FLUKE ®

Hart Scientific ®

9116A Furnace

User's Guide

Rev. 842101

Limited Warranty & Limitation of Liability

Each product from Fluke Corporation, Hart Scientific Division ("Hart") is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is 1 year for the Furnace. The warranty period begins on the date of the shipment. Parts, product repairs, and services are warranted for 90 days. The warranty extends only to the original buyer or end-user customer of a Hart authorized reseller, and does not apply to fuses, disposable batteries or to any other product, which in Hart's opinion, has been misused, altered, neglected, or damaged by accident or abnormal conditions of operation or handling. Hart warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective media. Hart does not warrant that software will be error free or operate without interruption. Hart does not warrant calibrations on the Furnace.

Hart authorized resellers shall extend this warranty on new and unused products to end-user customers only but have no authority to extend a greater or different warranty on behalf of Hart. Warranty support is available if product is purchased through a Hart authorized sales outlet or Buyer has paid the applicable international price. Hart reserves the right to invoice Buyer for importation costs of repairs/replacement parts when product purchased in one country is submitted for repair in another country.

Hart's warranty obligation is limited, at Hart's option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a Hart authorized service center within the warranty period.

To obtain warranty service, contact your nearest Hart authorized service center or send the product, with a description of the difficulty, postage, and insurance prepaid (FOB Destination), to the nearest Hart authorized service center. Hart assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If Hart determines that the failure was caused by misuse, alteration, accident or abnormal condition or operation or handling, Hart will provide an estimate or repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

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Rev. 842101

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Figures and Tables

1 Before You Start

1.1 Introduction

The Hart Scientific 9116A Furnace has a temperature range of 550°C to 1100°C and is designed for use in achieving aluminum, silver, or copper freezing point measurements.

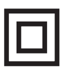
The furnace utilizes a sodium heat pipe to maintain a uniform temperature over the length of the metal freeze point cell. The temperature controller is programmable, a feature that may be conveniently used to simplify the melting, freeze initiation, and plateau control. The temperature control and uniformity of the furnace allows the user to achieve plateaus ranging many hours in length.

***NOTE:** Many of the illustrations and examples used in this manual assume the use of the copper point cell. Any of the three cells indicated may be used with the appropriate set-points.*

1.2 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 (Alternating Current)
	AC-DC
	Battery
	CE Complies with European Union Directives
	DC
	Double Insulated
	Electric Shock

Symbol	Description
	Fuse
	PE Ground
	Hot Surface (Burn Hazard)
	Read the User's Manual (Important Information)
	Off
	On
	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.

1.3 Safety Information

Use this instrument only as specified in this manual. Otherwise, the protection provided by the instrument may be impaired.

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.

1.3.1 ⚠ WARNINGS

To avoid personal injury, 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.
- **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.
- If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.
- Before initial use, or after transport, or after storage in humid or semi-humid environments, or anytime the instrument has not been energized for more than 10 days, the instrument needs to be energized for a "dry-out" period of 2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1. If the product is wet or has been in a wet environment, take necessary measures to remove moisture prior to applying power such as storage in a low humidity temperature chamber operating at 50°C for 4 hours or more.
- 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.
  May contain or form cristobalite (crystalline silica) with use at high temperatures (above 1600°F) which can cause severe respiratory disease.
  Possible cancer hazard based on tests with laboratory animals. Animal studies to date are inconclusive. No human exposure studies with this product have been reported.
  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).
- **HIGH TEMPERATURES PRESENT** in this equipment **FIRES AND SEVERE BURNS** may result if personnel fail to observe safety precautions.
- **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.
- In the unlikely event that the heat pipe should leak: **DO NOT** attempt to put out the fire with water or chemical fire extinguishers. **SMOTHER THE FIRE WITH DRY SODA ASH.** See the Material Safety Data Sheet (MSDS).
- Follow all safety guidelines listed in the user’s manual.

- 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. SPRT's should be placed in an annealing furnace if removed at temperatures greater than 500°C.
- Use only grounded AC mains supply of the appropriate voltage to power the instrument. See Section 2.1, Specifications, for power requirements.
- The 9116A 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.
- Calibration Equipment should only be used by Trained Personnel.

1.3.2 ⚠ CAUTIONS

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

- Components and heater lifetimes can be shortened by continuous high temperature operation.
- Operate the instrument in room temperatures as indicated in Section 2.2, Environmental Conditions. 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. The furnace is equipped with cooling coils, use cold water circulation when the furnace is used above 600°C. (For specifics see Section 4.5 Plumbing.)
- 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 not be operated in wet, oily, dusty or dirty environments. Keep the well of the instrument free of any foreign matter. Do not operate near flammable materials.
- Do not use fluids to clean out the well.
- 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 for some reason, be sure that the fixed point cell has been removed before moving the furnace. Any movement of the furnace with the cell inside can damage the cell. The unit is not designed to be lifted or carried. If it must be picked up, it is advisable that two people pick the unit up by placing their hands

under the unit and carefully lifting at the same time. Never move the furnace if it is hot.

- 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. Alternatively, if used, the cooling water should remain on until the furnace is cool.
- Once the unit has been taken to high temperatures (over 800°C), it takes days for the unit to cool completely.

1.4 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 Specifications and Environmental Conditions

2.1 Specifications

Temperature Range	550°C to 1100°C (1022°F to 2012°F)
Accuracy	±3.0°C
Stability	±0.15°C
Uniformity	±0.05°C
Control Probe	10Ω HTPRT
Resolution	0.1°C/°F below 1000°C/°F 1°C/°F above 1000°C/°F
Readout	Switchable °C or °F
Controller	Digital controller with data retention
Fault Protection	High temperature cutout (Type R cutout thermocouple) Sensor burnout and short protection
Cutout Accuracy	±10°C
Power	230 VAC (±10%), 50/60 Hz, 2500 W
Heater	2500 W
System Fuses	15 A 250 V fast acting
Exterior Dimension	838 mm H x 610 mm W x 406 mm D (33 x 24 x 16 in)
Weight	82 kg (180 lb.)
Safety	EN 601010-1, CAN/CSA C22.2 No. 601010.1-04

2.2 Environmental Conditions

Although the instrument has been designed for optimum durability and trouble-free operation, it must be handled with care. The instrument should not be operated in an excessively dusty or dirty environment. Maintenance and cleaning recommendations can be found in the Maintenance Section of this manual.

The instrument operates safely under the following conditions:

- ambient temperature range: 5 - 50°C (41 - 122°F)
- ambient relative humidity: maximum 80% for temperature <31°C, decreasing linearly to 50% at 40°C
- pressure: 75kPa - 106kPa
- mains voltage within ± 10% of nominal

- vibrations in the calibration environment should be minimized
- altitude less than 2,000 meters
- indoor use only

If the unit is operating at temperatures above 600°C, cooling coils are accessible on the rear of the chassis to prevent the furnace heat from loading down the room air conditioning system. (See Section 3.4 Plumbing)

3 Installation

3.1 Unpacking

Verify that the following components are present:

- Furnace
- Control HTPRT and Cutout Thermocouple
- Heat Radiation Guard (Quartz tube packed separately)
- Fixed Point Basket
- Fixed Point Basket Lid
- Fixed Point Basket removal tool
- Sodium Heat Pipe
- Circular 1.27 cm (0.5 in) fiber ceramic board (already installed in furnace)
- Top thermal shunt disk
- Bottom thermal shunt disk (already installed in furnace)
- Extra Insulation:
    - Fiber ceramic insulating paper for the fixed point cell
    - Small circles for fixed point basket
    - Miscellaneous for packing around the fixed point cell
    - Circular 1.27 cm (0.5 in) fiber ceramic board

Unpacking should be done carefully. Several parts are packed disassembled for safe shipment. Small parts may be packed in a separate box inside the crate. Check carefully for all parts. If there is any damage due to shipment, notify your carrier immediately.

3.2 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.

3.3 Power

The 9116A furnace power requirements are listed in Section 2.1 on page 7. 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

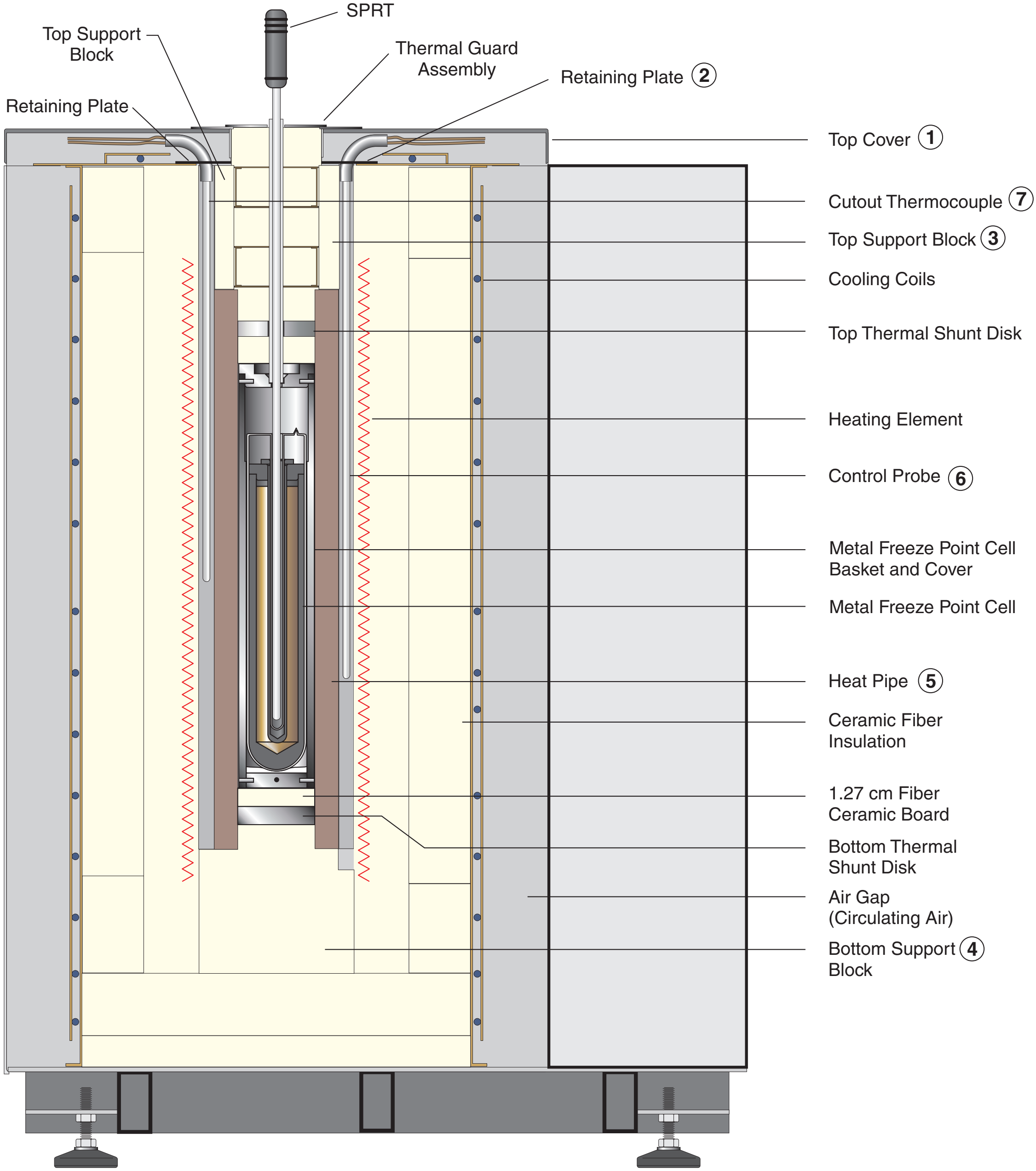


Figure 1. *Furnace Core Diagram*

rated for the specified current and voltage. (See Figure 5, Back Panel on page 19.)

