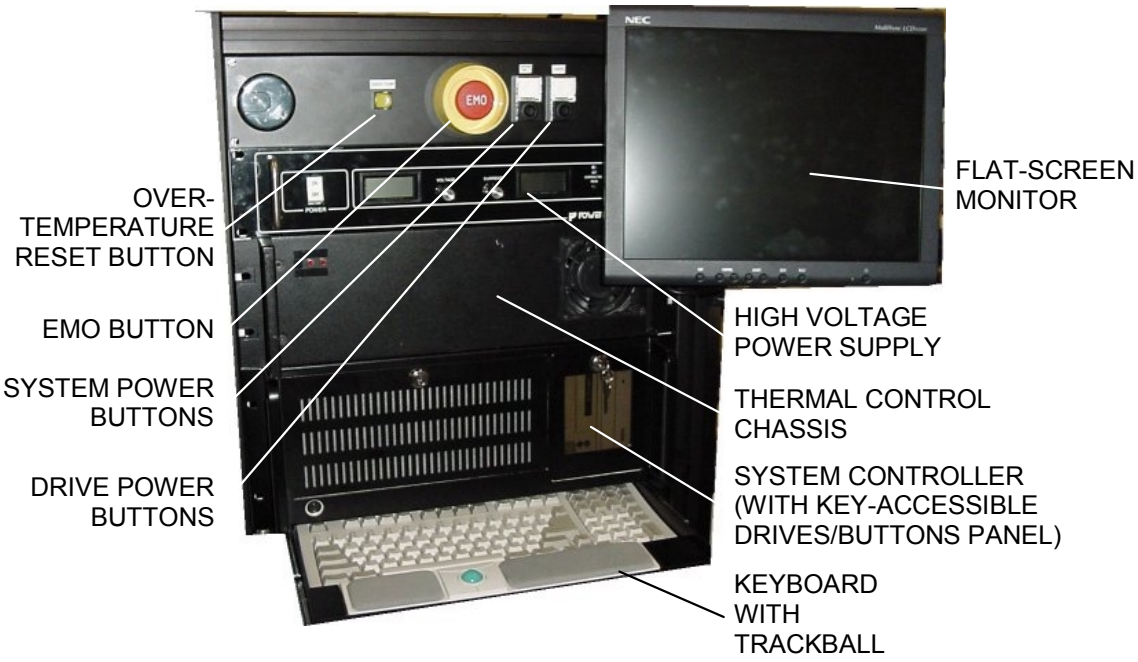


Figure 2-6. ETC 2000 Operator Interface and Electronics Rack Components

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2.5. Safety System



WARNING:	***Do not make any changes in electrical circuitry. The electrical system is designed with operator safety a primary objective. Changes in electrical circuitry can result in injury to personnel and damage to equipment.***



WARNING:	***Operating the ETC 2000 with the safety interlocks bypassed can result in severe personal injury. Ensure that the shroud and socket lid are in place before beginning a profile.***

The ETC 2000 safety system has two types of interlock, and an Emergency Machine Off (EMO) circuit:

The components of the ETC 2000 safety system are described in the next several sections.

2.5.1. Interlocks

- **Safety interlocks** are fail-safe hardware interlocks that are the last line of defense to protect against hazards.
- **System interlocks** combine hardware, firmware and software interlocks used as the first line of defense against hazards, to keep the system in a safe state without invoking the safety interlocks.

2.5.2. EMO Button

The **Emergency Machine Off (EMO) button** is a large red button on a yellow background. The EMO is located on the control buttons panel at the top of system side 1 (see Figure 2-6). When the EMO button is pressed, the main contactor is opened and power is removed from the system.

The System Power OFF button performs the same function as the EMO.



WARNING:	***After the EMO button is pressed, power still remains on the line side of the K1 relay and the EMO circuit 24 VDC power supply.***

2.5.3. Safety Interlocks: Environmental Chamber

The environmental chamber contains the Device Kit, and attaches to the socket adapter. The socket adapter mounts on the TIU (load board). The chamber incorporates two hardware interlock switches which sense:

- When the shutter is closed
- When the chamber is correctly mounted to and latched down on the socket adapter

If the chamber is in its up position or not on the socket adapter, *and* the shutter is open, the HVPS and amplifier/s is/are disabled and cannot be re-enabled until the system is returned to a safe state.

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Table 2-1 shows the possible states of the environmental chamber safety interlocks:

NOTE:	The socket adapter may or may not be mounted to the TIU; the chamber interlock refers to the relationship between the chamber and the socket adapter. This permits testing of the TU (thermal unit) even when the socket adapter is not mounted to a TIU and test head.

Table 2-1. Environmental Chamber Safety Interlock States

Shutter	Chamber	Condition
Closed	Down	HVPS **enabled**
Closed	Up	HVPS **enabled**
Open	Down	HVPS **enabled**
Open	Up	HVPS **disabled**

2.5.4. System Interlock

The heater enable depends on the state of the flow switch, and of the environmental chamber switches described in section 2.5.3.

The heater enable system interlock is activated when the process fluid flow drops below a minimum value, or the when the chamber and shutter switches do not satisfy the conditions described in Table 2-1 for enabling the HVPS. In most situations, when these conditions are not satisfied, the heater enable system will disable the output transistors of the HVPS before the mains AC supply of the HVPS is switched off.

2.5.5. Software Overtemperature Protection

The thermal control RT board measures feedback from the heater RTD. If the measured temperature exceeds a limit value selected in software, thermal control is disabled and an alarm message is triggered indicating that thermal is disabled.

The chiller is equipped with its own flow sensor which, together with the flow sensor in the return leg of the process fluid plumbing, is used to detect conditions in the FCS loop. If the flow switch is tripped, HVPS is disabled.

These are not hardware interlocks and are not used primarily for safety purposes.

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2.5.6. Safety Interlock: Overtemperature RTD

An **overtemperature safety RTD** in the TU is connected to an overtemperature module mounted in the AC enclosure. When an overtemperature condition is detected, an output relay in the module opens, which opens the HVPS contactor to disconnect AC power from the HVPS. In this condition, the reset button (located to the left of the EMO button shown in Figure 2-6) illuminates; the condition causing the overtemperature must be corrected, the reset button pressed and the alarm acknowledged, before the HVPS and amplifiers can be re-enabled.

Software detects this condition indirectly, when its attempts at thermal control fail due to the absence of high voltage power to the heater. When this condition is detected, the software will abort the profile.

2.6. Personnel and Equipment Hazards

Personnel and equipment hazards associated with the ETC 2000 are outlined in the next few subsections of this chapter.

2.6.1. Electric Shock: Personnel Hazards



WARNING:

Type 3, 4, and 5 electrical work hazards (see SEMI S2-93A section 11.1) exist in the machine. Use caution when working in the electrical enclosure.

Type 3: Equipment is energized and live circuits of less than 30 VRMS, 240 VA, and 20 joules are exposed to accidental contact.

Type 4: Equipment is energized and live circuits of greater than 30 VRMS, 240 VA, and 20 joules are exposed to accidental contact.

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

Work under the following conditions is considered extremely dangerous and should not be allowed:

Performing internal measurements and adjustments when equipment is energized and performance requires physical entry into the equipment.

Working without a partner.

Using non-clamp on probes to take measurements on the main distribution panels or power source where voltages are greater than 50 volts.

Electric shock can occur at areas of exposed high voltage. All efforts have been made to protect personnel from exposed voltages. However, the danger of electric shock still exists. Work around electrical components with caution.

2.6.1.1. High Voltage DC

DC voltages up to 400 VDC are used to run the heater unit on the ETC 2000.

2.6.1.2. Three-Phase AC

Both the ETC 2000 as a whole and the chiller use 208V three-phase AC power

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2.6.2. Electric Shock: Equipment Hazards

2.6.2.1. Device Kit Changeover



CAUTION:	**The system may be damaged if the electrical/gas umbilical is disconnected while high voltage power is present.**

The ETC 2000 application software should be shut down and power to the machine turned off, before elements of the Device Kit are removed and replaced.

2.6.2.2. Low Temperature Frosting



WARNING:	***Ice on the TU may be electrically energized. If ice is present, turn the HVPS OFF and wait until purge air has completely removed the water and ice.***

Precautions should be taken to prevent frosting or condensation on components inside the environmental chamber. Condensation and frosting may occur if the chamber lid or cover are opened soon after a low set point profile is run. Do not open the chamber until the TU and associated plumbing return to ambient temperature, as indicated by the PV display on the main screen of the application software.

2.6.2.3. Other Shock Hazards to Equipment

Removal or replacement of electrical connectors while power is on can damage circuitry.

2.6.2.4. Fuse Replacement Hazard



WARNING:	***For continued protection against risk of fire, replacement fuses must be of the specified type and current rating.***

Fuse locations and values are specified in section 8.4 of Chapter 8 (*Electrical System and System Controller*, P/N 7003110008) of the ETC 2000 *Maintenance Manual*.

2.6.3. Temperature Hazards





WARNING:	***During normal operation of the ETC 2000, all doors should be closed and locked, to protect against thermal hazards in the chiller and associated plumbing.*** ***Take care not to touch exposed metal surfaces of the process fluid umbilicals.***



CAUTION:	**Before opening the system cart's doors, make sure the chiller is set to a safe-to-touch temperature, as reported by the chiller PV display on-screen.**

Extreme hot (>60 degrees C) and cold (<4 degrees C) temperatures may be present on the underside of the TU while the ETC 2000 is in operation. Although the environmental chamber includes interlocks which switch off power to the thermal control system when the system is not in a safe condition, dangerous temperatures may still be present on the underside of the TU for some time after it is disconnected from a DUT. Contact with this surface should be avoided until a safe temperature has been reached.

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Inside the system cart, there are both hot and cold temperature hazards around the chiller. Care should be taken when the system's doors are open; avoid touching process fluid plumbing, the compressor housing, and the pump motor. The process fluid, in particular, takes some time to return to its default setting from high or low extreme temperatures.

Although the process fluid connections at the umbilical interface panel are insulated, their metal parts may be very hot or very cold. Care should be taken not to touch this area when the system is in use.

2.6.4. Laser Hazards



CAUTION:	**LEDs on the ETC 2000 are considered to be class I laser devices in the European Union; they are not considered laser devices in the United States.**

LEDs are visible on the front of the thermal control chassis in the electronics rack, visible from side 1 of the system; and on the RT board inside the system controller.

2.6.5. Compressed Gas Hazards

Before either the facilities air supply or the helium supply hose is disconnected, care should be taken to ensure that the supply has been shut off at the facilities panel. This precaution will prevent the hose from moving under its own force, and striking personnel.

The air supply should be turned off and locked out using the LOTO fixture inside the facilities panel, behind the door at side 3 of the system.

2.6.6. Mechanical Hazards

2.6.6.1. Sharp Edges

The exterior of the ETC 2000 does not have any sharp edges. Care should be taken when system cart panels are open, as the chiller radiator fins are sharp.

2.6.6.2. Pinch Points

Areas where it is possible to get pinched are listed below:

- Between environmental chamber and socket adapter.
- Monitor arm.
- Keyboard tray.
- Removable doors on the base frame.
- The floor lock brake mechanism. A foot, rather than hands, should be used to lock and unlock the brake.

2.6.6.3. Rolling/Crushing Hazard

Although the system can be immobilized using the floor lock brake, the cart is capable of rolling freely if it is not secured. Because the unit weighs approximately750 lbs, this presents a significant crushing hazard to personnel and other equipment.

Always use two people to move the ETC 2000. Before moving the system:

- Turn off the main breaker.

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- Check that all facilities connections – power, air, network, other communications – are disconnected.
- Ensure that the electrical/gas umbilical is disconnected from the environmental chamber and the umbilical panel.
- Ensure that the process fluid umbilicals are disconnected from the environmental chamber, and are secured to the system so they will not be damaged during the move.
- Check that all doors are securely attached and latched shut.

2.6.7. Lifting Hazards



CAUTION:	**Many components of the ETC 2000 are very heavy. Lifting the chiller, system controller or thermal control chassis must be carried out by at least two persons using appropriate equipment.**

The chiller is extremely heavy. If it is removed, it must be handled with care by at least two persons using appropriate equipment.

NOTE:	For a chiller removal procedure, refer to section 12.7 of Chapter 12 (*Fluid Circulation and Purge Subsystems*, P/N 7003110012) of the ETC 2000 *Maintenance Manual*.

The system controller, thermal control chassis and High Voltage Power Supply, may be removed from their racks in the electronics enclosure. For safety, when they are detached from their racks these components must be lifted by two persons.

2.6.7.1. Electronics Enclosure Component Removal

Components within the electronics enclosure are heavy, requiring more than one person for removal and installation (see Figure 2-6 for component locations). Get a helper before removing the system controller or the thermal control chassis.

1. Provide a place to put the component after it is removed from the machine.
2. Slide the component out and disconnect all cables from connectors on its back plate.
3. Position one person on each side of the component, slide it out carefully far enough to provide a handhold on each side, from underneath.
4. Grasp the component with fingers underneath and carefully slide the component straight out of the machine.
5. Place the component in the area provided.

2.6.7.2. Electronics Enclosure Component Installation

1. Get help before attempting to install a component.
2. Ensure the space for the component is clear and ready for installation.
3. Grasp the component, one person on either side, with fingers underneath and clear of the end that is to be inserted first.
4. Slide the component straight into position and secure in its slot.
5. Make connections as necessary.

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2.6.8. Chemical and Chilled Water Hazards

2.6.8.1. Process Fluid (HFE-7500) Hazards



CAUTION:

Do not expose HFE-7500 to an open flame, or to continuous temperatures in excess of 150°C. Extreme heat can produced decomposition products, which may cause irritation. The presence of a sharp, acrid odor is evidence of thermal decomposition.

HFE-7500 evaporates readily: At times, the chiller reservoir may be under pressure. Care should be taken when opening the cap; refer to the procedure described below.

HFE-7500 contracts and expands depending on its temperature. To prevent overfilling the reservoir, ensure that the process fluid is no colder than 20 degrees C and no warmer then 40 degrees C, when adding fluid.

Do not mix HFE-7500 with other chemicals, especially strong bases.

Liquid HFE-7500 on hands while smoking can cause injury. Wash your hands before smoking.

Read the MSDS, included in section 2.10.1 of this chapter, before using HFE-7500.

The chiller reservoir and the fluid loop of ETC 2000 contain 3M HFE-7500, a clear, colorless, low-odor fluid suitable for heat transfer applications. HFE-7500 has very low toxicity, and a boiling point of 130°C. Although it is not classed as a hazardous material, care should be taken in handling and disposing of it. When handling HFE-7500, chemical goggles and nitrile gloves should be used.

For further details, and spill clean-up and disposal information, refer to the Material Safety Data Sheet (MSDS) included with this chapter, at section 2.10.1. During normal system operation and maintenance, HFE-7500 exposure levels are below those required by SEMI S2-93A, based on the manufacturer's recommended exposure level. An exposure report is on file at Delta Design Columbus, and may be obtained by contacting Delta Design's Environment, Health and Safety officer.

Trace decomposition can occur at temperatures above 150 degrees C. The products of this decomposition are toxic, and include hydrofluoric acid. In practice, safety interlocks on the ETC 2000 will prevent the fluid from exceeding the temperature for which it is designed.

2.6.8.2. Removing the Process Fluid Reservoir Cap

For safe removal of the reservoir cap:

1. Ensure that process fluid temperature is between 20 and 40 degrees C.
2. Use glove and eye protection as specified in the MSDS.
3. Put a hand over the cap, turn while pressing down, and wait until the pressure is relieved.
4. Remove the cap.

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2.6.8.3. Potential Leak Sources of Process Fluid

The HFE-7500 loop external to the chiller has the following potential key failure points which may result in potential exposure to the fluid:

- Flow sensor
- Umbilical quick disconnects at environmental chamber
- Device Kit disconnects inside environmental chamber

2.6.8.4. Potential Leak Sources of Other Chiller Fluids



CAUTION:	**The chiller refrigerant fluid loop and compressor contain Genetron AZ-50 (R-507), Ritchie Fluorescent Leak Scanner solution, and Mobil EAL Arctic 22 CC. The loop and compressor are sealed. For details on these materials, refer to the MSDSs included in section 2.10 of this chapter.**

The refrigerant fluid loop and compressor contain a mixture of three fluids – Genetron AZ-50 (R-507), Ritchie Fluorescent Leak Scanner solution and Mobil EAL Arctic 22 CC.

The loop and compressor are sealed, and a leak is very unlikely. The most likely locations for a leak from the chiller are:

1. The piping on side 3 of the chiller, behind the electrical enclosure, which might be damaged during removal of the chiller.
2. The recharging valve, which might be closed improperly or damaged during charging.

Because Genetron AZ-50 (R-507) is a gas at room temperature and pressure, it will evaporate and disperse immediately if it leaks. There are 35 drops of Ritchie Fluorescent Leak Scanner solution mixed with 64 oz. of Mobil EAL Arctic 22 CC in the compressor. The mixed solution will appear as a clear liquid possibly with a light reddish tint.

A leak in the refrigerant loop is expected to release no solution or at most several drops.

A licensed or trained refrigeration technician must diagnose and repair any leak and recharge the refrigerant fluid loop.

2.6.8.5. Spill Cleanup and Disposal of Fluids

Return used HFE-7500 to 3M for reclamation if possible, and follow instructions for disposal provided in the MSDS. Follow MSDS instructions for disposal of other fluids.

If there is a leak, then for spill clean-up and disposal information refer to the Material Safety Data Sheet (MSDS) included with this chapter, at section 2.10.1.

If a large leak has saturated insulation, then remove the HFE-7500 by squeezing the insulation and wiping up the fluid with absorbent wipes. If necessary, remove the insulation and air-dry in a fume hood.

The chiller pan is capable of holding at least 150% of the process fluid contained in the system.

Follow instructions for personal protective equipment, spill clean-up and disposal described in the MSDSs for the three chemicals. Nitrile or neoprene gloves are acceptable.

Disposal must always be in accordance with current applicable laws and regulations, and product characteristics at time of disposal.

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2.6.8.6. Leaks from Fittings and Tooling

The process fluid supply and return hoses have a pressure rating considerably exceeding the operating pressure, and are mechanically very durable. Leaks at fittings are more probable escape routes for HFE-7500. Fittings inside the main system enclosure are covered with insulation, so that any spray from a leak will be contained and drip along the insulation to the lowest point.

Fittings at the umbilical panel on side 2 or 4 of the system, at the environmental chamber umbilical connection box, and at the Device Kit disconnects, are potential leak sources. If a spill does occur, follow instructions for personal protective equipment, spill cleanup and disposal (refer to the HFE-7500 MSDS in section 2.10.1 of this chapter, and to Chapter 6 of the ETC 2000 *Maintenance Manual*, *Periodic Preventive Maintenance*, P/N 7003110006).

2.6.8.7. Slip Hazard

Although the system is equipped with spill containment trays, it is possible for water or condensation from the system to drip from the unit onto the floor. Any accumulation of water presents a slip hazard to personnel working around the machine. Care should be taken to avoid spills and to clean them up immediately when they occur.

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2.7. Emergency Operating Procedures

Although interlock systems in the ETC 2000 will bring the system to a safe state in most situations, there are some cases that require operator or technician intervention to bring the system completely to a safe state, or to bring the system to a safe state for restart.

2.7.1. Heater Overtemperature Safety Interlock Tripped

In this case, HVPS has been disabled. Since the procedure involves removal of the Device Kit (DK), shut down the system and turn system power off.

1. If there are HFE-7500 leaks in the tooling visible through inside the environmental chamber, then shut off the chiller.
2. Allow the TU to return to a safe temperature, then open the environmental chamber.
3. Contain leak/s, if any; clean-up and dispose of the spilled HFE-7500 per instructions in the safety chapter and the MSDS.
4. Remove the DK.
5. Visually inspect the DK for damage, such as cracks in the heater, heater delamination, desoldered contact pins, or damaged overtemperature interlock RTD.
6. Check the heater trace, heater RTD, and interlock RTD for continuity and correct resistance range.
7. Install undamaged tooling before attempting to restart the system. Do not run the system with damaged tooling as further system damage may result.

2.7.2. Heater Outside Temperature Range

If the operator suspects that the heater is beyond the typical temperature range and shuts off the heater (turns off HVPS or presses the EMO), then the procedure described in section 2.7.1, above, must be followed before restarting the system.

2.7.3. Blown Heater Fuse in Thermal Control Chassis

1. Turn off the HVPS and allow two or three minutes for any retained charge to dissipate.
2. Verify that the cable carrying the heater and heater RTD signals from the tooling connector to the thermal control chassis is not shorted. Repair or replace as necessary.
3. Replace the fuse.
4. Check that the tooling is not shorted. Repair or replace as necessary.
5. Restart the system.

2.7.4. Chiller Failure due to Fluid Leak

This section refers to leaks of fluid **other than** process fluid: If the chiller compressor or refrigerant loop leaks, then follow the procedures described section 2.6.8.4, above.

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2.7.5. HFE-7500 Flow Interlock Tripped

1. Check for a leak in the HFE-7500 loop.
2. Check the reservoir level.
3. Check that the bypass valve is not opened completely.
4. Check that the tool is properly secured to the tooling connector.
5. Check that there are no obstructions in the flow path.

2.7.6. Condensation or Ice on DK/DK Disconnect

1. Turn off HVPS.
2. Set the chiller temperature to 40 degrees C.
3. Unlatch the environmental chamber from the socket adapter, and place it over a container or tray to catch any drops of water.
4. Open the lid of the environmental chamber.
5. When the DK and DK quick disconnects are free of ice, wipe the water off all accessible surfaces.
6. In order to speed drying, a fan can be used to move air across the tooling and tooling head or the shroud can be lowered and the purge air turned on.
7. Check that all water has evaporated.
8. Reconnect the DK, if necessary, close the chamber and remount it to the socket adapter.
9. Restart the system.

2.7.7. Chiller Pump Low Flow Fault



CAUTION:

Trapped air pressure can cause HFE-7500 to be expelled from the reservoir when the cap is opened. Take care to release pressure before removing cap.

Wear goggles and gloves, and cover the cap with spill cleanup wipe to contain any fluid leak.

This fault may result from loss of prime in the chiller pump, and can cause air pressure to be built up in the HFE-7500 reservoir. Follow the procedure below to put the system in a safe state for restart.

1. Put on goggles and gloves, and cover the reservoir cap with a spill cleanup wipe.
2. Place your hand over the reservoir cap and turn to release while pressing down. Hold the cap down for five seconds while the air pressure is released from the reservoir.
3. Remove the cap completely.
4. Find and repair the leaks in the HFE-7500 loop.
5. Refill the HFE-7500 reservoir.
6. Replace the reservoir cap. Refer to the ETC 2000 *Maintenance Manual* Chapter 6 (*Periodic Preventive Maintenance*, P/N 7003110006) for a cap greasing procedure.
7. Restart the system.

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2.7.8. Chiller Compressor Low Suction



CAUTION:	**This fault can lead to HFE-7500 over-temperature causing pressure in the process fluid system.** **Wait until the fluid temperature drops below 40 degrees C.** **Do not open the reservoir cap.**

1. Turn off the chiller if it has not turned off automatically.
2. Wait until the fluid temperature drops below 40 degrees C.
3. Turn off the main disconnect for the chiller to reset it.
4. Turn on the main disconnect for the chiller and restart the chiller.
5. If the problem persists, then turn off the chiller and call a licensed and trained refrigeration technician.

2.7.9. Chiller Pump Overload (Overcurrent)

1. Check for blocked lines.
2. Turn off the main disconnect for the chiller to reset it.
3. Turn on the main disconnect for the chiller and restart the chiller.
4. If the problem persists, then turn off the chiller and call a licensed and trained refrigeration technician.

2.7.10. Low Refrigerant Level

1. Turn off the main disconnect for the chiller to reset it.
2. Turn on the main disconnect for the chiller and restart the chiller.
3. If the problem persists, then turn off the chiller and call a licensed and trained refrigeration technician.

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2.8. Basic Lock Out/Tag Out Procedure (LOTO)

Included in this section is a typical minimal lockout procedure based on OSHA Regulation 29 CFR 1910.147.

2.8.1. Purpose

This procedure establishes the minimum requirements for the lockout of energy-isolating devices whenever maintenance or servicing is done on machines or equipment. It shall be used to ensure that the machine or equipment is stopped, isolated from all potentially hazardous energy sources, and locked out before employees perform any service or maintenance where the unexpected energization or start-up of the machine or equipment or release of stored energy could cause injury.

2.8.2. Scope of Compliance

All employees are required to comply with the restrictions and limitations imposed on them during the use of this lockout. Authorized employees are required to perform the lockout in accordance with this procedure.

2.8.3. Implementing LOTO

NOTE:	Only the authorized employees who are performing the servicing or maintenance may perform lockout.

1. Notify affected personnel that the ETC 2000 is to be locked out.
2. Shut down the ETC 2000 application software, and press the System Power OFF button.
3. Switch the main breaker on side 2 or 4 of the machine to its OFF position.
4. Insert a lock specifically designated for lockout through the holes provided (Figure 2-7). Lock it so as to prevent the breaker from being returned to its ON position. Attach a tag listing the name and contact telephone number of the individual performing the lockout, and the date.

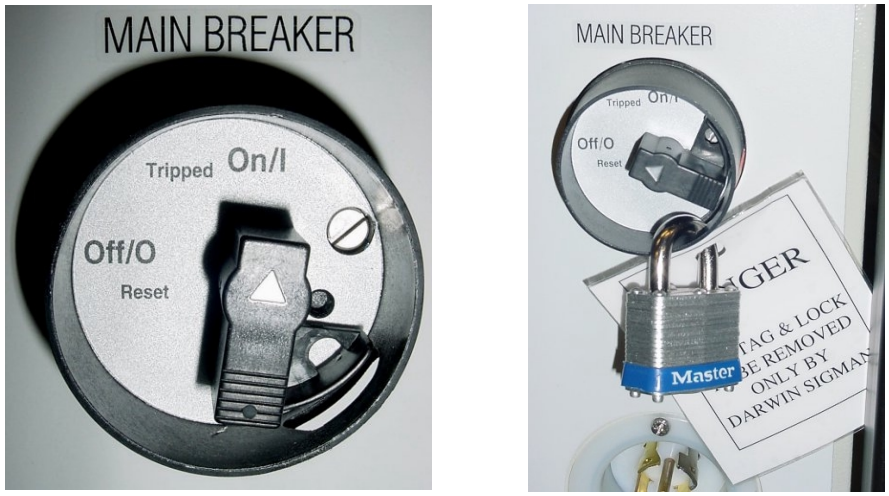


Figure 2-7. Main Breaker LOTO Feature – ON (left) and Locked OFF (right)

5. Unplug the power cable from the facilities panel.

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WARNING:	***Capacitors in the High Voltage Power Supply may store hazardous electrical energy even after the ETC 2000 is isolated from energy sources. Allow this energy to dissipate for a few minutes before attempting to access circuitry and connections in the electronics enclosure – including all wiring accessible through the doors on side 3 of the machine.***

5. Shut off the supply of facilities air using the LOTO feature (Figure 2-8). found under the AC enclosure and accessible through the door at side 3 of the system.



Figure 2-8. Air Supply LOTO Feature: Open (left) and Closed (right)

6. Shut off the supply of facilities helium.
7. Finally, verify a safe condition by attempting to energize the machine.

2.8.4. Releasing from LOTO

In order to release the ETC 2000 from a LOTO condition, and before energy is restored to the machine or equipment, the following conditions must be met:

- The work area must be inspected to ensure that nonessential items have been removed and that machine or equipment components are operationally intact.
- Affected employees must be notified that the machine is no longer locked out.
- The lockout device must be removed by the employee who applied the device.

Use the following procedure:

1. Remove the lockout devices and return power to the system at the main breaker.
2. Ensure that air, helium and power supplies are properly connected

The ETC 2000 is now ready for use.

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2.9. System Disposal at End of Life

When the useful life of the ETC 2000 is concluded, the system should be disposed of in accordance with local, state and federal regulations, which may supersede the instructions below. It is recommended that components be recycled by a properly trained supplier rather than sent to a landfill. The following components require special attention:

- The lithium battery in the system controller computer must be removed and sent to a battery recycler.
- Drain all HFE-7500 from the system, return the fluid to the original containers marked **Used**. Contact 3M (refer to the MSDS in section 2.10.1 of this chapter) to arrange for reclamation.
- The chiller must be disconnected and returned to Affinity to be recycled. Contact Affinity at 603.539.3600 or www.affii.com.
- Disassemble the process fluid loop outside the chiller, drain any remaining HFE-7500 into reclamation containers, and allow HFE-7500 to evaporate from all wetted surfaces in the process fluid loop. You may have to disassemble the flow switch, disconnects and filter bowl to drain and dry them effectively. Disassembly and drying must be done in a well-ventilated room.
- Recycle or dispose of process fluid components outside the chiller as uncontaminated materials.
- Electronic circuit boards and electronic components should be sent to a recycler with experience in this area.

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2.10. Material Safety Data Sheets

2.10.1. HFE-7500

3M

3M Center

St. Paul, Minnesota 55144-1000

1-800-364-3577 or (651) 737-6501 (24 hours)

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2) neither the copy nor the original is resold or otherwise distributed with the intention of earning a profit thereon.

DIVISION: 3M SPECIALTY MATERIALS

TRADE NAME: HFE-7500 3M (TM) NOVEC (TM) Engineered Fluid

ID NUMBER/U.P.C.:

98-0212-2928-5	00-51135-70369-4	98-0212-2929-3	00-51135-70370-0
98-0212-2930-1	00-51135-70371-7	98-0212-2932-7	00-51135-70373-1

ISSUED: February 13, 2001

SUPERSEDES: January 19, 2001

DOCUMENT: 09-5959-3

1. INGREDIENT

INGREDIENT	C.A.S. NO.	PERCENT
2-trifluoromethyl-3- ethoxydodecafluorohexane	297730-93-9	99.5

This material is not on EINECS and should be used in Europe only for research purposes in order to establish its properties. The components of this product are in compliance with the chemical notification requirements of TSCA.

2. PHYSICAL DATA

BOILING POINT: 130 C

VAPOR PRESSURE: 6 mmHg @ 20C

VAPOR DENSITY: N/D

EVAPORATION RATE: N/D

SOLUBILITY IN WATER: <6 PPB

SPECIFIC GRAVITY: 1.61 Water=1

PERCENT VOLATILE: 100 %

pH: N/A

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VISCOSITY:	.77 centistoke @ 25C
MELTING POINT:	-100 C
APPEARANCE AND ODOR:	Liquid, clear colorless, very faint sweet odor

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

3. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT:	None
FLAMMABLE LIMITS - LEL:	N/A
FLAMMABLE LIMITS - UEL:	N/A
AUTOIGNITION TEMPERATURE:	N/D
EXTINGUISHING MEDIA:	Water, Carbon dioxide, Dry chemical, Foam
SPECIAL FIRE FIGHTING PROCEDURES:	Wear full protective clothing, including helmet, self-contained, positive pressure or pressure demand breathing apparatus, bunker coat and pants, bands around arms, waist and legs, face mask, and protective covering for exposed areas of the head.
UNUSUAL FIRE AND EXPLOSION HAZARDS:	No unusual fire or explosion hazards are anticipated. See Hazardous Decomposition section for products of combustion.
NFPA HAZARD CODES:	HEALTH: 2 FIRE: 0 REACTIVITY: 0 UNUSUAL REACTION HAZARD: none

4. REACTIVITY DATA

STABILITY:	Stable
INCOMPATIBILITY - MATERIALS/CONDITIONS TO AVOID:	None known.

Avoid continuous exposure to temperatures exceeding 150C

HAZARDOUS POLYMERIZATION:	Hazardous polymerization will not occur.
HAZARDOUS DECOMPOSITION PRODUCTS:	Carbon Monoxide and Carbon Dioxide, Hydrogen Fluoride, Toxic Vapors, Gases or Particulates, Irritant Vapors or Gases Perfluoroacids

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

5. ENVIRONMENTAL INFORMATION

SPILL RESPONSE:

Observe precautions from other sections. Ventilate area. Contain spill. Cover with absorbent material. Collect spilled material. Clean up residue with an appropriate organic solvent. Read and follow safety precautions on the solvent label and MSDS. Place in a closed container.

RECOMMENDED DISPOSAL:

Incinerate in an industrial or commercial facility in the presence of a combustible material. Combustion products will include HF.

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ENVIRONMENTAL DATA:

Not determined.

REGULATORY INFORMATION:

Volatile Organic Compounds: N/D.

VOC Less H2O & Exempt Solvents: N/A.

Since regulations vary, consult applicable regulations or authorities before disposal. U.S. EPA Hazardous Waste Number = None (Not U.S. EPA Hazardous).

EPCRA HAZARD CLASS:

FIRE HAZARD: No PRESSURE: No REACTIVITY: No ACUTE: Yes CHRONIC: No

6. SUGGESTED FIRST AID

EYE CONTACT:

Immediately flush eyes with large amounts of water. Get immediate medical attention.

SKIN CONTACT:

Flush skin with large amounts of water. If irritation persists, get medical attention.

INHALATION:

If signs/symptoms occur, remove person to fresh air. If signs/symptoms continue, call a physician.

IF SWALLOWED:

Drink two glasses of water. Call a physician.

