

FLUKE®

Hart Scientific®

9117 Furnace

User's Guide

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1 Before You Start

1.1 Symbols Used

Table 1 lists the International Electrical Symbols. Some or all of these symbols may be used on the instrument or in this manual.

Table 1 International Electrical Symbols

Symbol	Description
	AC
	AC-DC
	Battery
	CE
	DC
	Double Insulated
	Electric Shock
	Fuse
	PE Ground
	Hot Surface
	Read the User's Manual
	Off
	On

Symbol	Description
	Canadian Standards Association
CAT II	OVERVOLTAGE (Installation) CATEGORY II, Pollution Degree 2 per IEC1010-1 refers to the level of Impulse Withstand Voltage protection provided. Equipment of OVERVOLTAGE CATEGORY II is energy-consuming equipment to be supplied from the fixed installation. Examples include household, office, and laboratory appliances.
	C-TIC Australian EMC Mark
	The European Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) mark.

1.1.1 Safety Information

Use this instrument only as specified in this manual. Otherwise, the protection provided by the instrument may be impaired. Refer to the safety information in Table 2.

The following definitions apply to the terms “Warning” and “Caution”.

- “WARNING” identifies conditions and actions that may pose hazards to the user.
- “CAUTION” identifies conditions and actions that may damage the instrument being used.

Table 2 *Warnings and Cautions*



WARNINGS

To avoid possible electric shock or personal injury, follow these guidelines.

HIGH VOLTAGE is used in the operation of this equipment.

SEVERE INJURY OR DEATH may result if personnel fail to observe safety precautions.

Before working inside the equipment, turn power off and disconnect power cord.

HIGH TEMPERATURES PRESENT in this equipment. **FIRES AND SEVERE BURNS** may result if personnel fail to observe safety pre-cautions.

Nothing should be placed over the top of the furnace. The furnace should not be placed under cabinets or tables. Extreme temperatures can be generated out the top of the well. **DO NOT PLACE ANYTHING ON TOP OF THE FURNACE WHILE IT IS HOT.**

DO NOT use this unit for any application other than calibration work.

DO NOT use this unit in environments other than those listed in the user’s manual.

Continuous use of this equipment at high temperatures for extended periods of time requires caution.

Completely **unattended high temperature operation is not recommended** for safety reasons.

Components and heater lifetimes can be shortened by continuous high temperature operation.

This unit contains ceramic fiber or other refractories, which can result in the following:

- May be irritating to skin, eyes, and respiratory tract.
- May be harmful if inhaled.
- Service personnel coming into contact with these materials should take proper precautions when handling them.
- Before maintaining this equipment, read the applicable MSDS (Material Safety Data Sheets).

Follow all safety guidelines listed in the user's manual.

Calibration Equipment should only be used by Trained Personnel.



CAUTIONS

To avoid possible damage to the instrument, follow these guidelines.

DO NOT operate this unit without a properly grounded, properly polarized power cord.

DO NOT connect this unit to a non-grounded, non-polarized outlet.

DO use a ground fault interrupt device.

Never touch the fused silica equilibration (see Section 7) with bare hands.

DO NOT change the values of the calibration constants from the factory set value. The correct setting of these parameters is important to the safety and proper operation of the equipment.

1.2 Authorized Service Centers

Please contact one of the following authorized Service Centers to coordinate service on your Hart product:

Fluke Corporation, Hart Scientific Division

799 E. Utah Valley Drive
American Fork, UT 84003-9775
USA

Phone: +1.801.763.1600
Telefax: +1.801.763.1010
E-mail: support@hartscientific.com

Fluke Nederland B.V.

Customer Support Services
Science Park Eindhoven 5108
5692 EC Son
NETHERLANDS

Phone: +31-402-675300
Telefax: +31-402-675321
E-mail: ServiceDesk@fluke.nl

Fluke Int'l Corporation

Service Center - Instrimpex
Room 2301 Sciteck Tower
22 Jianguomenwai Dajie
Chao Yang District
Beijing 100004, PRC
CHINA

Phone: +86-10-6-512-3436
Telefax: +86-10-6-512-3437
E-mail: xingye.han@fluke.com.cn

Fluke South East Asia Pte Ltd.

Fluke ASEAN Regional Office
Service Center
60 Alexandra Terrace #03-16
The Comtech (Lobby D)
118502
SINGAPORE

Phone: +65 6799-5588
Telefax: +65 6799-5588
E-mail: antng@singa.fluke.com

When contacting these Service Centers for support, please have the following information available:

- Model Number
- Serial Number

- Voltage
- Complete description of the problem

2 Introduction

The Hart Scientific 9117 Annealing Furnace has a temperature range of 300°C to 1100°C and is designed specifically for annealing Standard Platinum Resistance Thermometers (SPRTs) and High Temperature Standard Platinum Resistance Thermometers (HTSPRTs) without contaminating the delicate platinum sensors of the SPRTs or HTSPRTs. For the purpose of this manual, we will refer to both SPRTs and HTSPRTs as SPRTs unless the information applies specifically to HTSPRTs.

The temperature is accurately controlled by Hart's digital controller including RS-232 serial communication. The controller uses a Type R thermocouple as a sensor and controls the well temperature with a solid state relay (triac) driven heater. The temperature controller is programmable, with ramp and soak features. The LED display panel continuously shows the current well temperature. The temperature may be easily set with the control buttons to any desired temperature within the specified range. The furnace's multiple fault protection devices insure user and instrument safety and protection.

The furnace uses a specially designed fused silica encased alumina (Model 2129 Equilibration Block) block to eliminate contamination problems. The furnace has a vertical gradient of less than 1°C over the SPRT sensor area.

This furnace is specifically designed to assist the user in maintaining their SPRTs by providing the ideal environment for annealing SPRTs thus relieving any errors due to careless handling, shipping, or oxidation. The user should be familiar with the safety guidelines and operating procedures of the furnace as described in this user manual.

The annealing furnace features:

- Vertical gradient of less than 1°C over sensor area
- Specially designed fused silica alumina equilibration block to prevent sensor contamination

Built-in programmable features include:

- Ramp and soak
- Temperature scan rate control
- Temperature hold

3 Specifications and Environmental Conditions

3.1 Specifications

Operating Range	300°C to 1100°C
Stability	± 0.5°C
Uniformity	±0.5°C at 660°C ±1.0°C at 1000°C
Set-Point Resolution	0.1°C
Display Resolution	0.1°C below 1000°C, 1°C above 1000°C
Display Accuracy	5°C
Heater Power	2500 Watts
Exterior Dimensions	34" H x 13.5" W x 13.5" D
Power Requirements	230 VAC (± 10%), 50/60 Hz, 1 Phase, 12 Amps
Thermal Wells	5 Wells: 8 mm dia. x 430 mm long
Controller	PID, ramp and soak programmable, thermocouple sensor
Fault Protection	Sensor burnout protection, over-temperature thermal cut-out, electrical fuse (15A, 250V)
Weight	61 lb. (28 Kg)

3.2 Environmental Conditions

Although the instrument has been designed for optimum durability and trouble-free operation, it must be handled with care. The instrument should be operated in a clean laboratory environment. Maintenance and cleaning recommendations can be found in the Maintenance Section of this manual.

The instrument operates safely under the following conditions:

- temperature range: 5 - 50°C (41 - 122°F)
- ambient relative humidity: 15 - 70%
- pressure: 75kPa - 106kPa
- mains voltage within ± 10% of nominal
- vibrations in the calibration environment should be minimized
- altitude less than 2,000 meters
- this instrument is designed for indoor use only

3.3 Warranty

Fluke Corporation, Hart Scientific Division (Hart) warrants this product to be free from defects in material and workmanship under normal use and service for a period as stated in our current product catalog from the date of shipment. This warranty extends only to the original purchaser and shall not apply to any product which, in Hart's sole opinion, has been subject to misuse, alteration, abuse or abnormal conditions of operation or handling.

Software is warranted to operate in accordance with its programmed instructions on appropriate Hart products. It is not warranted to be error free.

Hart's obligation under this warranty is limited to repair or replacement of a product which is returned to Hart within the warranty period and is determined, upon examination by Hart, to be defective. If Hart determines that the defect or malfunction has been caused by misuse, alteration, abuse or abnormal conditions or operation or handling, Hart will repair the product and bill the purchaser for the reasonable cost of repair.

To exercise this warranty, the purchaser must forward the product after calling or writing an Authorized Service Center for authorization. The Service Centers assume NO risk for in-transit damage.

For service or assistance, please contact an Authorized Service Center (see Section 1.2).

THE FOREGOING WARRANTY IS PURCHASER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR MERCHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE. HART SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSS WHETHER IN CONTRACT, TORT, OR OTHERWISE.

4 Safety Guidelines

- Operate the instrument in room temperatures between 5-50°C (41-122°F). Allow sufficient air circulation by leaving at least 6 inches of space between the furnace and nearby objects. Nothing should be placed over the top of the furnace. The furnace should not be placed under cabinets or tables. Extreme temperatures can be generated out the top of the well.
- **DO NOT PLACE ANYTHING ON TOP OF THE FURNACE WHILE IT IS HOT.**
- The furnace is a precise instrument. Although it has been designed for optimum durability and trouble free operation, it must be handled with care. The instrument should be operated in a clean laboratory environment. Keep the well, which holds the fused silica alumina block, free of any foreign matter. Do not operate near flammable materials.
- The Model 9117 Annealing Furnace utilizes high voltages and currents to create high temperatures. Caution should always be maintained during installation and use of this instrument to prevent electrical shock and burns. Fire can be a hazard for any device that produces high temperatures. Proper care and installation must be maintained. Responsible use of this instrument will result in safe operation.
- Do not use fluids to clean out the well.
- **WARNING:** The furnace generates extreme temperatures. Precautions must be taken to prevent personal injury or damage to objects. Probes may be extremely hot when removed from the furnace. Cautiously handle probes to prevent personal injury. Carefully place probes on a heat resistant surface or rack until they are at room temperature.
- Use only grounded AC mains supply of the appropriate voltage to power the instrument. The furnace requires 12 amps at 230VAC ($\pm 10\%$), 50/60 Hz.
- Before initial use, after transport, and anytime the furnace has not been energized for more than 7 days, the instrument needs to be energized for a “dry-out” period of 1-2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1.
- The instrument is equipped with operator accessible system fuses. If a fuse blows, it may be due to a power surge or failure of a component. Replace the fuse once. If the fuse blows a second time, it is likely caused by failure of a component. If this occurs, contact Hart Scientific Customer Service. Always replace the fuse with one of the same rating, voltage, and type. Never replace the fuse with one of a higher current rating.
- If a main supply power fluctuation occurs, immediately turn off the furnace. Power bumps from brown-outs and black-outs can damage the instrument. Wait until the power has stabilized before re-energizing the furnace.