Be sure that the furnace chassis is always solidly grounded. A shock hazard may exist if it is not. All switches are double pole for safety in such hot-hot-neutral installations and both lines are fused.

3.4 Plumbing

The cooling coils are accessible from the back panel of the 9116A chassis (See Figure 5, Back Panel on page 19). The cooling tubes are 6.35 mm (0.25 in) copper. Water cooling prevents much of the furnace heat from loading down air conditioning systems. Provide cold tap water with a valve convenient for operation near the rear of the furnace. A flow rate of about 0.4 GPM of tap water is required. Pressure should not exceed 60 PSIG. Drain the warm exit water into an appropriate sump.

3.5 Heat Pipe Installation

NOTE: The first heat of the furnace should be done without the heat pipe to verify operation and to become familiar with the furnace. Remove any packing material before operating.

The heat pipe is shipped separately in order to prevent damage to the heater and delicate fiber ceramic insulation. Re-installation of the control HTPRT and cutout thermocouple is also required. Follow the instructions carefully. Many of the materials are fragile. Refer to Figure 1 on page 10. Should the furnace be relocated, the heat pipe must be removed and reinstalled at the new location. See Figure 1 which shows the internal components of the furnace core.

1. Remove the top cover (1) of the furnace. Remove the metal retaining plate (2) by detaching the four screws holding it in. Remove the top support block (3) and any packing material (used for shipping) from the central furnace core. Leave the bottom support block (4) in place at the bottom of the core.

2. Locate the heat pipe (5) and the heat pipe installation tool. Use cotton gloves to handle the heat pipe. Finger prints will cause corrosion of the Inconel at high temperatures. The installation tool has a handle with heavy gauge wire hooks which fit into the tabs on the top of the furnace. Remove any packing materials from the heat pipe. *(Any finger oils must be removed with reagent grade alcohol before installation.)* The heat pipe has a protrusion on the top between the installation tabs which served as a filling port. This port must be rotated appropriately to fit the matching notch on the top support block. Note the orientation of the notch on the top support block and be sure to rotate the heat pipe accordingly. The larger notches in the top support block are toward the rear of the furnace. There is a grounding wire attached to the top flange of the heat pipe. **BE CAREFUL** that it does not damage the ceramic heaters as the heat pipe is lowered into the furnace.

3. Attach the installation tool to the heat pipe and lower it very carefully into the furnace. Maintain the heat pipe in the center of the well so as to allow the bottom support block to slide into the cavity at the bottom of the heat pipe. The fiber-ceramic material is very fragile. The heater and the support can easily be damaged if care is not taken during heat pipe installation.

4. Once the heat pipe is in place, position the top support block (3) over the heat pipe. Be careful to position the notch onto the heat pipe, the flanges of the heat pipe (5) into the slits in the support block and the grounding wire through the right rear access notch (when facing the furnace) in the support block. If necessary, use a knife to cut pieces of the ceramic blanket material provided to center and firmly locate the top support block in place.

5. Re-attach the metal retaining plate (2) using the four screws. The ground wire from the heat pipe must be routed through the right rear access hole in the plate and attached to the closest screw using two star washers and a screw. Make sure that the ground wire is securely attached to the furnace chassis. Check the ground continuity to ensure that the ground wire is intact and the heat pipe (5) is grounded. Insure that the wire routing for the Control (6) and Cutout (7) probe is as shown in Figure 2.

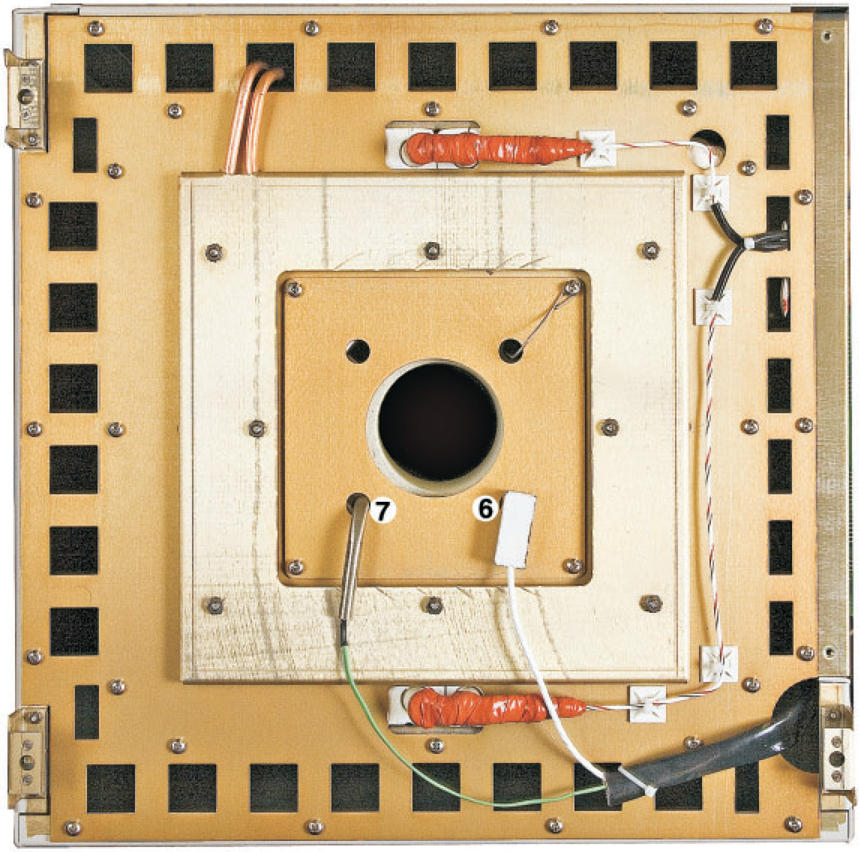


Figure 2 *HTPRT control probe and cutout thermocouple wire routing and heat pipe ground wire placement..*

6. Reinstall the control HTPRT (6) and the cutout thermocouple (7) as shown in Figure 2 on page 13. They must be inserted far enough to clear the top cover. They should also be centered in the air space between the element and the heat pipe. Small pieces of the fiber ceramic material can be used to fix their positions. The wires from the probes must be properly routed and connected to the controller as shown in Figure 2. Remove the cover over the electronics panel. Route the probe wires through the hole in the top of the furnace (at the front right of the furnace when facing the furnace) and down to the access hole into the electronics compartment (at the center left when facing the electronics panel). Connect the probe wires to the controller. The labels on the probes and the controller must be used to correctly complete the wiring. The thermocouple wires should be firmly attached using the screw-down terminals on the controller printed circuit board. The HPRT connection must be firmly seated on the controller Make sure that the leads from the thermocouples are directed away from the central well of the furnace, and will not be pinched or interfere with other parts. See Figure 3

7. Reinstall the top cover. Locate the cover over the ball catches and press down firmly.

8. Become familiar with the operation of the furnace before installing the metal freeze point cell.

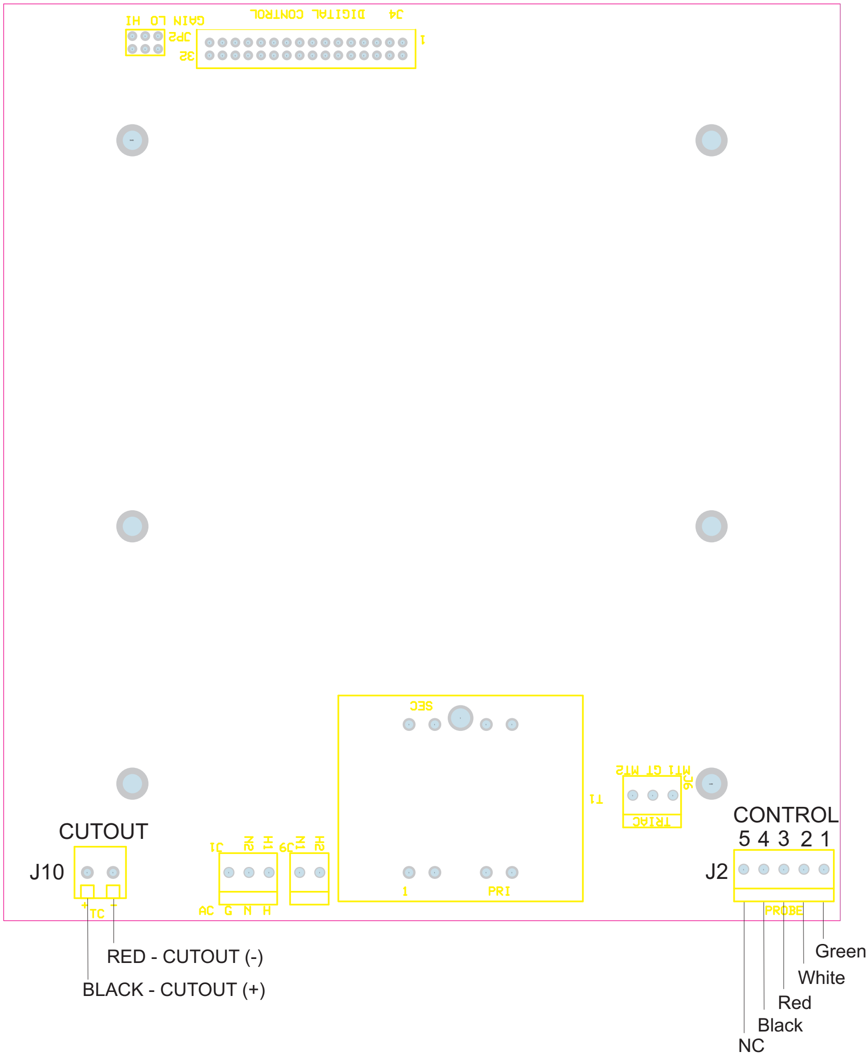


Figure 3 *Attachment of thermocouples*

4 Parts and Controls

The 9116A consists of a control panel, furnace core, and a back panel. Each part and control is described below.