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

7. PRECAUTIONARY INFORMATION

EYE PROTECTION:

Avoid eye contact. Wear vented goggles.

SKIN PROTECTION:

Avoid skin contact. Wear appropriate gloves when handling this material. A pair of gloves made from the following material(s) are recommended: polyethylene/ethylene vinyl alcohol, fluoroelastomer (Viton). Use one or more of the following personal protection items as necessary to prevent skin contact: apron.

RECOMMENDED VENTILATION:

Use with appropriate local exhaust ventilation. Provide appropriate local exhaust ventilation at transfer points. Provide appropriate local exhaust ventilation on open containers. If exhaust ventilation is not adequate, use appropriate respiratory protection. Provide ventilation adequate to control vapor concentrations below recommended exposure limits and/or control spray or mist.

RESPIRATORY PROTECTION:

Avoid breathing of vapors, mists or spray. Select one of the following NIOSH approved respirators based on airborne concentration of contaminants and in accordance with OSHA regulations: half-mask organic vapor respirator, full-face organic vapor respirator, full- face supplied air respirator.

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PREVENTION OF ACCIDENTAL INGESTION:

Do not eat, drink or smoke when using this product. Wash exposed areas thoroughly with soap and water. Wash hands after handling and before eating. Do not ingest.

RECOMMENDED STORAGE:

Store away from heat. Keep container closed when not in use. Keep container in well-ventilated area.

FIRE AND EXPLOSION AVOIDANCE:

Nonflammable. Keep away from heat, sparks, open flame, and other sources of ignition.

OTHER PRECAUTIONARY INFORMATION:

Store work clothes separately from other clothing, food and tobacco products. To avoid thermal decomposition, avoid continuous exposure of the fluid to temperatures exceeding 150 degrees C. Applications involving exposure to greater than 150 degrees C should be reviewed with 3M technical service.

HMIS HAZARD RATINGS:

HEALTH: 1 FLAMMABILITY: 0 REACTIVITY: 0 PERSONAL PROTECTION: X (See precautions, section 7.)

EXPOSURE LIMITS

INGREDIENT	VALUE	UNIT	TYPE	AUTH	SKIN*
2-trifluoromethyl-3-ethoxydodecafluorohexane	NONE	NONE	NONE	NONE	

SKIN NOTATION: Listed substances indicated with 'Y' under SKIN refer to the potential contribution to the overall exposure by the cutaneous route including mucous membrane and eye, either by airborne or, more particularly, by direct contact with the substance. Vehicles can alter skin absorption.

SOURCE OF EXPOSURE LIMIT DATA:

- NONE: None Established

8. HEALTH HAZARD DATA

EYE CONTACT:

Contact with the eyes during product use is not expected to result in significant irritation.

SKIN CONTACT:

Contact with the skin during product use is not expected to result in significant irritation.

INHALATION:

Health effects from inhalation are not expected unless the product is over heated and decomposition occurs.

IF SWALLOWED:

Swallowing a relatively large amount of this material is unlikely to produce serious illness or death.

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SECTION CHANGE DATES

INGREDIENTS SECTION CHANGED SINCE January 19, 2001 ISSUE

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2.10.2. HFE-7100

MATERIAL SAFETY DATA SHEET

3M

3M Center

St. Paul, Minnesota
55144-1000
1-800-364-3577 or (651) 737-6501 (24 hours)

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DIVISION: 3M SPECIALTY MATERIALS

TRADE NAME:

HFE-7100 3M (TM) Novec (TM) Engineered Fluid

ID NUMBER/U.P.C.:

98-0211-8895-2 00-51135-11134-5 98-0211-8940-6 00-51135-11037-9
98-0211-8941-4 00-51135-11038-6 98-0211-8942-2 00-51135-11039-3
98-0211-8943-0 00-51135-11040-9 98-0211-8944-8 00-51135-11041-6
98-0211-8945-5 00-51135-11042-3 98-0211-8946-3 00-51135-11043-0
98-0212-1011-1 00-51135-45035-2 98-0212-1035-0 00-51135-45055-0
98-0212-1102-8 00-51135-45124-3 98-0212-1128-3 00-51135-45146-5
98-0212-1148-1 00-51135-63012-9

ISSUED: August 23, 1999

SUPERSEDES: August 11, 1999

DOCUMENT: 07-6378-9

1. INGREDIENT

METHYL NONAFLUOROISOBUTYL ETHER.

METHYL NONAFLUOROBUTYL ETHER.

C.A.S. NO.		PERCENT
163702-08-7	50	- 70
163702-07-6	30	- 50

The components of this product are in compliance with the chemical notification requirements of TSCA.

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2. PHYSICAL DATA

BOILING POINT	60 C (Typical)
VAPOR PRESSURE	202 mmHg @ 25 C.
VAPOR DENSITY	8.6 Air=1
EVAPORATION RATE	N/D
SOLUBILITY IN WATER	< 20 ppm
SPECIFIC GRAVITY	1.5 g/ml
PERCENT VOLATILE	100 %
pH	N/A
VISCOSITY	0.6 centipoise @ 23 C
MELTING POINT	-135 C

Abbreviations: N/D - Not Determined N/A - Not Applicable CA - Approximately

APPEARANCE AND ODOR:

Clear, colorless, liquid. Slight ethereal odor.

3. FIRE AND EXPLOSION HAZARD DATA

FLASH POINT: None (CC, ASTM D56; OC, ASTM D92-85)

FLAMMABLE LIMITS - LEL: None (ASTM E681-94, @ 100 C)

FLAMMABLE LIMITS - UEL: None (ASTM E681-94, @ 100 C)

AUTOIGNITION TEMPERATURE: 405 C (ASTM E659-84)

EXTINGUISHING MEDIA:

Non flammable.

SPECIAL FIRE FIGHTING PROCEDURES:

When fire fighting conditions are severe and total thermal decomposition of the product is possible, wear full protective clothing, including helmet, self-contained, positive pressure or pressure demand breathing apparatus, bunker coat and pants, bands around arms, waist and legs, face mask, and protective covering for exposed areas of the head. No unusual effects are anticipated during fire extinguishing operations. Avoid breathing the products and substances that may result from the thermal decomposition of the product or the other substances in the fire zone. Keep containers cool with water spray when exposed to fire to avoid rupture.

UNUSUAL FIRE AND EXPLOSION HAZARDS:

Exposure to extreme heat can give rise to thermal decomposition. See section 8, **Health Hazard Data**.

NFPA HAZARD CODES: HEALTH: 3 FIRE: 1 REACTIVITY: 0

UNUSUAL REACTION HAZARD: none

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4. REACTIVITY DATA

STABILITY: Stable

INCOMPATIBILITY - MATERIALS/CONDITIONS TO AVOID:

Strong Acids, Strong Bases, Strong Oxidizing Agents. Avoid temperatures above the Boiling Point.

HAZARDOUS POLYMERIZATION: Hazardous polymerization will not occur.

HAZARDOUS DECOMPOSITION PRODUCTS: Hydrogen Fluoride, Perfluoroisobutylene (PFIB). See Health Hazard Data section.

5. ENVIRONMENTAL INFORMATION

SPILL RESPONSE:

Observe precautions from other sections. Ventilate area. Contain spill. Cover with absorbent material. Collect spilled material. Clean up residue with an appropriate organic solvent. Read and follow safety precautions on the solvent label and MSDS. Place in metal container. Seal the container.

In case of spills resulting in significant release in a confined area, warn others and leave immediately. Exposure to excessive vapor concentration in confined spaces may cause significant injury.

RECOMMENDED DISPOSAL:

As a disposal alternative, incinerate in the presence of a combustible material in an industrial or commercial facility capable of handling halogenated waste. Dispose of completely absorbed waste product in a hazardous waste facility. Reclaim if feasible. For information on product return, contact your distributor.

ENVIRONMENTAL DATA:

A Product Environmental Data Sheet (PED) is available.

Zero Ozone Depletion Potential (ODP). 4.1 year Atmospheric Lifetime.

320 Global Warming Potential (GWP) (100 year ITH, IPCC 94)

AQUATIC TOXICITY:

96-Hr LC50 for Fathead minnow (Pimephales promelas) = >7.9 mg/L (mean measured concentrations, limit of solubility in study) NOEC for Fathead minnow (Pimephales promelas) = 7.9 mg/L based on mortality. These results indicate that this product has insignificant toxicity to fathead minnows at its solubility limit.

48-Hr EC50 for Water flea (Daphnia magna) = >10 mg/L (mean measured concentrations, limit of solubility in study) NOEC for Water flea (Daphnia magna) = 6.7 mg/L (mean measured concentrations). These results indicate that this product has insignificant toxicity to water fleas at its solubility limit.

96-Hr ErC50 (growth) for Algae (Selenastrum capricornutum) = >8-9mg/L mean measured concentrations, limit of solubility in study) NOEC (growth) for Algae (Selenastrum capricornutum) = 8.9 mg/L mean measured concentrations. These results indicate that this product has insignificant toxicity to algae at its solubility limit.

DEFINITIONS:

LC50 = Median Lethal Concentration: It is the concentration of a substance necessary to kill 50% of the test species exposed to it in a specified time.

EC50 = Median Effective Concentration. It is the concentration of a substance necessary to produce the biological effect under study in 50% of the test species exposed to it.

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ErC50 = Median Effective Concentration as determined by measuring the average specific growth rate.

AQUATIC TOXICITY (June 1997)

Fathead Minnow (Pimephales promelas) 96-hr LC50: >750 mg/L

NOTE: The data above reflects the CA method which was used to satisfy2 Hazard Evaluation Bioassay

REGULATORY INFORMATION:

Volatile Organic Compounds: N/A.

VOC Less H20 & Exempt Solvents: N/A.

Since regulations vary, consult applicable regulations or authorities before disposal. U.S. EPA Hazardous Waste Number = None (Not U.S. EPA Hazardous).

The components of this product are in compliance with the chemical registration requirements of TSCA, ELINCS, MITI, AICS, KECI, PICCS, CICS, CEPA.

The U.S. Environmental Protection Agency (EPA) has listed 3M(TM) HFE-7100 as an acceptable substitute for ozone depleting substances in specific solvent cleaning and aerosol industry applications under its Significant New Alternatives Program (SNAP). Section 612 of the Clean Air Act requires the EPA to administer this program to evaluate and approve alternatives for ozone depleting substances.

OTHER ENVIRONMENTAL INFORMATION:

EPCRA 311/312 Reportable Quantity = Not Reportable.

Transportation Information: Not regulated, all transportation modes.

This low-solubility substance has insignificant toxicity to aquatic organisms (Lowest LL50 or EL50 is >1000 mg/L). LL50 (Lethal Level) and EL50 are similar to LC50 and EC50, but tests the water phase from incompletely-miscible mixtures.

Take precautions to prevent direct release of this substance to the environment.

These components are highly volatile and have high Henry's Law constants and are thus expected to move rapidly through vaporization from solution in an aquatic compartment or from a soil surface in a terrestrial compartment to the atmosphere. The high potenial of this substance to move from water to the atmosphere accounts for its low toxicity and make it unlikely that this substance will bioconcentrate in aerobic environments.

Atmospheric degradation products are expected to include: for methyl nonafluoroisobutyl ether: predominately iso-perfluorobutyric acid, C02, HF, and perhaps also CF3COOH; for methyl nonafluorobutyl ether; n-perfluorobutyric acid, C02, and HF.

EPCRA HAZARD CLASS:

FIRE HAZARD: No PRESSURE: No REACTIVITY: No ACUTE: No CHRONIC: No

6. SUGGESTED FIRST AID

EYE CONTACT:

Immediately flush eyes with large amounts of water. Get immediate medical attention.

SKIN CONTACT:

Wash affected area with soap and water.

INHALATION:

If signs/symptoms occur, remove person to fresh air. If signs/symptoms continue, call a physician.

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IF SWALLOWED:

No need for first aid is anticipated.

OTHER FIRST AID INFORMATION:

This product is not expected to be irritating to the eyes, skin or respiratory system at room temperature conditions. This assessment does not account for contaminants from product use. The suggested first aid measures are basic first aid measures for removal of foreign materials from the skin and/or eyes.

7. PRECAUTIONARY INFORMATION

EYE PROTECTION:

As a good industrial hygiene practice:

Wear safety glasses with side shields.

SKIN PROTECTION:

A pair of gloves made from the following material(s) are recommended:

neoprene, nitrile rubber.

As a good industrial hygiene practice:

Avoid skin contact. Wear appropriate gloves when handling the material.

RECOMMENDED VENTILATION:

Use in a well-ventilated area. Provide sufficient ventilation to maintain emissions below recommended exposure limits. If exhaust ventilation is not adequate, use appropriate respiratory protection.

RESPIRATORY PROTECTION:

Avoid breathing of vapors, mists or spray.

If thermal decomposition occurs:

Avoid breathing of thermal decomposition products. Select one of the following NIOSH approved respirators based on airborne concentration of contaminants and in accordance with OSHA regulations: half-mask supplied air respirator, full-face supplied air respirator.

PREVENTION OF ACCIDENTAL INGESTION:

Do not eat, drink or smoke when using this product. Wash exposed areas thoroughly with soap and water. Not an expected route of exposure.

RECOMMENDED STORAGE:

Store under normal warehouse conditions.

FIRE AND EXPLOSION AVOIDANCE:

Nonflammable. Do not pierce or burn container, even after use.

Avoid exposing material to extreme conditions of heat, i.e., above 150 C (welding, open flame, misuse or equipment failure).

OTHER PRECAUTIONARY INFORMATION:

No smoking: Smoking while using this product can result in contamination of the tobacco and/or smoke and lead to the formation of the hazardous decomposition products mentioned in the Reactivity Data section of this MSDS. For additional health and precautionary information, including air monitoring methodology, contact 3M.

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NFPA codes are designed for use by firefighters, sheriffs, or other emergency response teams who are concerned with the hazards of burning or exploding materials. These NFPA codes are not intended to address the hazards of this product other than in a fire situation.

HMIS codes are intended for use in everyday workplace settings to provide a rapid indication of the occupational hazards associated with chemicals used in the workplace.

HMIS HAZARD RATINGS: HEALTH: 0 FLAMMABILITY: 1 REACTIVITY: 0 PERSONAL PROTECTION: X (See precautions, section 7.)

EXPOSURE LIMITS

INGREDIENT	VALUE	UNIT	TYPE	AUTH	SKINx
METHYL NONAFLUOROISOBUTYL ETHER	750	PPM	TWA	AIHA	
			total for all isomers		
METHYL NONAFLUOROBUTYL ETHER	750	PPM	TWA	AIHA	
			total for all isomers		

x SKIN NOTATION: Listed substances indicated with 'Y' under SKIN refer to the potential contribution to the overall exposure by the cutaneous route including mucous membrane and eye, either by airborne or, more particularly, by direct contact with the substance. Vehicles can alter skin absorption.

SOURCE OF EXPOSURE LIMIT DATA:

- AIHA: American Industrial Hygiene Assoc. Workplace Environmental Exposure Level Guideline

8. HEALTH HAZARD DATA

EYE CONTACT:

Contact with the eyes during product use is not expected to result in significant irritation.

SKIN CONTACT:

Contact with the skin during product use is not expected to result in significant irritation.

INHALATION:

Animal studies revealed increased levels of urinary fluoride after repeated exposure.

IF SWALLOWED:

Ingestion is not a likely route of exposure to this product.

OTHER HEALTH HAZARD INFORMATION:

This product is not known to contain any substances regulated under California Proposition 65.

Hydrogen fluoride has an ACGIH Threshold Limit Value of 3 parts per million (as fluoride) as a Ceiling Limit and an OSHA PEL of 3 ppm of fluoride as an eight hour Time-Weighted Average and 6 ppm of fluoride as a Short Term Exposure Limit. The odor threshold for HF is 0.04 ppm, providing good warning properties for exposure.

Decomposition of this product at temperatures above 300 degrees C can form perfluoroisobutylene (PFIB), but PFIB will only accumulate with continuous exposure to excessive heat in a sealed vessel. The formation rate for PFIB is about 1000 times less than the rate for primary thermal decomposition products such as HF. No health hazard is associated with the use of HFE-7100 due to PFIB exposure. If you have questions or concerns regarding this issue, please contact Kurt Werner (651-733-8494)

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SUMMARY OF TOXICITY DATA FOR THE METHYL NONAFLUOROISOBUTYL ETHER AND METHYL NONAFLUOROBUTYL ETHER COMPONENTS:

Acute Inhalation Lethal Concentration: >100,000 ppm (rat, 4-hour)

Oral Toxicity: Practically Non-Toxic (LD50 > 5g/kg in rat)

Developmental Toxicity: No abnormal effects observed.

Mutagenicity: Not a mutagen in reverse mutation or chromosomal aberration assay.

Cardiac Sensitization: No signs of sensitization at exposures up to 100,000 ppm.

Primary Dermal Irritation: Minimally irritating.

Primary Ocular Irritation: Practically non-irritating.

Dermal Sensitization: Not a skin sensitizer.

90 Day Inhalation Study in rats: NOEL = 7500 ppm.

Dermal Absorption (5 daily applications in rabbits): Not a significant route of exposure.

SECTION CHANGE DATES

INGREDIENTS	SECTION CHANGED SINCE August 11, 1999	ISSUE
PHYSICAL DATA	SECTION CHANGED SINCE August 11, 1999	ISSUE
FIRE AND EXPL.	SECTION CHANGED SINCE August 11, 1999	ISSUE
REACTIVITY DATA	SECTION CHANGED SINCE August 11, 1999	ISSUE
ENVIRONMENTAL INFO.	SECTION CHANGED SINCE August 11, 1999	ISSUE
SUGG. FIRST AID	SECTION CHANGED SINCE August 11, 1999	ISSUE
PRECAUTIONARY INFO.	SECTION CHANGED SINCE August 11, 1999	ISSUE
HEALTH HAZARD DATA	SECTION CHANGED SINCE August 11, 1999	ISSUE

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2.10.3. Mobil EAL Arctic 22 CC

601559-00 MOBIL EAL ARCTIC 22 CC

MATERIAL SAFETY DATA BULLETIN

---
1. PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME: MOBIL EAL ARCTIC 22 CC
SUPPLIER: MOBIL OIL CORP.
NORTH AMERICA MARKETING AND REFINING
3225 GALLOWS RD.
FAIRFAX, VA 22037
24 - Hour Emergency (call collect): 609-737-4411
Product and MSDS Information: 800-662-4525 609-224-4644
CHEMTREC: 800-424-9300 202-483-7616

---
2. COMPOSITION/INFORMATION ON INGREDIENTS

CHEMICAL NAMES AND SYNONYMS: SYNTHETIC ESTERS AND ADDITIVES
INGREDIENTS CONSIDERED HAZARDOUS TO HEALTH:

This product is not formulated to contain ingredients which have exposure limits established by U.S. agencies. It is not hazardous to health as defined by the European Union Dangerous Substances/Preparations Directives. See Section 15 for a regulatory analysis of the ingredients. See Section 15 for European Label Information. See Section 8 for exposure limits (if applicable).

---
3. HAZARDS IDENTIFICATION

US OSHA HAZARD COMMUNICATION STANDARD: Product assessed in accordance with OSHA 29 CFR 1910.1200 and determined not to be hazardous. EFFECTS OF OVEREXPOSURE: No significant effects expected. EMERGENCY RESPONSE DATA: Straw Liquid. DOT ERG No. - NA. SEC: 0

---
4. FIRST AID MEASURES

EYE CONTACT: Flush thoroughly with water. If irritation occurs, call a physician.

SKIN CONTACT: Wash contact areas with soap and water.

INHALATION: Remove from further exposure. If respiratory irritation, dizziness, nausea, or unconsciousness occurs, seek immediate medical assistance and call a physician. If breathing has stopped, use mouth to mouth resuscitation.

INGESTION: Not expected to be a problem. However, if greater than 1/2 liter(pint) ingested, immediately give 1 to 2 glasses of water and call a physician, hospital emergency room or poison control center for assistance. Do not induce vomiting or give anything by mouth to an unconscious person.

---
5. FIRE-FIGHTING MEASURES

EXTINGUISHING MEDIA: Carbon dioxide, foam, dry chemical and water fog.

SPECIAL FIRE FIGHTING PROCEDURES: Water or foam may cause frothing. Use water to keep fire exposed containers cool. Water spray may be used to flush spills away from exposure. Prevent runoff from fire control or dilution from entering streams, sewers, or drinking water supply.

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SPECIAL PROTECTIVE EQUIPMENT: For fires in enclosed areas, fire fighters must use self-contained breathing apparatus.

UNUSUAL FIRE AND EXPLOSION HAZARDS: None. Flash Point C(F):

220(428) (ASTM D-92). Flammable limits - LEL: NA, UEL: NA.

NFPA HAZARD ID: Health: 0, Flammability: 1, Reactivity: 0

HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide.

---

6. ACCIDENTAL RELEASE MEASURES

NOTIFICATION PROCEDURES: Report spills as required to appropriate authorities. U. S. Coast Guard regulations require immediate reporting of spills that could reach any waterway including intermittent dry creeks. Report spill to Coast Guard toll free number (800) 424-8802. In case of accident or road spill notify CHEMTREC (800) 424-9300.

PROCEDURES IF MATERIAL IS RELEASED OR SPILLED: Adsorb on fire retardant treated sawdust, diatomaceous earth, etc. Shovel up and dispose of at an appropriate waste disposal facility in accordance with current applicable laws and regulations, and product characteristics at time of disposal.

ENVIRONMENTAL PRECAUTIONS: Prevent spills from entering storm sewers or drains and contact with soil.

PERSONAL PRECAUTIONS: See Section 8

---

7. HANDLING AND STORAGE

HANDLING: This material is not intended for use in air compressors for breathing applications. No special precautions are necessary beyond normal good hygiene practices. See Section 8 for additional personal protection advice when handling this product.

STORAGE: Do not store in open or unlabelled containers. Store away from strong oxidizing agents or combustible material.

---

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

VENTILATION: Use in well ventilated area.

RESPIRATORY PROTECTION: No special requirements under ordinary conditions of use and with adequate ventilation.

EYE PROTECTION: Normal industrial eye protection practices should be employed.

SKIN PROTECTION: No special equipment required. However, good personal hygiene practices should always be followed.

EXPOSURE LIMITS: This product does not contain any components which have recognized exposure limits. However, a exposure limit of 5.00 mg/m3 is suggested for oil mist.

---

9. PHYSICAL AND CHEMICAL PROPERTIES

Typical physical properties are given below. Consult Product Data Sheet for specific details.

APPEARANCE: Liquid
COLOR: Straw
ODOR: Mild
ODOR THRESHOLD-ppm: NE

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pH: NA
BOILING POINT C(F): 316(600)
MELTING POINT C(F): NA
FLASH POINT C(F): 220(428) (ASTM D-92)
FLAMMABILITY: NE
AUTO FLAMMABILITY: NA
EXPLOSIVE PROPERTIES: NA
OXIDIZING PROPERTIES: NA
VAPOR PRESSURE-mmHg 20 C: NA
VAPOR DENSITY: NE
EVAPORATION RATE: NE
RELATIVE DENSITY, 15/4 C: 0.99
SOLUBILITY IN WATER: Negligible
PARTITION COEFFICIENT: NE
VISCOSITY AT 40 C, cSt: 22.0
VISCOSITY AT 100 C, cSt: 4.9
POUR POINT C(F): < -54(-65)
FREEZING POINT C(F): NE
VOLATILE ORGANIC COMPOUND: NE
NA=NOT APPLICABLE NE=NOT ESTABLISHED D=DECOMPOSES
FOR FURTHER TECHNICAL INFORMATION, CONTACT YOUR MARKETING REPRESENTATIVE

---

10. STABILITY AND REACTIVITY

STABILITY (THERMAL, LIGHT, ETC.): Stable.
CONDITIONS TO AVOID: Extreme heat.
INCOMPATIBILITY (MATERIALS TO AVOID): Strong oxidizers.
HAZARDOUS DECOMPOSITION PRODUCTS: Carbon monoxide.
HAZARDOUS POLYMERIZATION: Will not occur.

---

11. TOXICOLOGICAL DATA

---ACUTE TOXICOLOGY---

ORAL TOXICITY (RATS): Practically non-toxic (LD50: greater than 2000 mg/kg). ---Based on testing of similar products and/or the components.

DERMAL TOXICITY (RABBITS): Practically non-toxic (LD50: greater than 2000 mg/kg). ---Based on testing of similar products and/or the components.

INHALATION TOXICITY (RATS): Not established

EYE IRRITATION (RABBITS): Practically non-irritating. (Draize score: greater than 6 but 15 or less). ---Based on testing of similar products and/or the components.

SKIN IRRITATION (RABBITS): Practically non-irritating. (Primary Irritation Index: greater than 0.5 but less than 3). ---Based on testing of similar products and/or the components.

---

12. ECOLOGICAL INFORMATION

ENVIRONMENTAL FATE AND EFFECTS: This material meets OECD ready biodegradability criteria.

---

13. DISPOSAL CONSIDERATIONS

WASTE DISPOSAL: Product is suitable for burning in an enclosed, controlled burner for fuel value or disposal by supervised incineration. Such burning may be limited pursuant to the Resource

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Conservation and Recovery Act. In addition, the product is suitable for processing by an approved recycling facility or can be disposed of at an appropriate government waste disposal facility. Use of these methods is subject to user compliance with applicable laws and regulations and consideration of product characteristics at time of disposal.

RCRA INFORMATION: The unused product, in our opinion, is not specifically listed by the EPA as a hazardous waste (40 CFR, Part 261D), nor is it formulated to contain materials which are listed hazardous wastes. It does not exhibit the hazardous characteristics of ignitability, corrosivity, or reactivity and is not formulated with contaminants as determined by the Toxicity Characteristic Leaching Procedure (TCLP). However, used product may be regulated.

---

14. TRANSPORT INFORMATION

USA DOT: NOT REGULATED BY USA DOT.
RID/ADR: NOT REGULATED BY RID/ADR.
IMO: NOT REGULATED BY IMO.
IATA: NOT REGULATED BY IATA.

---

15. REGULATORY INFORMATION

Governmental Inventory Status: All components comply with TSCA, EINECS/ELINCS, AICS, and DSL.

EU Labeling: EU labeling not required.

U.S. Superfund Amendments and Reauthorization Act (SARA) Title III:

This product contains no "EXTREMELY HAZARDOUS SUBSTANCES".

SARA (311/312) REPORTABLE HAZARD CATEGORIES: None.

This product contains no chemicals reportable under SARA (313) toxic release program.

The following product ingredients are cited on the lists below:

CHEMICAL NAME	CAS NUMBER	LIST CITATIONS
ETHENE, CHLOROTRIFLUORO-, HOMOPOLYMER (0.25%)	9002-83-9	22

--- REGULATORY LISTS SEARCHED ---

1=ACGIH ALL 6=IARC 1 11=TSCA 4 16=CA P65 CARC 21=LA RTK
2=ACGIH A1 7=IARC 2A 12=TSCA 5a2 17=CA P65 REPRO 22=MI 293
3=ACGIH A2 8=IARC 2B 13=TSCA 5e 18=CA RTK 23=MN RTK
4=NTP CARC 9=OSHA CARC 14=TSCA 6 19=FL RTK 24=NJ RTK
5=NTP SUS 10=OSHA Z 15=TSCA 12b 20=IL RTK 25=PA RTK
26=RI RTK
Code key: CARC=Carcinogen; SUS=Suspected Carcinogen; REPRO=Reproductive

---

16. OTHER INFORMATION

USE: COMPRESSOR OIL
NOTE: MOBIL PRODUCTS ARE NOT FORMULATED TO CONTAIN PCBS.

Please call the Customer Response Center on 800-662-4525 for formulation disclosure.
****
For Internal Use Only: MHC: 1* 1* NE 1* 1*, MPPEC: A, TRN: 601559-00, GLIS: 400706, CMCS97:

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978357, REQ: CHEMICAL PRODUCTS, SAFE USE: L EHS Approval Date: 03APR1998
****

****
Legally required information is given in accordance with applicable Information given herein is offered in good faith as accurate, but without guarantee. Conditions of use and suitability of the product for particular uses are beyond our control; all risks of use of the product are therefore assumed by the user and WE EXPRESSLY DISCLAIM ALL WARRANTIES OF EVERY KIND AND NATURE, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE IN RESPECT TO THE USE OR SUITABILITY OF THE PRODUCT. Nothing is intended as a recommendation for uses which infringe valid patents or as extending any license under valid patents. Appropiate warnings and safe handling procedures should be providedto handlers and users. Use or re- transmission of the information contained herein in any other format than the format as presented is strictly prohibited. Mobil neither represents nor warrants that the format, content or product formulas contained in this document comply with the laws of any other country except the United States of America.
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2.10.4. Dow Corning 111 Valve Lubricant and Sealant

Dow Corning ® 111 Valve Lubricant and Sealant

1. IDENTIFICATION OF THE SUBSTANCE AND OF THE COMPANY

Dow Corning Corporation
South Saginaw Road
Midland, Midland 48686

24 Hour Emergency Telephone: (517) 496-5900
Customer Service: (517) 496-6000
Product Disposal Information: (517) 496-6315
CHEMTREC: (800) 424-9300

MSDS No.: 01889834 Revision Date: 2000/01/17

Generic Description:	Silicone grease.
Physical Form:	Grease
Color:	Translucent white
Odor:	Odorless
NFPA Profile:	Health 0 Flammability 1 Instability/Reactivity 0

Note: NFPA = National Fire Protection Association

2. OSHA HAZARDOUS COMPONENTS

None present. This is not a hazardous material as defined in the OSHA Hazard Communication Standard.

3. EFFECTS OF OVEREXPOSURE

Acute Effects

Eye:	Direct contact may cause temporary redness and discomfort.
Skin:	No significant irritation expected from a single short-term exposure.
Inhalation:	No significant effects expected from a single short-term exposure.
Oral:	Low ingestion hazard in normal use.

Prolonged/Repeated Exposure Effects

Skin:	No known applicable information.
Inhalation:	No known applicable information.
Oral:	No known applicable information.

Signs and Symptoms of Overexposure

No known applicable information.

Medical Conditions Aggravated by Exposure

No known applicable information.

The above listed potential effects of overexposure are based on actual data, results of studies performed upon similar compositions, component data and/or expert review of the product. Please refer to Section 11 for the detailed toxicology information.

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4. FIRST AID MEASURES

Eye:	Immediately flush with water.
Skin:	No first aid should be needed.
Inhalation:	No first aid should be needed.
Oral:	No first aid should be needed.
Comments:	Treat symptomatically.

5. FIRE FIGHTING MEASURES

Flash Point:	> 214.0 °F / > 101.1 °C Closed Cup
Autoignition Temperature:	Not determined.
Flammability Limits in Air:	Not determined.
Extinguishing Media:	On large fires use dry chemical, foam or water spray. On small fires use carbon dioxide (CO2), dry chemical or water spray. Water can be used to cool fire exposed containers.
Fire Fighting Measures:	Self-contained breathing apparatus and protective clothing should be worn in fighting large fires involving chemicals. Determine the need to evacuate or isolate the area according to your local emergency plan. Use water spray to keep fire exposed containers cool.
Unusual Fire Hazards:	None.

Hazardous Decomposition Products

Thermal breakdown of this product during fire or very high heat conditions may evolve the following hazardous decomposition products: Silicon dioxide. Carbon oxides and traces of incompletely burned carbon compounds. Formaldehyde.

6. ACCIDENTAL RELEASE MEASURES.

Containment/Clean up:	Determine whether to evacuate or isolate the area according to your local emergency plan. Observe all personal protection equipment recommendations described in Sections 5 and 8. For large spills, provide diking or other appropriate containment to keep material from spreading. If diked material can be pumped, store recovered material in appropriate container. Clean up remaining materials from spill with suitable absorbant. Clean area as appropriate since some silicone materials, even in small quantities, may present a slip hazard. Final cleaning may require use of steam, solvents or detergents. Dispose of saturated absorbant or cleaning materials appropriately, since spontaneous heating may occur. Local, state, and federal laws and regulations may apply to releases and disposal of this material, as well as those materials and items employed in the cleanup of releases. You will need to determine which federal, state and local laws and regulations are applicable. Sections 13 and 15 of this MSDS provide information regarding certain federal and state requirements.

Note: See section 8 for Personal Protective Equipment for Spills. Call Dow Corning Corporation, (517) 496-5900, if additional information is required.

7. HANDLING AND STORAGE

Use with adequate ventilation. Avoid eye contact.

Use reasonable care and store away from oxidizing materials.

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8. EXPOSURE CONTROLS / PERSONAL PROTECTION

Component Exposure Limits

There are no components with workplace exposure limits.

Engineering Controls

Local Ventilation	None should be needed.
General Ventilation	Recommended.

Personal Protective Equipment for Routine Handling

Eyes	Use proper protection - safety glasses as a minimum.
Skin	Washing at mealtime and end of shift is adequate.
Suitable Gloves	No special protection needed.
Inhalation	No respiratory protection should be needed.
Suitable Respirator	None should be needed.

Personal Protective Equipment for Spills

Eyes	Use proper protection - safety glasses as a minimum.
Skin	Washing at mealtime and end of shift is adequate.
Inhalation/Suitable Respirator	No respiratory protection should be needed.
Precautionary Measures	Avoid eye contact. Use reasonable care.
Comments	None.

Note: These precautions are for room temperature handling. Use at elevated temperature or aerosol/spray applications may require added precautions.