- The unit is not equipped with wheels. It is considered to be permanently set once it has been installed. If the unit must be moved a considerable distance or shipped to a new location, be sure the fused silica alumina block is removed and shipped separately.
- Air circulated through the gap surrounding the furnace core keeps the chassis cool. **DO NOT SHUT OFF THE FURNACE WHILE AT HIGH TEMPERATURES.** The fan will turn off allowing the chassis to become hot.
- The fused silica alumina block is extremely fragile. Be very careful when handling it. **ALWAYS HANDLE THE FUSED SILICA ALUMINA BLOCK WITH GLOVED HANDS TO AVOID THE TRANSFER OF HAND OILS AND SALTS TO THE FUSED SILICA.** Be sure to clean the equilibration block with reagent grade alcohol to remove fingerprints and oils from hands if the block has been removed from the furnace.
- Always store the fused silica alumina equilibration block in the vertical position. **NEVER STORE THE BLOCK IN THE HORIZONTAL POSITION.**

5 Installation

5.1 Unpacking

Unpack the 9117 Furnace and 2129 Equilibration Block carefully and inspect them for any damage that may have occurred during shipment. If there is shipping damage, notify the carrier immediately.

The 2129 Equilibration Block is shipped disassembled in a second container. Check carefully for all parts.

Verify that all components are present:

9117 Annealing Furnace:

- 9117 Furnace
- Extra insulation
- Fused Silica Alumina Equilibration Block, Model 2129 (shipped in separate container)

2129 Fused Silica Alumina Equilibration Block:

- Large outside fused silica tube
- Five (5) fused silica entrant tubes
- Large 5-hole alumina block
- 5-hole alumina top shield
- Bottom Fiberfrax cushion
- Fiberfrax insulation (with 5-hole cutouts)
- Cotton gloves
- Rubber gloves
- Mask
- Removal Tool

5.2 Location

A furnace of this type is typically installed in a calibration laboratory where temperature conditions are generally well controlled. Best results will be obtained from this type of environment. Avoid the presence of flammable materials near the furnace. Allow 6 or more inches of air space around the furnace. Adjust the levelers on the bottom of the furnace to level the furnace and to keep it from rocking. Nothing should be placed over the top of the furnace. The furnace should not be placed under cabinets or tables.



WARNING: Extreme temperatures can be generated out the top of the well. DO NOT PLACE ANYTHING ON TOP OF THE FURNACE.

5.3 “Dry-out” Period

Before initial use, after transport, and any time the instrument has not been energized for more than 7 days, the unit needs to be energized for a “dry-out” period of 1-2 hours before it can be assured to meet all of the safety requirements of the IEC 1010-1.

5.4 Power

The 9117 Annealing Furnace requires approximately 12 amps of current at a nominal 230 VAC ($\pm 10\%$) 50/60 Hz. The furnace is supplied with a 14-gauge, 2-conductor plus ground cable and connector. Since building electrical installations may vary, the connector and cable may be removed at the furnace back panel and another used so long as it is rated for the specified current and voltage. (See Figure 4, Back Panel on page 19).

5.5 2129 Equilibration Block Assembly

In order to ensure a safe delivery, the 2129 Equilibration Block is shipped disassembled. The following simple steps allow for easy reassembly of the block. Be sure to follow all safety precautions.

1. Read the MSDS on the Fiberfrax before assembling the block.
2. Always wear enclosed mask and rubber gloves when handling the Fiberfrax.
3. The Fiberfrax shipped with the 2129 has been “burned in”. This makes the insulation very fragile. Use care when handling the Fiberfrax.
4. If new Fiberfrax is used (Fiberfrax not shipped with the unit), the Fiberfrax will need to be “burned in” in a well ventilated area in order to remove binder from the insulation. Noxious fumes are emitted during the “burn in” process. Contact Hart Customer Service if more information is required.
5. When handling the fused silica tubes, always wear the enclosed cotton gloves.
6. It may be easier for two people to be involved in the assembly—one to hold the outside tube and deal with the fused silica tubing—one to add the insulation.
7. Clean the fused silica tubes with reagent grade alcohol. Allow the tubing to air dry.
8. Place the bottom Fiberfrax cushion in the large fused silica tube. (See Figure 1 for assembly detail.)
9. Lay the large fused silica tube on it side. Use a clean piece of paper as a guide to start the 5-hole alumina block. The block is very heavy in comparison to the tube. Care must be used when sliding the block into the

- tube. Use one of the entrant well tubes to gently push the block to the bottom of the tube. Ensure that the block is fully seated in the bottom of the tube before raising the tube to an upright position.
10. Place the five entrant tubes into the alumina block. Ensure that the tubes are seated completely in the block. Place a plug made from a cotton ball or other soft material in the top of the entrant tubes to keep insulation from falling into the wells.
 11. Install the Fiberfrax insulation shipped with the unit between the block and the top of the large tube. Remove the cotton plugs from the 5 entrant wells.
 12. Place the 5-hole alumina disk on the top of the insulation filled tube—align the 5 holes with the entrant well tubes. The equilibration block is now ready for installation in the furnace.
 13. Place at one of one-inch Fiberfrax cushion in the furnace. The block cannot rest on the metal at the bottom of the furnace well. It must have a Fiberfrax cushion between the block and the metal bottom of the well.
 14. Use the removal tool shipped with the block to lower the assembled block into the furnace. Support the block with the other hand during lowering process. Ensure that the block is completely seated in the well before removing the tool.

5.6 Fused Silica Alumina Equilibration Block Installation

Be sure to remove any packing material before energizing the furnace. The electronics for the furnace are located in the base. This protects them from the extreme temperatures generated by the furnace. Several wires must be connected from the base to the lid of the furnace. In order to protect these wires when the lid is removed from the furnace, a special ground wire is attached with screws to keep the lid from dropping during insertion of the equilibration block.

Remove the furnace lid (it will “hang” by a ground wire during the process). **Always handle the fused silica alumina block with gloved hands to avoid transfer of hand oils and salts. Be sure to clean the outside of the equilibration block with alcohol to remove fingerprints and oils from hands before placing the block in the furnace well.** Check to see that the furnace well is free of foreign materials. Check to see that a 1 inch piece of insulation is placed in the well before carefully lowering the block into the well. Replace the furnace lid being careful that the ground wire is not pinched between the lid and the furnace top. We advise only removing the block from the furnace when the furnace needs to be moved.