4.1 Control Panel

The controls to the furnace are located on panels to the right of the instrument. The upper portion of the panel is sloped and contains the controller which is regularly used during operation of the furnace. An LED on the main display indicates when the controller is sending power to the heater. Red indicates the heater is on, green indicates the heater is off, pulsing means the heater power is being regulated by the controller between 0 and 100%.

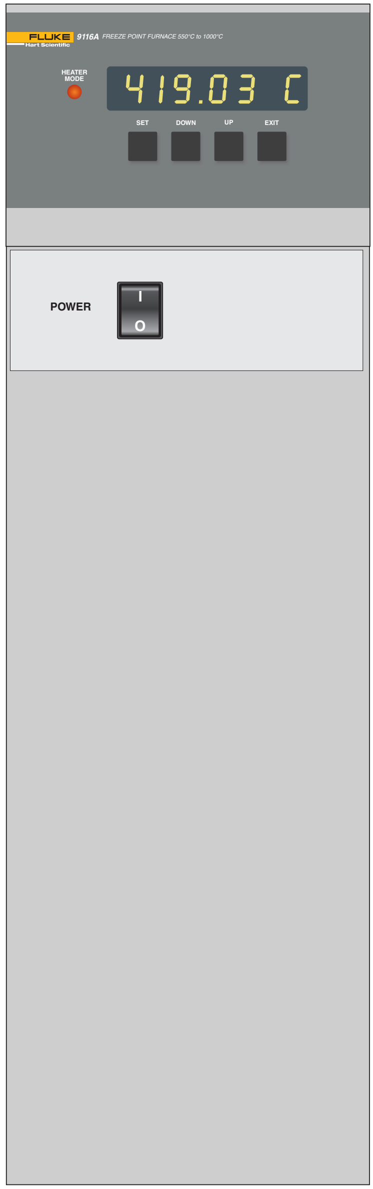


Figure 4. Front Control Panel (cover door remove)

4.1.1 Controller

The controller has overall control of the furnace. This sloped panel is located on the upper right portion of the furnace (see Figure 4). The controller itself is a hybrid analog/digital device utilizing the high stability of analog circuitry with the flexibility of a micro-processor interface and digital controls.

The following controls and indicators are present on the primary controller panel: (1) the digital LED display, (2) the control buttons, and (3) control indicator LED.

(1) 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.

(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 to the displayed value.

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.

4.2 Furnace Core

The furnace core consists of the heater, insulating materials, heat pipe, heat pipe support blocks, and the housing with water cooling. Refer to Figure 1 on page 10.

The heater is embedded in a fiber ceramic insulating block. A hollow section through the center contains the heat pipe.

The heat pipe is a double wall Inconel cylinder containing sodium. The minimum working temperature of the Sodium heat pipe is about 500°C. The heat pipe must be heated slowly (about 1-2 hours) to this temperature. The temperature may then be raised more quickly to the desired set-point. When the working temperature is achieved, the sodium circulates throughout the tube providing a uniform temperature. The heat pipe has a lifetime of many years. Do not use the heat pipe unnecessarily at high temperatures which reduces the lifetime. Refer to the Section 5 for more information.

***CAUTION:** In the unlikely event that the heat pipe should leak, do not attempt to put out the fire with water or chemical fire extinguishers. Smother the fire with dry soda ash in accordance with the MSDS sheets at the end of this manual.*

The heat pipe is centered in the heating element and supported by means of fiber ceramic blocks. One block fits into the bottom of the heat pipe and a second fits over the top centering the heat pipe in the heater assembly. The top block also supports the control HTPRT and cutout thermocouple. The heat pipe is shipped separately since its weight would damage the heater and supports if it were in place during shipment.

The entire heater and heat pipe assembly are contained and supported by a sheet metal housing. Copper cooling coils are attached to the outside of this housing. These cooling coils allow some of the heat lost to be removed from the lab area reducing the lab heat load. They are accessible on the rear of the furnace chassis (see Figure 5).

Air is circulated through the gap surrounding the furnace core. This keeps the chassis cool. Do not shut off the furnace while at high temperatures or the fan will turn off allowing the chassis to become hot. Alternatively, if used, the water cooling could remain on until the furnace is cool.

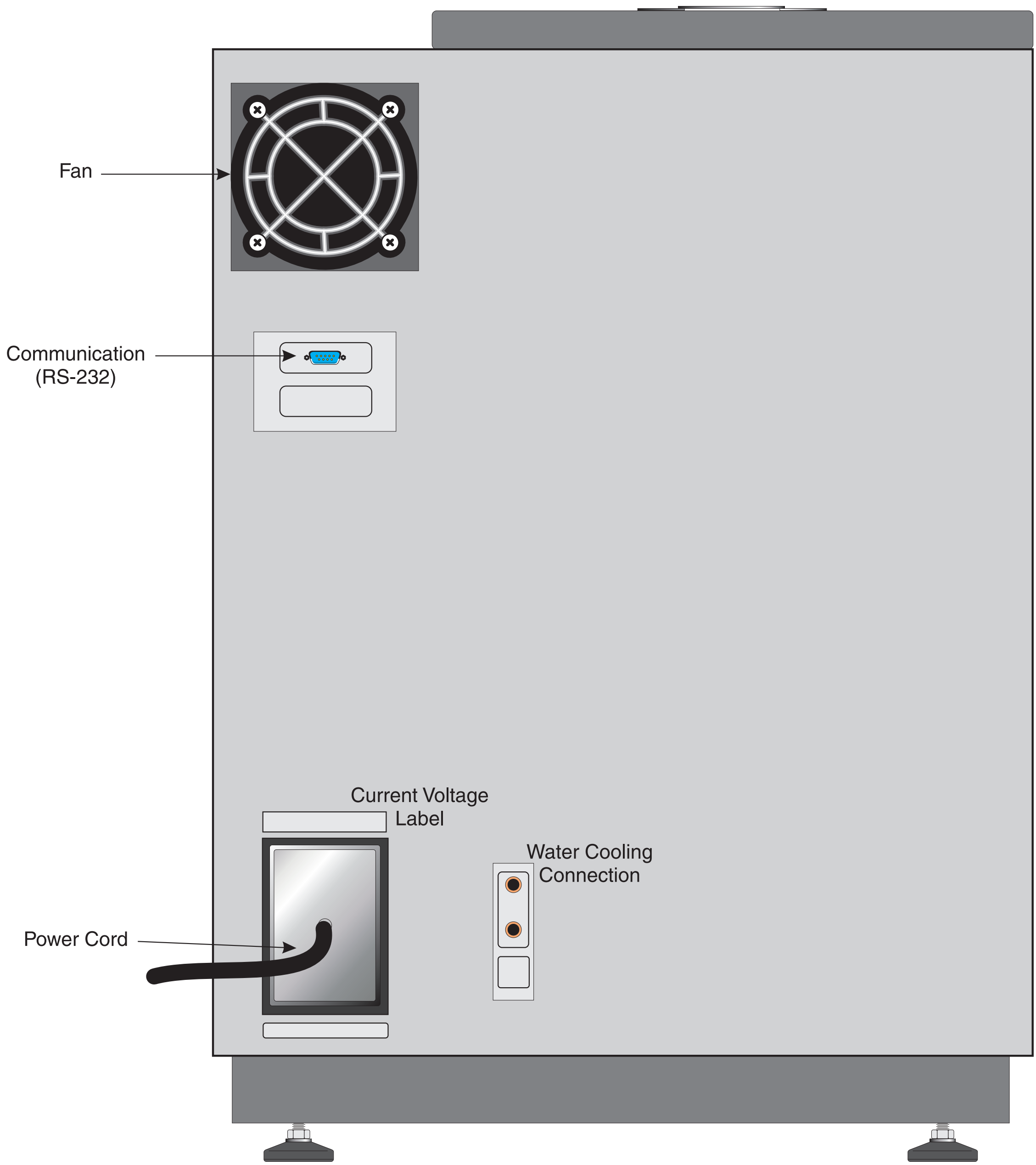


Figure 5. *Back Panel*

4.3 Access Well

The furnace access well is visible on top of the furnace.

The furnace access well is where the freeze point cell is inserted and removed from the furnace. After a freeze point cell is inserted into the furnace, a thermal shunt disk and thermal guard assembly are installed over it. This provides a block to the heat loss from the well and provides more temperature uniformity for the cell.

4.4 Back Panel

The back panel consists of an exhaust fan, a serial communications connector, a power cord, and cooling water ports. See Figure 5 on page 19.

1. The exhaust fan allows air circulation around the electrical components. Be sure to keep this fan free of foreign objects that could hinder air flow.
2. The serial communication connector is a DB-9 connector for interfacing the furnace to a computer or terminal with serial RS-232 communications. (See Section 7 starting on page 39 for details.)
3. The power cord is a non-removable cord.
4. The cooling water ports are provided for connecting to cooling water to reduce the heat load. See Section 4.5 Plumbing for details.

5 General

5.1 Sodium Heat Pipe Information

5.1.1 Minimum Temperature and Heat-Up Rate

The heat pipe should not be inserted into a hot furnace. The minimum operating temperature is 500°C. The heat pipe should be installed in a cold furnace and heated to the minimum operating temperature over a minimum 1 hour period. Above the minimum operating temperature the heat-up rate is not important.

5.1.2 ⚠ Safety Precautions

The heat pipe was designed for long-term maintenance free operation. It was performance tested at the factory and in the furnace.