9. PHYSICAL AND CHEMICAL PROPERTIES

Physical Form:	Grease
Color:	Translucent white
Odor:	Odorless
Specific Gravity @ 25°C:	1.1
Viscosity:	Not applicable.
Freezing/Melting Point:	Not determined.
Boiling Point:	Not determined.
Vapor Pressure @ 25°C:	Not determined.
Vapor Density:	Not determined.
Solubility in Water:	Not determined.
pH:	Not determined.
Volatile Content:	Not determined.

Note: The above information is not intended for use in preparing product specifications. Contact Dow Corning before writing specifications.

10. STABILITY AND REACTIVITY

Chemical Stability	Stable.
Hazardous Polymerization:	Hazardous polymerization will not occur.
Conditions to Avoid	None.
Materials to Avoid	Oxidizing material can cause a reaction.

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11. TOXICOLOGICAL INFORMATION

Acute Toxicology Data for Product

Complete information is not yet available.

Component Toxicology Information.

Complete information is not yet available.

Special Hazard Information on Components

No known applicable information.

12. ECOLOGICAL INFORMATION

Environmental Fate and Distribution

No specific information is available.

Environmental Effects

No specific information is available.

Fate and Effects in Waste Water Treatment Plants

No specific information is available.

Ecotoxicity Classification Criteria

Hazard Parameters (LC50 or EC50)	High	Medium	Low
Acute Aquatic Toxicity (mg/L)	<=1	>1 and <=100	>100
Acute Terrestrial Toxicity	<=100	>100 and <= 2000	>2000

This table is adapted from "Environmental Toxicology and Risk Assessment", ASTM STP 1179, p.34, 1993.

This table can be used to classify the ecotoxicity of this product when ecotoxicity data is listed above. Please read the other information presented in the section concerning the overall ecological safety of this material.

13. DISPOSAL CONSIDERATIONS

RCRA Hazard Class (40 CFR 261)

When a decision is made to discard this material, as received, is it classified as a hazardous waste? No

State or local laws may impose additional regulatory requirements regarding disposal.

Call Dow Corning Corporate Environmental Management, (517) 496-6315, if additional information is required.

14. TRANSPORT INFORMATION

DOT Road Shipment Information (49 CFR 172.101)

Not subject to DOT.

Ocean Shipment (IMDG)

Not subject to IMDG code.

Air Shipment (ICAO)

Not subject to ICAO regulations.

Call Dow Corning Transporation, (517) 496-8577, if additional information is required.

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15. REGULATORY INFORMATION

Contents of this MSDS comply with the OSHA Hazard Communication Standard 29 CFR 1910.1200.

TSCA Status: All chemical substances in this material are included on or exempted from listing on the TSCA Inventory of Chemical Substances.

EPA SARA Title III Chemical Listings

Section 302 Extremely Hazardous Substances:

None.

Section 304 CERCLA Hazardous Substances:

None.

Section 312 Hazard Class:

Acute	No
Chronic	No
Fire	No
Pressure	No
Reactive	No

Section 313 Toxic Chemicals:

None present or none present in regulated quantities.

Supplemental State Compliance Information

California

Warning: This product contains the following chemical(s) listed by the State of California under the Safe Drinking Water and Toxic Enforcement Act of 1986 (Proposition 65) as being known to cause cancer, birth defects or other reproductive harm.

None known.

Massachusetts

CAS Number	Wt %	Component Name
7631-86-9	7.0 - 13.0	SILICA, AMORPHOUS

New Jersey

CAS Number	Wt %	Component Name
63148-62-9	> 60.0	Polydimethylsiloxane
7631-86-9	7.0 - 13.0	SILICA, AMORPHOUS FUMED
70131-67-8	7.0 - 13.0	Dimethyl siloxane, hydroxy-terminated

Pennsylvania

CAS Number	Wt %	Component Name
63148-62-9	> 60.0	Polydimethylsiloxane
7631-86-9	7.0 - 13.0	Silica
70131-67-8	7.0 - 13.0	imethyl siloxane, hydroxy-terminated

16. OTHER INFORMATION

Prepared by: Dow Corning Corporation

These data are offered in good faith as typical values and not as product specifications. No warranty, either expressed or implied, is hereby made. The recommended industrial hygiene and safe handling

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procedures are believed to be generally applicable. However, each user should review these recommendations in the specific context of the intended use and determine whether they are appropriate.

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2.10.5. Fluorescent Leak Scanner Solution

Ritchie ENGINEERING COMPANY, INC.
10950 Hampshire Avenue South • Bloomington, MN 55438-2623 U.S.A.

Section 1: Product Information

Revision: N/A SF: 8/26/98

Name: Fluorescent Leak Scanner Solution 1,2,3,4,4-P,01

Emergency Telephone # 800-424-9300 (24 Hours) CHEMTREC

Description: Fluorescent Dye Solution

For calls originating outside continental U.S.: 202-483-7616

Use: Leak Detection

Product Information: 612-943-1333

Appearance and Odor: Dark Reddish Liquid, Like Gas Oil

Fax: 612-943-1605

Section 2: Hazardous Ingredients

A hazard evaluation of this product has been performed. The components listed below are identified as hazardous chemicals under the criteria of the OSHA Hazard Communication Standard (29 CFR 1910.1200).

Product	Common Name/Chemical Name	CAS Number	%W	PEL (mg/m^3)	TLV (mg/m^3)
Fluorescent Leak	Fluorescent Dye Solution	See Below	5-20	NA	NA
Scanner Solution 1	Lubricant Oil	See Below	80-95	5	5
Fluorescent Leak	Fluorescent Dye Solution	See Below	10-25	NA	NA
Scanner Solution 2	Lubricant Oil	See Below	75-90	5	5
Fluorescent Leak	Fluorescent Dye Solution	See Below	35-55	NA	NA
Scanner Solution 3	Lubricant Oil	See Below	45-65	5	5
Fluorescent Leak	Fluorescent Dye Solution	See Below	40-60	NA	NA
Scanner Solution 4	Lubricant Oil	See Below	40-60	5	5
Fluorescent Leak	Fluorescent Dye Solution	See Below	40-60	NA	NA
Scanner Solution 4-P	Lubricant Oil	See Below	40-60	5	5
Fluorescent Leak	Fluorescent Dye Solution	See Below	40-60	NA	NA
Scanner Solution 01	Lubricant Oil	See Below	40-60	5	5

Fluorescent Dye Solution: The specific identity has been withheld as a trade secret. New Jersey Trade Secret Registry Number 80100312-500 P.

Lubricant Oil: The specific identity has been withheld as a trade secret. New Jersey Trade Secret Number 80100312-5001 P.

Section 3: Emergency and First Aid Procedures

Eye Contact: Flush eyes with water for at least 15 minutes. If irritation develops, consult a physician. **Skin Contact:** Wash affected area with soap and water. If irritation develops, consult a physician. Wash contaminated clothing separately before reuse. **Inhalation:** Medical attention is not normally required. **Ingestion:** Seek medical attention. Unless advised otherwise, induce vomiting by either giving syrup of ipecac followed by 2 glasses of water or by sticking finger down throat. Do not give anything by mouth if the person is drowsy, unconscious or has no gag reflex. Ingestion creates a high risk of aspiration and subsequent chemical pneumonitis. However, the presence of aromatic and/or chlorinated hydrocarbons makes evacuation of the stomach advisable. **Note of Physician:** Treatment should be directed at preventing absorption, administrating to the symptoms as they occur, and providing supportive therapy.

Section 4: Health Effects Summary

Primary Route(s) of Exposure: Eye: Yes Skin: Yes Inhalation: Yes

Eye Contact: Can cause mild to moderate irritation. The severity of reaction depends on duration of exposure and first aid procedures administered. **Skin Contact:** Irritation can occur following prolonged or repeated contact.

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Inhalation: Under normal conditions of use, no adverse effects are expected. **Ingestion:** Ingestion can cause gastrointestinal irritation. **Aggravation of Existing Conditions:** Exposure to this product is not expected to contribute to, worsen or aggravate any existing medical conditions.

Section 5: Toxicologic Information

This section provides relevant information with regard to the toxicity of the "pure" form of the component(s) identified in section 2, as well as the results of any toxicity studies performed on the product. Though detailed, this information can be subject to misinterpretation. It is, therefore, essential that the following information be interpreted by individuals trained in its evaluation.

Fluorescent Dye Solution

Toxic Effects: Eye contact and prolonged or repeated skin contact may cause irriation. Ingestion may cause gastrointestinal irritation.

Acute Toxicity Studies: Oral-Rat LD50: >5 G/KG Dermal-Rabbit LD50: >2G/KG

Other Toxicity Studies: This material was negative in the Ames Salmonella Plate Assay.

Carcinogenicity – Listed By: ACGIH: No IARC Monographs: No NTP Annual Report: No OSHA: No

Lubricant Oil

Toxic Effects: Considered an OSHA hazardous substance base on established airborne exposure limits for oil mists.

Carcinogenicity – Listed By: ACGIH: No IARC Monographs: No NTP Annual Report: No OSHA: No

Section 6: Occupational Control Procedures

Eye Protection: Wear chemical spash goggles or safety glasses with side shields. **Skin Protection:** Wear protective clothing and appropriate impervious gloves. Because a variety of protective gloves exist, always consult glove manufacturer to determine the proper type for specific operation. **Respiratory Protection:** Avoid breathing vapor and/or mist. **Ventilation:** Maintain airborne concentrations below the established exposure limits (see TLV and PEL in Section 2) by providing adequate ventilation. General (dilution) ventilation may be acceptable. However, local exhaust ventilation is recommended when vapors, mists or dusts can be released. **Personal Hygiene:** Wash thoroughly after handling, especially before eating, drinking, smoking or using restroom facilities. Contaminated clothing and shoes should be thoroughly cleaned and dried before reuse.

Section 7: Fire Protection Information

Flash Point: Greater than 200°F (93.3°C) **Test Method:** Pensky Martins closed cup

Explosive Limit: LEL (%) Not Established UEL (%): Not Established **Autoignition Temperature:** Not Established

Extinguishing Media: **Small Fires:** Use dry chemical, carbon dioxide or chemical foam
Large Fires: Use water spray, fog or foam

Special Fire Fighting Procedures: Fire fighters and other who may be exposed to the products of combustion should be equipped with NIOSH-approved, positive-pressure, self-contained breathing apparatus (SCBA) and full protective clothing. Avoid using water on burning materials to reduce splattering and spreading of fire.

Unusual Fire and Explosion Hazards: May liberate irritating or toxic vapors during combustion or decomposition.

Section 8: Reactivity Data

Stable Under Normal Conditions of Storage and Use: Yes **Materials to Avoid:** Oxidizing agents and reducing agents **Hazardous Polymerization:** Will not occur. **Thermal Decomposition Products:** If heated to high temperatures, this product may emit smoke, soot and toxic fumes (e.g. carbon monoxide and carbon dioxide).

Section 9: Physical Data

Specific Gravity (H_20 = 1): 0.85-0.90 **Vapor Pressure 68°F (20°C):** <1 mmHg **Vapor Density (Air=1):** > 1

Percent Volatile by Volume: (%): 0 **Evaporation Rate (Butyl Acetate = 1):** <1 **Solubility in Water:** Insoluble **pH:** NA

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Boiling Range: >300°F (149°C)

Section 10: Spill and Leak Procedures

Response to Spills: Stop discharge and contain material. Use an absorbent such as fuller's earth, clay or other appropriate synthetic absorbent. Place contaminated material in a suitable container for disposal. **Precautions:** Eliminate all sources of ignition. **Disposal Methods:** The methods of disposal currently available vary by location. It is recommended that an alternative be selected according to the following order of preference, based upon environmental acceptability: **(1)** recycle or rework if at all feasible**, (2)** incinerate at an authorized facility, or **(3)** treat at an acceptable water treatment facility.

Section 11: Special Precautions

Recommended Storage Practice and Conditions: Store in a cool, dry, well-ventilated area. Do not store near heat or ignition sources. Always keep containers tightly closed to avoid contamination. **Special Warning:** Hot organic chemical vapors or mists can suddenly and without warning combust when mixed with air.

Section 12: Label and Transportation Information

DOT Shipping Name: Not regulated **DOT Label:** Not applicable **DOT Identification #:** Not applicable

Nonregulated for shipments by air under 49 CFR, IATA/ICAO and IMO.

Section 13: User's Responsibility

A bulletin such as this cannot be expected to cover all possible individual situations. As the user has the responsibility to provide a safe workplace, all aspects of an individual operation should be examined to determine if, or where, precautions (in addition to those described herein) are required. Any health hazard and safety information contained herein should be passed on to your customers or employees, as the case may be. Ritchie Engineering Company, Inc. must relay on the user to utilize the information we have supplied to develop work practice guidelines and employee instructional programs for the individual operation.

Section 14: Regulatory Information

Toxic Substance Control Act (TSCA): The chemical compounds of this product are contained on the Section 8 (B) Chemical Substance Inventory List (40 CFR 710)

SARA Title III Information

Section 313 – Toxic Chemicals: Pursuant to Section 313 of SARA title III, this product does not contain a toxic chemical in excess of 1% of the mixture (.01%, if the listed toxic chemical is a carcinogen). **Section 302 – Extremely Hazardous Substances:** No **Section 311/312 – Hazard Categories: Fire Hazard:** Yes **Sudden Release of Pressure Hazard:** No **Reactivity Hazard:** No

Immediate (Acute) Health Hazard: Yes **Delayed (Chronic) Health Hazard:** No

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2.10.6. Isopropyl Alcohol (IPA)

Mallinckrodt Chemical, Inc.
P.O. Box 800
Paris, Kentucky 40362 Emergency Telephone
314-539-1600

Effective Date: 02-17-95 Supersedes 04-06-89

PRODUCT IDENTIFICATION:

Synonyms: 2-propanol; sec-propyl alcohol; isopropanol

Formula CAS No.: 67-63-0 Molecular Weight: 60.10

Hazardous Ingredients: Isopropyl alcohol Chemical Formula: (CH3)2 CHOH

PRECAUTIONARY MEASURES

WARNING! FLAMMABLE LIQUID. HARMFUL IF SWALLOWED OR INHALED. CAUSES IRRITATION TO SKIN, EYES AND RESPIRATORY TRACT. AFFECTS CENTRAL NERVOUS SYSTEM.

Keep away from heat, sparks and flame.

Keep container closed.

Use with adequate ventilation.

Wash thoroughly after handling.

Avoid breathing vapor.

Avoid contact with eyes, skin and clothing.

EMERGENCY FIRST AID

If swallowed, induce vomiting immediately as directed by medical personnel.

Never give anything by mouth to an unconscious person. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. In case of contact, immediately flush eyes or skin with plenty of water for at least 15 minutes. In all cases call a physician.

SEE SECTION 5.

Physical Data SECTION 1

Appearance: Clear, colorless liquid.

Odor: Rubbing alcohol.

Solubility: Infinite in water.

Boiling Point: 82 C (180 F). Vapor Density (Air=1):2.1

Melting Point: -89 C (-128 F). Vapor Pressure (mm Hg):33 @ 20 C (68

Specific gravity: 0.79 Evaporation Rate:(n-BUAC = 1) 2.83

NFPA Ratings: Health: 1 Flammability: 3 Reactivity: 0

Fire and Explosion SECTION 2

Information

Fire: Flammable Liquid Flashpoint: 12 C (53 F). (closed cup). Autoignition temperature: 399 C (750 F). Flammable limits in air, % by volume: lel: 2.0; uel: 12.0.

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Explosion: Above flash point, vapor-air mixtures are explosive within flammable limits noted above. Contact with strong oxidizers may cause fire or explosion.

Fire Extinguishing Media: Water spray, dry chemical, alcohol foam, or carbon dioxide. Water spray may be used to keep fire exposed containers cool.

Special Information: In the event of a fire, wear full protective clothing and NIOSH-approved self-contained breathing apparatus with full facepiece operated in the pressure demand or other positive mode. Water may be used to flush spills away from exposures and to dilute spills to non-flammable mixtures. Vapors can flow along surfaces to distant ignition source and flash back.

Reactivity Data SECTION 3

Stability: Stable under ordinary conditions of use and storage. Heat and sunlight can contribute to instability.

Hazardous Decomposition Products: Toxic gases and vapors such as carbon monoxide may be released in a fire involving isopropyl alcohol.

Hazardous Polymerization: Will not occur.

Incompatibilities: Heat, flame, strong oxidizers, acetadehyde, acides, chlorine, ethylene oxide, hydrogen-palladium combination, hydrogen peroxide-sulfuric acid combination, potassium tert-butoxide, hypochlorous acid, isocyanates, nitroform, phosgene, oleum and perchloric acid.

Leak/Spill Disposal Information SECTION 4

Ventilate area of leak or spill. Remove all sources of ignition. Clean-up personnel require protective clothing and respiratory protection from vapors. Contain and recover liquid when possible. Collect as hazardous waste and atomize in a suitable RCRA approved combustion chamber, or absorb with vermiculite, dry sand, earth or similar material for disposal as hazardous waste in a RCRA approved facility. Do not flush to sewer!

Ensure compliance with local, state and federal regulations.

Health Hazard Information SECTION 5

A. Exposure/Health Effects

Inhalation: Inhalation of vapors irritates the respiratory tract. Exposure to high concentrations has a narcotic effect, producing symptoms of dizziness, drowsiness, headache, staggering, unconsciousness and possibly death.

Ingestion: May cause drowsiness, unconsciousness, and death. Gastrointestinal pain, cramps, nausea, vomiting, and diarrhea may also result. The single lethal dose for a human adult = about 250 mls.

Skin Contact: Has a defatting action of the skin that can cause irritation. May cause irritation with a stinging effect and burning sensation.

Eye Contact: Vapors may irritate the eyes. Splashes may cause severe irritation, possible corneal burns and eye damage.

Chronic Exposure: Prolonged contact with skin may cause mild irritation, drying, cracking, or contact may develop.

Aggravation of Pre-existing Conditions: Persons with pre-existing skin disorders or eye problems or impaired respiratory function may be more susceptible to the effects of the substance.

B. First Aid

Inhalation: Remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Call a physician.

Ingestion: Induce vomiting immediately as directed by medical personnel. Never give anything by mouth to an unconcious person.

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Skin Exposure: Remove any contaminated clothing. Wash skin with soap or mild detergent and water for at least 15 minutes. Get medical attention if irritation develops or persists.

Eye Exposure: Wash eyes with plenty of water for at least 15 minutes, lifting lower and upper eyelids occasionally. Get medical attention immediately.

C. Toxicity (RTECS, 1994)

Oral rat LD50: 5045 mg/kg; skin rabbit LD50: 12.8 gm/kg; investigated as a tumorigen, mutagen, reproductive effector.

Occupational Control Measures SECTION 6

Airborne Exposure Limits: -OSHA Permissible Exposure Limit (PEL): 400 ppm (TWA), 500 ppm (STEL) - ACGIH Threshold Limit Value (TLV): 400 ppm (TWA), 500 ppm (STEL)

Ventilation System: A system of local and/or general exhaust is recommended to keep employee exposures below the Airborne Exposure Limits. Local exhaust ventilation is generally preferred because it control the emissions of the contaminant at its source, preventing dispersion of it into the general work area. Please refer to the ACGIH document, "Industrial Ventilation, A Manual Recommended Practices", most recent details.

Personal Respirators If the TLV is exceeded a full facepiece chemical (NIOSH Approved) cartridge respirator may be worn, in general, up to the maximum use concentration specified by respirator supplier. Alternatively, a supplied air full facepiece respirator or airlined hood may be worn.

Skin Protection: Wear impervious protective clothing, including boots, gloves, lab coat, apron or coveralls, as appropriate, to prevent skin contact.

Eye Protection: Use chemical safety goggles and/or a full face shield where splashing is possible. Contact lenses should not be worn when working with this material. Maintain eye wash fountain and quick-drench facilities in work area.

Storage and Special Information SECTION 7

Protect against physical damage. Store in a cool, dry well-ventilated location, away from any area where the fire hazard may be acute. Outside or detached storage is preferred. Separate from oxidizing materials. Containers should be bonded and grounded for transfers to avoid static sparks. Storage and use areas should be No Smoking areas. Use non-sparking type tools and equipment.

****

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ISALC

Addendum to Material Safety Data Sheet

REGULATORY STATUS

This Addendum Must Not Be Detached from the MSDS

Identifies SARA 313 substance(s)

Any copying or redistribution of the MSDS must include a copy of this addendum

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Hazard Categories for SARA

Section 311/312 Reporting

Acute Chronic Fire Pressure Reactive

----- ------- ---- -------- --------

X X X

SARA Sec. 313

SARA EHS Chemicals CERCLA RCRA

Product or Components Sec. 302 Name Chemical Sec.103 Sec. of Product: RQ TPQ List Category RQ lbs

ISOPROPYL ALCOHOL

(67-63-0) No No Yes No No No

SARA Section 302 EHS RQ:

Reportable Quantity of Extremely Hazardous Substance, listed at 40 CFR 355.

SARA Section 302 EHS TPQ:

Threshold Planning Quantity of Extremely Hazardous substance. An asterisk (*) following a Threshold Planning Quantity signifies that if the material is a solid and has a particle size equal to or larger than 100 micrometers, the Threshold Planning Quantity = 10,000 LBS.

SARA Section 313 Chemicals:

Toxic Substances subject to annual release reporting requirements listed at 40 CFR 372.65.

CERCLA Sec. 103:

Comprehensive Environmental Response, Compensation and Liability Act (Superfund)

Releases to air, land or water of these hazardous substances which exceed the Reportable Quantity (RQ) must be reported to the National Response Center, (800-424-8802); Listed at 40 CFR 302.4

RCRA:

Resource Conservation and Recovery Act. Commercial chemical product wastes designated as acute hazards or toxic under 40 CFR 261.33

ISALC

ISOPROPYL ALCOHOL

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Chapter 3: Operation, Maintenance and Configuration Screens

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3. Operation, Maintenance and Configuration Screens

3.1. Purpose

This chapter describes the screens and windows used to access the maintenance and configuration features of the ETC 2000.

NOTE:	This chapter refers to ETC 2000 application software version 1.1.x.

3.2. Overview

Operation and maintenance screens allow the operator to run the system and to perform a variety of calibration and test tasks. The operator issues commands via the keyboard and trackball. In turn, the system sends information back to the operator via the monitor, and audio alerts through the PC speaker and system alarm.

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3.3. Starting the System

When the ETC 2000 application software initializes at machine startup, the thermal core initializes (Figure 3-1), and then the screen shown in Figure 3-2 indicates progress for each subsystem.



Figure 3-1. Thermal Core Startup

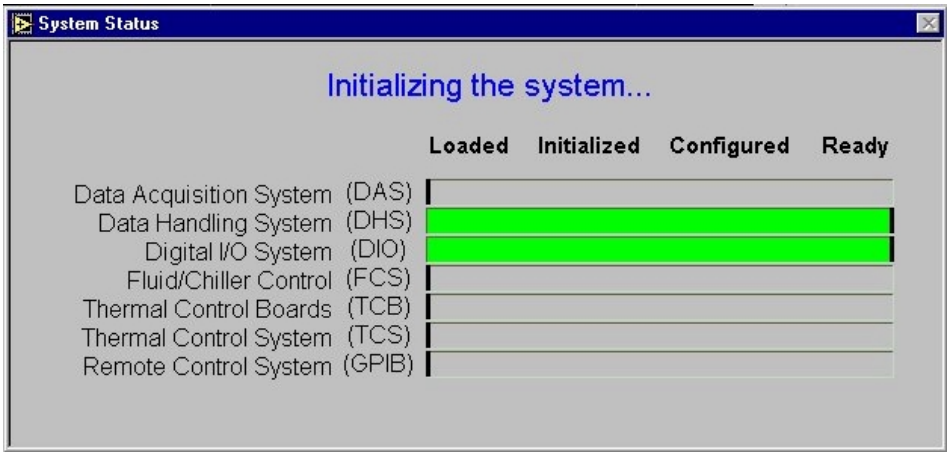


Figure 3-2. System Initialization

3.4. Log In/Log Out

Once the system has initialized, the Login screen (Figure 3-3) opens.

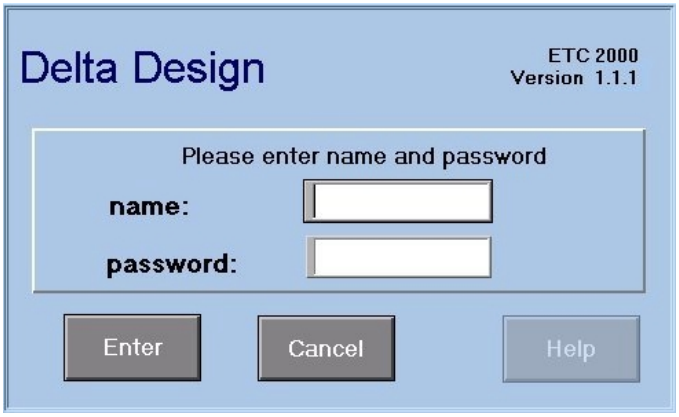


Figure 3-3. Log In/Log Out Screen

If login is successful, selecting Enter in this screen returns the user to the main screen, while the application software completes its initialization.

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If the login is not successful, or the login is cancelled, a cautionary dialog box appears (see Figure 3-4), and the main screen reappears, either with no login security level assigned (if the machine was just started) or at the previous login security level (if a prior login had succeeded). The login may now be re-attempted by selecting the Navigator button at the upper right, and then the Log In/Out button.



Figure 3-4. Failed Log In Dialog

3.5. Main Screen

The application software's main screen is the focal point of interaction with the ETC 2000. Each of the machine's subsystems is represented on this screen.

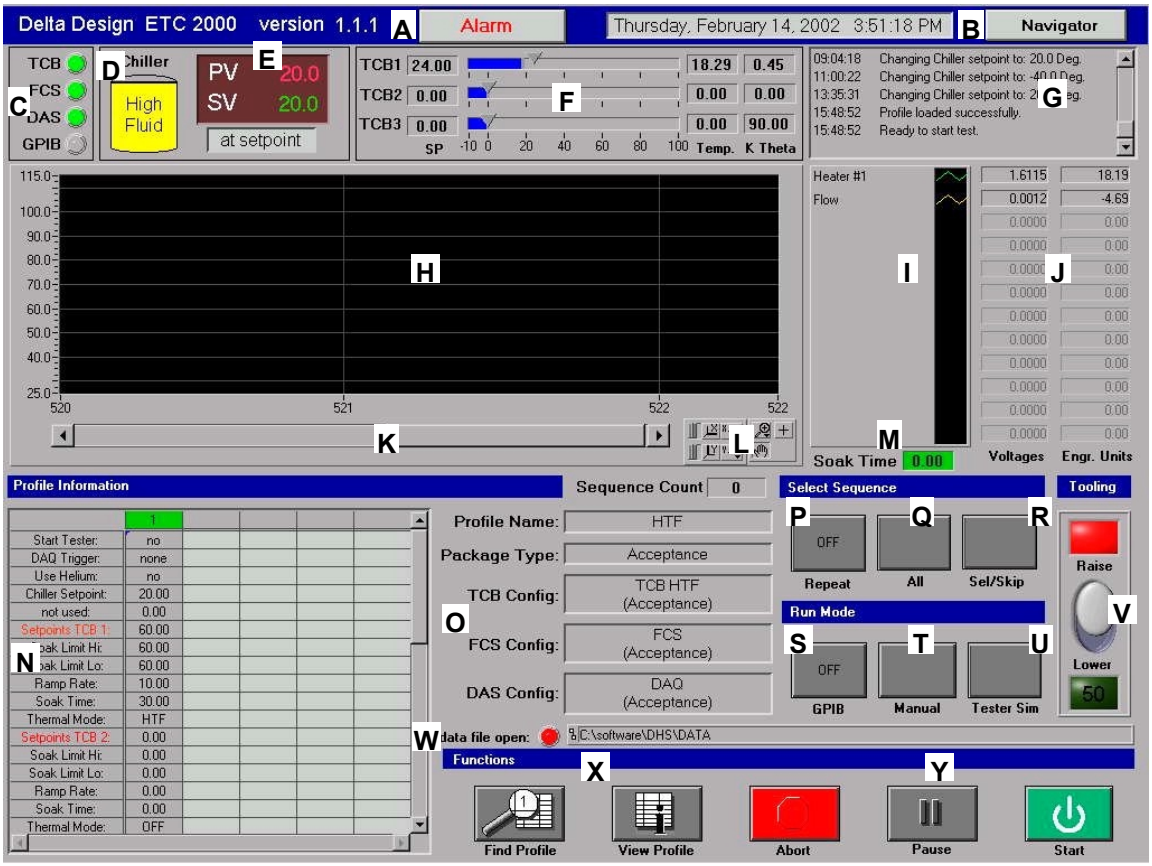


Figure 3-5. Main Screen

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Many of the functions and screen selections for the OIS are accessed via pull-down screens or buttons. Each screen or button may bring up additional selections from which the operator can choose. The various parts of the main screen are indicated in Table 3-1, and described in the next several paragraphs.

Table 3-1. Key to Components of the ETC 2000 Main Screen

Key	Description
A	Alarm screen access button, to see and acknowledge system alarms
B	Navigator toolbar access button
C	Subsystem status indicator 'lights'
D	FCS fluid level indicator
E	Chiller set value, present value and FCS current status indicator
F	TCB set point and present value indicators, digital and analog
G	Status and message box
H	Thermal control analog input graphic display
I	Key to graphic display
J	Digital display of analog input data
K	Graphic display slider
L	Graphic display control palette
M	Soak time display
N	Display of profile parameters by sequence
O	Display of profile configuration information
P	Repeat profile button
Q	Select All sequences button
R	Select/Skip sequences button
S	GPIB button
T	Manual control button
U	Tester simulator button
V	Socketing actuator toggle control, with socketing pressure display
W	Data file display
X	Profile management buttons
Y	Profile control buttons

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3.5.1. Alarms and Errors

The Alarm button [**A**] flashes red (Figure 3-6) to indicate a system alarm.



Figure 3-6. Alarm Button

When the button is selected, a window (Figure 3-7) opens listing current alarms. The operator may then select the appropriate buttons to Acknowledge Alarms, and then to Close the window. Current alarms are listed in red, acknowledged (but not cleared) alarms in blue and cleared alarms in green. A message area at the bottom left of the window provides details about the alarm. In this case, both the listed alarms are current.

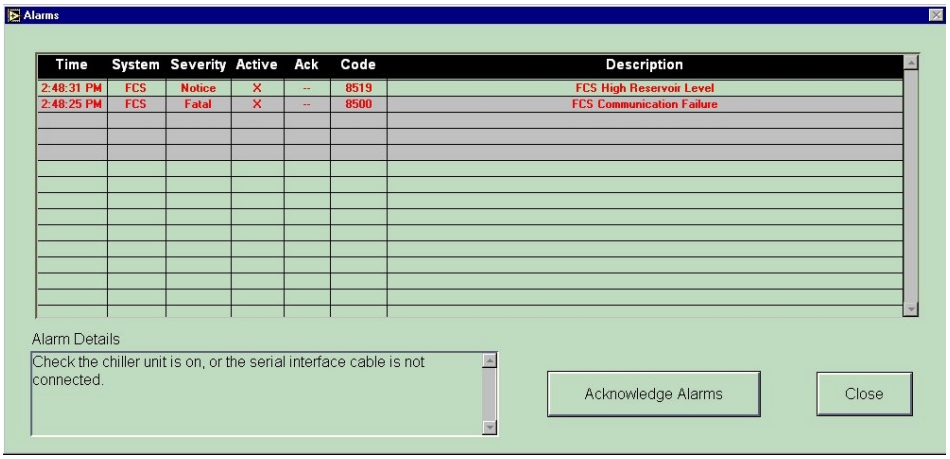


Figure 3-7. Alarms Window

3.5.2. Navigator Toolbar Button

When selected, the Navigator button [**B**] opens a toolbar which gives access to maintenance functions, including system login and shut down.

3.5.3. Indicator Lights

Indicator “lights” at the top left of the main screen [**C**] display information about the status of communication with the ETC 2000’s various subsystems, and with the tester. When an indicator is green, this signals that the subsystem is working correctly, and communication with it occurring properly. A red indicator signals a problem.

Table 3-2. Main Screen Indicator Definitions

Indicator Label	Subsystem
TCB	Thermal control
FCS	Fluid Circulation
DAS	Data Acquisition
GPIB	General Purpose Interface Bus

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3.5.4. Fluid Level Indicator

Sensors detect the state, among three possible states, of the process fluid (HFE-7100) level in the chiller's reservoir. The fluid level state is indicated by a graphic display [**D**] and text message as shown in Table 3-3:

Table 3-3. Chiller Reservoir States

Fluid Line in Display	Color of Fluid in Display	Text Message
Top	Yellow	High Fluid
Middle	Green	OK Fluid
Bottom	Red	Low Fluid

Further information on the status of the chiller may be found by accessing the Fluid Control Subsystem (FCS) maintenance screen (Figure 3-36), via the Navigator toolbar.

3.5.5. Fluid Circulation Subsystem (FCS) Status Display

The FCS status display [**E**], shown in detail in Figure 3-8 indicates the chiller's set and present values, and the current status of the subsystem.

The digital display is continuously updated, and indicates the chiller's fluid temperature – the present or actual value appears as PV, the set value as SV. The lower part of the display indicates the current state of the FCS. The FCS may be idle, ramping or at setpoint.