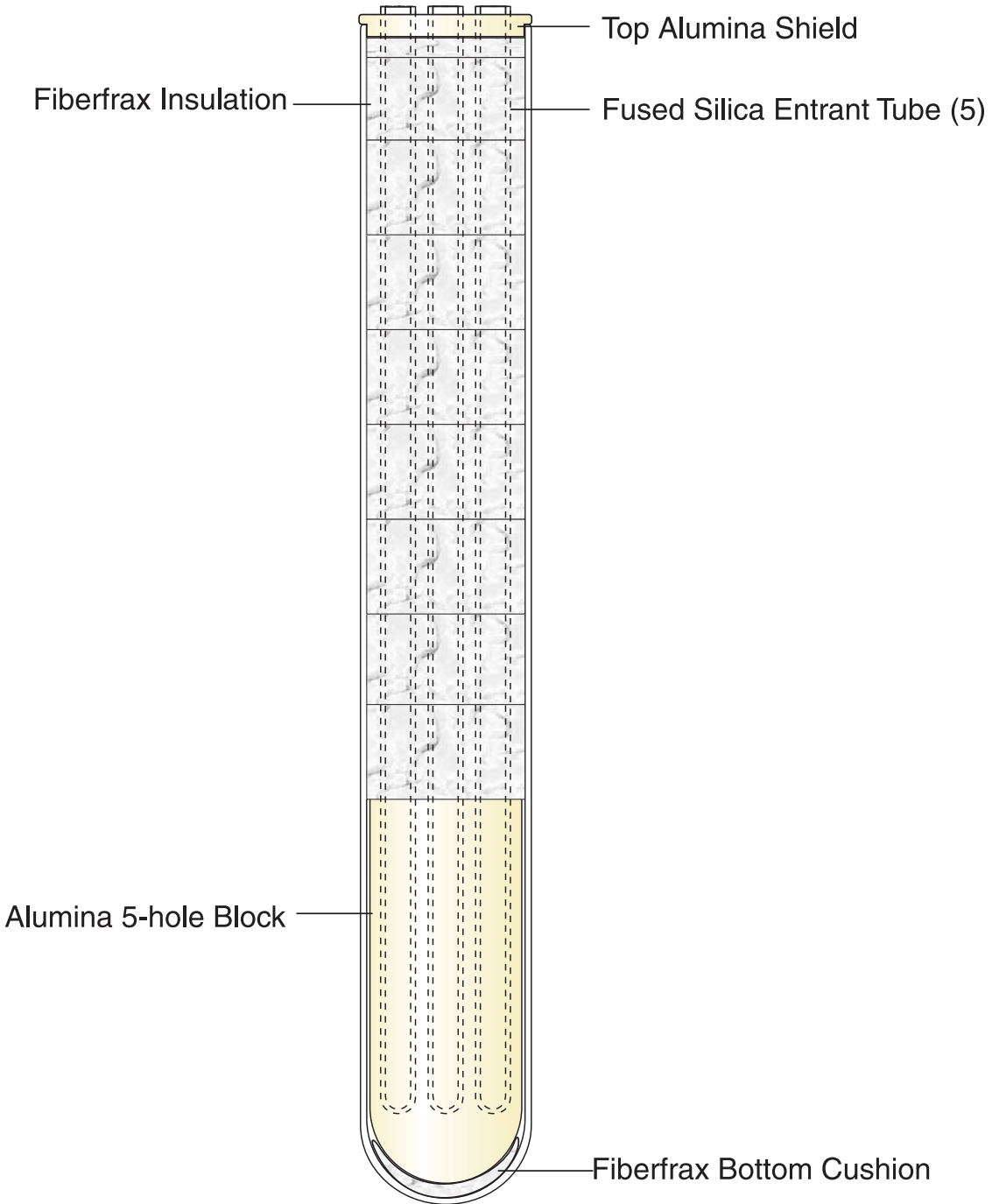


Figure 1 2129 Equilibration Block

6 Parts and Controls

The Model 9117 Annealing Furnace consists of a control panel, furnace core, access well, back panel, and fused silica alumina equilibration block. Each part and control is described below.

6.1 Control Panel

The control of the furnace is simple and easy-to-use. The controls of the furnace are located on a slanted surface on the front of the furnace lid. See Figure 2. Next to the controller display is: (1) the power switch, (2) the control buttons, and (3) the digital LED display.

- (1) The power switch is used to energize the unit.
- (2) The control buttons (SET, DOWN, UP, and EXIT) are used to set the furnace temperature set-point, access and set other operating and calibration parameters.

A brief description of the functions of the buttons follows:

SET - Used to display the next parameter in a menu and to store parameters.

DOWN - Used to decrement the displayed value of parameters.

UP - Used to increment the displayed value.

EXIT - Used to exit from a menu. When “EXIT” is pressed, any changes made to the displayed value are ignored.

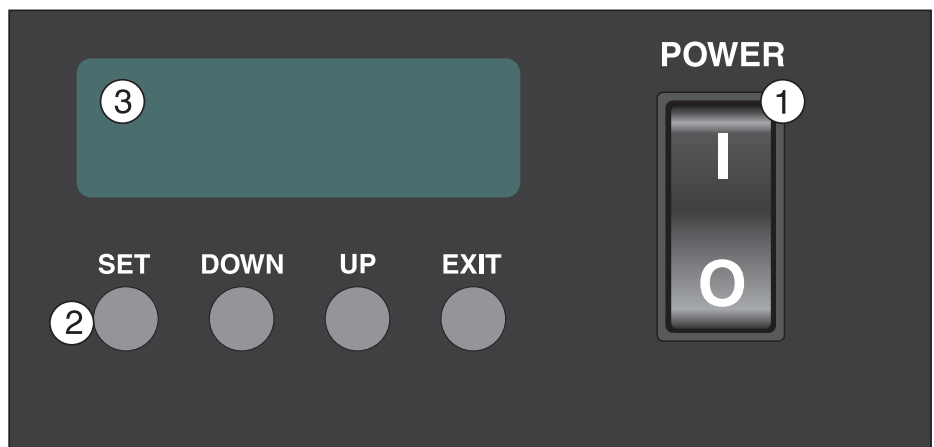


Figure 2 Control Panel

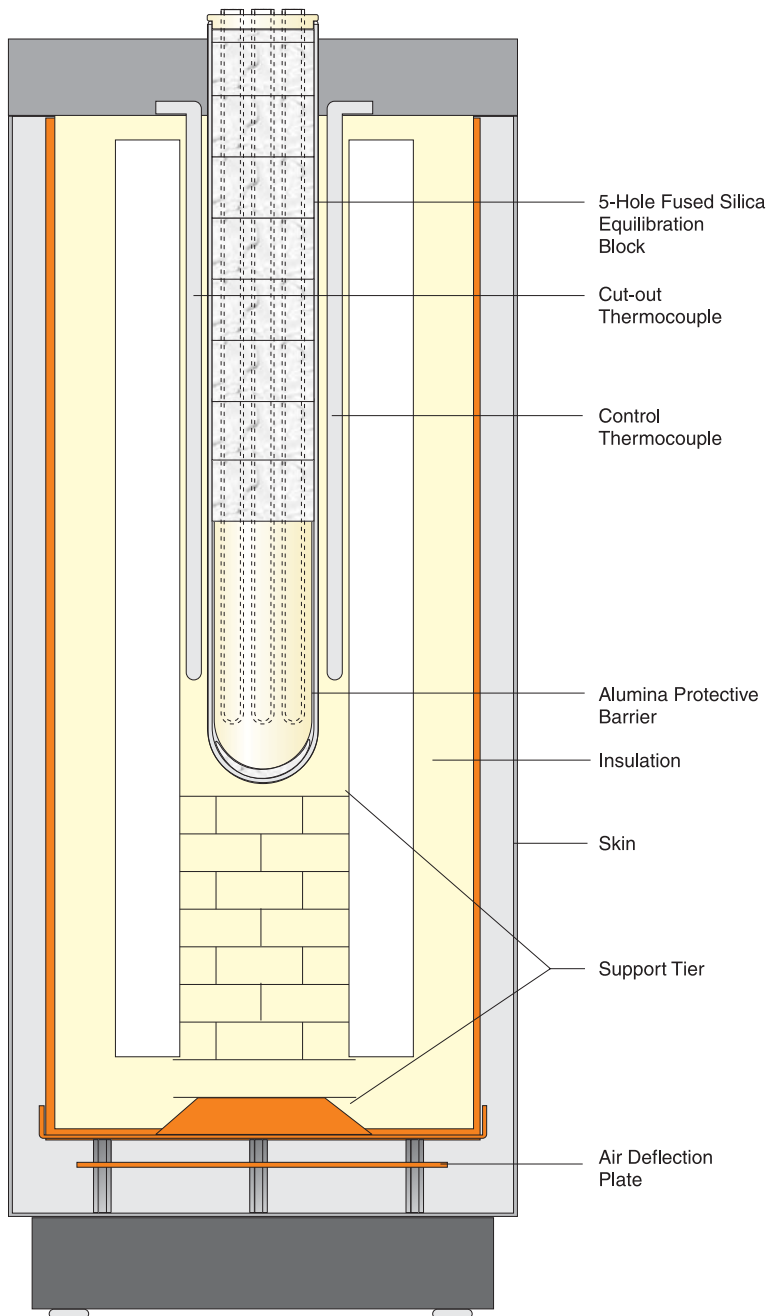


Figure 3 Furnace Core

- (3) The digital display shows the set and actual temperatures as well as various other functions, settings and constants. The temperature can be set in scale units of either °C or °F.

6.2 Furnace Core

The furnace core consists of the heater, insulating materials, support blocks, and the housing. Refer to Figure 3 on page 18.

The heater operates on a nominal 230 volts AC and generates 2500 Watts of power. It is embedded in a fiber ceramic insulating block. Two thermocouples are used for heater control and safety cutout. A hollow section through the center contains the quartz glass graphite equilibration block.

6.3 Access Well

The furnace access well is visible on top of the furnace. The furnace access well is where the equilibration block is inserted and removed from the furnace.

6.4 Back Panel

The back panel consists of: 1) a serial communications connector, 2) a power cord, and 3) the system fuses. See Figure 4 on page 19.

1. The serial communications connector is a DB-9 connector for interfacing the furnace to a computer or terminal with serial RS-232 communications. (See Section 9 starting on page 39 for details.)
2. The power cord is a non-removable cord for AC voltage (230 VAC ($\pm 10\%$)).
3. For easy access by the user, the system fuses of appropriate amperage (15 A, 250 V) are located at the bottom of the furnace. See Section 4 Safety Guidelines with regard to changing the fuses.

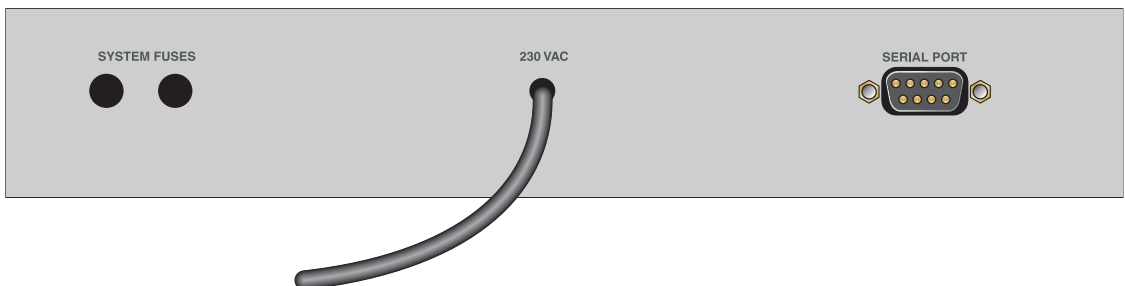


Figure 4 Back Panel

6.5 Fused Silica Alumina Equilibration Block

The specially designed fused silica alumina equilibration block is located in the access well. Five quartz glass lined wells provide protected access to the furnace for the annealing of probes. The alumina equilibration block provides a protective barrier to keep the sensors from being contaminated. See Figure 3 for details.

7 General

7.1 Care of the Fused Silica Alumina Equilibration Block

SPRTs become contaminated by metal ions at temperatures above 600°C. The fused silica alumina equilibration block is specifically designed to prevent contamination of the sensor during annealing. High purity alumina material is used along with fused silica that has been chemically cleaned. The alumina is enclosed in a fused silica envelope and five fused silica closed-end tubes provide wells for SPRT insertion.