In the event of an accident which results in a rupture of the heat pipe, the small quantity of sodium may burn. **DO NOT** use water or standard fire extinguishers on sodium fires. (Refer to MSDS) Standard commercially available materials for extinguishing sodium fires are dry soda ash (Na_2CO_3) or powdered graphite. *A container of one of these products should be kept in the laboratory near the furnace in case of an accident.*

Mechanical damage to the fill tube may cause in-leakage of air at low temperatures. This will evidence itself by cold regions in the heat pipe when at operating temperature. Operation should be discontinued and an Authorized Service Center should be consulted.

6 Controller Operation

This chapter discusses in detail how to operate the furnace temperature controller using the front control panel. Using the front panel key-switches and LED display the user may monitor the well temperature, set the temperature set-point in degrees C or F, monitor the heater output power, adjust the controller proportional band, set the cut-out set-point, and program the probe calibration parameters, operating parameters, serial and IEEE-488 interface configuration, and controller calibration parameters. Operation of the controller functions is summarized in Figure 6.

In the following discussion a solid box around the word SET, UP, EXIT or DOWN 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.

6.1 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,

100.00 C	*Well temperature in degrees Celsius*

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

6.2 Reset Cut-out

If the over-temperature cut-out has been triggered, the temperature display alternately flashes,

Cut-out	*Indicates cut-out condition*

This message continues to flash until the temperature is reduced and the cut-out is reset.

The cut-out has two modes — automatic reset and manual reset. The mode determines how the cut-out is reset which allows the instrument to heat up again. When in automatic mode, the cut-out resets itself as soon as the temperature is lowered below the cut-out set-point. When in manual reset mode the cut-out must be reset by the operator after the temperature falls below the set-point.

When the cut-out is active and the cut-out mode is set to manual (“reset”), the display flashes “cut-out” until the user resets the cut-out. **To access the reset cut-out function press the “SET” button.**

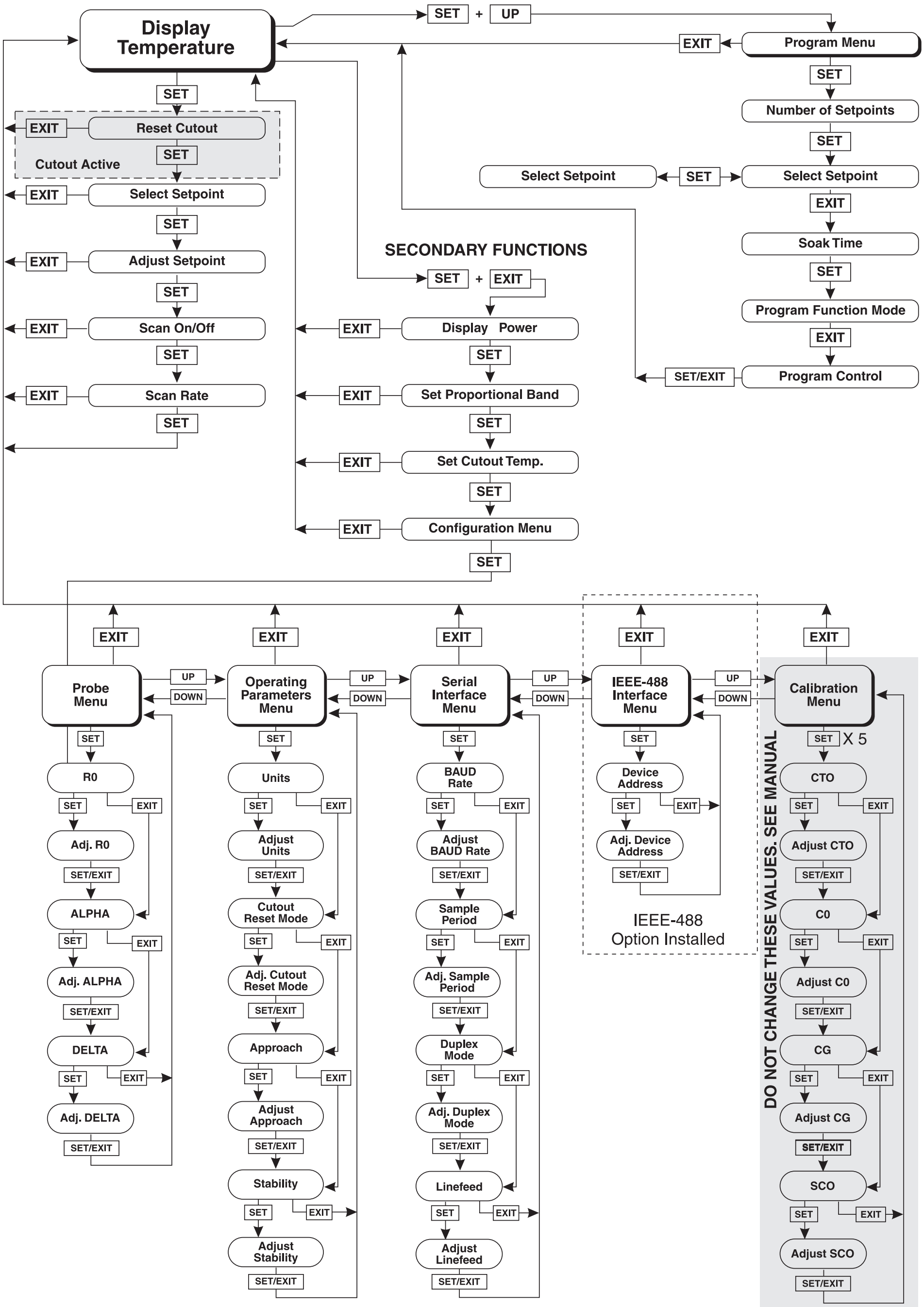


Figure 6. *Controller Flow Chart*

SET *Access cut-out reset function*

The display indicates the reset function.

RESET? *Cut-out reset function*

Press “SET” once more to reset the cut-out.

SET *Reset cut-out*

This also switches the display to the set temperature function. To return to displaying the temperature press the “EXIT” button. If the cut-out is still in the over-temperature fault condition the display will continue to flash “cut-out”. The well temperature must drop a few degrees below the cut-out set-point before the cut-out can be reset.

6.3 Temperature Set-point

The temperature set-point can be set to any value within the range and with the resolution as given in the specifications. Be careful not to exceed the safe upper temperature limit of any device inserted into the well. The safety cut-out should be properly adjusted to help prevent this occurrence.

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

6.3.1 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.

100.00 C *Well temperature in degrees Celsius*

SET *Access set-point memory*

1. 25.00 *Set-point memory 1, 25.00°C currently used*

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

4. 600.0 *New set-point memory 4, 600.0°C*

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

SET *Accept selected set-point memory*

6.3.2 Set-point Value

The set-point value may be adjusted after selecting the set-point memory and pressing "SET". The set-point value is displayed with the units, C or F, at the left.

`C 600.00` *Set-point 4 value in °C*

If the set-point value does not need to be changed, press "EXIT" to resume displaying the well temperature. Press "UP" or "DOWN" to adjust the set-point value.

`C 620.00` *New set-point value*

When the desired set-point value is reached press "SET" to accept the new value and access the temperature scale units selection. If "EXIT" is pressed, any changes made to the set-point are ignored.

[SET] *Accept new set-point value*

6.4 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.

6.4.1 Scan Control

The scan is controlled with the scan on/off function that appears in the main menu after the set-point function.

`ScAn=OFF` *Scan function off*

Press "UP" or "DOWN" to toggle the scan on or off.

`ScAn=On` *Scan function on*

Press "SET" to accept the present setting and continue.

[SET] *Accept scan setting*

6.4.2 Scan Rate

The next function in the main menu is the scan rate. The scan rate can be set from .1 to 100 °C/minute. The maximum scan rate, however, is actually limited by the natural heating or cooling rate of the instrument. This 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.

`Sr= 10.0` *Scan rate in °C/min.*

Press "UP" or "DOWN" to change the scan rate.

`Sr= 2.0` *New scan rate*

Press "SET" to accept the new scan rate and continue.

[SET] *Accept scan rate*

6.5 Ramp and Soak Program Menu

The ramp and soak program feature of the 9114 allows the user to program the furnace to automatically cycle through a number of set-point temperatures, holding at each for a determined length of time. The user can select one of four different cycle functions.

The program parameter menu is accessed by pressing "SET" and then "UP".

`100.00 C` *Well temperature*

[SET] + [UP] *Access program menu*

`ProG` *Program menu*

Press "SET" to enter the program menu

[SET] *Enter program menu*

6.5.1 Number of Program Set-points

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

`Pn=8` *Number of program set-points*

Use the "UP" or "DOWN" buttons to change the number from 2 to 8.

`Pn=3` *New number of program set-points*

Press "SET" to continue. Pressing "EXIT" causes any changes made to the parameter to be ignored.

SET *Save new setting*

6.5.2 Set-points

The next parameters are the program set-points.

1 25.00	*First set-point*

Use the "UP" or "DOWN" buttons to select any of the set-points.

3 500.00	*Third set-point*

Press "SET" to be able to change the set-point.

C 500.00	*Set-point value*

Use "UP" and "DOWN" to change the set-point value.

C 565.00	*New set-point value*

Press "SET" to save the new set-point value.

The other set-points can also be set in the same manner. Once the set-points are programmed as desired press "EXIT" to continue.

EXIT *Continue to next menu function*

6.5.3 Program Soak Time

The next parameter in the program menu is the soak time. The soak time is the time, in minutes, that the furnace maintains each of the program set-points after settling before proceeding to the next set-point. The duration is counted from the time the temperature settles to within a specified stability. The stability requirement can be set in the parameter menu as explained in Section 6.12.4. The default is 0.1°C.

Pt=15	*Soak time in minutes*

Use the "UP" or "DOWN" buttons to change the time.

Pt=5	*New soak time*

Press "SET" to continue.

SET *Save new setting*

6.5.4 Program Function Mode

The next parameter is the program function or cycle mode. There are four possible modes that 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. Table 2 below shows the action of each of the four program mode settings.

PF=1 *Program mode*

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

PF=4 *New mode*

Press “SET” to continue.

SET *Save new setting*

Table 2. *Program mode setting actions*

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

6.5.5 Program Control

The final parameter in the program menu is the control parameter. There are three choices to choose from 1) start the program from the beginning, 2) continue the program from where it was when it was stopped, or 3) stop the program.

Pr=oFF *Program presently off*

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

Pr=StArt *Start cycle from beginning*

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

SET *Activate new command*

6.6 Secondary Menu

Functions that 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 6 on page 24.)