Figure 3-8. Chiller Readout

3.5.6. Thermal Channel Indicators

The current set points of each thermal control channel are shown in three bar graphs and associated digital read-outs [**F**], labeled TCB1, TCB2 and TCB3. The set point of the TCB is shown by the small triangular marker, while its present value is shown by the bar graph. Beside the bar graphs, digital displays indicate the set point value (left) and current measured temperature (right) for each TCB.

3.5.7. Status and Error Message Box

The text display at the upper right-hand corner of the screen [**G**] shows status and error messages for the system. These messages are logged in text files, located in the root of the ETC 2000's C: drive:

- *C:\ETC errors.log*
- *C:\ETC errors FCS.log*
- *C:\ETCstatus.log*

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3.5.8. Thermal Control Profile Graphic Display

Points based on information gathered by the system are plotted on the graph [**H**] in the upper half of the screen. A key to the plots [**I**] appears immediately to the right of the graph, and the numerical values for each plot [**J**] to the right of the key. The numerical values are in two columns: raw voltage readings appearing on the left are converted to temperatures (Engineering Units) on the right. The appearance of this display, including the labels assigned to each plot, may be modified from the SETUP maintenance screen (see Figure 3-47).

3.5.8.1. Graphic Display Slider

The slider bar [**K**] below the display allows the user to view traces which have, with the passage of time, scrolled off the screen to the left. The amount of past traces which may be retrieved depends on the Y (horizontal) scaling of the display.

3.5.8.2. Control Palette

The control palette [**L**] to the right of the display has buttons to modify the scaling and magnification of the graph.

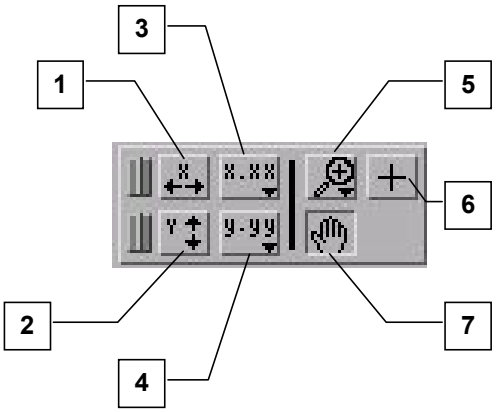


Figure 3-9. Graphical Display Control Palette

The control palette's functions are as follows:

Table 3-4. Graphical Display Control Palette Functions

1	Automatically scales the X-axis to show the extent of the current traces.
2	Automatically scales the Y-axis to show the amplitude of the current traces.
3	Opens a pull-down pick list for selection of scaling and precision options for the x-axis.
4	Opens a similar pull-down pick list for the y-axis.
5	Offers zoom options, to give a finer or grosser view of the current traces.
6	Allows the mouse cursor to "grab" the graph and scroll horizontally or vertically.
7	Moves plot area up, down and sideways, depending on what graphic mode is in use.

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3.5.9. Profile Information Display

3.5.9.1. Soak Time

The Soak Time display [**M**] dynamically shows the duration of soak. Except in Manual and GPIB modes, the display turns green once soak is completed successfully and after an SOT signal is sent. A green display confirms that polling is taking place to ensure that the test temperature remains within the range specified in the Test Temp Err Hi and Test Temp Err Lo parameters defined in the profile.

3.5.9.2. Profile Parameters by Sequence

At the main screen's lower left, the parameters for each sequence in the current profile are displayed in separate columns [**N**]. The values for each TCB are listed; a scroll bar, to the right, allows all the TCB information to be viewed.

3.5.9.3. Profile Configuration Information

To the right of the sequence information are boxes [**O**] specifying the name of the profile, the DUT type for which the profile has been created, and the names of the profile's associated configuration files.

3.5.10. Sequence and Mode Buttons

3.5.10.1. Select Sequence Buttons

To the right of the boxes are buttons used to specify how the profile is run.

A profile may be made to run repeatedly until aborted by selecting the Repeat Profile button [**P**], which toggles to show OFF or ON depending on its state.

It is possible to select all sequences within a profile by pressing the All button [**Q**], or to select some and skip others by selecting Select/Skip [**R**]. When Select/Skip is selected, a dialogue like the one show in Figure 3-27 appears.

3.5.10.2. Run Mode Buttons

The GPIB button [**S**] enables or disables the GPIB. When the button is selected to enable the GPIB, the GPIB indicator 'light' at the top left of the display [**C**] changes from grey to green and a "GPIB enabled" message appears in the status and error message display [**G**].

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The other mode buttons allow the operator to select Manual [**T**] and the Tester Sim [**U**]. When Manual Mode is selected, the window shown in Figure 3-10 appears, superimposed on the main screen.

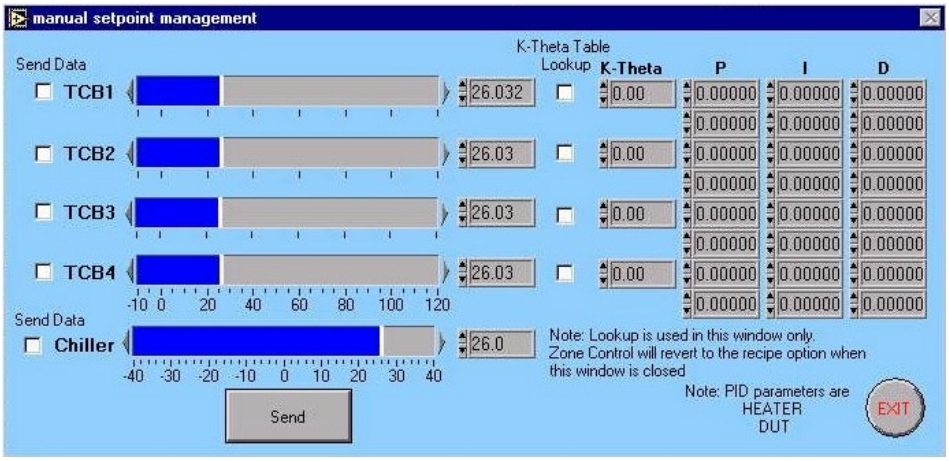


Figure 3-10. Manual Setpoint Management Dialog

The elements of the Manual Setpoint Management dialog are detailed in Table 3-5.

Table 3-5. Manual Setpoint Management Features

Element	Function
Send data [check-boxes]	Selects which values will be sent to the system when the Send button is selected.
TCB1/2/3/4 [labels]	Thermal control channels, two per RT board. The default configuration is a single-channel system – i.e. using only TCB1. Channels that are not installed are grayed out.
Slider bar/digital display field	Displays currently-selected setpoint (in degrees C) for each thermal control channel. Values may be changed by using the cursor to slide the bar, by clicking the arrows at either end of the bar, or by direct entry into the digital field.
K-Theta Table Lookup [check-boxes]	If checked for any channel, an interpolated value for that channel's k-theta is computed based on zones defined in the TCB configuration screen. The computed value appears in the K-Theta field immediately to the right of the check box.
K-Theta [digital entry fields]	If the K-Theta Table Lookup box is *not* checked, the value for this thermal channel's K-Theta may be entered here.
P I D [digital entry fields]	Sets PID values for each channel, upper row defining values for the Heater, lower for the DUT.
Chiller Slider bar/digital display field	Sets setpoint for process fluid. Slider bar and display field work as for the thermal control channels.
Send	Sends selected (checked-box) values to the system.
Exit	Terminates manual control and closes the window.

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When the ETC 2000 is used in conjunction with an additional external High Voltage Power Supply, selecting Tester Sim opens a utility (Figure 3-11) which simulates the input associated with a tester's power profile.

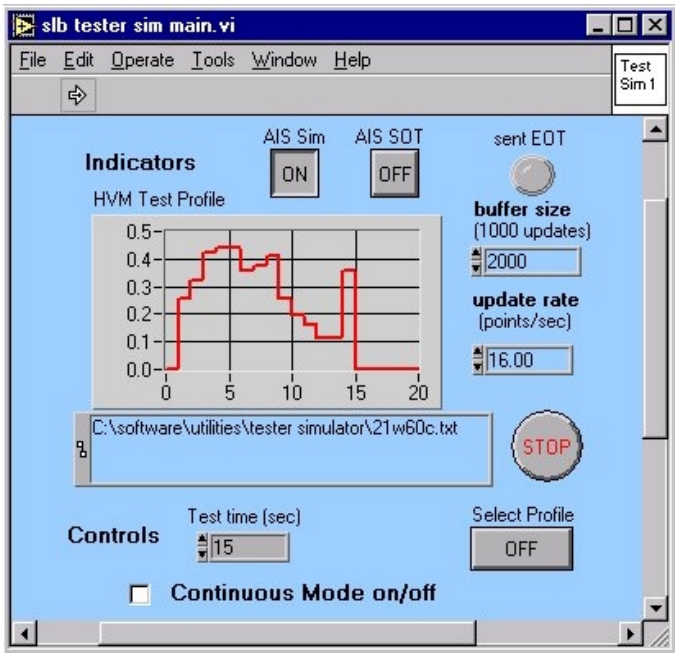


Figure 3-11. Tester Simulator Window

When checked, the Continuous Mode box causes the simulator to run the current profile repeatedly, until it is aborted by pressing the STOP button.

3.5.11. Tooling Control

CAUTION:	**Never actuate the socketing mechanism unless the environmental chamber is latched to the socket adapter, and there is a DUT in the socket. Never actuate the socketing mechanism when a test is in progress. Damage to the DUT and/or socket can result.**

The tooling Raise/Lower toggle switch [**V**] controls the pneumatically actuated socketing mechanism in the environmental chamber. The display also indicates the currently selected socketing pressure, in pounds.

3.5.12. Data File Display

The data file open indicator [**W**] shows green when data collection is triggered and data are being written to a file. A red indicator means that data are not being written to file. The name of the currently-selected data file is displayed in the field to the right of the indicator.

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3.5.13. Function Buttons

The buttons across the bottom of the main screen allow the operator to access different screens, exit the system, or request help. Table 3-6 shows the actions performed by these buttons.

Table 3-6. Profile Function Buttons

Profile Management [X]	
Find Profile	Allows the operator to find and select existing profiles.
View Profile	Allows the operator to view and edit an existing profile, to delete existing profiles and create new ones.
Profile Control [Y]	
Abort	Stops the current operation and returns the ETC 2000 to its idle state.
Pause	Pauses the current operation.
Start	Starts to run the loaded profile.

3.6. Profile Management Screens

3.6.1. Find Profile/View Profile

The Find Profile and View Profile buttons, at bottom center of the main screen, permit access to the profile management screens shown in the figures immediately below. The dialog box shown in Figure 3-12 appears when the Find Profile button is selected.

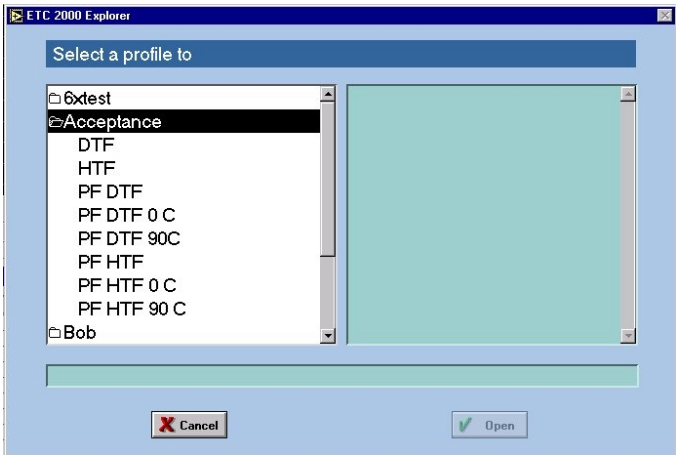


Figure 3-12. Profile Selection

Double clicking on a folder name in the left pane (Figure 3-12) shows one or more sub-folders containing profiles. Double clicking on the profile name displays the contents of the file in the right pane, and the full path and file name for the profile in the field below the two panes, as seen in Figure 3-13.

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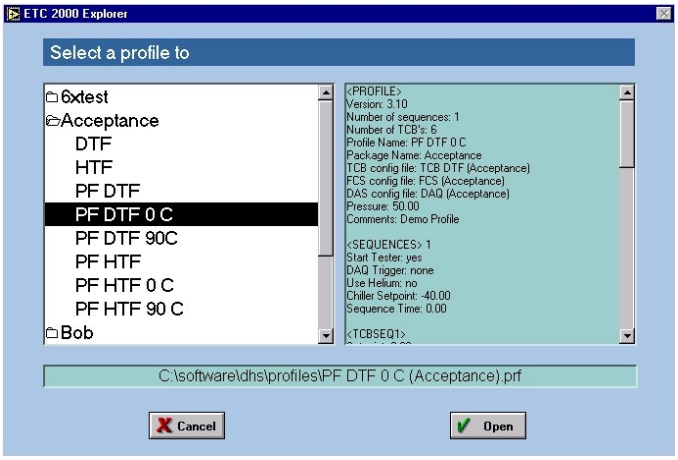


Figure 3-13. Profile Selected

Note that the right pane of the screen shown in Figure 3-13 lists the contents of the profile, including the names of the configuration files it uses. Once the profile is selected, this information will also appear at the bottom center of the main screen. The profile's path is listed directly above the buttons.

Selecting the Open button closes this window. The main screen shown in Figure 3-5 reappears.

Note that when the Start button is pressed on the main screen, the dialog shown in Figure 3-14 appears. Selecting OK starts the profile. This dialog does not appear when the system is run in remote mode, via the GPIB.



Figure 3-14. Socket DUT Reminder

Once the green Start button is pressed and the profile begins, the button is grayed (Figure 3-15):

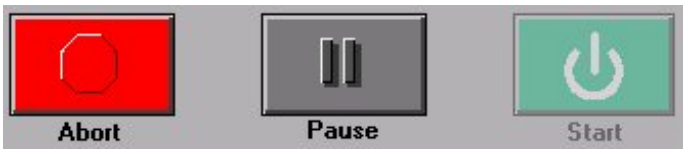


Figure 3-15. Start Button Grayed

If either the Abort or Pause button is pressed while the profile is running, the Pause button changes to show Resume (Figure 3-16):



Figure 3-16. Resume Button

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Selecting the View Profile button on the main screen opens the Select & Edit Profile screen shown in Figure 3-17. The screen displays the currently-loaded profile, with its name and associated package type displayed at upper left. Here, Edit Profile has been selected, so that the four editing tools to the right of the screen are enabled. In this example, a profile with one sequence is loaded.

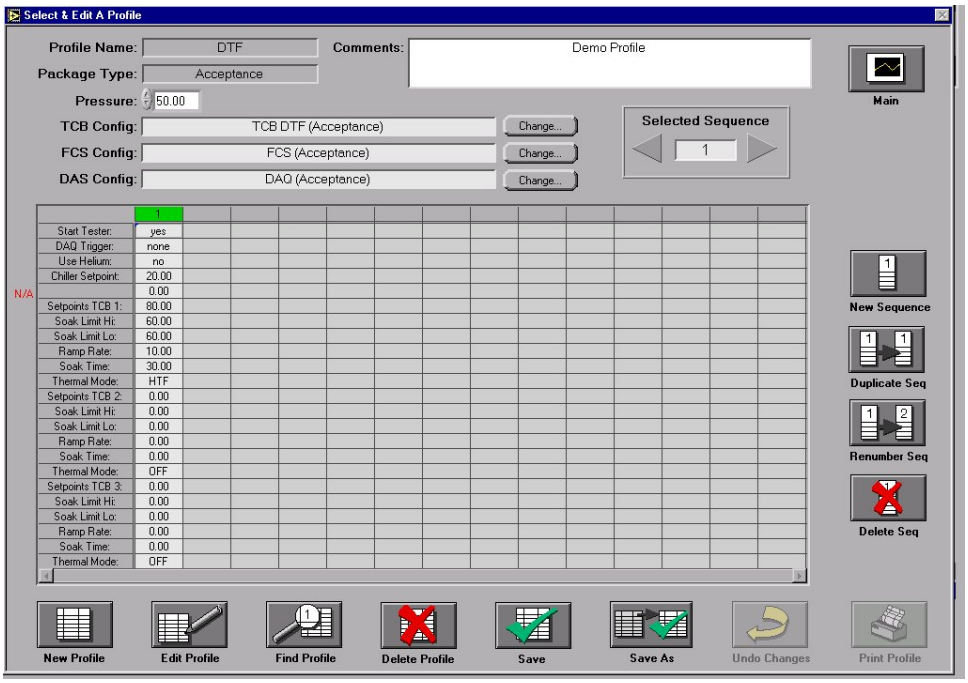


Figure 3-17. Select and Edit A Profile

The Pressure field (Figure 3-18) displays the value sent to the regulator which controls the socketing actuator in the environmental chamber. The value (set as described in Chapter 9, *System Configuration*, of the ETC 2000 Maintenance Manual, P/N 7003110009) may be entered directly by clicking on the field and typing a number, or by clicking on the up and down arrows to increase or decrease the number.

NOTE:	The value entered in this field is *not* the same as that shown on the digital display of the electronic regulator (mounted on the pneumatics panel, behind the door as system side 3). That value will be the Pressure parameter divided by approximately 3.1 (the cross-sectional area, in square inches, of the socketing actuator cylinder).

The value entered here is repeated on the Down indicator of the main screen Tooling display.



Figure 3-18. Socketing Actuator Force

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The Change… buttons next to the configuration file fields at top left of the Select & Edit A Profile screen allow the user to change the system configuration files associated with the profile currently loaded.

Selecting a Change… button opens an Explorer window like the one shown in Figure 3-19. In this view, the FCS Config button has been selected, and the relevant directory structure is displayed in the left pane. Selecting a file, and then clicking the Open button returns the user to the Select & Edit A Profile screen, with this configuration file associated with the profile.

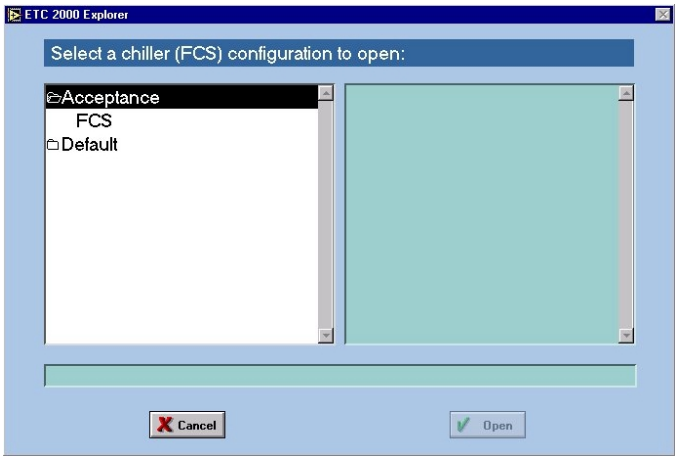


Figure 3-19. Change Configuration File Explorer Window

The New Profile button opens a new profile with no values entered.

When the screen shown in Figure 3-17 first opens, the editing buttons to the right are grayed and inaccessible. Selecting Edit Profile enables them.

Find Profile opens the window shown in Figure 3-12.

The entire profile may be deleted. When the Delete Profile button is selected, the confirmation dialog shown in Figure 3-20 is shown.

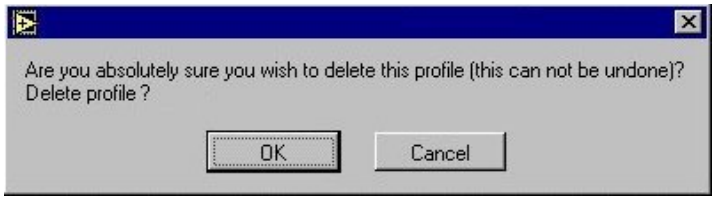


Figure 3-20. Delete Profile Confirmation

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The Save button saves the current values under the profile's existing name. Selecting the Save As button allows the profile to be saved under a new name, preserving the values of the profile on which the new profile is based (Figure 3-21).



Figure 3-21. Profile Save As Dialogue

3.6.2. Sequence Editing Options

Each element of the profile editing page may be clicked. For sequence values with a discrete set of options, clicking the value enables a pair of clickable buttons allowing the user to scroll through the options. The example shown (Use Helium) toggles between ON and OFF, which display as yes and no respectively.



Figure 3-22. Sequence Edit Scrolling Options

Each sequence may be toggled ON (green) or OFF (red) by clicking on its header. The header changes color depending on the state of the sequence.





Figure 3-23. Sequence Toggled to ON and OFF

Sequences may be selected by clicking the arrow buttons beside the Selected Sequence field at upper right of the Select & Edit a Profile screen, or by entering a number into the field.

To de-select an item, click on any other box.

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Once selected, a sequence may be inserted or duplicated (New Sequence, Duplicate Sequence):

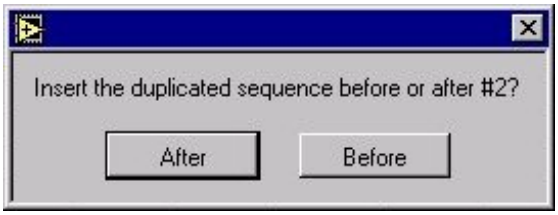


Figure 3-24. Duplicate Sequence Confirmation

Sequences may be reordered (Renumber Sequence):

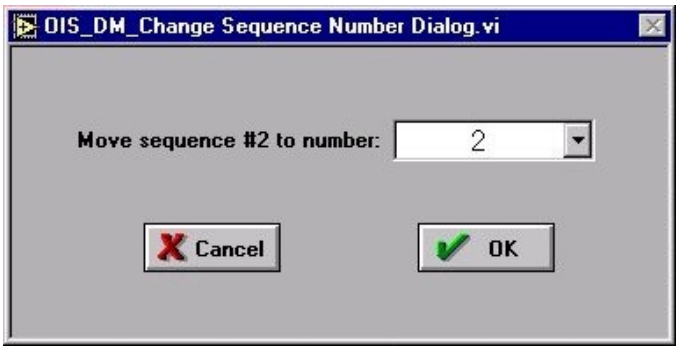


Figure 3-25. Renumber Sequence Confirmation

Finally, sequences may be deleted (Delete Sequence):



Figure 3-26. Delete Sequence Confirmation

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3.6.3. Select/Skip Sequence

From the main screen, sequences may be selectively skipped using the Select/Skip button appearing at the lower right of the main screen. When this button is selected, the screen shown in Figure 3-27 appears. This screen duplicates the function of the ON/OFF toggle in the Select and Edit window.

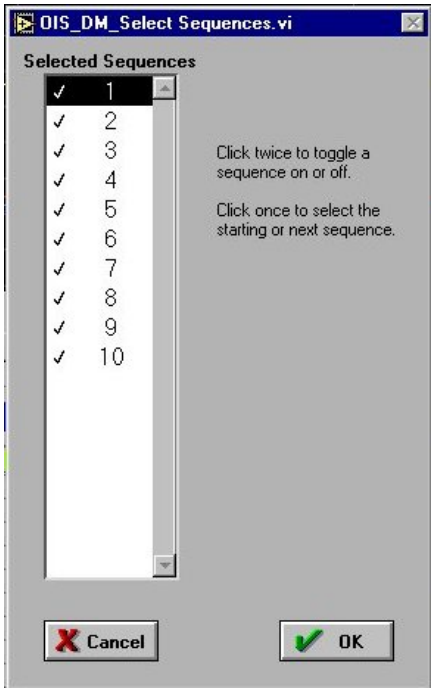


Figure 3-27. Select/Skip Sequence

The mouse may be used to toggle the selection of sequences to run. Selected sequences – those that will run – appear with a check mark.

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3.7. The Navigator Toolbar

The Navigator toolbar (Figure 3-28) floats over the right hand portion of the main screen. This toolbar allows access to a variety of functions, some of them duplicated by buttons on the main screen. The Navigator is accessible even when portions of the main screen are masked by a maintenance screen.

Button Image	Button Action
	Closes the navigator toolbar and returns to the main screen. (See Figure 3-5) Views the currently-loaded profile, and allows it to be edited. (See Figure 3-17) Used for thermal control when the ETC 2000 is used in conjunction with a separate handler. Opens the virtual (on-screen) keyboard. (Not implemented at present.) Opens the maintenance selection screen. (See Figure 3-30) Opens the Help system. (Not implemented at present) Opens the log in screen. (See Figure 3-3) Exits the application software. (See Figure 3-29)

Figure 3-28. The Navigator Toolbar

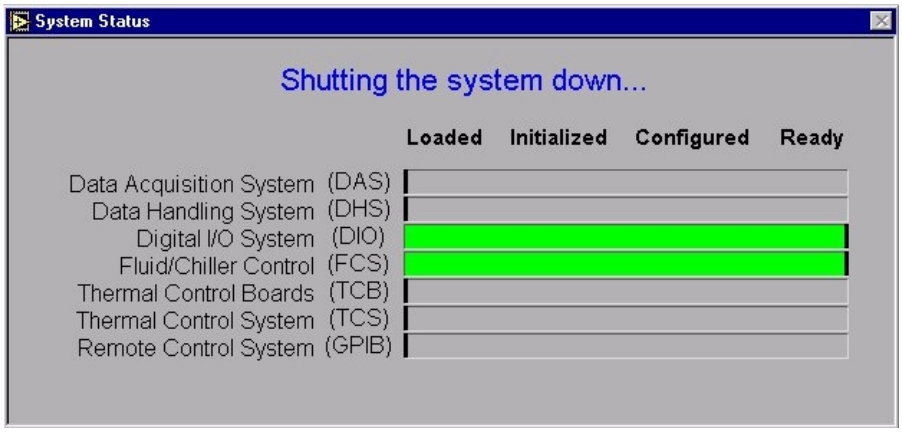


Figure 3-29. System Shut-Down

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3.8. Maintenance and Configuration Screens

3.8.1. Maintenance Selection

Figure 3-30 shows the maintenance selection screen, from which the other maintenance screens may be accessed. The characteristics and functions of these screens are detailed in sections 3.8.1through 3.8.9, below.



Figure 3-30. Maintenance Selection

NOTE:	To return to the main screen from any maintenance screen, select the Navigator button or the Main button, if present.

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3.8.2. Digital I/O Maintenance

The Digital I/O maintenance screen illustrated in Figure 3-31 shows the assignment of each Input and Output bit. The screen allows testing of the DIO system, as each bit toggles when the number representing it is selected.



Figure 3-31. DIO Maintenance

Refer to Chapter 10 (*I/O System*, P/N 7003100010) of the ETC 2000 Maintenance Manual for details of I/O assignments.

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3.8.3. General Purpose Interface Bus (GPIB) Maintenance

Figure 3-32 shows the GPIB maintenance screen, which provides status information about system communication with the tester.

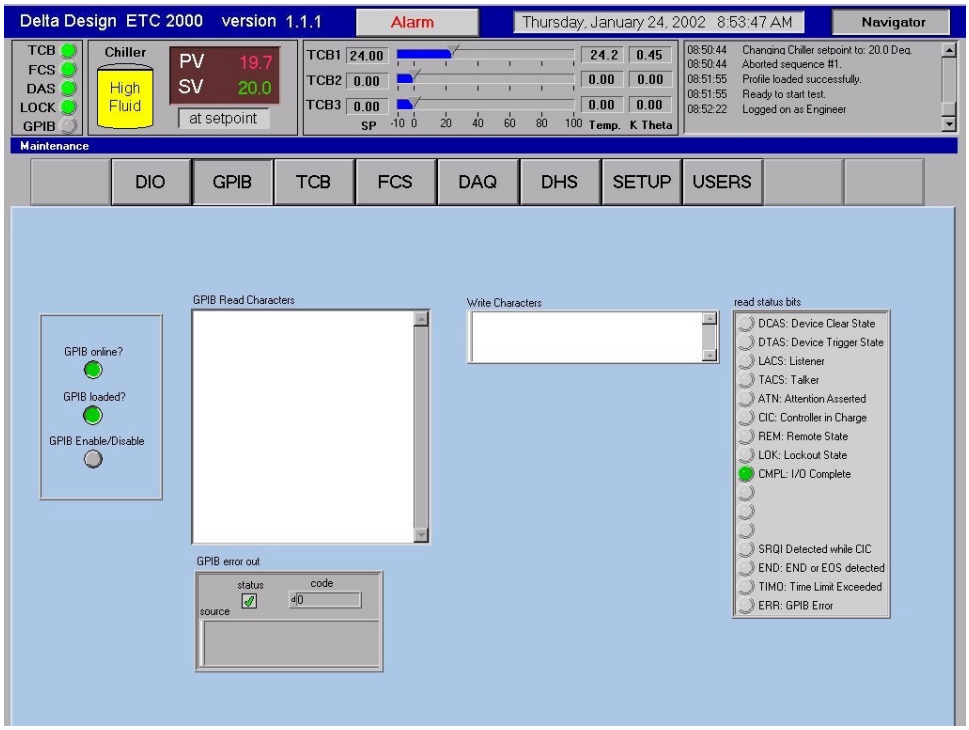


Figure 3-32. GPIB Maintenance

When the GPIB is enabled, the tester controls the running of a test profile, using a single sequence and adjusting the TCB setpoint/s. Table 3-7 shows the commands and status messages which the GPIB can pass to and from the tester. A complete listing of GPIB communications is available in Chapter 9 (*System Configuration*, P/N 7003110009) of the ETC 2000 *Maintenance Manual.*

Table 3-7. GPIB Maintenance Screen Elements

Element	Function
Status switch and indicators (box at left of screen)	The two indicators display the current state of the GPIB board, and the toggle switch enables and disables the board.
GPIB Read Characters	Displays messages sent from ETC 2000 to tester.
Write Characters	Displays messages sent from tester to ETC 2000.
GPIB Error Out	Displays GPIB error codes.
read status bits	Indicates status using status word mnemonics

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3.8.4. Thermal Control Board (TCB) Maintenance

The TCB maintenance window (Figure 3-33) permits the user to select and control the thermal control channels.

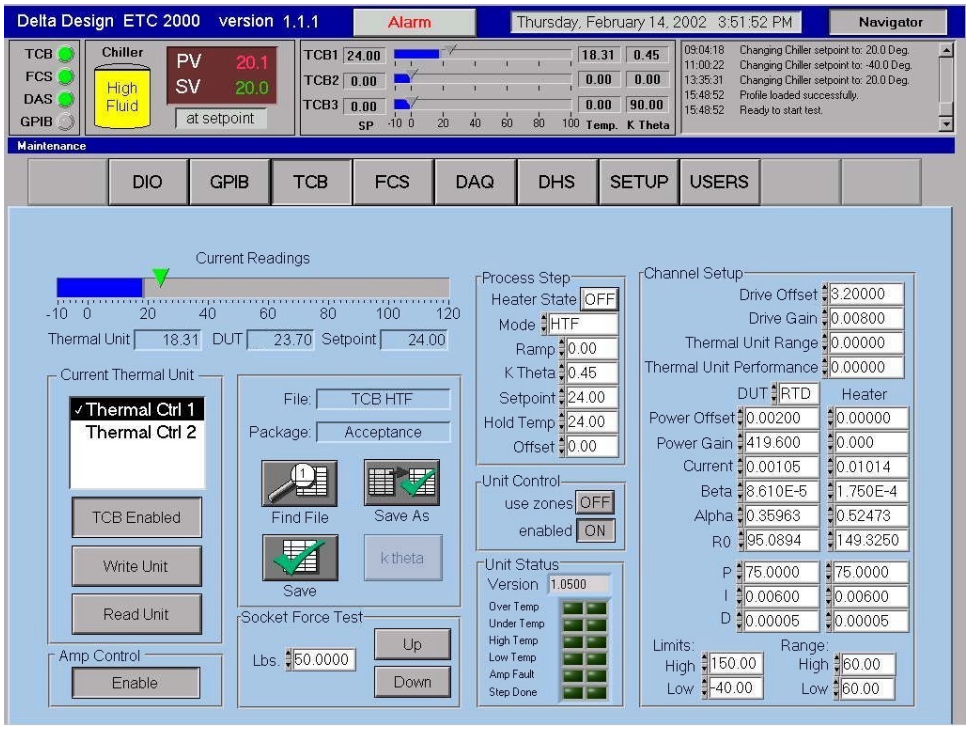


Figure 3-33. Thermal Control Configuration

The elements of this screen are detailed in the next several paragraphs. These functions are detailed in Chapter 9 of the ETC 2000 Maintenance Manual (*System Configuration*, P/N 7003110009).

3.8.4.1. Current Readings

The Current Readings section at upper left displays a graphical and digital readout of the actual temperatures of the TU and – if it incorporates a temperature sensing device, and is properly connected – the DUT, as well as the set temperature. If the DUT feedback is not connected, the DUT field may display NaN (Not a Number), as in the illustration.

3.8.4.2. Current Thermal Unit

Thermal Ctrl 1, *etc.*	A check mark next to a channel name indicates that that it is enabled. Thus, in Figure 3-33, Thermal Ctrl 1 is shown enabled.
TCB Enabled	With a channel selected in the list pane, clicking this button will toggle between enabling and disabling that channel.
Write Unit	Saves new values to the thermal control RT board's memory.
Read Unit	*Not used.*

3.8.4.3. Amp Control

This toggle button controls the amplifier/s. Once enabled, the amplifier/s will remain enabled until they encounter a fault condition, or until this button is pressed. Turning the amplifier/s off manually ensures that high voltage power is not present in the Environmental Chamber.