Always handle the fused silica alumina block with gloved hands to avoid transfer of hand oils and salts. Be sure to clean the fused silica alumina equilibration block with reagent grade alcohol to remove fingerprints and oils before placing the block in the furnace well.

7.2 Metal Ion Contamination of SPRTs

Since the acceptance of ITS-90, information has been accumulating about contamination of SPRTs. ITS-90 extended the range of the SPRT as an interpolation device and new problems manifested themselves. Metal ion contamination is one of the new problems and can start at approximately 600°C.

At high temperatures the lattice structure of most metals becomes quite loose. This allows some of the metal ions to come off the surface analogous to steam rising from hot water. Since the molecular activity increases with temperature, so does the amount of ion loss and the risk of contamination. Ion transfer occurs at different temperatures for different metals. Copper (Cu), nickel (Ni), iron (Fe), and manganese (Mn) are metals that have been attributed to causing contamination. In addition the quartz lattice structure also becomes quite loose at these high temperatures. This allows the quartz glass to become transparent to these metal ions permitting the transfer of these ions to the pure platinum wire of the SPRT sensor. The new alloy formed has a different alpha (α) curve than the pure platinum meaning a loss of calibration.

Contamination can be spread by an “infected” SPRT to other primary standards analogous to a virus. Therefore, it is very important to avoid contamination as much as possible to ensure the longevity of the SPRT itself and to decrease the spread to other standards.

Isolation of sensitive materials can prevent contamination. Pure platinum foil is being used by some experts to absorb the ions before they reach the SPRT sensor. Silicon carbide is also used by some experts to shield the SPRT sensor because it is less expensive. Information on contamination effects and prevention is still being gathered by experts in the field.

If you use metal-sheathed probes with the fused silica alumina block on a regular basis, be sure to mark the wells which are used with metal. **Do not place a**

quartz sheathed probe into the same wells as those used for metal sheathed probes.

7.3 Devitrification of Quartz

Devitrification is a natural process with quartz materials. The quartz is utilized in a glass state. The most stable state for quartz is crystalline. Therefore, devitrification is the tendency of the quartz to return to its most stable state. If the quartz is kept extremely clean and free of contamination, devitrification will occur only at high temperatures. The process occurs more rapidly and at lower temperatures when the glass has become contaminated by alkaline metals (Na, K, Mg, and Ca). The alkalis found in normal tap water can cause the process to start. There is conflicting opinion among the experts as to whether the process can be stopped. Some say that once the process starts, it does not stop. Others indicate that once the alkali is removed, the process will stop.

Removal of the devitrification is not practical as it requires drastic measures and is potentially dangerous to the instrument and/or the user.

Devitrification starts with a dulling or opacity of the quartz. It develops into a rough and crumbling surface. Devitrification ultimately weakens the glass/quartz until it breaks or is otherwise no longer useful.

The best cure for contamination and devitrification is prevention. Being aware of the causes and signs of contamination can help the user take the steps necessary to control contamination of the quartz. Keep your quartz clean and avoid contact with metals at temperatures above 600°C.

8 Controller Operation

This section discusses in detail how to operate the furnace temperature controller using the front control panel. By using the front panel key-switches and LED display the user may monitor the well temperature, adjust the set-point temperature in degrees C or F, monitor the heater output power, adjust the controller proportional band, and program the probe calibration parameters, operating parameters, serial interface configuration, and controller calibration parameters. Operation of the functions and parameters are shown in the flowchart in Figure 5 on page 24. This chart may be copied for reference.

In the following discussion a button with the word SET, UP, DOWN, or EXIT inside indicates the panel button while the dotted box indicates the display reading. Explanation of the button or display reading are to the right of each button or display value.

8.1 Well Temperature

The digital LED display on the front panel allows direct viewing of the actual well temperature. This temperature value is what is normally shown on the display. The units, C or F, of the temperature value are displayed at the right. For example,

962.3 C *Well temperature in degrees Celsius*

The temperature display function may be accessed from any other function by pressing the “EXIT” button.

8.2 Temperature Set-point

The temperature set-point can be set to any value within the range and resolution as given in the specifications. Be careful not to exceed the safe upper temperature limit of any device inserted into the well.

Setting the temperature involves two steps: (1) select the set-point memory and (2) adjust the set-point value.

8.2.1 Programmable Set-points

The controller stores 8 set-point temperatures in memory. The set-points can be quickly recalled to conveniently set the calibrator to a previously programmed temperature set-point.

To set the temperature one must first select the set-point memory. This function is accessed from the temperature display function by pressing “SET”. The number of the set-point memory currently being used is shown at the left on the display followed by the current set-point value.

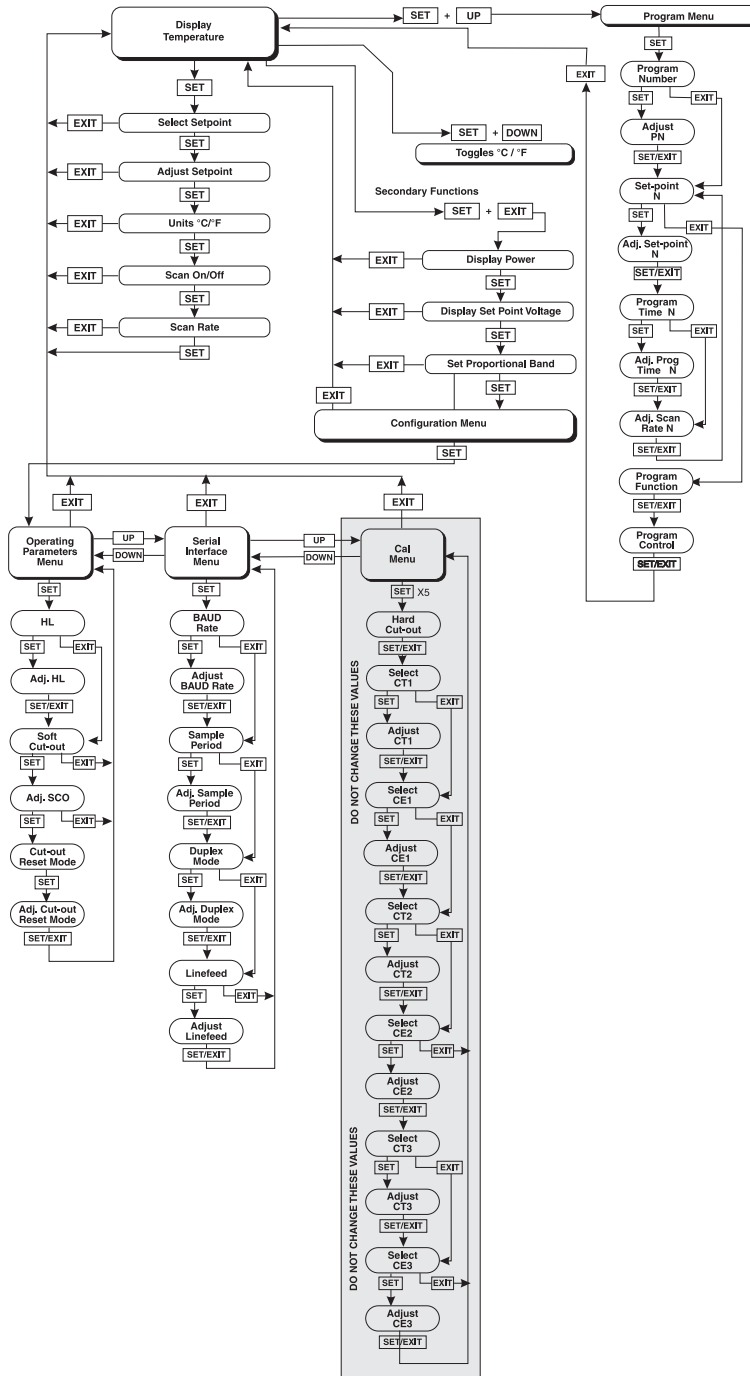



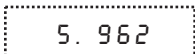
Figure 5 Controller Operation Flowchart

 Well temperature in degrees Celsius


 Access set-point memory

 Set-point memory 1, 300.0°C currently used

To change the set-point memory press “UP” or “DOWN”.

 New set-point memory 5, 962.0°C

Press “SET” to accept the new selection and access the set-point value.

 Accept selected set-point memory

8.2.2 Set-point Value

The set-point value may be adjusted after selecting the set-point memory and pressing “SET”.

 Set-point value in °C

If the set-point value is correct, press “EXIT” to display the well temperature scale units. Press “UP” or “DOWN” to adjust the sign of the temperature positive and negative. The sign will be flashing on and off. If the sign is correct press “SET”. The first digit of the temperature should now be flashing. Adjust this digit by pressing “UP” or “DOWN”.

 New set-point value

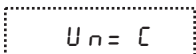
Press “SET” to accept the first digit and repeat until the last digit has been adjusted. Press “SET” to accept the new set-point. If “EXIT” is pressed all changes made to the set-point are discarded and the temperature scale units are displayed.

 Accept new set-point value

8.2.3 Temperature Scale Units

The temperature scale units of the controller are set by the user to degrees Celsius (°C) or Fahrenheit (°F). The units are used in displaying the well temperature, set-point, and proportional band.

Press “SET” after adjusting the set-point value to change display units.

 Scale units currently selected

Press “UP” or “DOWN” to change the units.

$U_n = F$ *New units selected*

Press “SET” to accept the new units and to access the scan control. Press “EXIT” to display the well temperature without accepting the new units.

8.3 Scan

The scan rate can be set and enabled so that when the set-point is changed the furnace heats or cools at a specified rate (degrees per minute) until it reaches the new set-point. With the scan disabled the furnace heats or cools at the maximum possible rate.