6.7 Heater Power

The temperature controller controls the temperature of the well 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. This value may be estimated by watching the red/green control indicator light or read directly from the digital display. 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 ±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.

100.00 C	*Well temperature*
SET + EXIT	*Access heater power in secondary menu*
12 Pct	*Heater power in percent*

To exit out of the secondary menu press "EXIT". To continue on to the proportional band setting function press "SET".

6.8 Proportional Band

In a proportional controller such as this 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 back down. In this way the temperature is maintained at a fairly constant temperature.

The temperature stability of the well and response time depends on the width of the proportional band. See Figure 7. If the band is too wide the well temperature deviates excessively from the set-point due to varying external conditions. This 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.

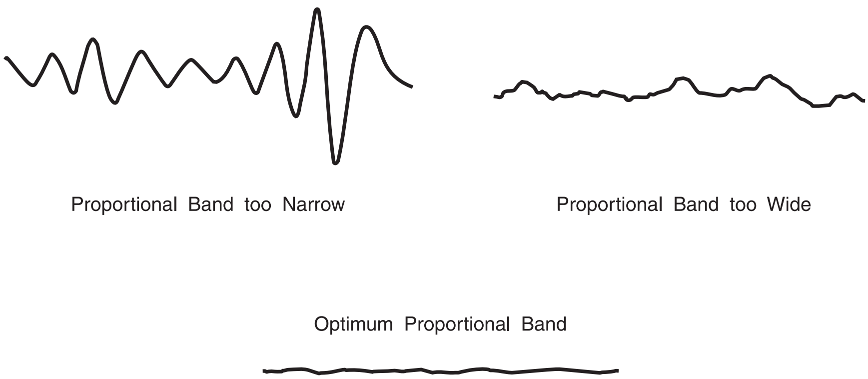


Figure 7. *Proportional Band Settings*

The proportional bandwidth is set at the factory. Check your Report of Test to verify factory settings. The proportional band width may be altered if the user desires to optimize the control characteristics for a particular application.

The proportional bandwidth 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 is accessed within the secondary menu. Press “SET” and “EXIT” to enter the secondary menu and show the heater power. Then press “SET” to access the proportional band.

[SET] + [EXIT] *Access heater power in secondary menu*

`12 Pct` *Heater power in percent*

[SET] *Access proportional band*

`Pb= 4.01C` *Proportional band setting*

To change the proportional band press “UP” or “DOWN”.

`Pb=10.00C` *New proportional band setting*

To accept the new setting and access the cut-out set-point press “SET”. Pressing “EXIT”, exits the secondary menu ignoring any changes just made to the proportional band value.

SET *Accept the new proportional band setting*

6.9 Cut-out

As a protection against software or hardware fault, shorted heater triac, or user error, the calibrator is equipped with an adjustable heater cut-out device that shuts off power to the heater if the well temperature exceeds a set value. This protects the instrument and probes from excessive temperatures. The cut-out temperature is programmable by the operator from the front panel of the controller.

If the cut-out is activated because of excessive well temperature, power to the heater shuts off and the instrument cools. The well cools until it reaches a few degrees below the cut-out set-point temperature. At this point the action of the cut-out is determined by the setting of the cut-out mode parameter. The cut-out has two modes — automatic reset or manual reset. If the mode is set to automatic, the cut-out automatically resets itself when the temperature falls below the reset temperature allowing the well to heat up again. If the mode is set to manual, the heater remains disabled until the user manually resets the cut-out.

The cut-out set-point may 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 cut-out set- point.

SET + EXIT *Access heater power in secondary menu*

12 Pct *Heater power in percent*

SET *Access proportional band*

PB= 4.01C *Proportional band setting*

SET *Access cut-out set-point*

CO= 610C *Cut-out set-point*

To change the cut-out set-point press "UP" or "DOWN".

CO= 400C *New cut-out set-point*

To accept the new cut-out set-point press "SET".

SET *Accept cut-out set-point*

The next function is the configuration menu. Press "EXIT" to resume displaying the well temperature.

6.10 Controller Configuration

The controller has a number of configuration and operating options and calibration parameters that are programmable via the front panel. These are accessed from the secondary menu after the cut-out set-point function by pressing "SET". There are 5 sets of configuration parameters — probe parameters, operating parameters, serial interface parameters, IEEE-488 interface parameters, and controller calibration parameters. The menus are selected using the "UP" and "DOWN" keys and then pressing "SET".

6.11 Probe Parameters

The probe parameter menu is indicated by,

PrObE *Probe parameters menu*

Press "SET" to enter the menu. The probe parameters menu contains the parameters, R0, ALPHA, and DELTA, which characterize the resistance-temperature relationship of the platinum control sensor. These parameters may be adjusted to improve the accuracy of the calibrator. This procedure is explained in detail in Section .

The probe parameters are accessed by pressing "SET" after the name of the parameter is displayed. The value of the parameter may be changed using the "UP" and "DOWN" buttons. After the desired value is reached press "SET" to set the parameter to the new value. Pressing "EXIT" causes the parameter to be skipped ignoring any changes that may have been made.

6.11.1 R0

This probe parameter refers to the resistance of the control probe at 0°C. The value of this parameter is set at the factory for best instrument accuracy.

6.11.2 ALPHA

This probe parameter refers to the average sensitivity of the probe between 0 and 100°C. The value of this parameter is set at the factory for best instrument accuracy.

6.11.3 DELTA

This probe parameter characterizes the curvature of the resistance-temperature relationship of the sensor. The value of this parameter is set at the factory for best instrument accuracy.

6.12 Operating Parameters

The operating parameters menu is indicated by, PAr *Operating parameters menu*

Press "UP" to enter the menu. The operating parameters menu contains the units scale setting, cut-out reset mode setting, approach setting, and soak stability setting.

6.12.1 Temperature Scale Units

The temperature scale units of the controller may be set by the user to degrees Celsius (°C) or Fahrenheit (°F). The scale is used in displaying the well temperature, set-point, proportional band, and cut-out set-point.The temperature scale units selection is the first function in the operating parameters menu.

Un=C *Scale units currently selected*

Press "UP" or "DOWN" to change the units.

Un=F *New units selected*

Press "SET" to accept the new selection and resume displaying the well temperature.

6.12.2 Cut-out Reset Mode

The cut-out reset mode determines whether the cut-out resets automatically when the well temperature drops to a safe value or whether the operator must manually reset the cut-out.

The parameter is indicated by,

CtorSt *Cut-out reset mode parameter*

Press "SET" to access the parameter setting. Normally the cut-out is set for manual mode.

Cto=rSt *Cut-out set for manual reset*

To change to automatic reset mode press "UP" and then "SET".

Cto=Auto *Cut-out set for automatic reset*

6.12.3 Approach

The approach parameter can be used to reduce overshoot. The larger the value the less overshoot. However, if the value is too large it may take too long for the temperature to settle to a new set-point. The default value is 5. It can be changed in the parameter menu.

6.12.4 Soak Stability

The soak stability controls the required stability of the well temperature for the soak time (see Section 6.5.3). The stability is in degrees Celsius. The default is 0.1°C. This value can be changed in the parameter menu.

6.13 Serial Interface Parameters

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

SErIAL	*Serial RS-232 interface parameters menu*

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

6.13.1 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 displayed.

1200 b	*Current baud rate*

The baud rate of the serial communications may be programmed to 300, 600, 1200, or 2400 baud. Use “UP” or “DOWN” to change the baud rate value.

2400 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.

6.13.2 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,

SAMPLE	*Serial sample period parameter*

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

SA= 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.

SA= 60	*New sample period*

6.13.3 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 calibrator 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,

DUPL	*Serial duplex mode parameter*

Press “SET” to access the mode setting.

DUP=FULL	*Current duplex mode setting*

The mode may be changed using “UP” or “DOWN” and pressing “SET”.

DUP=HALF	*New duplex mode setting*

6.13.4 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,

LF	*Serial linefeed parameter*

Press “SET” to access the linefeed parameter.

LF=On	*Current linefeed setting*

The mode may be changed using “UP” or “DOWN” and pressing “SET”.

LF=OFF	*New linefeed setting*

6.14 IEEE-488 Parameters

The calibrator may optionally be fitted with an IEEE-488 GPIB interface. In this case the user may set the interface address and termination within the IEEE-488 parameter menu. This menu does not appear on instruments not fitted with the interface. The menu is indicated by,

IEEE	*IEEE-488 parameters menu*

Press “SET” to enter the menu.

6.14.1 IEEE-488 Address

The IEEE-488 interface must be configured to use the same address as the external communicating device. The address is indicated by,

AddrESS	*IEEE-488 interface address*

Press “SET” to access the address setting.

Add=22	*Current IEEE-488 interface address*

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

Add=15	*New IEEE-488 interface address*

6.14.2 Termination

The transmission termination character can be set to carriage return only, linefeed only, or carriage return and linefeed. Regardless of the option selected the instrument will interpret either a carriage return or linefeed as a command termination during reception. The termination parameter is indicated with,

EOS	*IEEE-488 termination*

Press “SET” to access the termination setting.

EOS=Cr	*Present IEEE-488 termination*

Use “UP” or “DOWN” to change the selection.

EOS=LF	*New termination selection*

Use “SET” to save the new selection.

6.15 Calibration Parameters

The user has access to a number of the instrument calibration constants namely CTO, C0, and CG. 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 calibrator. Access to these parameters is available to the user only so that in the event that the controller's memory fails the user may restore these values to the factory settings. The user should have a list of these constants and their settings with the manual.

The calibration parameters menu is indicated by,

CAL	*Calibration parameters menu*

Press "SET" five times to enter the menu.

6.15.1 CTO

Parameter CTO sets the calibration of the over-temperature cut-out. This is not adjustable by software but is adjusted with an internal potentiometer.

6.15.2 CO and CG

These parameters calibrate the accuracy of the temperature set-point. These are programmed at the factory when the instrument is calibrated. Do not alter the value of these parameters. If the user desires to calibrate the instrument for improved accuracy, calibrate R0 and ALPHA according to the procedure given in Section .

6.15.3 SCO

This parameter is used at the factory for testing purposes and SHOULD NOT be altered by the user.

7 Digital Communication Interface

The furnace calibrator is capable of communicating with and being controlled by other equipment through the digital interface. Two types of digital interface are available — the RS-232 serial interface and the optional IEEE-488 GPIB 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.

7.1 Serial Communications

The calibrator may be 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 6 with the exception of the baud rate setting.

7.1.1 Wiring

The serial communications cable attaches to the calibrator through the DB-9 connector at the back of the instrument. Figure 8 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.