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3.8.4.4. File Management

This area includes the following elements:

- The name of the thermal control file currently loaded
- The name of the DUT package for which this file is appropriate
- Find File/Save/Save As buttons. These function as elsewhere in the software.
- K-Theta button – when the Unit Control | Use Zones button is selected (refer to section 3.8.4.7, below), this button is enabled (Figure 3-34). Clicking it pops up the K-theta zones management dialog shown in Figure 3-35.

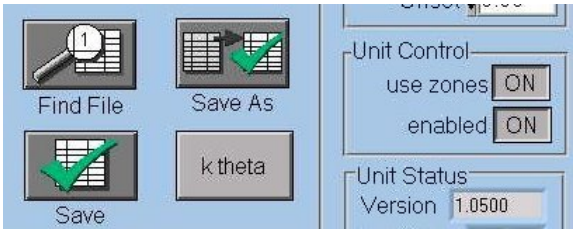


Figure 3-34. K-Theta Zones Enabled

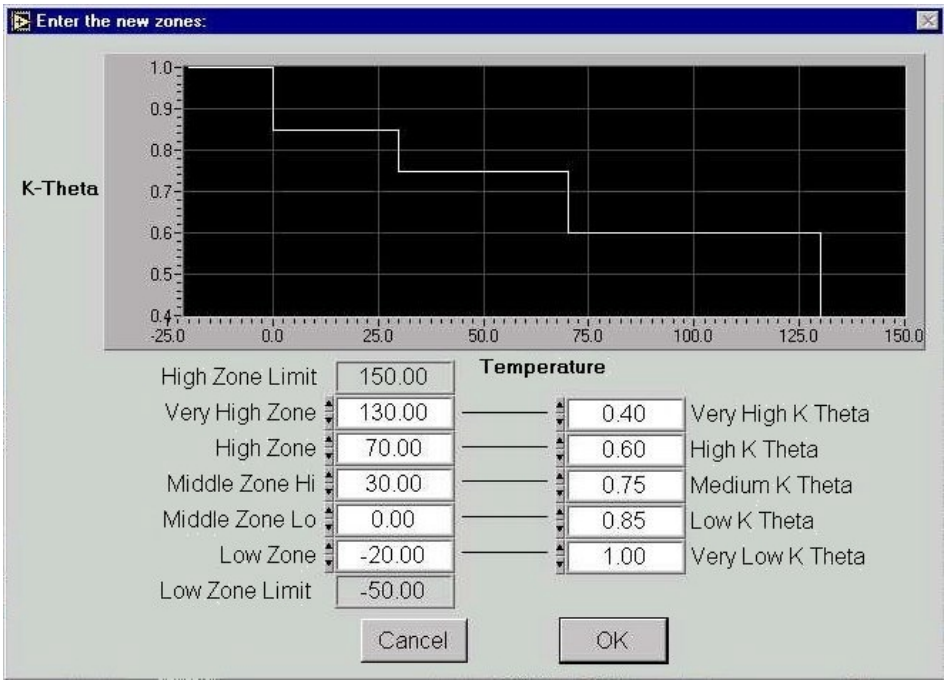


Figure 3-35. K Theta Zones Dialog

The editable fields in this screen permit K-theta values to be entered for various set point ranges. The fields on the left set the zone limits, and the fields on the right the values of K-theta at the limit of each zone. Actual K-theta values are computed interpolations based on these limits; thus, in the example shown above, a set point of 10 degrees C (or one third of the way between 0 and 30) would yield a K-theta one third of the way from 0.85 to 0.75, or approximately 0.883. Values may be entered directly, or the scroll buttons to the left of each field may be used to increase or decrease the value.

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3.8.4.5. Socket Force Test

Lbs.	Sets the socketing actuator force.
Up/Down	Moves the socketing actuator up and down.

3.8.4.6. Process Step

These real-time displays show the state of the thermal unit relative to the profile currently running.

Heater State	Toggles between OFF and ON.
Mode	Shows the thermal mode currently in use.
Ramp	Shows the rate of change between temperatures.
K-Theta	Shows the current value for K-Theta.
Setpoint	Shows the current set point – the temperature to which the DUT will be taken if there is no ramp step.
Hold Temp	Shows the temperature at which the DUT will be held once the test sequence has started. **Note**: Setpoint and Hold Temp often are the same; a higher Setpoint may be used to drive the DUT more rapidly to the Hold Temp at which testing will take place.
Offset	*Not used.*

3.8.4.7. Unit Control

Use zones	Enables K-Theta zones, and makes the K Theta button functional.
Enabled	Displays the status of the thermal control channel currently selected in the Current Thermal Unit pane.

3.8.4.8. Unit Status

Version	Thermal Control RT Board software version, communicated from board.
Over Temp Under Temp	Indicates TU has exceeded absolute high or low temperature limit defined in Channel Setup.
High Temp Low Temp	Indicates TU temperature is outside tolerance band defined in Channel Setup.
Amp Fault	Indicates presence of an amplifier fault.
Step Done	When green, indicates most recent step communicated to the Thermal Control RT Board is executing; when blue, indicates step is complete. **Note**: This indication is visible only when the system is run in Manual mode, with the TCB maintenance screen open, and will not be visible when a normal profile is running.

3.8.4.9. Channel Setup

Drive Offset	Sets bias for the amplifier/s.
Drive Gain	Sets scale of volts-to-output current supply to heater.
Thermal Unit Range Thermal Unit Performance	Not used.

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The following values are displayed separately for the DUT and the Heater:

Power Offset Power Gain	Used for any Power Following™ mode – converts the input signal to watts, using the formula **(Input-Offset)*Gain**

Note: If tool ID is present, the next four values are entered automatically.

Current	This field is used to enter the value of the current sent to the heater and/or DUT RTD (when this is the type of DUT feedback device).
Beta Alpha R0	DUT- and Thermal Unit- -specific calibration values.
P I D	Proportional, Integral and Differential terms for the thermal control algorithm.

The limits and range values work as follows:

Limits High/Low	Sets absolute temperature limits. If either limit is exceeded, HVPS is disabled and an alarm triggered. Exceeding the Low limit typically means that the heater is disconnected or faulty.
Range High/Low	Defines a range of temperatures, in degrees C, around the set point. If the range value is exceeded in either direction, the profile is aborted and a warning message displayed.

3.8.5. Fluid Circulation Subsystem (FCS) Maintenance

The FCS maintenance window (Figure 3-36) permits the user to issue commands directly to the chiller, and to modify its default parameters. It also shows status and alarm indicators for the FCS.

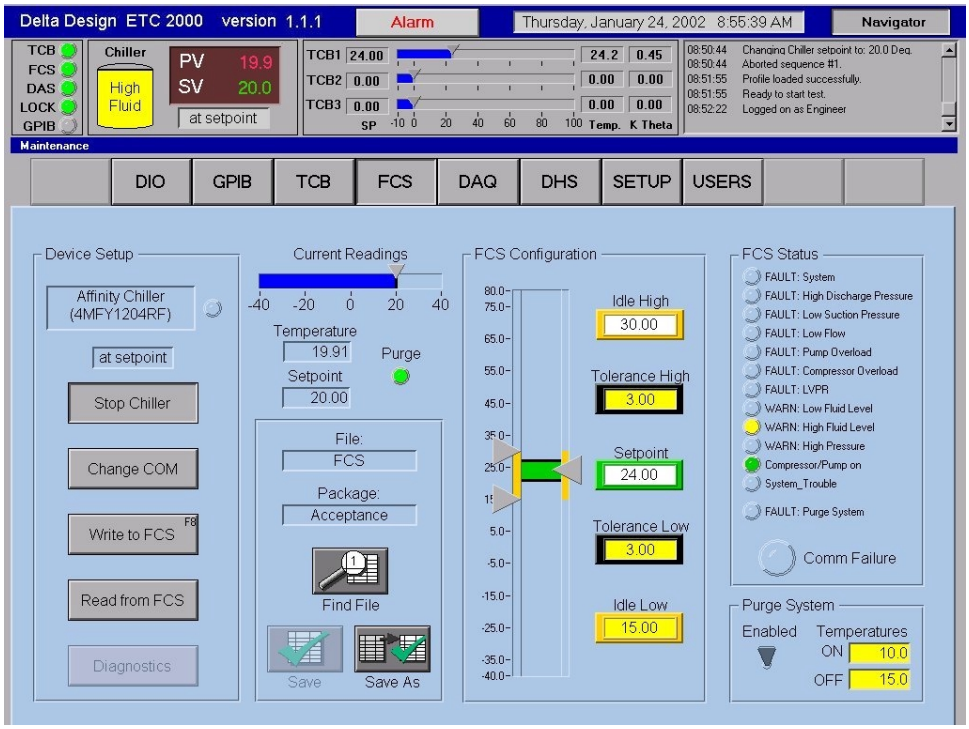


Figure 3-36. FCS Maintenance

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The elements of this window are described in the next several paragraphs.

3.8.5.1. Device Setup

Various chiller functions and parameters may be set using these controls. Selecting Stop Chiller causes the chiller to shut down.

When clicked, the Change COM button opens the window shown in Figure 3-37. Generally speaking, the values in these fields should not be changed.

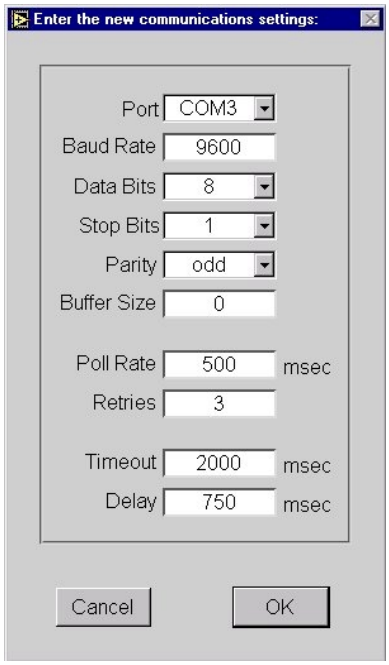


Figure 3-37. FCS Change COM Dialog

Write to FCS sets the current values for the chiller, while Read from FCS displays the chiller's current values. Note that writing to the FCS causes the chiller to respond to the new settings, but does *not* save the values in that file. To save values, refer to section 3.8.5.3.

The FCS Diagnostics are not currently enabled.

3.8.5.2. Current Readings

The slider bar and digital readouts give the same information shown at the top left of the main screen (Figure 3-5). When green, the Purge light indicates that purge is running.

3.8.5.3. File

The (non-editable) fields show the name of the currently loaded FCS configuration file, and the name of the package (DUT type) to which it refers. The Find File, Save and Save As buttons function as they do elsewhere.

3.8.5.4. FCS Configuration

To maximize the efficiency and speed of response of the chiller, the idle set point varies depending on the test set point. After a high set point profile, the chiller returns to the idle high value, in anticipation of another high set point profile. Conversely, at the end of a low set point profile, the chiller will return to the low low idle value. If the profile's last set point falls within the range, the chiller will idle at its current temperature.

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Figure 3-38 shows the parts of the analog display indicating these values. The same values are shown in digital readouts to the right of the bar graph. The triangular value indicators may be dragged into position using the trackball and cursor.

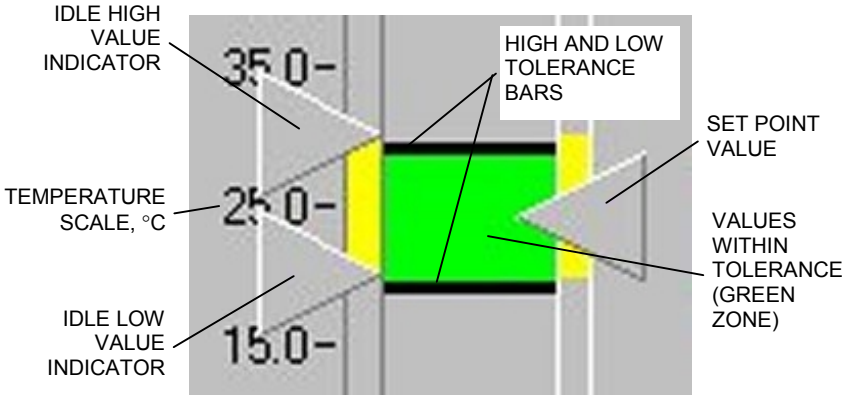


Figure 3-38. FCS Configuration Controls

3.8.5.5. PCS Configuration

The application software's ability to control the Purge Control Subsystem (PCS) valve is enabled and disabled by clicking the 'toggle switch' at the lower right of the FCS configuration screen.

When software control is enabled, the ON and OFF temperatures determine the set points at which purge air is supplied to the environmental chamber. At low set points, dry purge air is required to prevent condensation and frosting, while at high set points purge air is not necessary and would render thermal control less efficient.

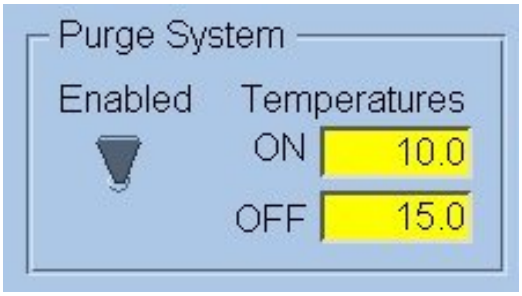


Figure 3-39. FCS Configuration: PCS Enabled

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3.8.6. Data Acquisition Subsystem (DAQ) Configuration

The Data Acquisition Subsystem (DAQ) controls how the ETC 2000 collects data when a profile is run. Selecting the DAQ button in the maintenance selection screen causes the maintenance window, shown in Figure 3-40, to display. This screen details parameters for each of the eight data collection channels.

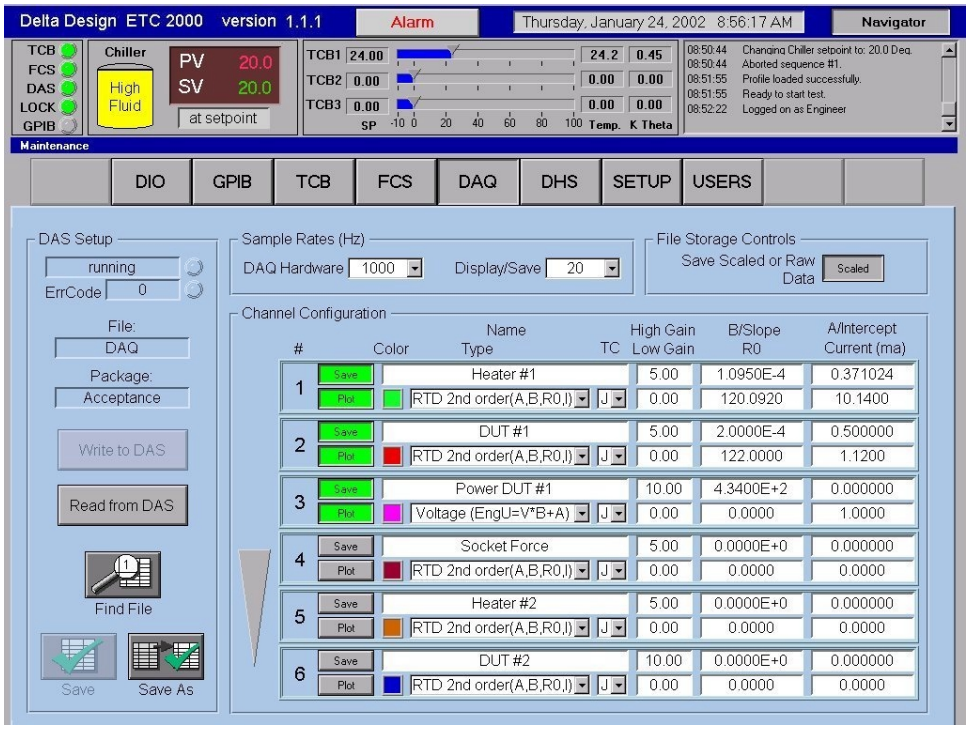


Figure 3-40. DAQ Configuration

3.8.6.1. DAS Setup

The DAS Setup section indicates the status of the DAS, any current error code, and file and package names in use. The Write to DAS and Read from DAS buttons function like their equivalents in the TCB and FCS maintenance windows.

3.8.6.2. Sample Rates

The two sample rate values are:

- DAQ Hardware: This value determines the rate in Hz at which the DAQ actually samples thermal control data.
- Display/Save: This value determines the number of times a second the acquired values are displayed and saved.

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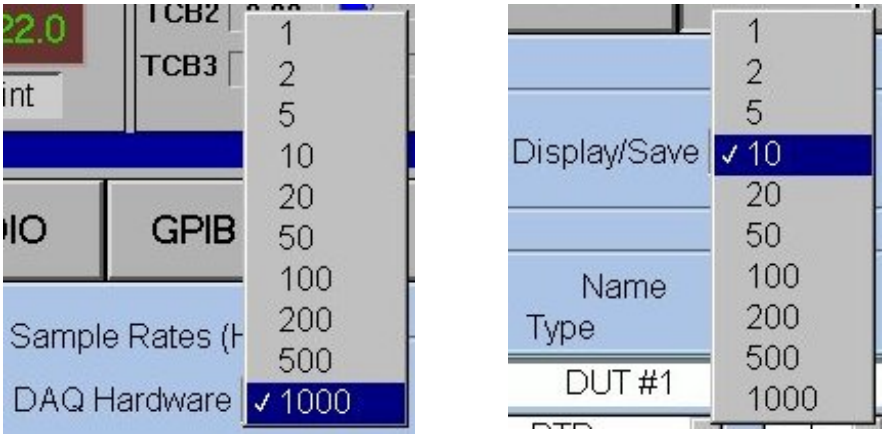


Figure 3-41. DAQ Rate Settings: Hardware (left), Display/Save (right)

3.8.6.3. File Storage Controls

Scaled data may be saved to file, or discarded. The two buttons in this section toggle between Saving and Discarding. It is important to bear in mind that, depending on the display/save sample rate and the duration of the profile, saved files may be extremely large.

3.8.6.4. Channel Configuration

This part of the window permits each channel to be configured independently. Note that not all channels are visible at once in this window; the arrow at the left of the display allows the user to scroll down and view additional channels.

Note that the calibration values entered in this screen for DUT and HTR **will be over-ridden** by values read from the tooling ID module, and those recorded in the TCB configuration file.

To the left of each channel configuration, Save and Plot buttons permit the feedback from each channel to be saved to a data file, or plotted, or both. When a Save or Plot button is selected, it turns green.

Each channel may be labeled (Name) and colored (Figure 3-42), and its Type (Figure 3-43) and High Gain and Low Gain rate selected.

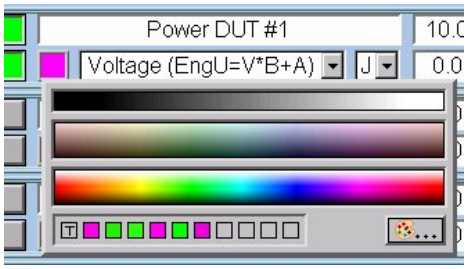


Figure 3-42. Channel Configuration: Color Palette

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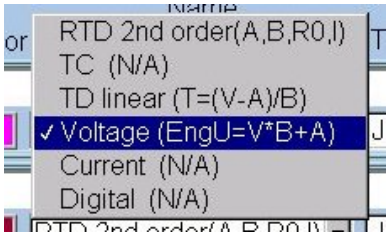


Figure 3-43. Channel Configuration: Type Selection List

Table 3-8. DAQ Channel Configuration

Label	Type	Description
R0	Intercept	Constant: The resistance of the heater RTD at 0°C.
Alpha	Slope	Describes the average slope of the RTD's temperature/resistance curve. (Ω / °C)
Beta	2nd order curve fit	Describes amount of curve (Ω / °C / °C).

3.8.7. Data Handling Subsystem (DHS) Maintenance

The DHS maintenance screens allow the operator to delete and modify the ETC 2000's subsystem and data handling configuration files.

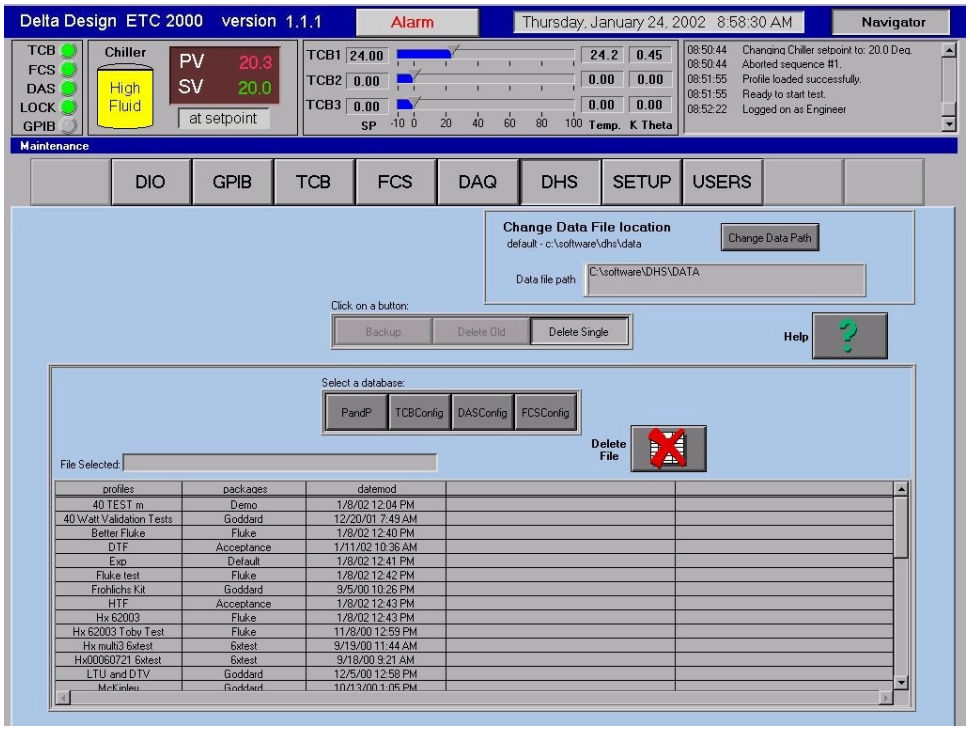


Figure 3-44. DHS Maintenance

Figure 3-44 shows the default DHS maintenance screen. Each type of configuration file may be displayed by selecting the appropriate button under the Select a database heading at the center of the screen.

NOTE:	The grayed Backup and Delete Old buttons represent features that are not implemented at present.

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For example, selecting TCBConfig displays all currently available thermal control configuration files, including the package (DUT) to which they apply, and the date on which they were created.

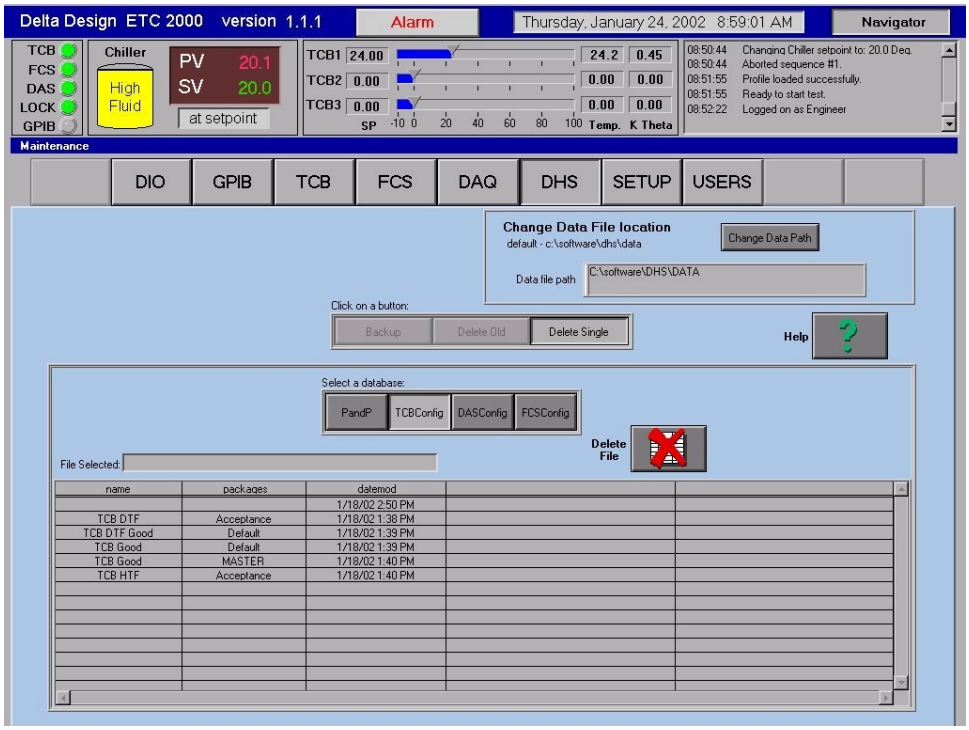


Figure 3-45. DHS Maintenance: TCBConfig Selected

Files are selectable, the file name appearing in the File Selected field above the table. Once a file is selected, it may be deleted by selecting the Delete File button,

Finally, selecting the Change Data Path button, at upper right allows the user to change the location in which the Data Handling Subsystem saves its output files. When this button is selected, a confirmation dialogue appears, like the one shown in Figure 3-46.

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To set a new data path, navigate to the folder in which files should be stored, and click on Select Cur Dir to open a dialog box like that shown in Figure 3-46. The File name field must be left **blank** – the system will supply a file name based on the profile name, creation date and time, with an ordinal suffix.

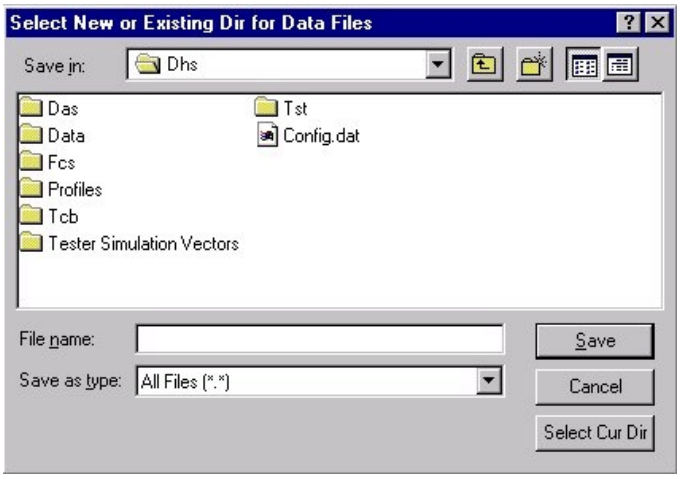


Figure 3-46. DHS: Change Data Path Dialogue

3.8.8. SETUP for On-Screen Display

The DAQ maintenance window (refer to section 3.8.6, above) may be used to set up the parameters for individual channels of data acquisition; the SETUP maintenance screen governs the way the information is displayed on-screen. The window, shown in Figure 3-47, permits the operator to make changes in the legends, scales and colors of the on-screen thermal control information display, at the upper left corner of the main screen (Figure 3-5).

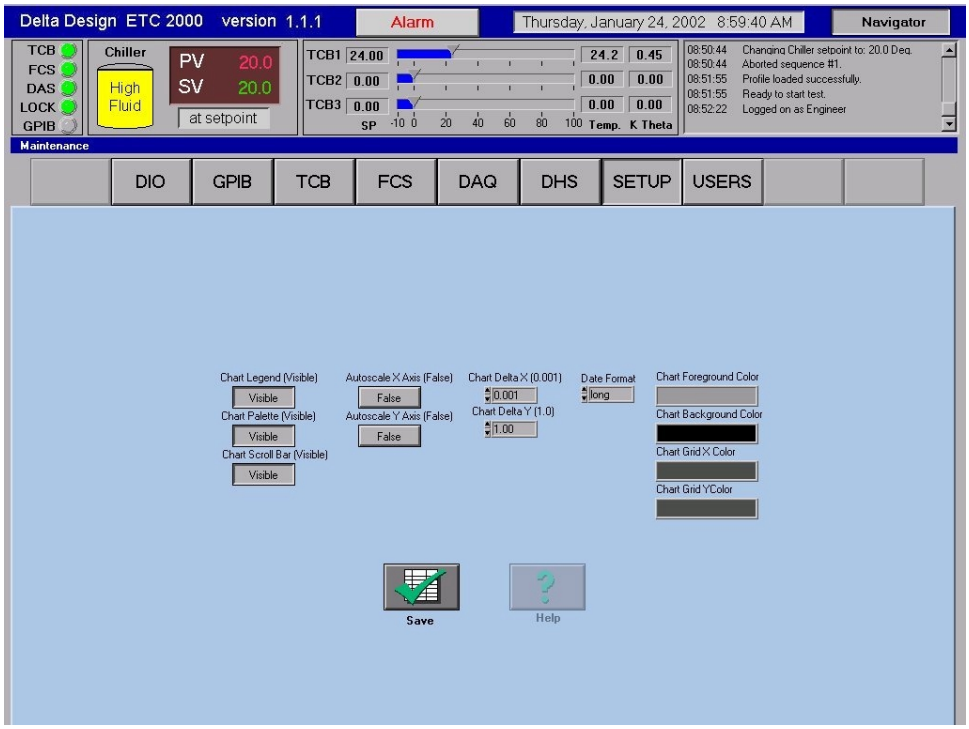


Figure 3-47. SETUP for On-Screen Display

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Selecting one of the color setting boxes to the right of this screen opens a window (see Figure 3-48) offering a range of color options.



Figure 3-48. Display Color Options

3.8.9. Users Maintenance

This screen (Figure 3-49) allows user names, passwords and access levels to be set up. The USERS maintenance screen is accessible only to personnel logged on at the engineer level. Note that Figure 3-49 shows the Save button enabled, meaning a change has been made and a save operation is pending.

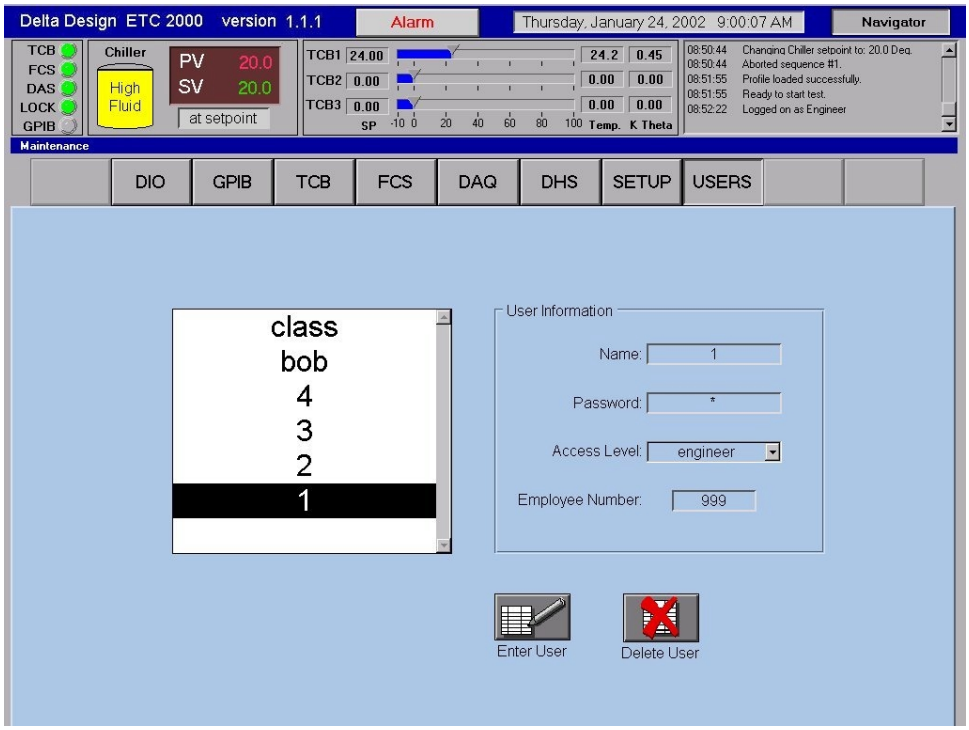


Figure 3-49. USERS Maintenance

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When the Enter User button is selected, the User Information screen shown in Figure 3-50 appears. The engineer can then enter a login name, password, and security level for the new user, or change password or security level for an existing user.