8.3.1 Scan Control

The scan is controlled with the scan on/off function that appears in the main menu after the temperature scale units.

$S_c = OFF$ *Scan function off*

Press “UP” or “DOWN” to toggle the scan on or off.

$S_c = ON$ *Scan function on*

Press “SET” to accept the present setting and then to adjust the scan rate. Press “EXIT” to display the well temperature without accepting the new setting.

 *Accept scan setting*

8.3.2 Scan Rate

The next function in the main menu is the scan rate. The scan rate can be set from 0.1 to 99.9°C/minute. The maximum scan rate however is actually limited by the natural heating or cooling rate of the instrument. This rate is often less than 100°C/minute, especially when cooling.

The scan rate function appears in the main menu after the scan control function. The scan rate units are in degrees per minute, degrees C or F depending on the selected units.

$S_r = 10.0$ *Scan rate in °C/min.*

Press “UP” or “DOWN” to change the scan rate.

$S_r = 5.8$ *New scan rate*

Press “SET” to accept the new scan rate. Press “EXIT” to discard the changes. Either “SET” or “EXIT” displays the well temperature.



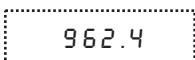
Accept scan rate

8.4 Ramp and Soak Program

The ramp and soak program feature for the 9117 allows the user to program a number of set-points, cycle the furnace automatically between the temperatures at a scan rate set by the user, and hold the furnace at each temperature for a period of time set by the user. The user can select one of four different cycle functions. The Ramp and Soak Menu is accessed by pressing “SET” and “UP” simultaneously.

8.4.1 Program Points

The 9117 contains eight “program points”. Each program point contains a set-point, scan rate, and soak time. When the unit is in program mode the unit heats or cools to the current program set-point at the current program scan rate. Once the program set-point is reached the unit waits for the program soak time before heating or cooling to the next program set-point. To access the Ramp and Soak Program Menu press “SET” and “UP” simultaneously.



Well temperature



+



Access Ramp and Soak Program Menu

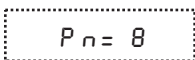


Ramp and Soak Program

Press “SET” to access the number of program points.

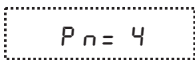
8.4.2 Number of Program Points

The first parameter in the program menu is the number of program points to cycle through. Up to 8 set-points can be used in a ramp and soak program.



Number of program points to cycle through

Use the “UP” and “DOWN” buttons to change the program points. The valid range is from 2 to 8.



Number of program points

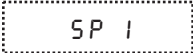
Press “SET” to continue. Pressing “EXIT” causes any changes made to the parameter to be discarded.



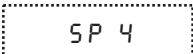
Accept the new number of program points.

8.4.3 Program Set-Points

The controller allows the user to adjust up to eight program points. These are accessed by pressing “SET” after setting the number of program points as described in Section 8.4.2. Each program point has three associated parameters: the program set-point, the program scan rate, and the program hold (or soak) time. After adjusting the number of program points press “SET”.

 *Program point 1*

Use the “UP” or “DOWN” buttons to select any of the program points. The controller only allows the user to edit program points that are less than or equal to the number of programs points selected as explained in Section 8.4.2. For example, if the user has selected 4 program points program points 5, 6, 7, and 8 cannot be edited.

 *Program point 4*


Press “SET” to edit a program point.

 *Edit program point*


The first value to edit is the program set-point.

 *Program set-point value in °C*

Use “UP”, “DOWN”, and “SET” to adjust the set-point as each digit flashes.

 *New program set-point value for program point 4*

Press “SET” to save the new set-point value or “EXIT” to discard changes.

 *Accept the program point set-point*

The next value to edit is the program soak time.

 *Program point 4 soak time*

Press “SET” to edit the program soak time.

 *Edit program point soak time*

 *Current program soak time*

Use “UP”, “DOWN”, and “SET” to adjust the program soak time. This value can be any integer from 0 to 14400. This time is the minutes the program set-point maintains after the temperature of the furnace has settled and before

proceeding to the next set-point. Each digit flashes individually to indicate that it can be adjusted.

00200 *Program point 4 soak time set for 200 minutes*

Press “SET” to save the new soak-time value or “EXIT” to discard changes

SET *Accept the program point soak time*

The next value to edit is the program scan rate. This value is ignored if scan is not enabled for the unit (See Section 8.3.1).

5r 4 *Program point 4 scan rate*

Press “SET” to edit the program scan rate.

SET *Edit the program point scan rate*

10.0 *Current program point 4 scan rate*

Use “UP” and “DOWN” to adjust the program scan rate.

11.3 *New program point 4 scan rate*

Press “SET” to save the new scan rate value.

SET *Accept the program point scan rate*

After “SET” is pressed the controller advances to the next program point or, if there are no more program points to edit, exits to the Program Function Menu. Repeat the above steps to edit any program point.

8.4.4 Program Function Mode

The next parameter is the program function or cycle mode. There are four possible modes which determine whether the program scans up (from set-point 1 to n) only or both up and down (from set-point n to 1), and also whether the program stops after one cycle or repeats the cycle indefinitely. The table below shows the action of each of the four program mode settings.

Function	Action
1	up-stop
2	up-down-stop
3	up-repeat
4	up-down-repeat

$P F = 1$ *Program mode*

Press “SET” to adjust the program mode and “UP” or “DOWN” to change the mode.

$P F = 4$ *New mode*

Press “SET” to continue or “EXIT” to continue without saving the new value.

 *Save new setting*

8.4.5 Program Control


The final parameter in the program menu is the control parameter. You may choose between three options to either start the program from the beginning, continue the program from where it was when it was stopped, or stop the program.

$P = 0 F F$ *Program presently off*

Use the “UP” or “DOWN” buttons to change the status.

$P = 0 0$ *Start cycle from beginning*

Press “SET” to activate the new program control command and return to the temperature display.

 *Activate new command*

8.5 Secondary Menu

Functions which are used less often are accessed within the secondary menu. The secondary menu is accessed by pressing “SET” and “EXIT” simultaneously and then releasing. The first function in the secondary menu is the heater power display. (See Figure 5 on page 24.)

8.6 Heater Power

The temperature controller controls the temperature of the furnace by pulsing the heater on and off. The total power being applied to the heater is determined by the duty cycle or the ratio of heater on time to the pulse cycle time. By knowing the amount of heating the user can tell if the calibrator is heating up to the set-point, cooling down, or controlling at a constant temperature. Monitoring the percent heater power lets the user know how stable the well temperature is. With good control stability the percent heating power should not fluctuate more than $\pm 1\%$ within one minute.

The heater power display is accessed in the secondary menu. Press “SET” and ”EXIT” simultaneously and release. The heater power is displayed as a percentage of full power.

962.4 *Well temperature*

 +  *Access heater power in secondary menu*



41.5P *Heater power in percent*

To exit out of the secondary menu press “EXIT”. To continue on to the set-point voltage display setting function press “SET”.


8.7 Set-point Voltage

The 9117 controller uses thermocouples to measure the temperature of the furnace. A thermocouple outputs a temperature-dependent voltage. As the temperature in the furnace rises or falls the voltage across the control thermocouple also rises or falls. The set-point voltage is the voltage (in millivolts) that the control thermocouple outputs at the current set-point temperature.

The value of the set-point voltage can only be changed by adjusting the set-point temperature or the thermocouple calibration functions DC1 and DC2. The set-point voltage is displayed for informational purposes only.

 +  *Access heater power in secondary menu*

41.5P *Heater power in percent*

 *Access set-point voltage*

10.006V *Set-point voltage in millivolts*

To exit out of the Secondary Menu, press “EXIT”. To continue on to the proportional band setting function, press “SET”.

8.8 Proportional Band

In a proportional controller, the heater output power is proportional to the well temperature over a limited range of temperatures around the set-point. This range of temperature is called the proportional band. At the bottom of the proportional band the heater output is 100%. At the top of the proportional band the heater output is 0. Thus, as the temperature rises the heater power is reduced, which consequently tends to lower the temperature. In this way the temperature is maintained at a fairly constant temperature.


The temperature stability of the well and response time depend on the width of the proportional band. If the band is too wide the well temperature deviates excessively from the set-point due to varying external conditions. This deviation is because the power output changes very little with temperature and the controller cannot respond very well to changing conditions or noise in the system. If the proportional band is too narrow the temperature may swing back and forth because the controller overreacts to temperature variations. For best control stability the proportional band must be set for the optimum width.

The factory default for the proportional band is 30.0°C. In testing the unit, the proportional band may have been changed. Check the furnace “Report of Test” to see if the proportional band was changed before shipping. The proportional band width may be altered by the user if he desires to optimize the control characteristics for a particular application.


The proportional band width is easily adjusted from the front panel. The width may be set to discrete values in degrees C or F depending on the selected units. The proportional band adjustment can be accessed within the secondary menu. Press “SET” and “EXIT” to enter the secondary menu and show the heater power. Then press “SET” twice to access the proportional band.

 +  *Access heater power in secondary menu*

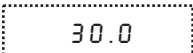
 *Heater power in percent*

 *Access set-point voltage*

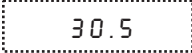
 *Set-point voltage in millivolts*

 *Access proportional band*


 *Flashes “P r o P” and then displays the setting*

 *Proportional band*

Press “UP” or “DOWN” to change the setting.

 *New proportional band setting*

Press “SET” to store the new setting. Press “EXIT” to continue without storing the new value.

 *Accept the new proportional band setting*

8.9 Controller Configuration

The controller has a number of configuration and operating options and calibration parameters which are programmable via the front panel. These are accessed from the secondary menu after the proportional band function by pressing “SET”. Pressing “SET” again enters the first of three groups of configuration parameters—operating parameters, serial interface parameters and calibration parameters. The groups are selected using the “UP” and “DOWN” keys and then pressing “SET”.

8.10 Operating Parameters

The operating parameters menu is indicated by...