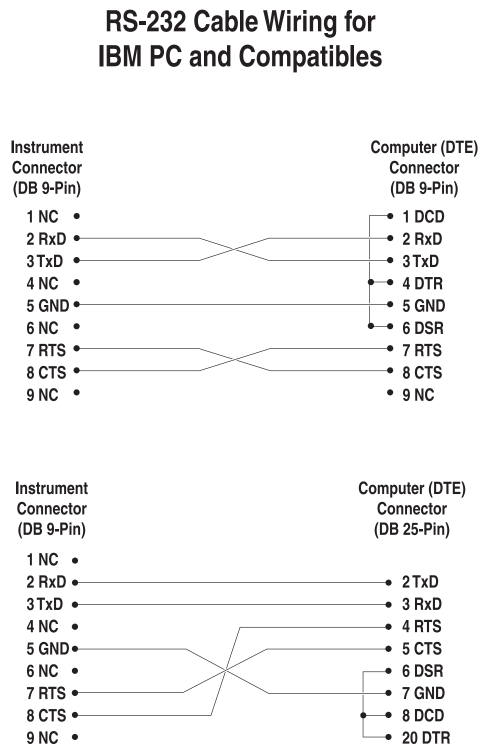


Figure 8. *Serial Cable Wiring*

7.1.2 Setup

Before operating the serial interface, set up 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

"ProbE". This is the menu selection. Press "UP" repeatedly until the serial interface menu is indicated with "SERIAL". Finally press "SET" to enter the serial parameter menu. In the serial interface parameter menu are the BAUD rate, the sample rate, the duplex mode, and the linefeed parameter.

7.1.2.1 Baud Rate

The baud rate is the first parameter in the menu. The display prompts with the baud rate parameter by showing "bAud". Press "SET" to choose to set the baud rate. The current baud rate value is displayed. The baud rate of the 9114 serial communications may be programmed to 300, 600, 1200, or 2400 baud. The baud rate is pre-programmed to 1200 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.

7.1.2.2 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 for instance then 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. 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.

7.1.2.3 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".

7.1.2.4 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".

7.1.3 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 7.3. All commands are ASCII character strings terminated with a carriage-return character (CR, ASCII 13).

7.2 IEEE-488 Communication

The IEEE-488 interface is available as an option. Instruments supplied with this option may be connected to a GPIB type communication bus that allows many instruments to be connected and controlled simultaneously. To eliminate noise, the GPIB cable should be shielded.

7.2.1 Setup

To use the IEEE-488 interface first connect an IEEE-488 standard cable to the back of the calibrator. Next set the device address. This parameter is programmed within the IEEE-488 interface menu.

To enter the IEEE-488 parameter programming menu first press “EXIT” while pressing “SET” and release to enter the secondary menu. Press “SET” repeatedly until the display reaches “PrObE”. This is the menu selection. Press “UP” repeatedly until the IEEE-488 interface menu is indicated with “IEEE”. Press “SET” to enter the IEEE-488 parameter menu. The IEEE-488 menu contains the IEEE-488 address parameter.

7.2.2 IEEE-488 Interface Address

The IEEE-488 address is prompted with “AddrESS”. Press “SET” to program the address. The default address is 22. Change the device address of the calibrator if necessary to match the address used by the communication equipment by pressing “UP” or “DOWN” and then “SET”.

IEEE-488 Operation Commands may now be sent via the IEEE-488 interface to read or set the temperature or access other controller functions. All commands are ASCII character strings and are terminated with a carriage-return (CR, ASCII 13). Interface commands are listed below.

7.3 Interface Commands

The various commands for accessing the calibrator functions via the digital interfaces are listed in this section (see Table 3). These commands are used with both the RS-232 serial interface and the IEEE-488 GPIB interface. In either case the commands are terminated with a carriage-return character. The interface makes no distinction between upper and lower case letters therefore either may be used. Commands may be abbreviated to the minimum number of letters that 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” returns the current set-point and “s=150.00” sets the set-point to 150.00 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. Characters are shown in lower case although upper case may be used. Spaces may be added within command strings and are ignored. Backspace (BS, ASCII 8) may be used to erase the previous character. A terminating CR is implied with all commands.

Table 3. *Digital Interface Command Summary*

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Display Temperature					
Read current set-point	s[etpoint]	s	set: 9999.99 {C or F}	set: 150.00 C	
Set current set-point to n	s[etpoint]=n	s=450			Instrument Range
Read scan function	sc[an]	sc	scan: {ON or OFF}	scan: ON	
Set scan function:	**sc[an]=on/of[f]**				ON or OFF
Turn scan function on	sc[an]=on	sc=on			
Turn scan function off	sc[an]=of[f]	sc-of			
Read scan rate	sr[ate]	sr	srat: 999.99 {C or F}/min	srat: 10.0 C/min	
Set scan rate to *n* degrees per minute	sr[ate]=*n*	sr=5			.1 to 100°C
Read temperature	t[emperature]	t	t: 9999.99 {C or F}	t: 55.69 C	
Secondary Menu					
Read proportional band setting	pr[op-band]	pr	pb: 999.9	pr: 15.9	
Set proportional band to *n*	pr[op-band]=n	pr=8.83			Depends on Configuration
Read cutout setting	c[utout]	c	c: 9999 {C or F}	c: 620 C, in	
Set cutout setting:	**c[utout]=n/r[eset]**				
Set cutout to *n* degrees	c[utout]=n	c=500			Temperature Range
Reset cutout now	c[utout]=r[eset]	c=r			
Read heater power (duty cycle)	po[wer]	po	p%: 9999	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 *n*	pn=*n*	pn=4			1 to 8
Read programmable set-point number *n*	ps*n*	ps3	ps*n*: 9999.99 {C or F}	ps1: 50.00 C	
Set programmable set-point number *n* to *n*	ps*n*=*n*	ps3=50			1 to 8, Instrument Range
Read program set-point soak time	pt	pt	ti: 999	ti: 5	
Set program set-point soak time to *n* minutes	pt=*n*	pt=5			0 to 500
Read program control mode	pc	pc	prog: {OFF or ON}	prog: OFF	

Digital Interface Command Summary 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 *n*	pf=*n*	pf=2			1 to 4
Configuration Menu					
Probe Menu					
Read R0 calibration parameter	r[0]	r	r0: 999.999	r0: 100.578	
Set R0 calibration parameter to *n*	r[0]=n	r=100.324			98.0 to 104.9
Read ALPHA calibration parameter	al[pha]	al	al: 9.9999999	al: 0.0038573	
Set ALPHA calibration parameter to *n*	al[pha]=n	al=0.0038433			.00370 to .00399
Read DELTA calibration parameter	de[lta]	de	de: 9.99999	de: 1.46126	
Set DELTA calibration parameter to *n*	de[lta]=*n*	de=1.45			0.0 to 2.9
Operating Parameters Menu					
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 cutout mode	cm[ode]	cm	cm: {xxxx}	cm: AUTO	
Set cutout mode:	**cm[ode]=r[eset]/a[uto]**				RESET or AUTO
Set cutout to be reset manually	cm[ode]=r[eset]	cm=r			
Set cutout to be reset automatically	cm[ode]=a[uto]	cm=a			
Read approach setting	ap[proach]	ap	ap:9	ap:5	
Set approach setting to *n* degrees	ap[proach]=*n*	ap=15			0 to 20°C
Read stability	ts	ts	ts:9.9	ts:0.5	
Set soak stability to *n* degrees	ts=*n*	ts=.1			.01 to 4.99°C
Serial Interface Menu					
Read serial sample setting	sa[mple]	sa	sa: 9	sa: 1	

Digital Interface Command Summary continued

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Set serial sampling setting to *n* seconds	sa[mple]=*n*	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/of[f]**				ON or OFF
Set serial linefeed mode to on	lf[eed]=on	lf=on			
Set serial linefeed mode to off	lf[eed]=of[f]	lf=of			
Calibration Menu (WARNING – changing the following calibration values may change the accuracy of the instrument.)					
Read C0 calibration parameter	*c0	*c0	c0: 9	c0: 0	
Set C0 calibration parameter to *n*	*c0=n	*c0=0			–999.9 to 999.9
Read CG calibration parameter	*cg	*cg	cg: 999.99	cg: 406.25	
Set CG calibration parameter to *n*	*cg=n	*cg=406.25			–999.9 to 999.9
These commands are only used for factory testing.					
Read software cutout mode	*sco	*sco	sco: {ON or OFF}	sco: ON	
Set software cutout mode:	***sco=ON/OF[F]**				ON or OFF
Set software cutout mode on	*sco=ON	*sco=on			
Set software cutout mode off	*sco=OF[F]	*sco=off			
Miscellaneous (not on menus)					
Read firmware version number	*ver[sion]	*ver	ver.9999,9.99	ver.9123,3.54	
Read structure of all commands	h[elp]	h	list of commands		
Legend:	[] Optional Command data / Alternate characters or data {} Returns either information n Numeric data supplied by user–may be entered in decimal or exponential notation 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.				

8 Fixed Point Cell Installation Instructions

CAUTION: *An Inconel basket is used as the example for the installation instructions in this section. The furnace is shipped with an Alumina basket which does not have a locking mechanism for the lid.* ***DO NOT*** *install the basket into the furnace with the lid installed, otherwise the cell and the basket may be broken. The Alumina basket needs to be installed before the basket lid is placed on the basket.*

8.1 Installing the Metal Freeze Point Cell

CAUTION: *Never touch the cell with bare hands. When handling the cell, wear gloves.*

CAUTION: *The support canister must also be free of oils and other contaminating materials.*

A metal freeze point cell must always be handled with extreme care due to its high value and fragility. It must also be kept free of any foreign material such as finger oils. Alkaline from these oils cause devitrification or physical breakdown of the quartz shell. **Handle the cell with cotton gloves. Discard the gloves before they become appreciably soiled.** Any foreign material should be carefully removed with high purity alcohol. Refer to Figure 9 on page 48.

Sealed cells for freezing points are delicate devices and the quartz shell is prone to be broken. THE CELL MUST BE HANDLED WITH EXTREME CARE.

Maintain the cell in vertical orientation for safety. Although putting the cell in horizontal orientation for a short period of time may not cause any damage, transporting the cell by any means while in this position is dangerous. Transporting a cell by common carrier is also dangerous. The cell should be hand carried from one place to another. Keep the surface of the cell clean.

8.2 Purpose

To maintain uniform cell installation throughout the laboratory.