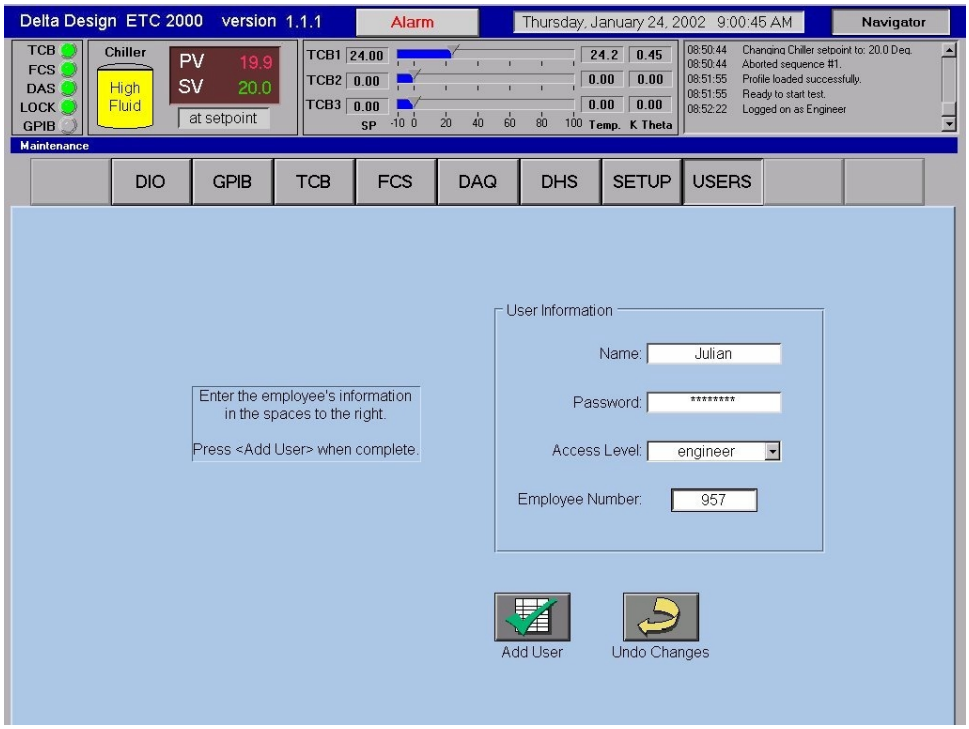


Figure 3-50. Adding/Deleting a User

Changes made in the User Information screen may be undone by selecting the Undo Changes button. When the Delete User button on the Users maintenance screen (Figure 3-49) is selected, a confirmation dialog (Figure 3-51) appears.

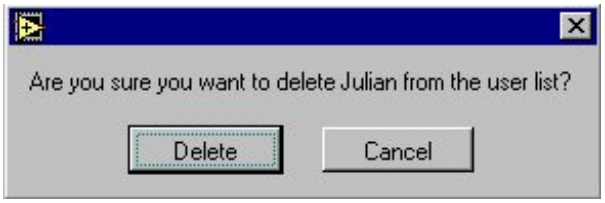


Figure 3-51. Delete User Confirmation Dialog

Finally, if the User screen is exited after information has been added, deleted or modified, the dialogue shown in Figure 3-52appears.

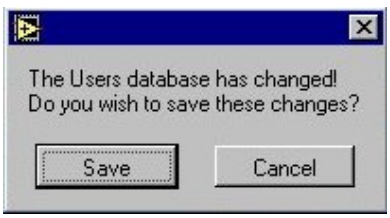


Figure 3-52. Save Users Database Confirmation

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Chapter 4: Operating Procedures

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4. Operating Procedures

4.1. Introduction

This chapter explains how to operate the ETC 2000 with version 1.1.x application software.

NOTE:	Throughout this chapter, "click" refers to pressing the left trackball button.

Maintenance and setup procedures are documented in the ETC 2000 *Maintenance Manual* (P/N 7003110000). Of particular relevance to system operation are the following:

- *Operation, Maintenance and Configuration Screens*, Chapter 3 of this manual (P/N 7003100003), gives a detailed account of the various screens and buttons encountered in the ETC 2000 application software's interface
- *Error Recovery Guide*, Chapter 5 of this manual (P/N 7003100005), explains error conditions and error recovery options.
- *Calibration*, Chapter 5 of the *Maintenance Manual* (P/N 7003110005)
- *System Configuration*, Chapter 9 of the *Maintenance Manual* (P/N 7003110009), explains configuration options for the ETC 2000

4.2. Overview

Basic operation of the ETC 2000 generally involves the following:

NOTE:	In general, except as noted, this document assumes that the ETC 2000 is in use in its stand-alone configuration, with an environmental chamber and socket adapter mounted on the load board, on the test head. In some cases, reference is made to a separate handler; please refer to your handler documentation for handler-specific operating procedures.

- Positioning the system next to the tester or handler
- Making facilities connections to supply the ETC 2000 with power, air and helium
- Mounting the socket adapter and environmental chamber on the TIU (on the tester head), if the system is in use in its stand-alone configuration
- Connecting the system's umbilicals to the environmental chamber umbilical interface, or to a separate handler

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- Turning on the ETC 2000, and logging on to the application software
- Creating, editing or selecting an existing profile
- Accessing the environmental chamber (if in use) to socket a Device Under Test (DUT)
- Actuating the socketing mechanism to apply thermal control and socketing force to the DUT
- Waiting for the DUT to reach its first test temperature set point
- Running a profile
- Once the DUT has been restored to a safe-to-touch temperature, opening the chamber and removing the DUT from the socket
- Storing the test data

4.3. Positioning the ETC 2000

4.3.1. Moving the System Cart

The ETC 2000 rolls on four casters. A foot-actuated floor-stop brake holds the system in position. With the brake actuated, the system can be pivoted to adjust its position relative to the test head.



CAUTION:	**To ensure proper control of the rolling system, two people should carry out the procedure described below.**

To move the system:

1. Turn off the main breaker and put the system into a Lock-Out/Tag-Out (LOTO) state. (Refer to Chapter 2 of this manual, *Safety Hazards and Precautions*, P/N 7003100002.)
2. Disconnect the following:
   - Facilities supply lines
   - AC power cord
   - Umbilicals
   - GPIB, DUT and network connections.



CAUTION:	**Take care to tighten the umbilical support arm in place so it does not swing out while the cart is in motion.**

3. Stow the umbilical support arm parallel to side 4 of the system. The process fluid umbilicals remain suspended from the arm and attached to the umbilical panel.
4. Turn the system to align its long axis with the direction in which it is to be moved. The system should be moved so that side 3 is at the front.



WARNING:	***Use feet, not hands, to lock or unlock the brake. Fingers can be pinched when the lock snaps into place.***

5. Push the system in the desired direction.

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CAUTION:	**The ETC 2000 weighs approximately 750 pounds. Care must be taken when moving the system, especially over uneven surfaces.**

Once the system cart is in place (for example, so that the tester head is within the normal reach of the umbilicals) lock the brake.

4.3.2. Making Facilities Connections

Once the ETC 2000 is in position, all the items disconnected in section 4.3.1, step 2, must be re-connected.

For facilities requirements and machine installation procedures, refer to the ETC 2000 *Maintenance Manual,* Chapters 3 (*Shipping and Receiving*, P/N 7003110003) and 4 (*Site Preparation and Machine Installation*, P/N 7003110004).

4.3.3. Setting up the Environmental Chamber and Umbilicals

For details on these procedures, refer to section 4.5, below.

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4.4. ETC 2000 Connections

Figure 4-1 shows the layout of the facilities panel, and Figure 4-2 that of the umbilical panel.

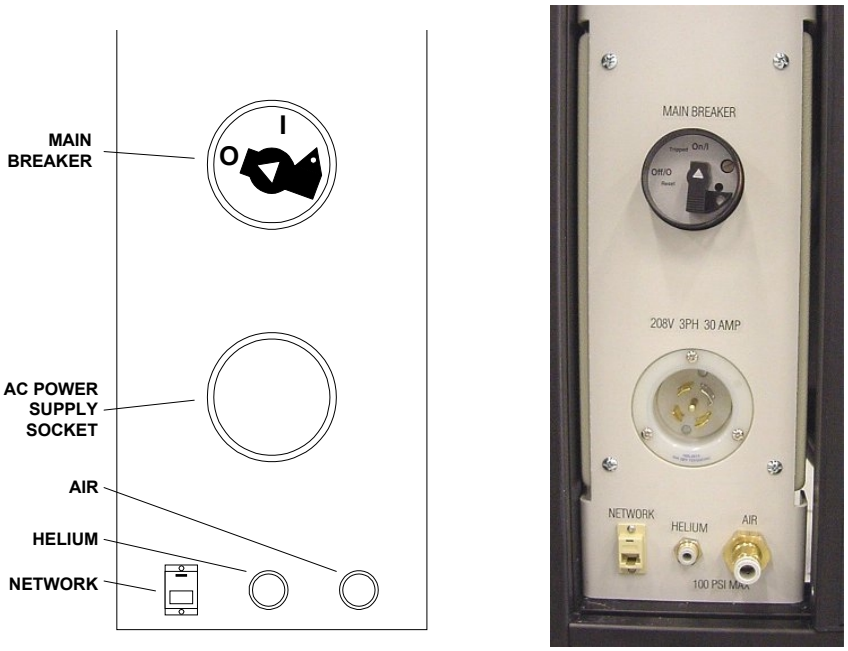


Figure 4-1. Facilities Panel

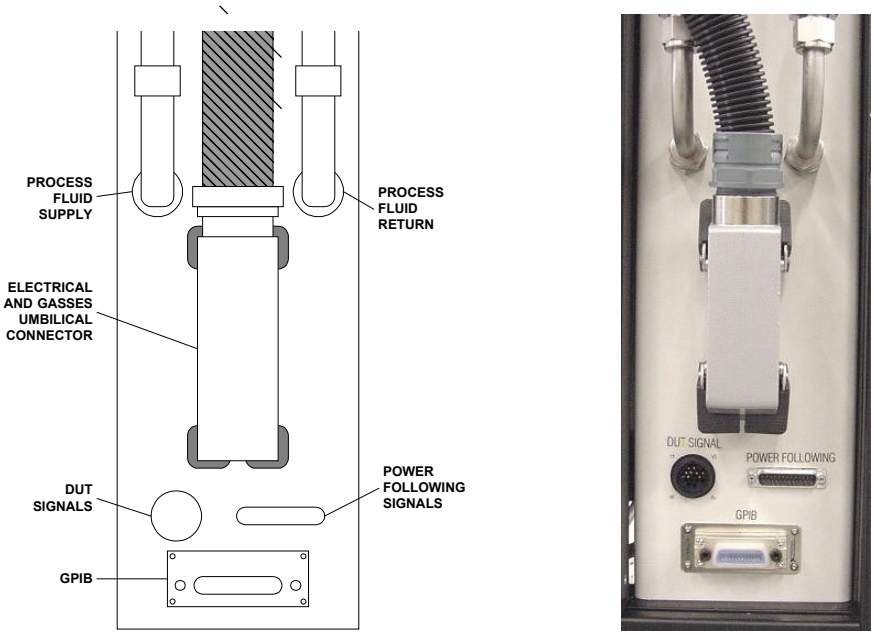


Figure 4-2. Umbilical Panel

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4.4.1. Facilities Panel

The facilities panel (Figure 4-1) includes the following:

- Main breaker
- AC power socket
- RJ45 network port
- Facilities air connection
- Facilities helium connection

4.4.2. Umbilical Panel

The features of the umbilical panel (Figure 4-2) are described in the following paragraphs.

4.4.2.1. Process Fluid Connectors

The process fluid supply and return umbilicals are hard-plumbed to connectors at the umbilical panel. The connections are insulated inside and outside the panel, to prevent condensation and icing as well as to protect personnel from hot surfaces.

4.4.2.2. Electrical/Gas Umbilical Connector

A single integrated socket provides a connection for the third umbilical. This umbilical carries air and helium to the environmental chamber, and contains the necessary electrical connectors to run the thermal unit and its associated sensors.

4.4.2.3. Power Following Signal Connector

A 25-pin D-sub connector is provided for cable connection between the power-summing board or APECS board and the tester's power supplies, to provide feedback for Power Following thermal control modes.

4.4.2.4. AMP Connector for DUT Signals

This connector accepts data for thermal control feedback from DUTs equipped with their own temperature-sensing device.

4.4.2.5. GPIB Connector

This connector permits test status communication between the ETC 2000 and the tester.

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4.5. Environmental Chamber and Umbilicals

For a detailed account of these subsystems, refer to Chapter 12 of the ETC 2000 Maintenance Manual, *Umbilicals and Environmental Chamber* (P/N 7003110012).

4.5.1. Umbilical Connection

The three umbilicals – process fluid supply and return, and electrical/gas – are suspended from the umbilical support arm (Figure 4-3). For the most part, the umbilicals will remain attached to the ETC 2000.

CAUTION:	**Tension will be removed from the spring balance, and stress placed on the umbilicals, if the lever indicated in Figure 4-3 is moved.**

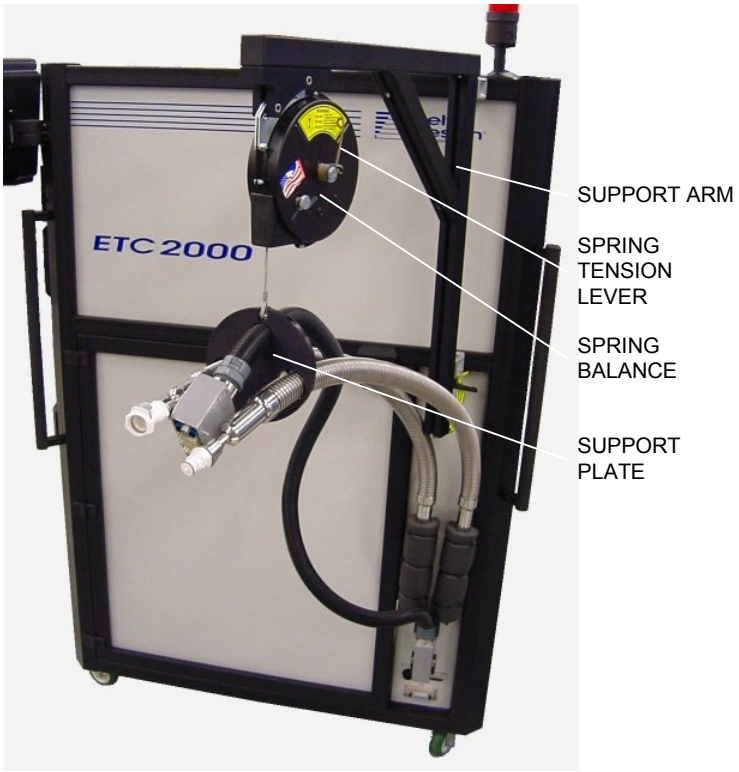


Figure 4-3. Umbilicals with Support Mechanism

4.5.2. Initial Set-Up

The system cart should be position relative to the test head so that the umbilicals can attach to the connector box on the environmental chamber, without strain on the connections. Once the correct position is found, engage the floor-lock brake, then attach the connections. The process fluid umbilical quick disconnects are asymmetrical to ensure that the system is plumbed correctly.

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4.6. Starting the System

4.6.1. Normal

This procedure assumes the ETC 2000 is properly connected to all facilities supplies, and that the chiller fluid level is within the normal range.

1. Turn the main circuit breaker (see Figure 4-1) CW to its ON position.

NOTE:	OFF is at the 9 o'clock position, ON at the 12:00 o'clock position.

2. Press the SYSTEM POWER ON button, located to the right of the EMO button.
3. Observe as the operating system boots. Log on to the operating system. For initial log-on, enter Administrator then press <RETURN>.
4. Double-click the application software icon on the desktop, and wait while the software loads and the system initializes.

NOTE:	For information on setting up user names and passwords, refer to Chapter 9 of the ETC 2000 *Maintenance Manual*, *System Configuration* (P/N 7003110009).

5. When the log-in screen appears (Figure 4-9), enter a user name and password, and click Enter to log on to the system. For initial log-on, user name and password are both 1.

4.6.2. After EMO

If the machine was shut down by pressing an Emergency Machine Off (EMO) button, follow this procedure to re-start the system.

1. Reset the EMO button by twisting CW and allowing the button to pop up.
2. Press the SYSTEM POWER ON button.
3. When re-booting the machine, perform all file and disk integrity checks and repairs as prompted by the Windows operating system.

4.6.3. After Power Failure

If a facilities power failure occurs, immediately switch the main circuit breaker CCW to its OFF position. When facilities power is restored, turn on the circuit breaker, then follow the procedure used to restart after an EMO has been pressed, omitting step 1.

4.6.4. Profile in Progress

If facilities power loss occurs while a profile is being run, the following steps must be taken:

1. When re-booting the machine, perform all file and disk integrity checks and repairs as prompted by the Windows operating system.
2. Once the application software is running, and log-in has been effected, check the integrity of any data files produced before the power loss.
3. Any configuration settings and profile setup information not saved before the power loss must be re-entered using the appropriate maintenance screens.
4. If the results of the profile are desired, it must be re-started from the beginning once the above steps have been carried out. Be sure to delete any incomplete data files, if the DAQ was configured to save data from any channels used in the profile.

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4.7. ETC 2000 Device Kits

4.7.1. Overview

The thermal unit (TU) is packaged in a replaceable, DUT-specific Device Kit. The kit is attached to the socket actuator in the environmental chamber, and by quick disconnects to the chamber's umbilical connector box.

The basic sequence of operations is as follows:

NOTE:	Most of these procedures are maintenance functions. Procedural details are provided in Chapter 12, *Umbilicals and Environmental Chamber* (P/N 7003110012).

- Install a tool in the environmental chamber
- Mount the socket adapter on the TIU
- Attach the environmental chamber base to the socket adapter
- Connect ETC 2000 umbilicals to environmental chamber



CAUTION:	**To avoid possible equipment damage, the HVPS must be OFF and the chiller switched off before the Device Kit is changed.**

NOTE:	Whenever a Device Kit change is made, the Overtemperature detection module reset button (to the left of the EMO button) must be pressed.

4.7.2. Device Kits: Functional Description of Major Components

The ETC 2000 is equipped with tooling which applies an adjustable socketing force to DUTs. An ETC 2000 tool comprises the following components:

- Thermal unit (TU: heater/heat exchanger), mounted in a block with wires and tubes for heater power, RTD connections, process fluid and helium
- Pusher/face-plate with replaceable spring
- Tool body, to which the TU block mounts
- Clamp plate, for connection to the cylinder piston.
- Tool ID module

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Figure 4-4, Figure 4-5 and Figure 4-6 show the main components of a DK, mounted in the environmental chamber.

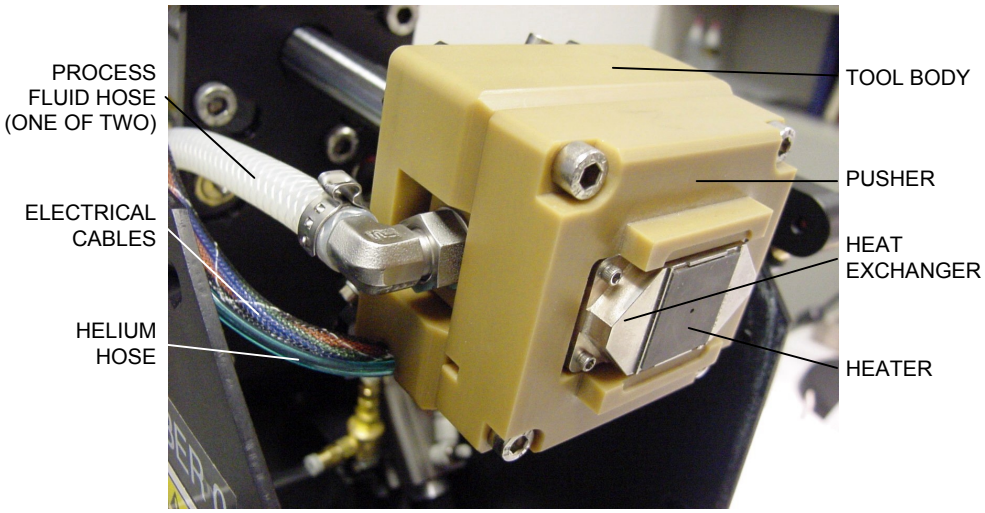


Figure 4-4. Components of the Tool

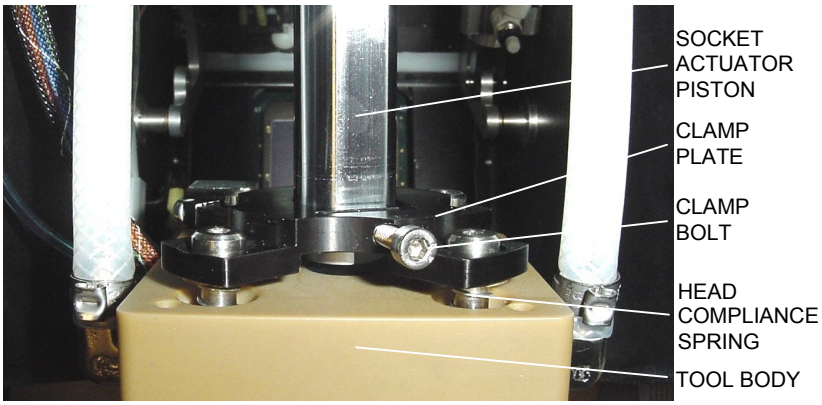


Figure 4-5. Tool Attachment Features

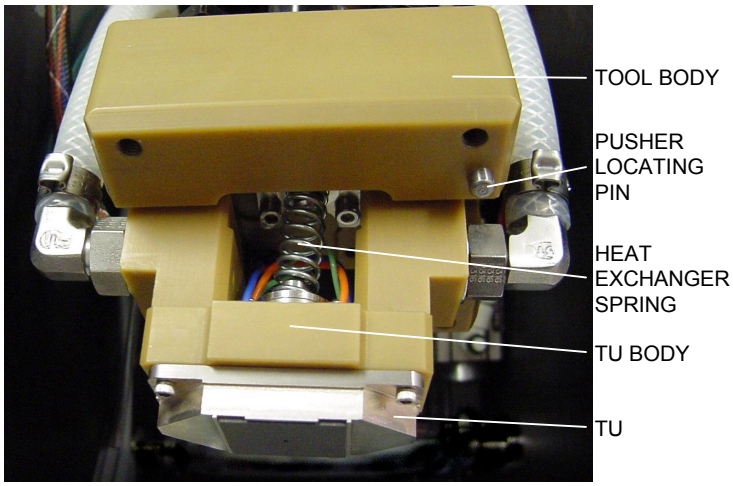


Figure 4-6. Tool, Pusher Removed

These components mount to the piston shaft of an electronically-regulated pneumatic cylinder. Tubes and wires leading from the TU body connect, via quick

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disconnects internal to the chamber, to the fluid, helium and electrical supplies provided via the umbilicals. The socketing actuator is connected to pneumatic lines also provided via the electrical/gas umbilical.

The final element of a Device Kit is the socket adapter. This plate mounts on the TIU/load board; the environmental chamber base mounts to the adapter.

4.7.3. Change DUT-Specific Elements of DK

The following procedure assumes either that the chamber is not yet connected to the umbilicals or, if it is, that HVPS, pneumatic air and the chiller are OFF, and facilities air is in a LOTO condition.

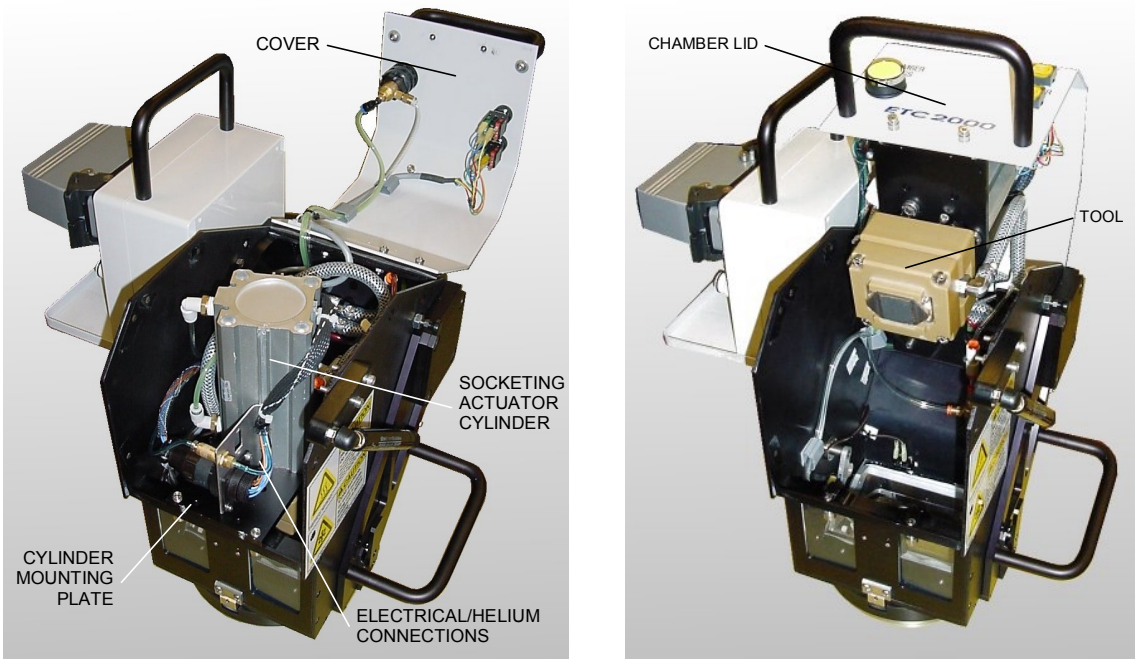


Figure 4-7. Chamber: Open for Internal Connector Access (left) and Tool Access (right)

CAUTION:	**In raising the lid and cover, be sure to pivot them as far back as possible so they don't fall forward and damage any of the chamber components.**

1. Loosen the two 3mm hex bolts holding down the sheet metal chamber cover (Figure 4-7, left), and raise the cover.
2. Unfasten the electrical, (blue) helium and process fluid quick disconnects. Position the tool side connectors so that they can pass beside the cylinder mounting plate when the tool is detached.
3. Loosen the two 5mm hex bolts securing the cylinder mounting plate (Figure 4-7, right).
4. Raise the plate.
5. Pull on the tool to extend the piston, guiding the hoses and cables past the cylinder mounting plate as the assembly moves.
6. Use a 3mm hex wrench to loosen the clamp (Figure 4-5) holding the tool to the piston.
7. Pull off the TU, taking care not to strain the hoses and cables disconnected in step 2.

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8. Attach the new TU -- the clamp has a flat anti-rotate feature, and can be attached in one of two positions 180 degrees apart; make sure that the wires are at the back.
9. Tighten the clamp with a 3mm hex wrench.
10. Push the piston back into the cylinder.
11. Route the tool-side quick disconnects up beside the cylinder mounting plate, as appropriate for the umbilical-side disconnects.
12. Close the plate and fasten its bolts.
13. Open the sheet metal cover.
14. Attach the electrical, pneumatic and fluid connectors.
15. Close and fasten the cover.

4.7.4. Pusher and Spring Change-Out

In some cases where a new DUT is in the same family as the one for which a DK is already installed, it may be necessary to replace only the pusher (Figure 4-4), or the spring, or both, without changing out the TU body.

The pusher (Figure 4-4) is attached to the tool body by four 5mm hex bolts. When removing these bolts to change out the pusher, hold the TU body in place so as to avoid straining its fluid, gas and electrical connections.

Once the pusher is removed, the spring is accessible. It fits between the features identified in Figure 4-8. In replacing the pusher, or installing a new one, be sure to locate the spring correctly before fastening the bolts.

Note that the pusher is asymmetrical; a groove on one side accommodates the RTD wires from the TU. Check the orientation of the pusher before fitting it around the TU body. Figure 4-8 shows the TU body with the non-RTD side uppermost.

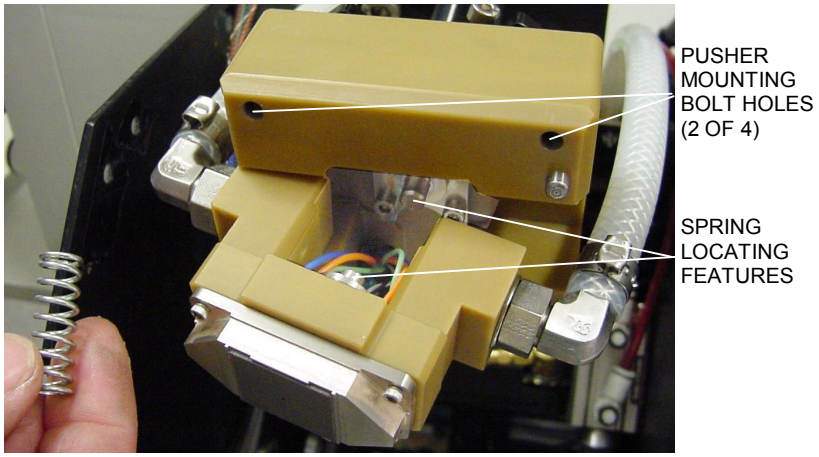


Figure 4-8. Pusher and Spring Removed

4.7.5. Mount the Socket Adapter on the TIU

The socket adapter attaches to the TIU using two 5mm bolts or a set of latches.

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4.7.6. Mount the Environmental Chamber on the Socket Adapter



CAUTION:	**Always disconnect the umbilicals from the environmental chamber umbilical interface box before removing the chamber from the socket adapter.**

The chamber base mounts to the socket adapter using a bayonet system:

1. Set the chamber base onto the socket adapter, with the front of the chamber slightly to left of center.
2. Move the chamber base until the bolts engage in the slotted holes in the socket adapter.
3. Twist the chamber CCW (to the right) until the latch engages in the feature on the socket adapter.

To remove the chamber from the socket adapter, press in the upper part of the latch to disengage it from the adapter, and twist the chamber CW so the bolts disengage and it can be lifted off.

4.8. Operating Precautions

4.8.1. Preventing Condensation during DUT Exchange

Since the presence of moisture can allow a path for current from the heater to ground, it is important to prevent the formation of moisture around the heater area. When the application calls for the HFE process fluid temperature to be below the dew point (typically, <10 degrees C) condensation may form on the TU. If the process fluid temperature is to be set below 10 degrees C, the following points must be considered when the environmental chamber is to be raised and lowered to allow access to the socket:

4.8.1.1. Set FCS Idle Temperature

NOTE:	Since the TU is enclosed in the environmental chamber and is not exposed to ambient air during normal operation, the problem of condensation is obviated. However, the DUT must be returned to a non-condensing temperature before the environmental chamber is raised after the end of testing.

To ensure that the tooling temperature is above the dew point after a profile is completed or aborted:

NOTE:	The following procedure must be carried out individually for each FCS configuration file.

1. From the FCS maintenance screen (accessed via Navigator | Maintenance | FCS), set the Idle High and Idle Low temperatures. Typical values are 30 and 15 degrees C, respectively.
2. Select the Save button, then the Write to FCS button.

4.8.1.2. Set Purge Control

To ensure that the purge system runs appropriately for profiles using this FCS configuration file.

1. Check that the purge flow regulator (at lower right of the pneumatics panel behind the door on side 3) is correctly set. Typically, it will be 1 to 2 SCFM.
2. Access Navigator | Maintenance | FCS, and toggle the purge control to its Enabled position.
3. Typical purge values are: ON = 10 degrees C; OFF = 20 degrees C.

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4. Select Save, then Write to FCS.

4.8.2. Avoiding Condensation While Running Profiles

Note the following after a profile has been run or aborted:

1. When a low temperature profile has completed or is aborted, the chiller set point will automatically return to the idle low or high value (set in section 4.8.1.1, above). **Wait** for the chiller PV (present value, displayed at upper left of the main screen) to reach 15 degrees C before raising the shroud.
2. If it is necessary to abort a cold profile before it completes, turn off the HVPS, then push the abort button and wait for the PV to show at least 15 degrees C.
3. Raise the shroud and remove or replace the DUT. Lower the shroud back to its closed position.



CAUTION:	**If condensation starts to form on any part of the Device Kit while changing out the DUT, immediately lower the shroud and seal it to the load board. Ensure that the PCS is blowing dry air into the shroud.** **If the purge system has stopped, access Navigator | Maintenance | FCS and set the chiller temperature to 10 degrees C. Wait until the condensation has evaporated before turning on the HVPS and resuming operation.**

4. Press the HVPS ON switch.
5. Ensure that the correct profile is loaded for the next DUT, and select Start.
6. When the last DUT has been removed, the system should be left with HVPS off, and the FCS temperature set above the dew point.

4.9. Preparing for System Operation

4.9.1. Logging In/Logging Out

4.9.1.1. Logging In

When the ETC 2000's SYSTEM POWER ON button is pressed, the Windows NT operating system boots. Log in to Windows and then double-click the ETC 2000 application software icon on the desktop. After system initialization is complete, the main screen of the application software appears (refer to Chapter 3 of this manual, *Operating and Maintenance Screens*, P/N 7003100003), with the log-in dialog superimposed upon it.

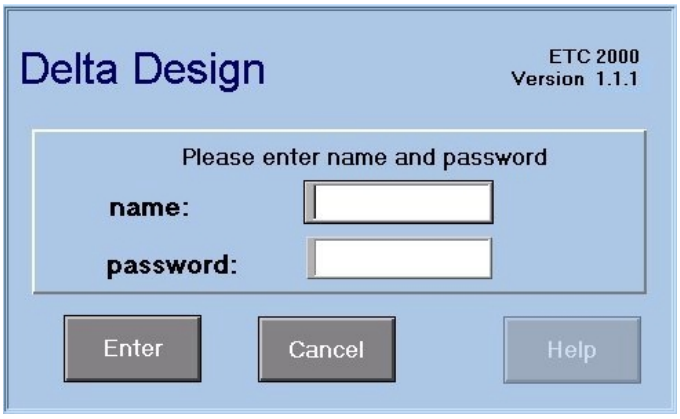


Figure 4-9. Login Screen

Enter your user name and password and select Enter.

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To log in as a new user when a login is already in effect, carry out the following procedure:

NOTES:	Logging out while the application software is running returns the system security level to a null setting, from which only the Log In/Log Out screen is accessible.