 *Operating parameters menu*

Press “SET” to enter the menu. The operating parameters menu contains the HL (High Limit) parameter, the Soft cutout Parameter, and the Cutout Reset Mode parameter.

8.10.1 High Limit

The HL parameter adjusts the upper set-point temperature. The factory default and maximum are set to 1100. For safety, a user can adjust the HL down so the maximum temperature set-point is restricted.

 *High Limit parameter*

Press “SET” to enable adjustment of HL.

 *Access High Limit parameter*

 *Flashes the current HL setting value and then displays the value for adjustment*

Adjust the HL parameter digit by digit using “UP”, “DOWN”, and “SET” as each digit flashes.

 *New HL setting*

Press “SET” to accept the new temperature limit.

8.10.2 Soft Cutout

The Soft Cutout temperature parameter is used by the controller to shut the unit down during over-temperature conditions.

S o F t C u t o *Soft Cutout parameter*

Press “SET” to enable adjustments of the Soft Cutout

SET *Access Soft Cutout*

1 1 2 5 *Flashes the current Soft Cutout value and then displays the value for adjustment*

Adjust this parameter by using “UP”, “DOWN”, and “SET” as each digit flashes.

1 1 0 2 . 0 *New Soft Cutout setting*

Press “SET” to accept the new temperature limit.

If the temperature of the unit is ever greater than the “Soft Cutout” temperature the controller shuts itself down and displays, alternately, “S c t o u t” and “E r r B”.

8.10.3 **Cutout Reset Mode**

The cutout reset mode determines if the cutout resets automatically when the well temperature drops to a safe value or if it must be manually reset by the operator.

The parameter is indicated by,

C t o r S t *Cutout reset mode parameter*

Press “SET” to access the parameter setting. Normally the cutout is set for automatic mode.

A u t o *Cutout set for automatic reset*

To change to manual reset mode, press “UP” or “DOWN” and then “SET”.

r S t *Cutout set for manual reset*

8.11 **Serial Interface Parameters**

The serial RS-232 interface parameters menu is indicated by,

S E R I A L *Serial RS-232 interface parameters menu*

The serial interface parameters menu contains parameters which determine the operation of the serial interface. The parameters in the menu are: BAUD rate, sample period, duplex mode, and linefeed.

8.11.1 BAUD Rate

The BAUD rate is the first parameter in the menu. The BAUD rate setting determines the serial communications transmission rate.

The BAUD rate parameter is indicated by,

`BAUD` *Serial BAUD rate parameter*

Press “SET” to choose to set the BAUD rate. The current BAUD rate value is then be displayed.

`2400 b` *Current BAUD rate*

The BAUD rate of the serial communications may be programmed to 300 600, 1200, 2400, 4800, or 9600 BAUD. The default setting is 2400 BAUD. Use “UP” or “DOWN” to change the BAUD rate value.

`4800 b` *New BAUD rate*

Press “SET” to set the BAUD rate to the new value or “EXIT” to abort the operation and skip to the next parameter in the menu.

8.11.2 Sample Period

The sample period is the next parameter in the serial interface parameter menu. The sample period is the time period in seconds between temperature measurements transmitted from the serial interface. If the sample rate is set to 5, the instrument transmits the current measurement over the serial interface approximately every five seconds. The automatic sampling is disabled with a sample period of 0. The sample period is indicated by,

`SPEr` *Serial sample period parameter*

Press “SET” to choose to set the sample period. The current sample period value is displayed.

`SP=1` *Current sample period (seconds)*

Adjust the value with “UP” or “DOWN” and then use “SET” to set the sample rate to the displayed value.

`SP=60` *New sample period*

Press "SET" to accept the new value or "EXIT" to continue on to the next parameter without storing the new setting.

8.11.3 Duplex Mode

The next parameter is the duplex mode. The duplex mode may be set to full duplex or half duplex. With full duplex any commands received by the furnace via the serial interface are immediately echoed or transmitted back to the device of origin. With half duplex the commands are executed but not echoed. The duplex mode parameter is indicated by,

`d U P L` *Serial duplex mode parameter*

Press "SET" to access the mode setting

`d = F U L L` *Current duplex mode setting*

The mode may be changed using "UP" or "DOWN".

`d = H A L F` *New duplex mode setting*

Press "SET" to accept the new value or "EXIT" to continue on to the next parameter without storing the new setting.

8.11.4 Linefeed

The final parameter in the serial interface menu is the linefeed mode. This parameter enables (on) or disables (off) transmission of a linefeed character (LF, ASCII 10) after transmission of any carriage-return. The linefeed parameter is indicated by,

`L F` *Serial linefeed parameter*

Press "SET" to access the linefeed parameter.

`L F = O n` *Current linefeed setting*

The mode may be changed using "UP" or "DOWN".

`L F = O F F` *New linefeed setting*

Press "SET" to accept the new value or "EXIT" to continue on to the next parameter without storing the new setting.

8.12 Calibration Parameters

The operator of the 9117 has access to the furnace calibration constants. These values are set at the factory and must not be altered. The correct values are important to the accuracy and proper and safe operation of the furnace. Access to these parameters is available to the user only in the event that the controller memory fails, the user may restore these values to the factory settings. These parameters and their current value are listed on the Report of Test.



CAUTION: *DO NOT change the values of the furnace calibration constants from the factory set values. The correct settings of these parameters is important to the safety and proper operation of the furnace.*

The calibration parameters menu is indicated by,

 *Calibration parameters menu*


Press “SET” five times to enter the menu. The calibration parameters menu contains the parameters Hard cutout, CT1, CE1, CT2, CE2, CT3, and CE3.

8.12.1 Hard Cutout

This parameter is the temperature above which the unit shuts down automatically. The parameter is set at the factory to approximately 1150°C and cannot be changed by the user.

 *Hard Cutout display*

Press “SET” to display the current Hard Cutout value. This parameter can only be changed internally. Contact Hart Scientific Customer Service if the parameter needs to be changed.

 *Accept the new Hard Cutout value*

Press “SET” or “EXIT” to skip to the next parameter.

8.12.2 CT1, CT2, CT3

The calibration parameters CT1, CT2, and CT3 are the calibration temperatures.

8.12.3 CE1, CE2, CE3

The calibration parameters CE1, CE2, and CE3 are the calibration errors corresponding to the calibration temperatures.

9 Digital Communication Interface

The furnace is capable of communicating with and being controlled by other equipment through the RS-232 digital interface.

With a digital interface the instrument may be connected to a computer or other equipment. This allows the user to set the set-point temperature, monitor the temperature, and access any of the other controller functions, all using remote communications equipment.

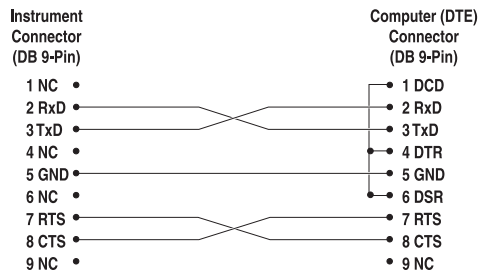
9.1 Serial Communications

The calibrator is installed with an RS-232 serial interface that allows serial digital communications over fairly long distances. With the serial interface the user may access any of the functions, parameters and settings discussed in Section 8 with the exception of the BAUD rate setting.

9.1.1 Wiring

The serial communications cable attaches to the calibrator through the DB-9 connector at the back of the instrument. Figure 6 shows the pin-out of this connector and suggested cable wiring. To eliminate noise, the serial cable should be shielded with low resistance between the connector (DB-9) and the shield.

RS-232 Cable Wiring for IBM PC and Compatibles



9.1.2 Setup

Before operation the serial interface must first be set up by programming the BAUD rate and other configuration parameters. These parameters are programmed within the serial interface menu.

To enter the serial parameter programming mode first press “EXIT” while pressing “SET” and release to enter the secondary menu. Press “SET” repeatedly until the display reads “*C O N F I G*”.

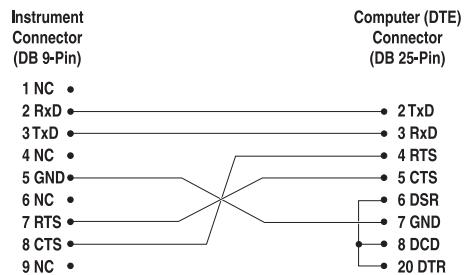


Figure 6 Serial Cable Wiring

This is the menu selection. Press “UP” repeatedly until the serial interface menu is indicated with “*S E R I A L*”. Finally press “SET” to enter the serial parameter menu. In the serial interface parameters menu are the BAUD rate, the sample rate, the duplex mode, and the linefeed parameter.

9.1.2.1 BAUD Rate

The BAUD rate is the first parameter in the menu. The display will prompt with the BAUD rate parameter by showing “BAUD”. Press “SET” to choose to set the BAUD rate. The current BAUD rate value will then be displayed. The BAUD rate of the 9117 serial communications may be programmed to 300, 600, 1200, 2400, 4800, or 9600 BAUD. The BAUD rate is pre-programmed to 2400 BAUD. Use “UP” or “DOWN” to change the BAUD rate value. Press “SET” to set the BAUD rate to the new value or “EXIT” to abort the operation and skip to the next parameter in the menu.

9.1.2.2 Sample Period

The sample period is the next parameter in the menu and prompted with “*SAMPLE*”. The sample period is the time period in seconds between temperature measurements transmitted from the serial interface. If the sample rate is set to 5, then the instrument will transmit the current measurement over the serial interface approximately every five seconds. The automatic sampling is disabled with a sample period of 0. Press “SET” to choose to set the sample period. Adjust the period with “UP” or “DOWN” and then use “SET” to set the sample rate to the displayed value.