Equipment needed:

- Cell basket and Lid
- Reagent grade alcohol
- Fixed Point Cell
- Sheet of standard printer paper
- Insulation

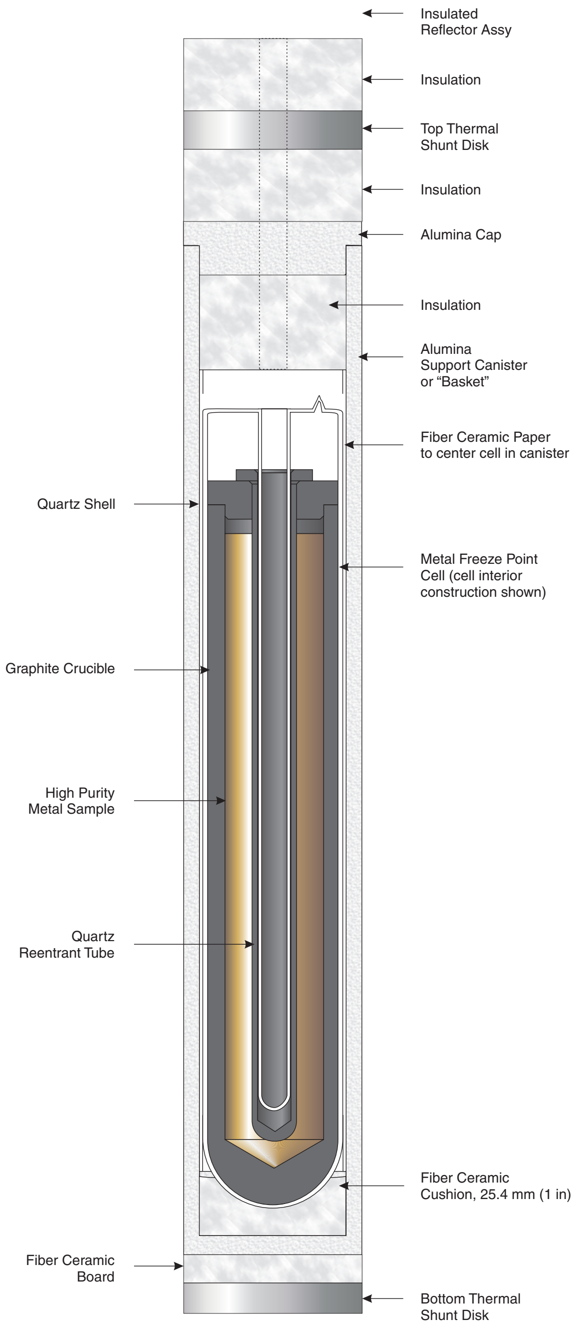


Figure 9. *Metal Freeze Point Cell installed in canister*

- Circular 2.54 cm (1 in) thick for below cell in basket
- Circular 0.64 cm (0.25 in) thick with hole in center for over the cell
- 12.7 cm x 5.72 cm x 0.004 cm (5 in x 2.25 in x 0.016 in) fiber ceramic paper for cushioning around cell
- 0.64 cm (0.25 in) diameter piece to be placed in the re-entrant well of the cell

- Quartz rod
- Cotton gloves
- Paper towels
- Stand to support cell
- Cell installation/removal tool

8.3 Procedure

1. Remove cell from packaging and place in stand or support it in a vertical position.

Figure 10 *Cell supported by stand.*

2. Put on cotton gloves to avoid contaminating cell with body oils.

Figure 11 ⚠ *Cotton gloves MUST be used.*

3. Clean cell with reagent grade alcohol to remove any dust or oil that may be on the cell.

Figure 12 *Preparing paper towel with reagent grade alcohol.*

Figure 13 *Clean cell completely.*

4. Return cell to stand(see Figure 10).
5. Place the 0.64 cm (0.025 in) diameter piece of insulation in the re-entrant well of the cell.

Figure 14 *Place insulation in re-entrant well.*

6. Using quartz rod move insulation to the bottom of the cell.

Figure 15 *Push insulation to bottom of re-entrant well.*

7. Clean cell basket with reagent grade alcohol

Figure 16 *Clean the basket thoroughly*

8. Place 2.54 cm (1 in) thick piece of insulation in the cell basket.

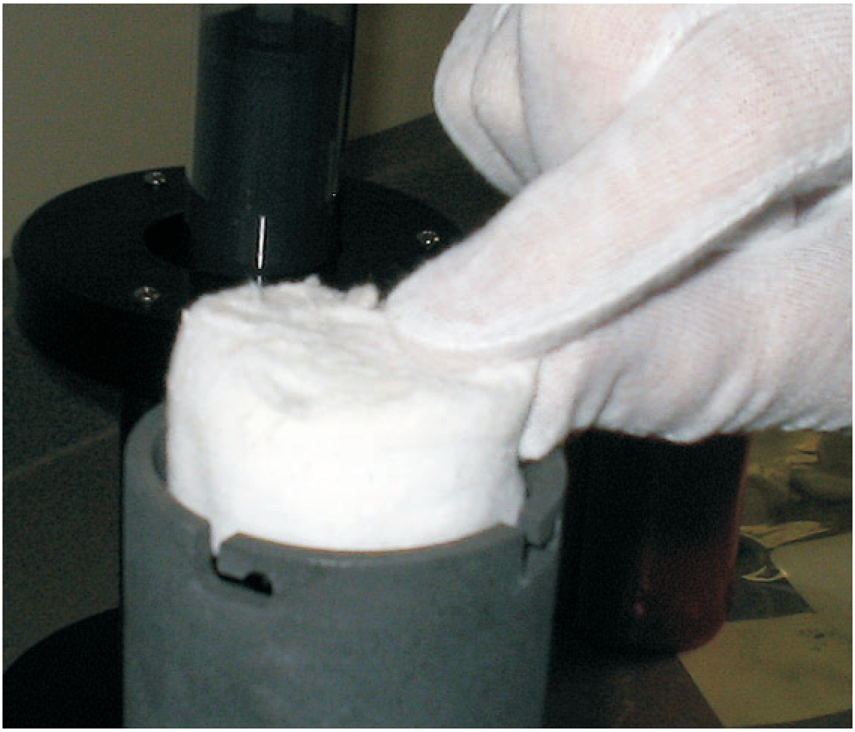


Figure 17 *Place insulation in cell basket*

9. Use quartz rod to verify that insulation is at the bottom of the basket and flat.

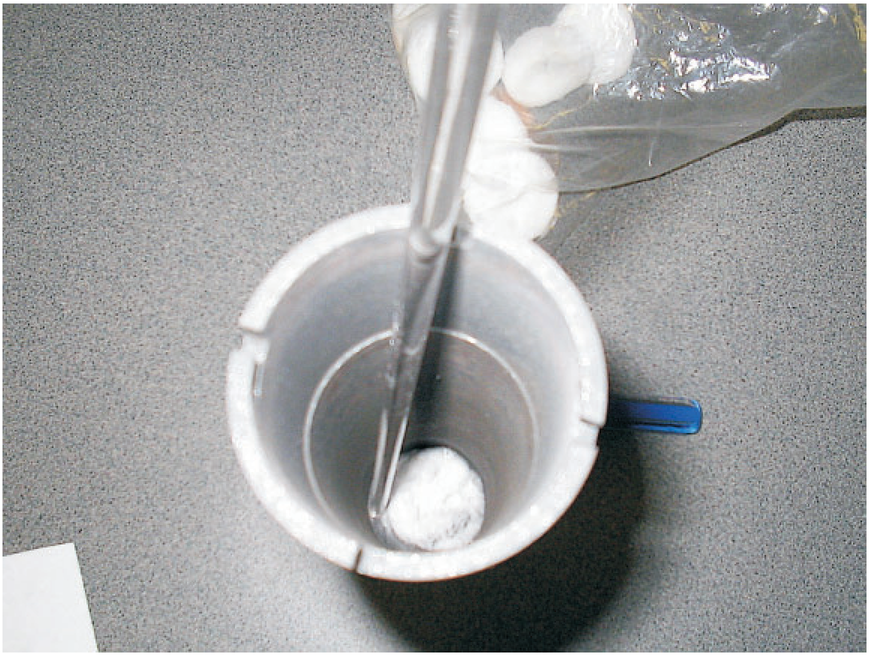


Figure 18 *Insure the insulation is flat at the bottom of the cell basket.*

10. Make a 21.6 x 14 cm (8.5 x 5.5 in) piece of paper from standard printer paper. This paper is used to protect the cell from being scratched while installing the cell into the basket..