1. Click the Navigator button at the extreme top right of the screen.
2. The Navigator Toolbar appears, with several buttons on it. Click the Log On/Off button.
3. The login screen (Figure 4-9) appears, superimposed on the main screen. Type your user name and password in the appropriate fields, and click ENTER.
4. If either your user name or password is incorrect, an Access Denied box will appear. Click OK to continue, and retry your log in.

4.9.1.2. Exiting the Software

To close the ETC 2000's application software, make sure that no profile is running, and that the HVPS is not enabled. (Check the HVPS ON/OFF switch light). Then click Navigator | Exit (the bottom icon).

NOTE:	For system shut-down information, refer to section 4.12.1, below.

4.9.2. Tester and TIU/Load Board Setup

The ETC 2000 can interface with a variety of testers. Therefore, operating procedures involving the TIU should be taken from the manual of the tester you are using. Most of the necessary actions will be covered in your tester manual.

4.9.3. Profile Management

The following procedures assume that:

- The ETC 2000 is powered, and the application software is running.
- A user with authority to modify profiles is logged on.

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4.9.3.1. Creating Setup Files

CAUTION:	**The files listed here, and all setup files, should only be modified using the maintenance screens, and never edited directly.**

Before a profile can be written, the setup files must be created. You will need:

- TCB, FCS and DAS configuration files

The ETC 2000 is equipped with a set of default files on which user-specified files may be modeled using the Save As option. The flow chart in Figure 4-10 shows the relationships between a profile and its associated configuration files.

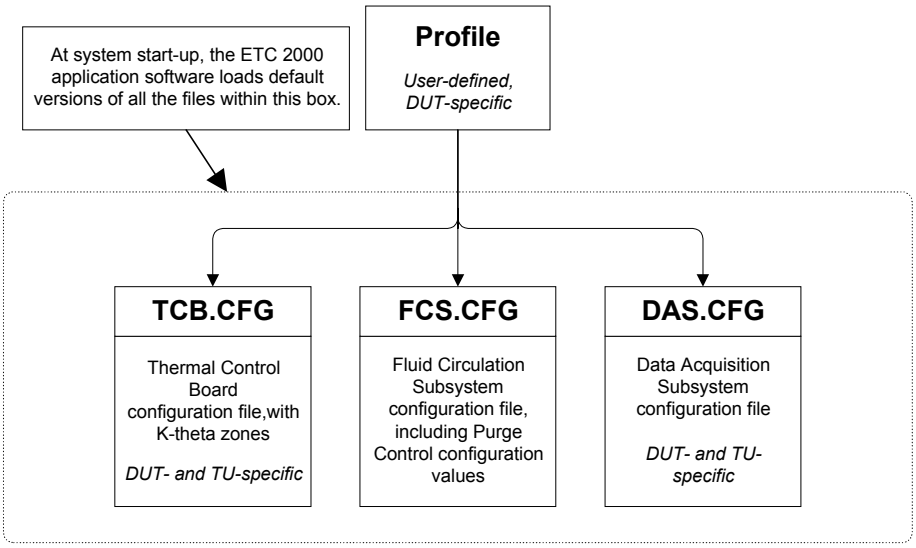


Figure 4-10. Setup File Relationships

4.9.3.2. Values for a Typical Profile

Refer to the ETC 2000 *Maintenance Manual* Chapter 9, *System Configuration* (P/N 7003110009) for an explanation of the values entered to create a profile. Profile creation and modification are engineering functions which are not accessible to Operator-level logins.

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4.9.3.3. Creating a Profile

To make a new profile:

1. ***Either*** click the Navigator button at the top right of the main screen, and select the View Profile button,

   or click the View Profile button at the lower right of the main screen

2. The Select & Edit A Profile screen opens, superimposed on the main screen. Figure 4-11 shows the screen with a single-sequence profile already loaded, and edit enabled.

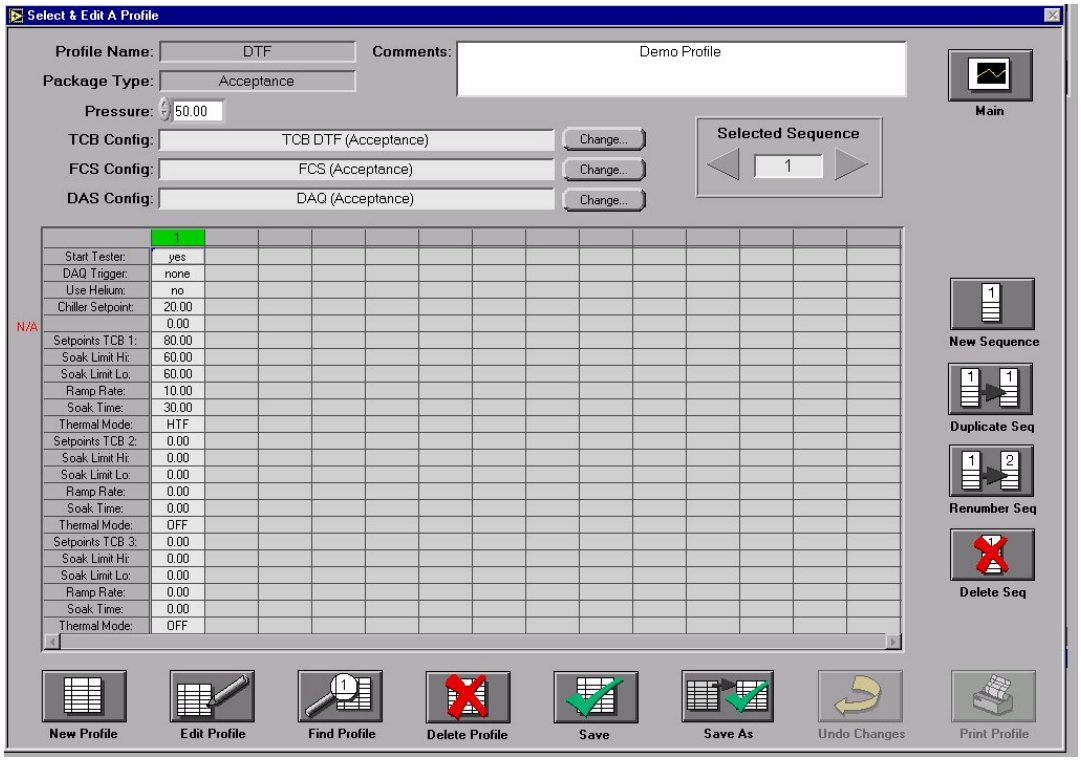


Figure 4-11. Select and Edit Profiles

3. Click the New Profile button at the bottom left of the Select & Edit A Profile Screen. The screen will re-appear, with its edit functions enabled.

NOTE:	It is also possible to open an existing profile, modify it using the edit functions, and then use the Save As button to save it under a new name.

4. Use the trackball to move the insertion point from row to row and column to column, in order to enter sequence values in the table. Sequences may be selected using the arrow keys at the upper right. Use the trackball to position the cursor in the boxes in the top third of the screen, to enter profile configuration information.

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Buttons to the right of the screen perform the actions shown in Table 4-1:

Table 4-1. Profile Create/Edit Button Actions

Button Label	Action
New Sequence	Inserts a new sequence in the currently selected column.
Duplicate Seq	Duplicates the currently selected column as a new sequence, to the right of that column.
Renumber Seq	Moves selected sequence to a different position in the profile. (e.g. makes current sequence 4 into second sequence.)
Delete Seq	Deletes the currently selected sequence.
Arrow-shaped buttons	Move between sequences

5. To select from a list of available configuration files, click the Change buttons next to the configuration file fields at the upper left of the screen. Once a file has been selected, click OK to return to the profile editing screen.

6. When all the appropriate files and values have been entered, click the button marked Save or, if you are creating a new profile based on an existing one, click the button marked Save As.

CAUTION: **To avoid overwriting an existing profile you wish to keep, use the Save As button when creating a new profile based on an existing one.**

7. When prompted, enter a name for the new profile. Descriptive filenames are encouraged, in order to facilitate retrieval of the correct profile.

8. To return to the main screen, click the button labeled Main, at the top right of the screen.

4.9.3.4. Accessing an Existing Profile

To open a profile that already exists, click the Find Profile button, either on the main screen or in the Select & Edit A Profile screen. A screen like the one shown in Figure 4-12 will open. The left pane lists the folders containing profiles. When clicked with the trackball cursor, each of these expands to show the profiles created for that package type.

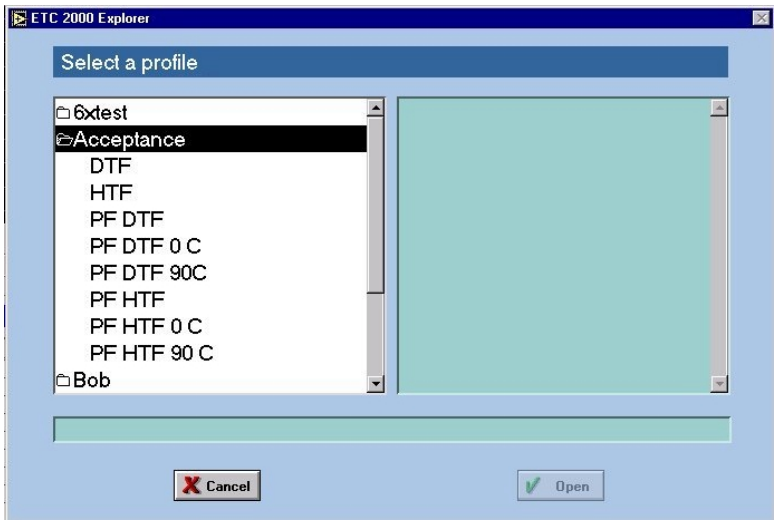


Figure 4-12. Select a Profile to Open

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When a profile is selected from the left pane, its contents appear in the right pane. Figure 4-13 illustrates the result of selecting one of the profiles listed under 'Acceptance.' Clicking the Open button returns the user either to the main screen or to the Select & Edit A Profile screen, depending on where the Find Profile button was clicked. In either case, the new profile is now loaded.

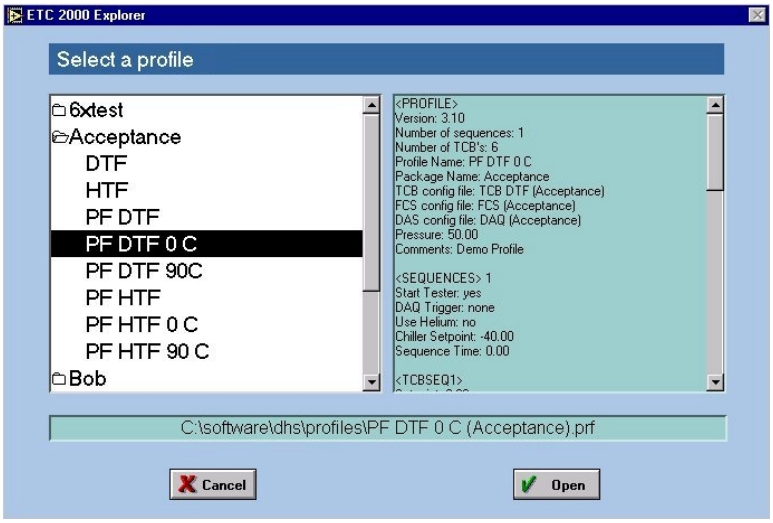


Figure 4-13. Select a Profile to Open: Profile Showing

4.9.3.5. Editing a Profile

Once the desired profile has been opened, clicking View Profile – either from the main screen or from the Navigator toolbar – opens the Select & Edit a Profile screen. Once this screen is open, follow this procedure:

1. Click the Edit Profile button at the lower left part of the screen in order to enable the editing functions (see Figure 4-11).
2. Use the trackball to move from row to row and column to column, in order to enter sequence values in the sequence table in the lower two thirds of the screen. Use the trackball to position the cursor in the boxes in the top third of the screen, and enter profile information in the appropriate places.

   Buttons to the right of the screen perform editing functions while creating a profile: Refer to Table 4-1 on page 17 for an explanation of these buttons.
3. When all the appropriate values have been entered, click the button marked Save or, if you are want to create a new profile based on the one you opened, click the button marked Save As.

   If you select Save As, when prompted enter a name for the profile. Descriptive filenames are encouraged, in order to facilitate retrieval of the correct profile from the Select a profile to open: list.
4. To return to the main screen, click the button labeled Main, at the top right of the screen.

4.9.3.6. Saving a Profile

As indicated in the procedures described immediately above, while the Select & Edit A Profile window is open, a profile may be saved under the same name (Save) or as a new profile under a different name (Save As) by clicking the appropriate buttons at the bottom of the screen.

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4.9.3.7. Deleting a Profile

To delete a profile from the Select & Edit A Profile window, make sure that the profile you wish to delete is open, and click Delete Profile at bottom center of the window.

4.9.4. K-Theta Zones

4.9.4.1. Overview

To account for differences in DUT-to-TU thermal resistance over a range of set points in Power Following (PF) mode, the Show K Theta Zones feature of the TCB configuration screen permits the selection of five different K-Theta settings.

4.9.4.2. Setting K-Theta Zones

Thermal control configuration is a maintenance function. Refer to the ETC 2000 *Maintenance Manual*, chapters 5, *Calibration* (P/N 7003110005), and 9, *System Configuration* (P/N 7003110009), for parameters and procedures for setting K-Theta zones.

4.9.5. Setting the Socketing Pressure

The socketing pressure is controlled by an electronic regulator mounted on the pneumatics panel on the back of the door at system side 3. The pressure is set by a parameter in the profile.

NOTE:	The force value set in the profile is a multiple of the value displayed by the regulator. The latter value should not be confused with the socketing force.

For details on setting the socketing pressure parameter in a profile, and the relation of the regulator readout to profile parameter, refer to section 5.4 of Chapter 5, *Calibration* (P/N 7003110005) of the ETC 2000 Maintenance Manual.

4.9.6. Collecting and Saving Data

NOTE:	The settings described in this section and in section 4.9.7 are accessible only to log-ins above Operator level. The information provided here is presented as an overview for operators. For a detailed description of these options and settings, refer to Chapter 9 (*System Configuration*, P/N 700311009) of the ETC 2000 *Maintenance Manual*.

Data acquisition is controlled through the Data Acquisition Subsystem (DAQ) and Data Handling Subsystem (DHS) maintenance windows.

4.9.6.1. The Data Acquisition Subsystem (DAQ) Maintenance Window

In the DAQ window, data from each channel may be selected using the Save and Plot buttons; the former causes the system to write data to a file, the latter to display a trace in the on-screen graphic display. Data may be saved in either Raw or Scaled format, by toggling the File Storage Controls button.

The profile DAQ Trigger parameter controls whether or not data are collected.

4.9.6.2. The Data Handling Subsystem (DHS) Maintenance Window

Once data collection has been selected in the DAQ maintenance window, a storage location can be selected in the DHS maintenance window, by clicking the Change Data Path button.

NOTE:	While data files may be stored in a user-defined location, configuration files are kept only in the directory structure described in Table 4-4.

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Select the button labeled DHS from the main maintenance selection screen to open the DHS maintenance screen. This screen permits the user to delete superseded or unused configuration file, and to change the location in which data files are saved. Data files may be saved on the system's own hard drive, or on a network drive.

In the DHS maintenance screen, a row of buttons allowing the user to select the type of file to delete – PandP (Packages and Profiles), TCBconfig, DASconfig and FCSconfig files. Once one of these buttons is pressed, the table below the buttons displays all available files. Individual files may be selected and deleted by clicking the button labeled Delete File. The name of the selected file appears in a field at top right of the table.

4.9.7. Saving Test Data

The DHS folder described in section 4.14 also contains a Data subdirectory. This is the default location for data collected during testing. Files in the Data folder will be exported routinely for data analysis, and usually need not be backed up.

NOTE:	The files in the Data folder may be quite large. Once current files have been exported for data analysis, it is best to delete the files on the ETC 2000's system controller's drive, in order to ensure that free space remains for further data collection. Refer to section 4.9.7.1, immediately below.

4.9.7.1. Guarding Against Filling the Hard Disk Drive



CAUTION:	**If data collection is left running indefinitely, the system controller's hard drive will become full, causing the system to crash. Observe the precautions listed below in order to avoid system failure and possible loss of data.**

Once data have been collected, be sure to copy the files either to floppy disks or (since data files usually are large) to a network drive, and delete them from the ETC 2000 system controller's drive.

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4.10. System Operation

Once a profile has been selected and loaded, and the Select & Edit A Profile window closed, the lower left two-thirds of the main screen lists the profile configuration and calibration files, and shows a table of the settings stored in the profile's sequences. Each sequence occupies one column in the profile setup data display.

4.10.1. Profile Control: Overview

The ETC 2000 offers three ways to run a profile:

- In normal (continuous) mode
- By manually selecting sequences using the Select/Skip option
- Remotely, via the GPIB

4.10.1.1. ETC 2000-Controlled Profiles

Normal mode is the default state of the system. Manual and GPIB Control modes are selected by clicking the appropriate buttons at the right of the screen.

Repeat Profile mode runs the profile continuously until it is aborted, while manual mode allows the operator to enter thermal control values from a window (Figure 4-19) superimposed on the main screen. GPIB Control mode is used when communication with a tester is established. Figure 4-14 shows the features of the main screen.

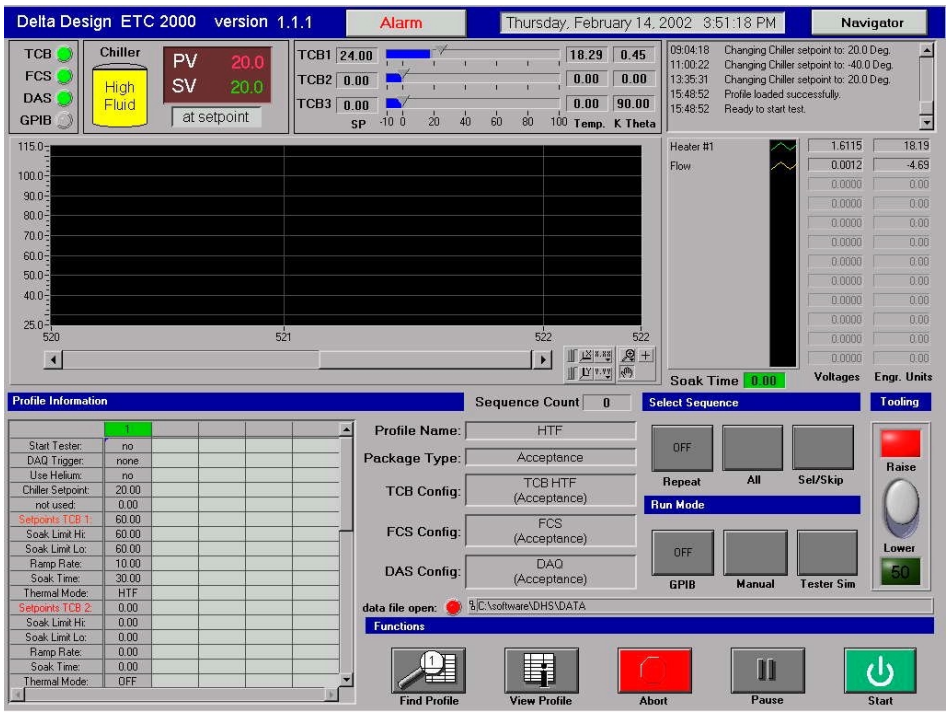


Figure 4-14. ETC 2000 Main Screen

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Once the Start button is pressed, if the system is operating in its stand-alone configuration the operator is given the reminder shown in Figure 4-15:



Figure 4-15. Close Chamber Reminder

Figure 4-16 and Figure 4-17 show two views of the main screen, each with traces generated from PF-DTF (Power Following™ with DUT temperature feedback) profiles, run using the Tester Simulator (Figure 4-18) in its continuous mode.

In the first instance, a profile using TCB1 is still cycling. The power input to the DUT (purple trace) is compensated by variations in the heater temperature (green trace); these variations keep the DUT temperature (red trace) within 2.5 degrees C of the 90 degree C set point. The chiller is set to 30 degrees C, giving a high delta T to enable optimum response to power inputs to the DUT.

Note that the Soak Time field is green, indicating soak is completed, and the Start and Abort buttons are grayed.

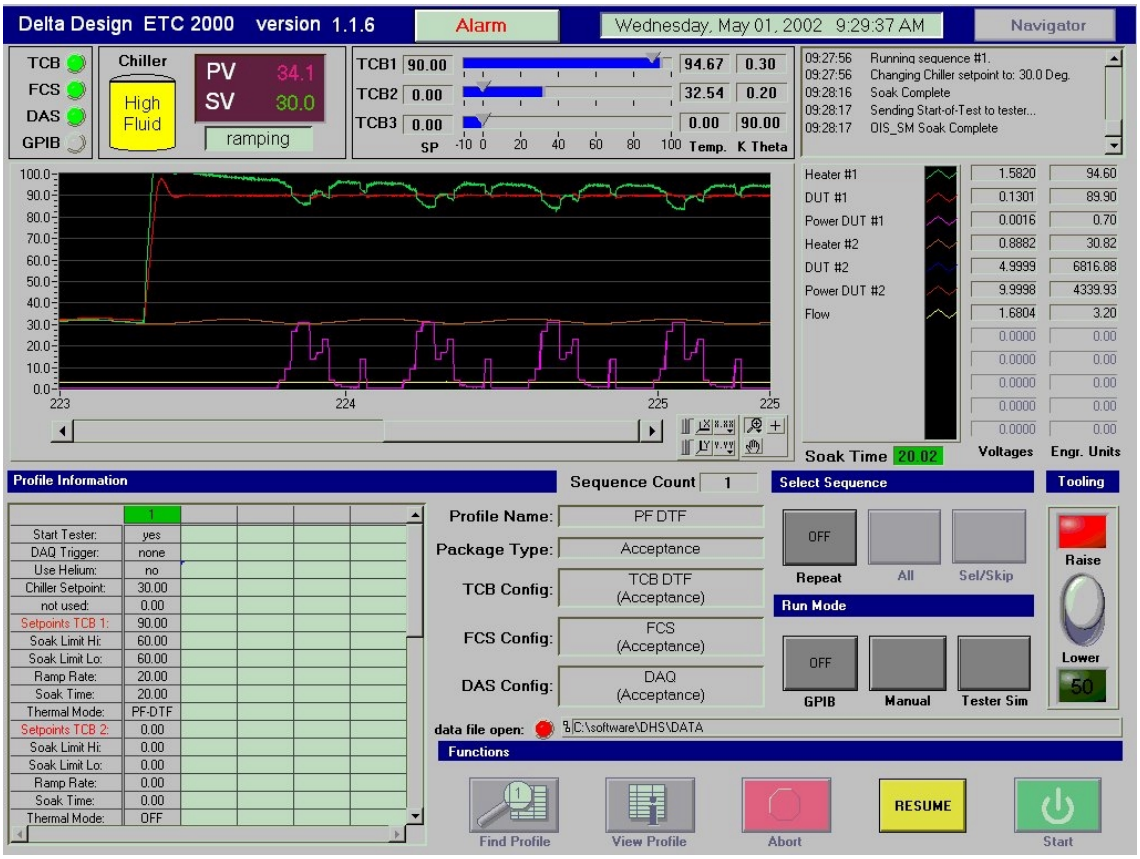


Figure 4-16. Main Screen, Profile Running: PF-DTF, Hot, Channel 1

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The second figure shows a 0 degree C profile using the second thermal channel, labeled TCB2 on screen. The chiller has been set to -40 degrees C.

In this case, the profile has just been terminated, as indicated by the Heater #2 and DUT #2 traces (yellow and blue traces) falling to match the chiller fluid temperature, and the Power DUT #2 (the red trace) going flat at zero.

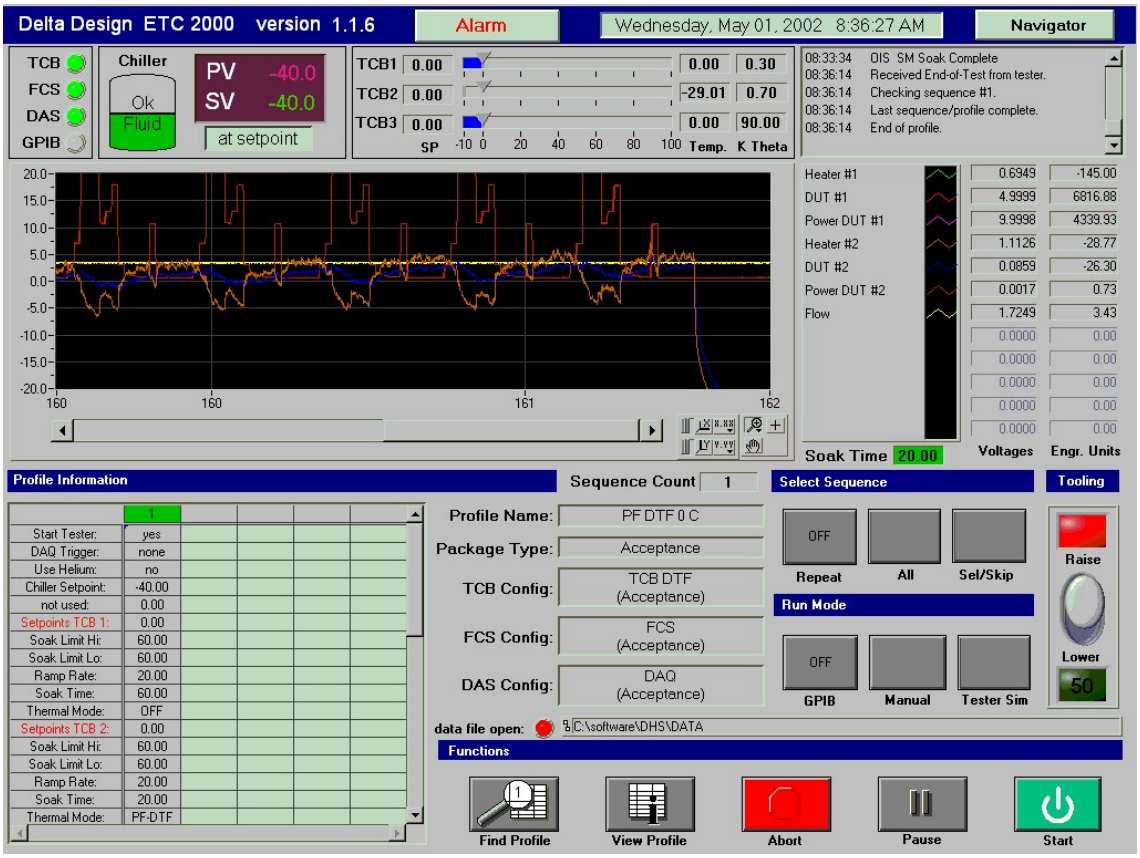


Figure 4-17. Main Screen, Profile Running: PF-DTF, Cold, Channel 2

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4.10.2. Tester Simulator

The Tester Sim button opens the screen shown in Figure 4-18. In combination with an external power source, load board and socket, this utility simulates the power inputs of a tester to the DUT and permits Power Following™ profiles to be run for troubleshooting and validation purposes.

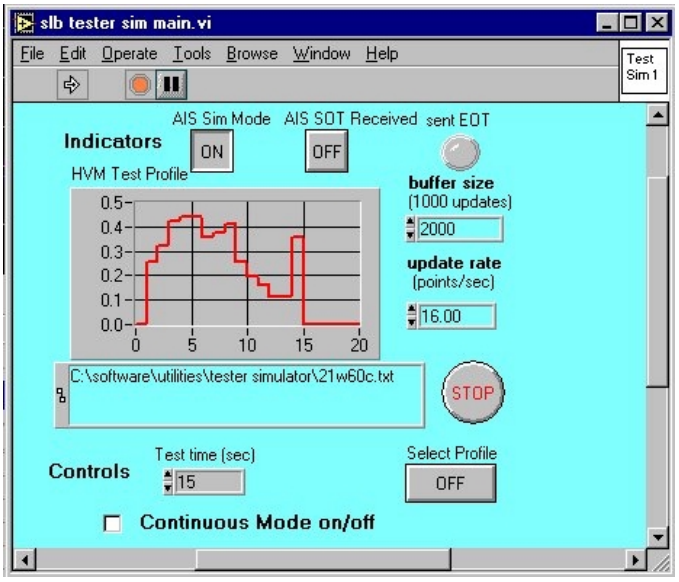


Figure 4-18. Tester Simulator

4.10.3. GPIB: Control by Tester

General Purpose Interface Bus (GPIB) is enabled by clicking the GPIB Control button in the Run Mode section at the lower right of the main screen (Figure 4-14). A green indicator at the top left of the main screen shows when the GPIB is enabled.

With GPIB enabled, the tester can control the ETC 2000. A single-sequence profile is used to initiate tester-to-GPIB control.

NOTE:	The ETC 2000's Start button is disabled when the tester is in control, and the reminder to close the environmental chamber (Figure 4-15) is not displayed.

The tester may command set point changes while a profile is running. As it continues to send its series of set point commands to the RT board, it reads temperature measurements, and issues a stop profile command when testing is complete.

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4.10.4. Manual Control

Clicking the Manual Control button in the Run Mode section of the main screen (Figure 4-14) opens the window shown in Figure 4-19.

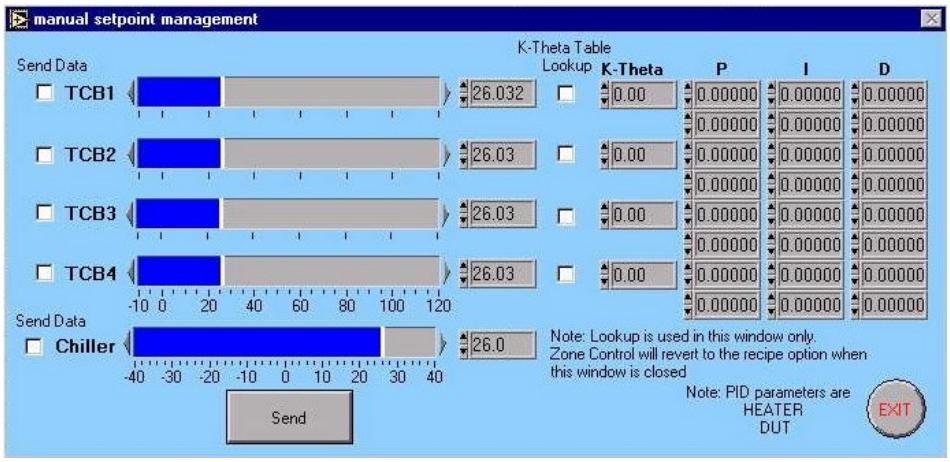


Figure 4-19. Manual Control Mode Window

To set the set point of a TCB, the OFF/ON check box next to its name must be checked. Then the temperature may be set in one of three ways:

- Dragging the bar across the chart and watching the digital read-out to the right.
- Entering a number into the digital readout field.
- Using the up and down buttons to the left of the digital readout to increase or decrease the figure.

Once the desired figures are set, clicking the Send button communicates the settings to the thermal control RT board and the FCS. To leave manual mode, click the EXIT button. Focus is returned to the main screen, where selecting Start runs the system with the values entered in the currently-loaded profile.

4.10.4.1. K-Theta/K-Theta Table Lookup

If the K-theta lookup box is checked, the system will ***not*** use the value entered in the K-theta field in this window; instead, it will use the look-up table to compute a value of K-theta appropriate for the current set point, and this value will appear in the K-theta field.

If the box is not checked, K-theta is fixed at the value entered in the K-theta field.

4.10.5. Manual Selection of Sequences from a Profile

It is also possible to select sequences from a profile manually, including some and excluding others.

1. Click the button at center right labeled Select/Skip. The Select Sequences window appears, superimposed upon the main screen.
2. In the left pane of the Select Sequences window, click sequence numbers, or use the track-ball to highlight a sequence number. Double-click using the left track-ball button to deselect the sequence. Selected sequences appear with a check mark to their left; deselected sequences show no check mark.

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NOTE:	The details of sequences may be viewed on the main screen, where the profile setup data are still visible at lower left. Click the scroll bar below the data in order to scroll right or left to view additional sequences in the profile.

3. Once all the sequences you wish to run are checked, and those you wish to skip unchecked, click OK or, to abort the selection, click Cancel.
4. Click to highlight the header of the profile you want to run first.
5. Run the profile as normal, by selecting Continuous or Step mode, and then clicking Start.

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4.10.6. Running the System: DUT Exchange and Thermal Control

Table 4-2 details the operator's actions when testing DUTs, together with the system's actions and purpose or effect of each operation. This description assumes that:

- System Power is ON
- The application software is booted
- An operator log-in is in effect

NOTE:	In **linear mode** amplifier systems (with Power Ten amp), the enable lights on the front of the thermal control chassis illuminate when HVPS is turned on. In **switch mode** amplifier systems, the enable lights only illuminate when the START button is selected to run the profile.