9.1.2.3 Duplex Mode

The next parameter is the duplex mode indicated with “*dUPL*”. The duplex mode may be set to half duplex (“*HALF*”) or full duplex (“*FULL*”). With full duplex any commands received by the thermometer via the serial interface are immediately echoed or transmitted back to the device of origin. With half duplex the commands are executed but not echoed. The default setting is full duplex. The mode may be changed using “UP” or “DOWN” and pressing “SET”.

9.1.2.4 Linefeed

The final parameter in the serial interface menu is the linefeed mode. This parameter enables (“*On*”) or disables (“*OFF*”) transmission of a linefeed character (LF, ASCII 10) after transmission of any carriage-return. The default setting is with linefeed on. The mode may be changed using “UP” or “DOWN” and pressing “SET”.

9.1.3 Serial Operation

Once the cable has been attached and the interface set up properly the controller immediately begins transmitting temperature readings at the programmed rate. The serial communications uses 8 data bits, one stop bit, and no parity. The set-point and other commands may be sent via the serial interface to set the

temperature set-point and view or program the various parameters. The interface commands are discussed in Section 9.2. All commands are ASCII character strings terminated with a carriage-return character (CR, ASCII 13).

9.2 Interface Commands

The various commands for accessing the calibrator functions via the digital interfaces are listed in this section (see Table 3 starting on page 42). These commands are used with the RS-232 serial interface. The commands are terminated with a carriage-return character. The interface makes no distinction between upper and lower case letters, hence either may be used. Commands may be abbreviated to the minimum number of letters which determines a unique command. A command may be used to either set a parameter or display a parameter depending on whether or not a value is sent with the command following a “=” character. For example “s”<CR> will return the current set-point and “s=50.00”<CR> will set the set-point to 50.00 degrees.

In the following list of commands, characters or data within brackets, “[” and “]”, are optional for the command. A slash, “/”, denotes alternate characters or data. Numeric data, denoted by “n”, may be entered in decimal or exponential notation. Spaces may be added within command strings and will simply be ignored. Backspace (BS, ASCII 8) may be used to erase the previous character. A terminating CR is implied with all commands.

Table 3 *Digital Communications Commands*

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Display Temperature					
Read well temperature	t[emperature]	t	t: 9999.9	t: 950.0C	
Read current set-point	s[etpoint]	s	set: 9999.9 {C or F}	set: 150.00 C	
Set current set-point to <i>n</i>	s[etpoint]= <i>n</i>	s=450			Instrument Range
Set temperature units:	u[nits]=c/f				C or F
Set temperature units to Celsius	u[nits]=c	u=c			
Set temperature units to Fahrenheit	u[nits]=f	u=f			
Read scan function	sc[an]	sc	scan: {ON or OFF}	scan: ON	
Set scan function:	sc[an]=on/off[f]				ON or OFF
Turn scan function on	sc[an]=on	sc=on			
Turn scan function off	sc[an]=off[f]	sc=of			
Read scan rate	sr[ate]	sr	srat: 99.99 {C or F}/min	srat: 10.0 C/min	
Set scan rate to <i>n</i> degrees per minute	sr[ate]= <i>n</i>	sr=5			.1 to 99.9
Secondary Menu					
Read proportional band setting	pr[op-band]	pr	pb: 999.9	pb: 15.9	
Set proportional band to <i>n</i>	pr[op-band]= <i>n</i>	pr=8.83			0.1 to 100
Read heater power (duty cycle)	po[wer]	po	po: 999	po: 1	
Ramp and Soak Menu					
Read number of programmable set-points	pn	pn	pn: 9	pn: 2	
Set number of programmable set-points to <i>n</i>	pn= <i>n</i>	pn=4			1 to 8
Read programmable set-point number <i>n</i>	ps <i>n</i>	ps3	ps <i>n</i> : 9999.99 {C or F}	ps1: 50.00 C	
Set programmable set-point number <i>n</i> to <i>n</i>	ps <i>n</i> = <i>n</i>	ps3=50			1 to 8, Instrument Range
Read program set-point soak time	pt <i>n</i>	pt3	ti: 999	ti: 5	
Set program set-point soak time to <i>n</i> minutes	pt <i>n</i> = <i>n</i>	pt3=5			0 to 14400
Read program scan rate	px <i>n</i>	px3	sr <i>n</i> : 99.9	sr3: 11.3	
Set program scan rate	px <i>n</i> = <i>n</i>	px3=10			.1 to 99.9
Read program control mode	pc	pc	prog: {OFF or ON}	prog: OFF	

Digital Communications Commands continued

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Set program control mode:	pc=g[o]/s[top]/c[ont]				GO or STOP or CONT
Start program	pc=g[o]	pc=g			
Stop program	pc=s[top]	pc=s			
Continue program	pc=c[ont]	pc=c			
Read program function	pf	pf	pf: 9	pf: 3	
Set program function to <i>n</i>	pf= <i>n</i>	pf=2			1 to 4
Configuration Menu					
Operating Parameters Menu					
Read soft cutout	scut	scut	scut: 9999.9	scut: 1150.0	
Set soft cutout setting:	cu[tout]=<i>n</i>				
Set soft cutout to <i>n</i> degrees	cu[tout]= <i>n</i>	cu=500			0.0 to 1150.0
Serial Interface Menu					
Read serial sample setting	sa[mple]	sa	sa: 9	sa: 1	
Set serial sampling setting to <i>n</i> seconds	sa[mple]= <i>n</i>	sa=0			0 to 4000
Set serial duplex mode:	du[plex]=f[ull]/h[alf]				FULL or HALF
Set serial duplex mode to full	du[plex]=f[ull]	du=f			
Set serial duplex mode to half	du[plex]=h[alf]	du=h			
Set serial linefeed mode:	lf[eed]=on/off[f]				ON or OFF
Set serial linefeed mode to on	lf[eed]=on	lf=on			
Set serial linefeed mode to off	lf[eed]=off[f]	lf=of			
Cal Menu					
Read CT <i>n</i> calibration parameter	ct <i>n</i>	ct1	ct <i>n</i> : 99.9C	ct1: 300C	
Set CT <i>n</i> calibration parameter to <i>n</i>	ct <i>n</i> = <i>n</i>	ct1=300.4			0 to 1100
Read CE <i>n</i> calibration parameter	ce <i>n</i>	ce1	ce <i>n</i> : 99.9C	ce1: -10.1C	
Set CE <i>n</i> calibration parameter to <i>n</i>	ce <i>n</i> = <i>n</i>	ce1=-10			-99.9 to 99.9

Digital Communications Commands continued

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
These commands are only used for factory testing.					
Miscellaneous (not on menus)					
Read firmware version number	*ver[sion]	*ver	ver.9999,9.99	ver.9122,3,54	
Read structure of all commands	h[elp]	h	list of commands		
Legend:	[] Optional Command data {} Returns either information n Numeric data supplied by user 9 Numeric data returned to user x Character data returned to user				
Note:	When DUPLEX is set to FULL and a command is sent to READ, the command is returned followed by a carriage return and linefeed. Then the value is returned as indicated in the RETURNED column.				

10 Using the 9117 Annealing Furnace

10.1 General

The 9117 Annealing Furnace is designed to assist in maintaining an SPRT. The National Institute of Standards and Technology (NIST) lists annealing as the first step in the calibration procedure for SPRTs. Experimentation specific to the NIST PRT laboratory conducted by B.W. Mangum, E.R. Pfeiffer, and G.F. Strouse provides the “optimum” time outlined for annealing an SPRT before calibration as listed in Table 4. Although Table 4 lists specific cool-down times for temperatures, Hart experts recommend the 100°C/hr general rule which will satisfy the cool-down requirements, equalize the point-defect concentration, and simplify the process.

If the following circumstances occur, it is advisable to anneal an SPRT.

10.1.1 Mechanical Shock

During the course of normal use, the SPRT is subjected to mechanical shock which induces strain in the wire resulting in a change in resistance. Mechanical shock can be incurred by the slightest tap to the SPRT sensor while inserting or removing it from an instrument. Vibration during transport can also be a cause of mechanical shock. The SPRT is an extremely delicate instrument. Even with great care, mechanical shock can be introduced causing a significant change in the resistance of the SPRT. Annealing the SPRT at 660°C for one hour can eliminate most of the strains caused by minor shocks and restore the resistance

Table 4 SPRT Annealing Procedure Based on NIST Research

Range of SPRT Use	Procedure	Time
Up to Zn Point (419.527°C)	Hold at 450°C - 480°C	4 hours
Up to Al Point (660.323°C)	Thoroughly Clean	
	Heat from 500°C to 670°C	Over 1 hour
	Hold at 670°C	1.5 hours
	Cool to 500°C	Over 3 hours
	Remove to room temperature	
Up to Ag Point (961.78°C)	Measure R_{tp} for baseline	
	Thoroughly Clean	
	Heat to 970°C	Over 2 hours
	Hold at 970°C	1 hour
	Cool to 500°C	Over 4 hours
	Remove to room temperature	

close to its original value. Annealing is always advisable after any transport of the SPRT by commercial carrier.

10.1.2 Inherent Defects

All solids inherently contain defects. A “crystalline defect” is defined as a lattice irregularity having one or more of its dimensions on the order of an Angstrom (Å). Point defects, a type of crystalline defect, are associated with one or two atomic positions in the crystalline structure. The simplest and most common point defect is a vacancy or vacant lattice site, one normally occupied from which an atom is missing. Vacancies are formed during solidification and as a result of atomic vibrations. The concentration of the point defects is dependent upon the temperature. The equilibrium concentration of vacancies (N_v) in the pure platinum wire of the SPRT increases exponentially to the increase in temperature as shown by:

$$N_v = N \exp\left(-\frac{Q_v}{kT}\right)$$

N is the total number of atomic sites, Q_v is the vibration energy required for the formation of a vacancy, T is the absolute temperature in Kelvin, and K is Boltzmann’s constant ($1.38 \times 10^{-23} \text{ J K}^{-1}$). For most metals, the fraction of vacancies, N_v/N , just below the melting point, is on the order of 10^{-4} or one lattice site out of every 10,000 is empty. Removing an SPRT at a high temperature and rapidly cooling to room temperature traps this high concentration of point defects in the crystalline structure causing an increase in resistance. This increase can be as high as 30 mK. Annealing the SPRT at 700°C for two hours can significantly reduce the increase due to the trapped point defects. The SPRT should be cooled to at least 500°C at a rate of roughly 100°C/hour. Once the SPRT has reached 500°C, it may be removed immediately to room temperature without harm.

10.1.3 Fixed Point Calibration

Although the removal of the SPRT to room temperatures from high temperatures should be avoided as much as possible, it is an inescapable part of fixed-point calibration.

During the calibration process at high temperatures, the SPRT should be preheated and kept in the annealing furnace at a temperature close to the fixed point to be calibrated. Preheating the SPRT before inserting it in a fixed point cell, helps to maintain a longer freezing plateau. Once the SPRT has been calibrated in the fixed point, it can be removed quickly from the fixed point cell and returned to the annealing furnace. Annealing the SPRT for two hours after calibration and slowly lowering the temperature to 500°C prevents the quenching in of lattice defects found in the platinum wire.

10.1.4 Using a High Temperature Standard Platinum Resistance Thermometer (HTSPRT)

According to supplemental information for the ITS-90, after using a HTSPRT at temperatures above 700°C, the thermometer should be annealed before making measurements at lower temperatures, particularly before making the measurements at R_p .

11 Calibration Procedure

At times the user may want to calibrate the unit to improve the temperature set-point accuracy. Calibration is done by adjusting the controller probe calibration constants CE1, CE2, and CE3 so that the temperature of the unit as measured with a standard thermocouple agrees more closely with the set-point. The thermometer used must be able to measure the well temperature with higher accuracy than the desired accuracy of the unit.

11.1 Calibration Points

In calibrating the unit, CE1, CE2, and CE3 are adjusted to minimize the set-point error at each of three different well temperatures. Any three reasonably separated temperatures may be used for the calibration. Improved results can be obtained for shorter ranges when using temperatures that are just within the most useful operating range of the unit. The farther apart the calibration temperatures, the larger will be the calibration range but the calibration error will also be greater over the range. Choosing a range of 300°C to 700°C may allow the calibrator to have an accuracy of maybe $\pm 2.0^\circ\text{C}$ but outside that range the accuracy may be greater than $\pm 10.0^\circ\text{C}$.

11.2 Calibration Procedure

1. Choose three set-points to use in the calibration of CE1, CE2, and CE3 parameters. These set-points are generally CT1 = 300°C, CT2 = 700°C and CT3 = 1000°C but other set-points may be used if desired or necessary. Using these three temperature set-points may result in $\pm 5.0^\circ\text{C}$ accuracy.
2. If the normal set-points are not used, initialize CT1, CT2, and CT3 to the desired set points and CE1, CE2, and CE3 to 0. Where CT1 is the low-set point and CT3 is the high set-point.
3. Set the unit to the low set-point. When the unit reaches the set-point and the thermometer reference display is stable, wait 15 minutes or so and take a reading from the thermometer. Repeat step 3 for the other two set-points recording them as Tm1, Tm2 and Tm3.
4. Retrieve the original calibration errors from the unit.
5. Calculate CE1, CE2, and CE3 using the following formula.

$$T_{mn} - T_{sn} + C_{En} = C_{Em}$$

Where Tmn is the temperature measured, Tsn (CTn) is the set-point temperature, CEn is the old value for calibration error, and CEm is the new value for calibration error.

6. Enter new CEm in the calibration parameter menu using either the keypad or through the serial port.
7. Repeat steps 1-6 if required accuracy is not obtained.1

12 Maintenance

- The instrument has been designed with the utmost care. Ease of operation and simplicity of maintenance have been a central theme in the product development. Therefore, with proper care the instrument should require very little maintenance. Avoid operating the instrument in an oily, wet, dirty, or dusty environment.
- If the outside of the instrument becomes soiled, it may be wiped clean with a damp cloth and mild detergent. Do not use harsh chemicals on the surface which may damage the paint.
- Be sure that the well of the furnace is kept clean and clear of any foreign matter. **DO NOT** use fluids to clean out the well.
- If a hazardous material is spilled on or inside the instrument, the user is responsible for taking the appropriate decontamination steps as outlined by the national safety council with respect to the material.
- If the mains supply cord becomes damaged, replace it with a cord of the appropriate gauge wire for the current of the instrument. If there are any questions, call Hart Scientific Customer Service for more information.
- Before using any cleaning or decontamination method except those recommended by Hart, users should check with Hart Scientific Customer Service to be sure that the proposed method will not damage the equipment.
- If the instrument is used in a manner not in accordance with the equipment design, the operation of the furnace may be impaired or safety hazards may arise.
- The over-temperature soft cutout should be checked every 6 months to see that it is working properly. In order to check the user selected cutout, follow the controller directions (Section 8.10.2) for setting the soft cutout.
- Periodically check the fused silica alumina equilibration block for cracks. The block may not be used if it is cracked.
- The over-temperature hard cutout should be checked every 6 months. To check the hard cutout see Section 8.12.1.
- The electronics in the bottom of the furnace should be cleaned periodically. The schedule is dependent upon the particular laboratory. It is recommended that the electronics be checked 4 to 6 weeks after the unit is placed into service. If the electronics are covered with dust or the fan guard is covered with dust preventing proper air flow, remove the dust gently with a vacuum cleaner. Set a cleaning maintenance schedule for the furnace based on initial findings. Adjust the schedule as history warrants.
Note: The unit must be turned on its side and one leg removed in order to remove the cover plate to the electronics. Unplug the unit before removing the electronics cover. Remove the fused silica alumina equilibration block before maintenance.

13 Troubleshooting

This section contains information on troubleshooting, CE Comments, and a wiring diagram.

13.1 Troubleshooting Problems, Possible Causes, and Solutions

In the event that the instrument appears to function abnormally, this section may help to find and solve the problem. Several possible problem conditions are described along with likely causes and solutions. If a problem arises, please read this section carefully and attempt to understand and solve the problem. If the problem cannot otherwise be solved, contact Hart Scientific Customer Service for assistance (1-801-763-1600). Be sure to have the model number, serial number, and voltage of your instrument available.

Problem	Possible Causes and Solutions
Incorrect temperature reading	<p>Incorrect calibration parameters. If the first number displayed is less than “-005”, the instrument has been re-initialized. Find the value for CT1, CT2, CT3, CE1, CE2, and CE3 on the Report of Test that was shipped with the instrument. Reprogram the calibration parameters into the Model 9117 memory (see Section 8.12). Allow the instrument to stabilize and verify the accuracy of the temperature reading.</p> <p>Controller locked up. The controller may have locked up due to a power surge or other aberration. Initialize the system by performing the Factory Reset Sequence.</p> <p>Factory Reset Sequence. Hold the SET and EXIT buttons down at the same time while powering up the instrument. After the instrument displays <code>-101E-</code>, release the buttons. The display shows <code>-101E-</code>, then displays <code>9117</code>, and finally then displays the firmware version. After performing the master reset sequence, all of the configuration parameters are reset to their default values. Reprogram the calibration parameters into the Model 9117 memory (see Section 8.12) and any other applicable configuration parameters. Allow the instrument to stabilize and verify the accuracy of the temperature reading.</p>
The instrument heats or cools too quickly or too slowly	<p>Incorrect scan and scan rate settings. The scan and scan rate settings may be set to unwanted values. Check the Scan and Scan Rate settings. The scan may be off (if the unit seems to be responding too quickly). The scan may be on with the Scan Rate set low (if unit seems to be responding too slowly).</p>
The display shows any of the following: <code>Err 1</code> , <code>Err 2</code> , <code>Err 3</code> , <code>Err 4</code> , or <code>Err 5</code>	<p>Controller problem. The error messages signify the following problems with the controller.</p> <p><code>Err 1</code> - a RAM error <code>Err 2</code> - a NVRAM error <code>Err 3</code> - a RAM error <code>Err 4</code> - an ADC setup error <code>Err 5</code> - an ADC ready error</p> <p>Initialize the system by performing the Factory Reset Sequence describe above.</p>

Problem	Possible Causes and Solutions
The display shows <i>Error 6</i>	Defective control sensor. The control sensor may be shorted, open or otherwise damaged. Disconnect the power cord from the instrument. Contact Hart Scientific Customer Service for further instructions.
The display shows <i>Error 7</i>	Heater control error. Initialize the system by performing the Factory Reset Sequence describe above. If the instrument repeats the error code, turn the instrument off and allow the instrument to sit at least one-half hour. Turn the instrument back on. If the instrument repeats the error code, turn off the unit and contact Hart Scientific Customer Service for a return authorization and for instructions on returning the instrument.
The display shows <i>Error 8</i>	Soft cutout error. Initialize the system by performing the Factory Reset Sequence describe above. The Factory Reset Sequence resets the Soft Cutout temperature to the default of 1125°C. If the instrument repeats the error code, turn the instrument off and allow the instrument to sit at least one-half hour. Turn the instrument back on. If the instrument repeats the error code, turn off the unit and contact Hart Scientific Customer Service for a return authorization and for instructions on returning the instrument.

13.2 Comments

13.2.1 EMC Directive

Hart Scientific's equipment has been tested to meet the European Electromagnetic Compatibility Directive (EMC Directive, 89/336/EEC). The Declaration of Conformity for your instrument lists the specific standards to which the unit was tested.

13.2.2 Low Voltage Directive (Safety)

In order to comply with the European Low Voltage Directive (73/23/EEC), Hart Scientific equipment has been designed to meet the IEC 1010-1 (EN 61010-1) and the IEC 1010-2-010 (EN 61010-2-010) standards.