- HVPS is ON
- No DUT is in socket
- Helium and system air (for low setpoint purge in stand-alone configuration) are present

Figure 4-20 shows a chamber raised to permit access to the socket for the exchange of DUTs:

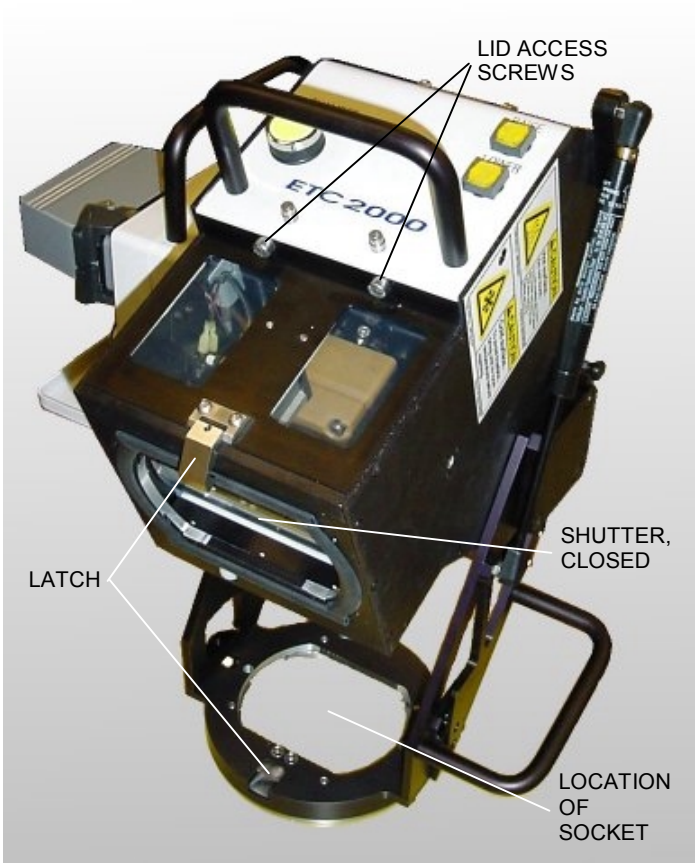


Figure 4-20. Environmental Chamber, Open for DUT Exchange

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NOTE:	References in Table 4-2 to pushing UP or DOWN buttons refer both to the hardware buttons mounted on the environmental chamber and to the cursor-clickable virtual buttons in the on-screen display. Both sets have the same effect.

Table 4-2. Sequence of Operation

Step	Operator Action	Machine Action/s	Effect/Purpose
1	Push the UP button.	If down, the pusher is now raised, placing TU in its up position; if open, the shutter closes.	Ensures proper pusher position for socket access, plus prevents hand access to face of TU
2	Push the CHAMBER ACCESS button.	The pneumatic system unlatches the chamber from the socket interface; the HVPS remains enabled.	Chamber body unlatches from socket interface, gas cylinder slowly raises chamber
3	Use the handle to raise the chamber off the socket.		Helps lift chamber up out of the way.
4	Insert a DUT into the socket.		Positions DUT ready to test.
5	Use the handle to push the chamber down against its latch.		The system is ready for application of socketing force.
6	Push the DOWN button.	The shutter opens. An open position switch enables the socket actuating cylinder, which lowers the TU onto chip and applies the socketing force specified in the profile. The Down button is lit.	Prepares system for thermal control of DUT in socket, and running thermal profile & test sequence.
7	Observe the completion of the move commanded in step 6, then start profile.	The profile starts: The Start button is grayed and the system ramps the DUT to temp. When the DUT is ready, the system signals the tester and the test sequence is run. On receiving the EOT message from the tester, the system runs the balance of profile.	Tests DUT at set temperature/s.



WARNING:	***The profile should be set up so as to return the DUT to a safe-to-touch temperature after the last step of the sequence. Depending on the test set point/s in use, the DUT may be very hot or very cold after testing.***





CAUTION:	**DO NOT press the UP button, or select UP from the on-screen display, until the test sequence is finished. Damage to the DUT and/or socket can result from premature release of socketing pressure.**

8	Observe on-screen display for completion of profile, then push UP button.		
9	Press the CHAMBER ACCESS button.	Pneumatic system unlatches chamber from socket interface; pneumatic system disabled, the HVPS remains enabled.	Chamber body unlatches from socket interface, gas cylinder raises chamber; disabled cylinder/closed shutter ensures operator safety. See Figure 4-20.
NOTE:	If shutter is opened by some means while the chamber is up, the HVPS is turned off and can only be re-enabled once a safe condition is restored.		
10	Remove tested DUT and insert a new one. Repeat steps 5 through 10.		

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4.10.7. Viewing the Graphic Display of Thermal Data

The upper left portion of the ETC 2000 application software's main screen shows a graphic display of temperature, power and flow rate traces. This consists of a set of color-coded line graphs which show a real-time representation of values from a variety of sources. The y-axis represents the variable values (temperature, power or flow rate), and the x-axis represents time. The traces advance in a positive x direction.

At any time, eight traces may be displayed.

To the right of the graphic display, boxes show the precise value for each trace in both voltages (left) and engineering units (right). These readouts are helpful in assessing DUT deviation from set-point with best accuracy. In order to gain a general impression of the progress of a profile, the graphical traces give the clearer picture.

4.10.7.1. Clearing the Display

To clear the display of traces, right click on the chart and select "Clear Chart" from the menu which appears.

4.10.7.2. Configuring Traces

The trace labels and color codes are user-configurable. To change the labels, do the following:

1. Click the Navigator button at the top right of the main screen.
2. Select Maintenance from the Navigator toolbar.
3. Select the SETUP button from the maintenance selection screen.
4. In the screen which opens, modify the chart settings appropriately.
5. Select the DAQ button.
6. In the screen which opens, the name and color rows determine how the data appear in the graphical display. Placing the cursor within the appropriate field and clicking with the left trackball button opens a color palette or enables a new or modified name to be typed in, depending on which type of field you have selected.
7. Gain limits and calibration values (for Alpha, Beta and R0) may be edited here, in the appropriate rows. Refer to Chapter 9, *System Configuration* (P/N 7003110009) of the ETC 2000 *Maintenance Manual* for details on DAQ setup options.
8. Once all the changes have been made, click the button marked Save.
9. Select Main from the Navigator toolbar to return to the main screen.

4.10.8. Adjusting Scale and Format for the Graphic Display

The on-screen graphic display of thermal control data may be formatted using the display control palette. Refer to Chapter 3 of this manual, *Operating, Maintenance and Configuration Screens* (P/N 7003100003), section 3.5.8.2., for an explanation of the use of this palette.

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4.10.9. Ending a Profile

A profile may be ended:

- when the operator clicks the Pause and then the Abort button.
- by an End of Test (EOT) signal sent by the tester after the last sequence has run.
- if no was selected for the Start Tester parameter in the profile, the profile will end after temperatures are obtained and soak completed on the last sequence.



CAUTION:	**Abort will stop the profile, but will not interrupt the tester. Do not press the UP button or open the chamber until the tester has completed its test.**

4.10.10. Data Analysis

The ETC 2000 saves acquired data in flat files, which may be exported for off-line analysis.

4.11. Emergency Operating Procedures

Section 2.7 of Chapter 2 of this manual, *Safety Hazards and Precautions* (P/N 7003100002) details emergency operating procedures. These specify how to restore the system to a safe state, or to achieve a safe state in preparation for re-start, when certain errors have occurred.

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4.12. Shutting Down the System

4.12.1. Shutdown Procedure

To shut down the ETC 2000:

1. If necessary, take the appropriate steps to remove the DUT from the socket.
2. Click the Navigator button on the main screen.
3. On the Navigator toolbar, click the Exit button.
4. Select Start | Shut Down | OK from the Windows desktop.
5. When the on-screen display indicates that it is safe to do so, press System Power OFF, to the right of the EMO button.
6. Turn the main breaker (on the facilities panel at side 2 of the system) CCW to its OFF (9 o'clock) position.
7. If necessary, turn off and disconnect facilities air and helium supplies, and disconnect the AC power cable from the facilities panel.

4.13. Managing User Names and Passwords

Only Engineer-level logins can modify user names and passwords. The Users button on the Maintenance Selection screen gives access to this function.

Note that after logging in at machine start-up, logging out returns the system security level to a null state from which only the Log In/Log Out screen is accessible, via the Navigator Toolbar.

The login security levels are shown in Table 4-3:

Table 4-3. Login Security Levels

Level	Access/Capabilities
Nobody	The default when no user is logged in. Can see some screens, but cannot modify any values or perform any operation.
Operator	Can select and run profiles.
Supervisor	Has all the capabilities of an Operator, and can also modify and delete profiles and set up and execute a manual profile.
Engineer	Has access to all machine functions, including all Maintenance capabilities. Can also manage user names and passwords.

4.13.1. Adding a User

To add a user, follow this procedure:

1. Access the Users maintenance screen: select Navigator | Maintenance | Users.
2. Click the Enter User button.
3. In the screen which appears, enter the user's name, password, employee number, and security level. Security level is set by using the up and down arrow symbols to click through the three options.
4. Once all the fields are complete, click OK. The Users maintenance screen reappears, with the new user showing in the pick list to the left.
5. To exit the Users maintenance screen, click Navigator | Main. The main screen will reappear.

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NOTE:	To log on as the newly added user, it is necessary to go through the Log In/Out screen, accessible by clicking Navigator | Log In/Out.

4.13.2. Modifying a User's Information

In order to modify a user's information – change the name or password or security level – the user must be deleted, then re-added using the procedure described in section 4.13.1, above. To delete a user, click the Delete User button on the Users maintenance screen, and answer positively to the confirmation dialog that appears.

4.14. Saving System Configuration Files

The system uses a number of configuration files, each of which is critical to its correct operation. Many of these files include DUT-specific values and user-selected calibration and configuration information. It is important to save and back up these files regularly. Table 4-4 lists the locations from which files must be backed up.

Table 4-4. Files to be Backed Up

C:\software\DHS\profiles*.*
C:\software\DHS\TCB*.*
C:\software\DHS\DAS*.*
C:\software\DHS\FCS*.*



CAUTION:	**The four directories listed in Table 4-4 are interconnected – files they contain refer to one another. All four must be backed up or restored at the same time.**

The contents of the three folders under the DHS directory should be saved to diskette, or to a network drive, so the folders can be restored in case any files become damaged or lost. Ideally, this backup operation should be carried out whenever new configuration files are added (such as those associated with new tooling), or after any modification of existing files.

In general, the routine should be as follows:

1. Save data to a storage/analysis location, and delete the files from the system controller hard drive.
2. With data files deleted, the configuration files listed above may be copied to a floppy disk.

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Chapter 5: Error Recovery Guide

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5. Error Recovery Guide

5.1. Introduction

This chapter explains how to interpret and recover from errors that may occur during ETC 2000 operation.

5.2. Basic System Recovery Procedure

5.2.1. Restarting the System after EMO or Facilities Power Loss

When the EMO button has been pressed, or facilities power is interrupted, while a profile is running, to complete the profile it is necessary to power up the ETC 2000 and re-run it. Refer to Chapter 4 of this manual, *Operating Procedures* (P/N 7003100004), for a detailed procedure for starting the machine.

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5.3. Information about Errors and System Status

5.3.1. Introduction

Error and status messages provide the operator with information about problems with the system.

Figure 5-1 shows the location of error and status information on the ETC 2000 application software's main screen. Each subsystem maintenance screen (accessible via Navigator | Maintenance) provides additional information on the status of that subsystem.

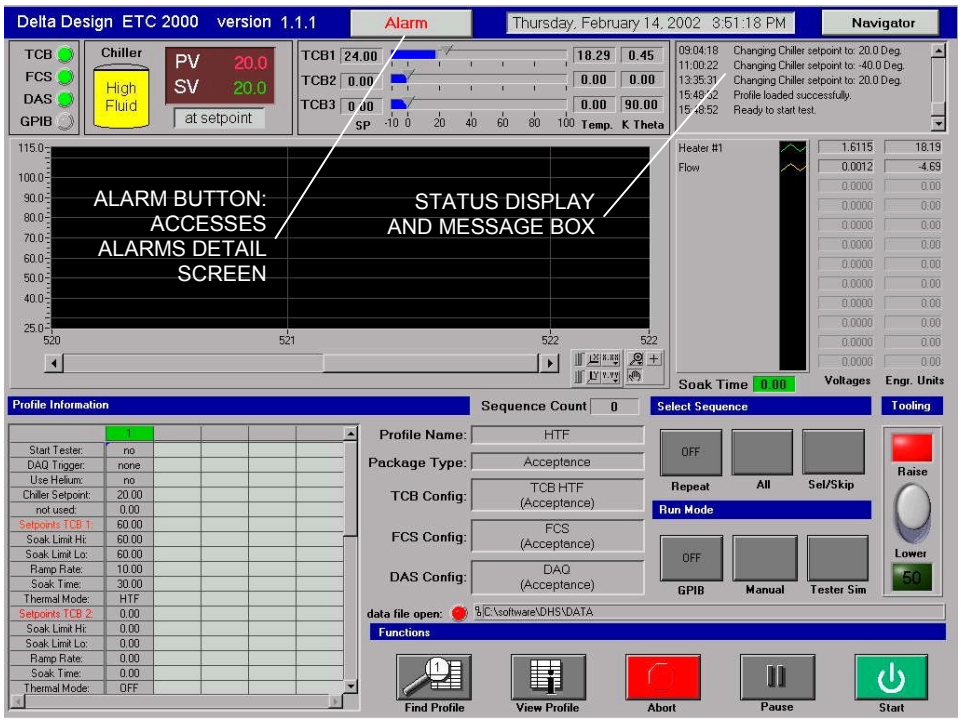


Figure 5-1. ETC 2000 Main Screen, Showing Location of Error Messages

The main error display features are noted in Figure 5-1:

- The status display and message box shows the time and content of all status information passing between the system controller and the subsystems. Messages scroll upward, but they can be reviewed using the trackball cursor to move the scroll bar at the right of the panel.
- The Alarm button flashes red to indicate an alarm condition. Clicking this button opens the screen shown in Figure 5-2, which explains alarm conditions and allows the operator to acknowledge the alarm.

NOTE:	An alarm may re-set itself without operator intervention, if the condition causing the alarm is no longer present.

Other information is provided by the communication and status lights, which show the status of communication between the system controller and the ETC 2000's subsystems, and between the system controller and the tester.

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Figure 5-2 shows the alarms list in red, indicating that the alarms have not been acknowledged:

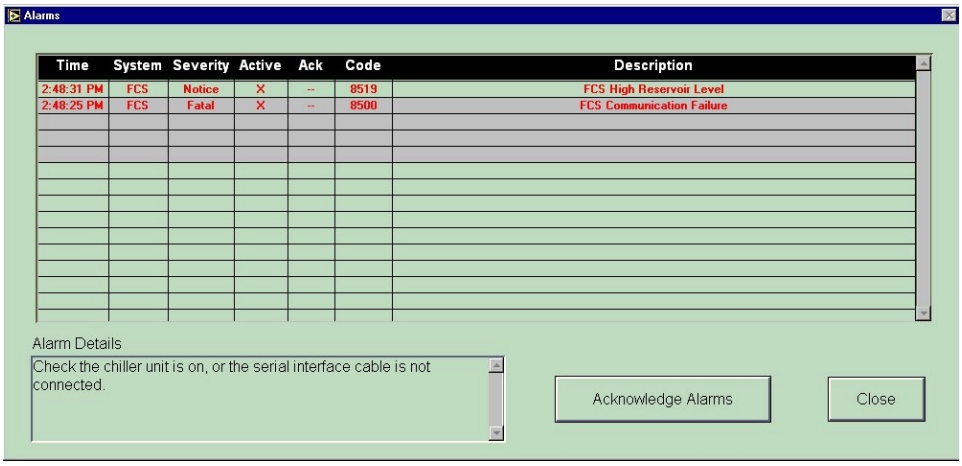


Figure 5-2. Alarm Screen

Table 5-1 shows the format for alarms listed in the screen shown in Figure 5-2.

Table 5-1. Color Key to Alarm Display

Color	Alarm Status
Red	Current
Blue	Acknowledged but not cleared
Green	Cleared

5.4. Errors, by Subsystem

5.4.1. Generic Error Recovery Procedure

Typically, when an error arises the subsystems involved are named in the error message and status display box at the top right of the main screen. Fatal errors automatically abort a running profile; in order to protect the DUT, it is not possible to abort a profile manually after the Start of Test (SOT) signal has been sent to the tester.

If an error occurs which does not abort the profile, click the Alarm button (top center of the main screen). The alarm screen will open, displaying the error/s, the subsystem/s involved, and some information about possible cause/s. Note this information, and then clear any alarms showing in the alarm screen (see Figure 5-2).

Once an error has occurred, this general procedure should be followed:

1. Select Navigator | Maintenance, and touch the button corresponding to the subsystem for which an error has been reported.
2. Check the subsystem maintenance screen/s for improper values. Some subsystems include diagnostic tools for checking subsystem status.

   For instance, the FCS screen includes a number of status indicators, which report various types of errors in the FCS.
3. In the profile information windows (the main screen, and the Select and Edit A Profile window), where configuration files are listed, check that the files are

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correctly selected. If possible restore an earlier version of the same file, in case the current files have become corrupted.

5.4.2. Error Levels

Table 5-2 summarizes ETC 2000 error levels. Recovery options for each type of level are described in sections 5.4.1 to 5.4.7 of this chapter.

Table 5-2. Error Levels

Error Level	Explanation/System Status
Fatal	Stops profile, shuts down TCS, turns heater off, sets chiller to idle temp
Warning, Operator Intervention	Indicates a bad configuration: select different driver and retry
Warning, Information	System OK: provides user with information.

5.4.3. Digital Input/Output (DIO)

Table 5-3. DIO Errors

Status Screen Text	Description	Action/Recovery
Initialization failure	The program's path is incorrectly specified; the application software cannot load.	From the desktop, in Windows Explorer, check that the application software is installed in the correct directory *or* change the path specified in the profile to make the software accessible.
Cannot execute command or failure	The DIO Maintenance screen cannot be loaded, because the software is inaccessible.	From the desktop, in Windows Explorer, check that the application software is installed in the correct directory *or* change the path specified in the profile to make the software accessible.

5.4.4. Thermal Control RT Board (TCB)

Table 5-4. Thermal Control RT Board Errors

Error Text	Description	Level	Recovery
TCB Heater Overtemp Limit	The device temperature has exceeded the setpoint and high limit. Set in TCB maintenance screen.	Fatal	Indicates that the temperature during soak, or at a change in setpoint (as during manual or GPIB control) exceeded or fell below the selectable value set in TCB configuration file. Typically, an Undertemp error means the TU is not connected.
TCB Heater Undertemp Limit	The device temperature has fallen below the setpoint and low limit. Set in TCB maintenance screen.	Fatal	
TCB Heater Overtemp **TCB Heater Undertemp**	The TCB has read a TU temperature exceeding the limit value of approximately 115 degrees C.	Fatal	Check tooling calibration coefficients in TCB configuration screen. Troubleshoot tooling and TCB. Check pre-amplifier and amplifier in TCS chassis for shorts.
TCB Communication Failure	The system controller and the TCB are not communicating. This error is initiated after all specified retries have been exhausted.	Fatal	Thermal control RT board may be faulty.

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5.4.5. Thermal Control Subsystem (TCS)

Table 5-5. TCS Errors

Error Text	Description	Level	Recovery
TCS loss of soak	The measured temperature is outside the temperature range set in the profile by the Soak Limit Hi and Soak Limit Lo parameters.	Fatal	Check that the HVPS is on. If the system is being run for the first time, increase the profile parameter values to give a wider range. Check that the tooling calibration coefficients are correctly entered in the TCB configuration screen. Troubleshoot the tooling and the TCB/s.
TCB1 temp error at test **TCB2 temp error at test** **TCB3 temp error at test**	The temperature measured during test by the named TCB (1, 2 or 3) is outside the range set in the TCB configuration screen by the Test Temp Err Hi and Test Temp Err Lo parameters.	Fatal	If the system is being run for the first time, increase the TCB configuration values to give a wider range. Troubleshoot the tooling, HVPS and TCB/s.

5.4.6. Fluid Circulation Subsystem (FCS)

NOTE: Many of recovery options listed below must be carried out by a technician who has completed the Delta Design Columbus training class and, in some cases, by a licensed refrigeration technician.

Table 5-6. FCS Errors

Error Text	Description	Level	Recovery
FCS Communication Failure	Communication failure between the system controller and the FCS. Initiated after all specified retries have been exhausted.	Fatal	Check that the chiller unit is on; check that the serial interface cable is connected.
FCS Not Loaded	The FCS is offline due to initialization failure, bad calibration or configuration file, etc.	Fatal	Check the serial port assignment; check for valid setup files.
FCS Initialization Failure	Initialization failure because the assigned serial port defined by default or configuration file cannot be allocated for FCS.	Fatal	Check the communication port through Rocket port diagnostic program.
FCS Bad Configuration File	Indicates that the FCS could not read or process the specified configuration file, or has no valid configuration information. (Communication port information)	Fatal	Check the directory and file name of FCS configuration file.
FCS Cannot Execute Command	Occurs when the FCS cannot execute a LabView command. This is a standard ETC 1000 error definition for all subsystems.	Fatal, Notice, or Warning	Check the command. **Note:** Reserved for future use.
FCS Cannot Program Controller	Indicates that the FCS driver could not set the chiller with the set point temperature. The error will be initiated after all specified retries have been exhausted.	Fatal	Check Fuji controller in the chiller.
FCS Overtemperature	The fluid temperature has exceeded a high temperature threshold.	Fatal	Check thermal expansion valve and/or hot gas bypass valve in the chiller.

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Error Text	Description	Level	Recovery
FCS Temp Over Setpoint	The chiller temperature has exceeded the setpoint high alarm limit.	Warning	Check thermal expansion valve and/or hot gas bypass valve in the chiller.
FCS Temp Under Setpoint	The chiller temperature has fallen below the setpoint low alarm limit.	Warning	Check thermal expansion valve and/or hot gas bypass valve in the chiller.

Table 5-7. Error Status from Chiller

Error Text	Description	Level	Recovery
FCS System Fault	The FCS unit has reported a system fault with the unit. The fault reasons are specified further in other faults.	Fatal	Remove fault conditions.
FCS Low Suction Pressure	Low compressor inlet pressure (below 20" Hg) due to malfunctioning hot gas valve.	Fatal	The chiller shuts down by itself. Check the refrigerant level and hot gas valve.
FCS Low Flow Rate	Low or no flow in the chiller EVEN if the pump is on.	Fatal	Check the pump. Check for low HFE level. The chiller shuts down by itself.
FCS Pump Overload	Pump amperage exceeds overload setting.	Fatal	The chiller shuts down by itself.
FCS Low Voltage, Phase Reversal	Polarity of chiller's AC power is incorrect. The chiller cannot start up.	Fatal	Check the polarity of the 3-phase AC supply to the chiller. Refer to ETC 1000 Maintenance Manual, Chapter 12 (*Fluid Circulation and Purge Subsystems*, P/N 7002210012), section 12.4.1.
FCS High Reservoir Level	The reservoir is full of HFE-7100 process fluid. The operator should stop filling the reservoir.	Notice	Stop adding fluid.
FCS Low Reservoir Level	Low level condition in the chiller's process fluid reservoir, due to coolant leakage or evaporative loss.	Warning	Add more fluid to the chiller's reservoir.
FCS High Pressure	High compressor discharge (above 300 psig).	Warning	Check valves in chiller.
FCS Low Refrigerant Level	Low refrigerant level.	Warning	Add more refrigerant to the chiller's refrigeration loop.

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5.4.7. Data Acquisition Subsystem (DAS)

Problems with the DAS typically are caused by hardware failure. The DAQ board is a Field Replaceable Unit (FRU); to troubleshoot persistent DAS errors, replace the DAQ board and check to see whether the error recurs.

Table 5-8. DAS Errors

Error Text	Description	Level	Recovery
DAS Not Loaded	Set when the DAS is offline due to initialization failure, bad configuration setup, etc.	Fatal	Check the NIDAQ hardware.
DAS Initialization Failure	Initialization failure on NIDAQ link.	Fatal	Check the NIDAQ hardware.
DAS Bad Configuration	Indicates that the DAS could not read or process the specified configuration file, or has no valid configuration information. (channel/calibration information)	Fatal	Check the directory and file name of DAS configuration file.
DAS Cannot Execute Command	This situation occurs when the DAS cannot execute a LabView command. This is a standard ETC error definition for all subsystems.	Fatal, Notice, or Warning	Check the command. **Note:** Not currently implemented; reserved for future use.
DAS Data Acquisition Error	Indicates that the DAS system could not acquire data.	Fatal	Check the NIDAQ hardware.
DAS Data Read Error	Indicates that the DAS system could not transfer data.	Fatal	Check the NIDAQ hardware.

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Chapter 6: Troubleshooting Guide

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6. Troubleshooting Guide

NOTE:	This chapter provides general troubleshooting guidelines only. Users with login levels higher than Operator should refer to Chapter 7 (*Troubleshooting Guide*, P/N 7003110007) of the ETC 2000 *Maintenance Manual* (P/N 7003111000).

6.1. Introduction

This chapter provides guidance to operators confronted with problems that surface during machine operation. For problems that cannot be resolved by an operator, the operator is instructed to contact a maintenance technician for assistance.

6.2. Troubleshooting Guidelines

The guidelines provided in this section illustrate a systematic approach to isolating and identifying problems with the ETC 2000.

6.2.1. Troubleshooting Process

Follow the steps below to perform a general troubleshooting procedure on the system:

1. Respond to any safety emergency first, before addressing the machine problem.
2. Document the problem by noting the following:
   - Machine serial number.
   - System Configuration – Number of channels; tooling type and serial number.
   - Software revision level.
   - Profile in use, including package type.
   - Message or messages in OIS Status Window (upper right hand corner of the screen; copy message/s down exactly).
   - Alarm Message, visible when the Alarm button (top center of OIS display) is pressed.
   - System Status (general information about the system's current status – number of parts processed, HVPS on/off, TCB/s enabled).

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- Sequence of Actions before Failure (what the operator did from the time the START button was pressed until the moment when the error occurred)
- Bystander Observations (what took place before and after the error occurred)

3. Review the information above and attempt to troubleshoot the problem systematically.
4. If necessary, contact responsible maintenance personnel.

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ETC 2000 Operation Manual

Purpose

The following chapters make up the ETC 2000 *Operation Manual*.

List of Chapters

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1	Overview	7003100001	01	05.15.02	14
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ETC 2000 Glossary

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Purpose 1

Glossary of Terms 1

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ETC 2000 Glossary

Purpose

This glossary provides definitions of terms specific to the ETC 2000 *Operation* and *Maintenance* manuals, as well as terms in more general use.

Glossary of Terms

NOTE: Cross-referenced items appear in italics.

Term	Definition
AC	Alternating Current.
Acquired data	The data sent to the *DAS* for data transformation and eventual storage.
Acquired data report	A report containing the data acquired from the *DAS*. It is sent to the *DHS* for storage purposes.
Acquired measurements	These measurements are temperature and control data that are monitored external of the controller thermal control processor.
Acquisition request	A request from the operator workstation to the data acquisition subsystem to initialize or enable the data acquisition function.
AIS	ATE Interface Subsystem.
Analysis report	The response the operator receives when an analysis request is submitted.
Analysis request	A request from the operator workstation to the data analysis subsystem to generate an analysis report. The parameters for data analysis are selected by the operator.
Application software	Proprietary software used to run the ETC 2000; programmed using LabView.
CCW / CW	Counter Clockwise / Clockwise
Chiller	Air-cooled refrigeration unit, supplying constant temperature fluid (*HFE*-7500 or HFE-7100) to the *TU*.
DAQ board	Data Acquisition board; a National Instruments device, included in the ETC 2000's system controller. See *NIDAQ*.

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Term	Definition
DAQ status	The status of the DAQ as reported to the diagnostics subsystem.
DAS	Data Acquisition Subsystem.
DC	Direct Current.
ΔT (Delta T)	The difference in temperature between the *FCS* process fluid set point and the Heater temperature. $\Delta T = T_{HTR} - T_{HFE}$.
Device Kit	*DUT*-specific tooling mounted in the *environmental chamber*. The *thermal unit* is pneumatically actuated to provide an adjustable socketing force.
DHS	Data Handling Subsystem. Handles collected data.
DTF	DUT Temperature Feedback: A method of thermal control that measures *DUT* temperature using *RTD*s or thermal diodes (depending on which measuring device the *DUT* incorporates), and reacts to changes.
DUT	Device Under Test.
EMO	**E**mergency **M**achine **O**ff, or **EM**ergency **O**ff; a large red button with yellow background and raised protective surround, which removes all power from the machine (except for line side of K1 relay and the 24VDC EMO power supply) when pressed.
Environmental chamber	The environmental chamber attaches to the *socket adapter* and contains the *Device Kit (DK)*. The upper part of the module is pivoted up to permit *DUT* exchange. When the chamber is in its raised position, a shutter closes to preserve the purged environment. The chamber has a cover and a lid, both tool accessible, which permit access to its internal components, including the quick disconnects used for DK change, and the face of the TU for cleaning.
EOT	End of Test.
ETC	Engineering Thermal Control.
FCS	Fluid Circulation Subsystem.
GPIB	General Purpose Interface Bus.
GUI	Graphical User Interface.
HFE	Dielectric fluid (Hydrofluoroether) used in *FCS* loop to *TU*. The two types, 7100 and 7500, differ in their suitability for different temperature ranges. HFE-7100 and HFE-7500 are trademarks of 3M Corporation.
HTF	Heater Temperature Feedback; a thermal mode using feedback from the heater RTD (*RTDh*).
HVPS	High Voltage Power Supply.
I/O	Input/Output.
IPA	Isopropyl Alcohol – used for cleaning the system.
Kit change time	The time required to convert the system to handle a different package type, including setup via application software.
KΘ (K-Theta)	A measure of the thermal resistance between the *TU* and the *DUT*.
Load Board	See *TIU*.
OIS	Operator Interface Subsystem.
PandP	In *DHS* maintenance screen: Profiles and Packages.
PC	See *System Controller*.

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Term	Definition
PCS	Purge Control Subsystem; supplies dry air and helium to the *environmental chamber* to prevent condensation or icing at low FCS set points.
PCS request	This request is sent by the *TCS* Sequence Process Subsystem to the *PCS*. It includes a request to activate the purge conditioning process.
PCS status	The status of the *PCS* as reported to the diagnostics subsystem.
PF	Power Following: A thermal control mode that uses a "Power to DUT" signal to predict temperature change on the *DUT* and react before the change occurs. Also reacts to temperature feedback from either the *TU heater* or the *DUT*.
PID	Proportional Integral Differential control – the three-term logic applied to temperature feedback data to drive the ETC 2000's thermal control subsystem.
Ramp	The rate (expressed in degrees Centigrade per second) at which the DUT and TU are brought up or down to a set point temperature during a sequence. Parameter set in the *profile*.
RTD	Resistive Temperature Device.
RTDc	A temperature sensor built into the center of the *DUT*.
RTDe	A temperature sensor built into the edge of the *DUT*.
RTDh	The temperature sensor in the *TU* heater.
Soak	The period during which the DUT is held at a set temperature before *SOT*. A possible, but not necessary, stage of a *profile*.
Socket Adapter	The component of the *environmental chamber* which attaches its base to the *TIU*.
Socketing Actuator	Pneumatically-actuated cylinder inside the *environmental chamber*, to which a *thermal engine* (including *TU*) is mounted.
SOT	Start of Test.
System Controller	Personal Computer (PC) used to run the application software, handle system I/O, and pass profile parameters to the *Thermal Control RT Board*.
Thermal Control RT Board	The semi-autonomous device, occupying a PCI slot in the system controller, which runs the *TCS*.
TCS	Thermal Control Subsystem.
Test request	This request is sent to the Tester by the *TCS*. It includes a request to initiate a test of the current *DUT*.
Test response	This response is sent back to the *DUT* Thermal Control Subsystem as a result of a *DUT* test completion. It includes the test result (pass/fail/bin code).
Thermal control response	The response to the thermal control request. It contains the status of the request, along with other pertinent information such as test bin code results.
Thermal control status	The status of the thermal control subsystem as reported to the diagnostics subsystem.
TIU	Test Interface Unit (or *Load Board*). A board mounted on the tester, onto which the DUT is socketed for testing. See also *TIU socket*.
TU	Thermal Unit – includes a thin-film heater, heat exchanger, and thermal measurement device/s. Different package types require specific TUs, and each TU has specific calibration values associated with it, stored in its *Tooling ID* and read by the application software when a *Device Kit* containing the new TU is installed in the system.

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Term	Definition
Thermal Engine	Part of a pneumatically socketed device kit, including a *TU* and pusher module for exerting socketing pressure on the *DUT*.
Tooling ID	Identity EPROM chip incorporated into each TU, from which the system reads the TU-specific calibration data necessary for thermal control accuracy.
Umbilicals	Hardware connecting the main system to the *environmental chamber* at the tester head. The umbilicals include two vacuum-insulated process fluid (HFE-7500) hoses and one bundle of hoses including electrical cables and gas hoses. The process fluid umbilicals connect to the environmental chamber with quick disconnects and are hard-plumbed to the umbilical panel at side 4 of the system; the gas/electrical umbilical terminates in quick disconnects at either end.
Umbilical Support	A mechanism, including a hinged arm, a spring-balanced connector and an umbilical support disk. Together, these components support and position the *umbilicals* in order to relieve strain on the plumbing and quick disconnect at the system umbilical panel, and the quick disconnects at the *environmental chamber*.
V	Voltage.
VAC	AC Voltage.
VDC	DC Voltage.

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