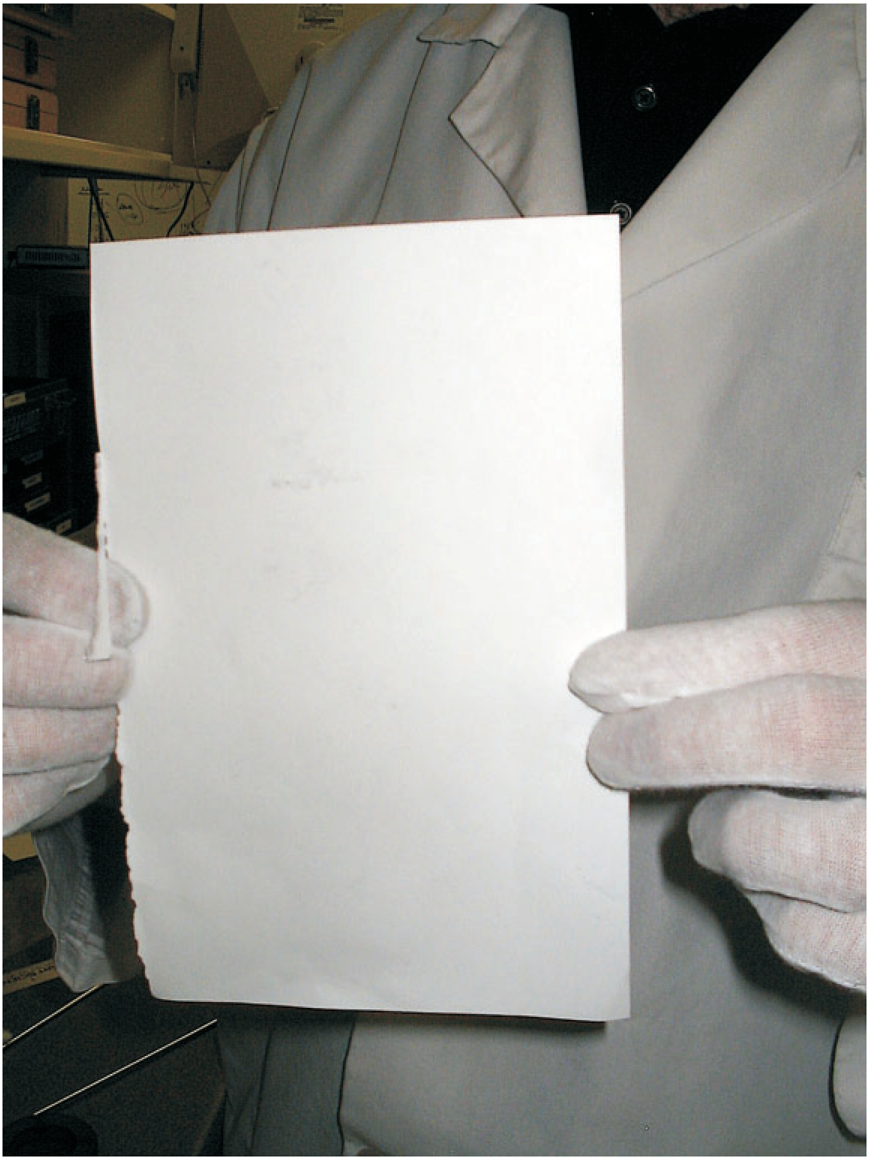


Figure 19 *21.6 x 14 cm (8.5 x 5.5 in) paper*

11. Roll the paper lengthwise and place it in the opening of the basket.

Figure 20 *Paper placement.*

12. Hold basket horizontally and slide cell into basket. Push with your finger until cell reaches bottom of the basket.

Figure 21 *Insert cell into basket.*

13. Remove paper and return cell and basket to stand in the vertical position.

14. Roll a 12.7 x 5.72 x 0.04 cm (5 x 2.25 x 0.016 in) piece of fiber ceramic paper width wise and place it in the cell basket.

Figure 22 *Place fiber ceramic paper to center the cell in cell basket.*

15. Slide fiber ceramic paper into basket.

Figure 24 *Fiber ceramic paper pushed below cell basket top.*

16. Place a circular 0.64 cm (0.25 in) thick piece of insulation on top of the cell and use rod to verify the alignment of the hole in the insulation.

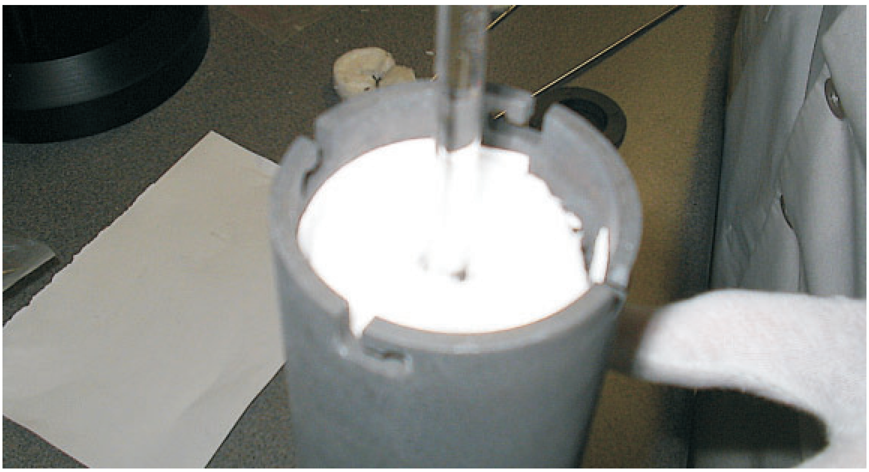


Figure 23 *Fiber ceramic insulation installed on top of cell.*

⚠ ***CAUTION:*** *An Inconel basket is used as the example for the installation instructions in this section. The furnace is shipped with an Alumina basket which does not have a locking mechanism for the lid.* ***DO NOT*** *install the basket into the furnace with the lid installed, otherwise the cell and the basket may be broken. The Alumina basket needs to be installed before the basket lid is placed on the basket.*

17. Place the cell removal/installation tool into the holes on the basket. Using both hands, one on the removal/installation tool, lift and move basket assembly into the furnace.

Figure 25 *Preparing basket assembly for installation in furnace.*

18. Slowly insert cell into furnace.

Figure 26 *Installing basket assembly in furnace.*

19. Place the cell removal/installation tool into the holes on the lid. Carefully install the lid onto the basket, where the basket was installed previously in the furnace.
20. Place one circular 2.54 cm (1 in) thick piece of insulation on top of basket.

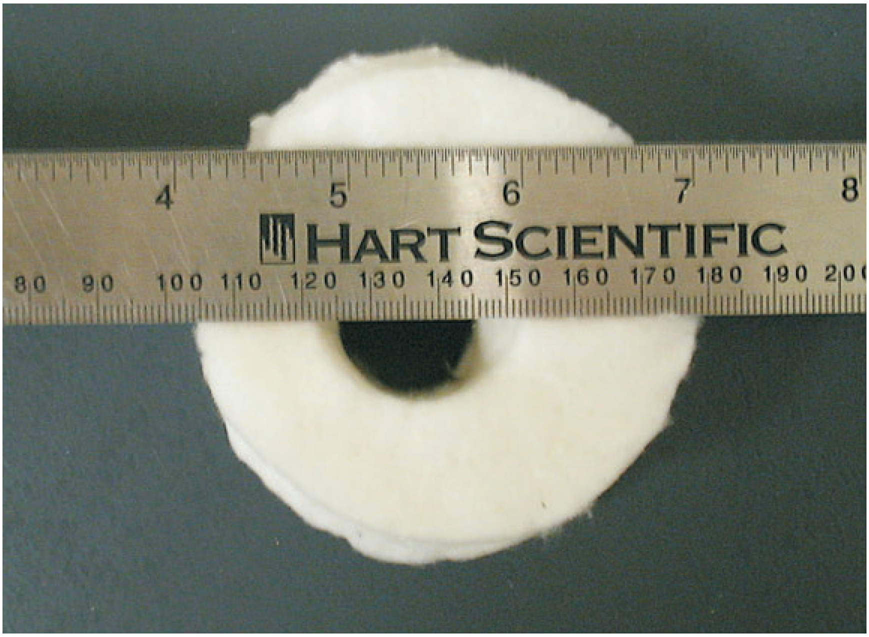


Figure 27 *Width of insulation placed on top of basket assembly.*

21. Place the top thermal shunt disk in the furnace.
22. Place one circular 2.54 cm (1 in) thick piece of insulation on top of the thermal shunt disk.

23. Install the furnace lid (Figure 28).

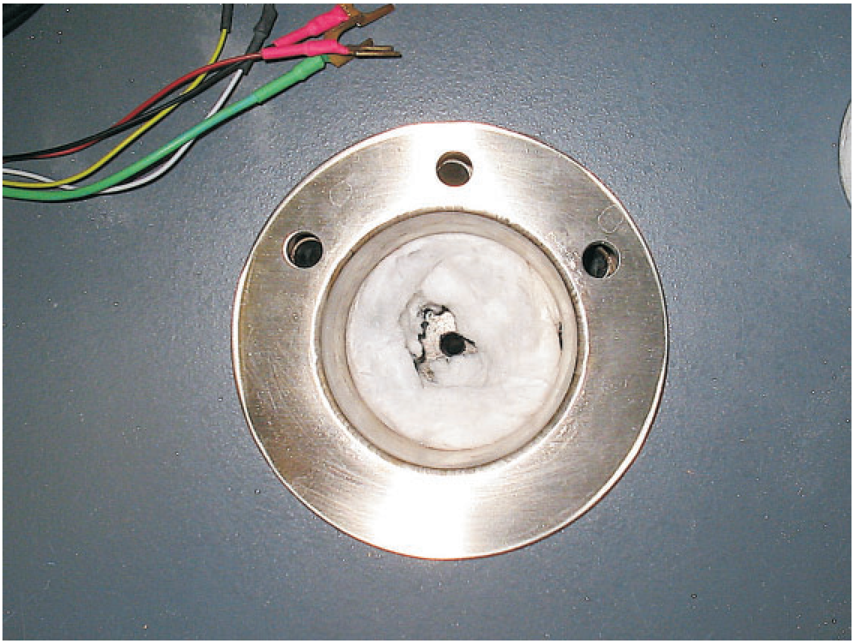


Figure 28 *Basket, insulation, and furnace lid installed .*

24. Install the heat radiation guard (Figure 29).

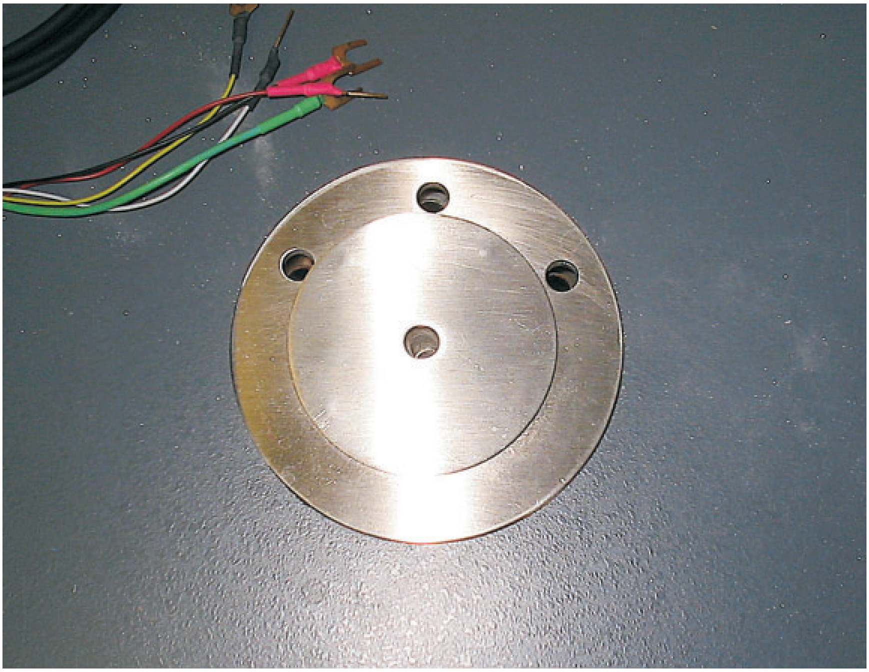


Figure 29 *Heat radiation guard installed.*

9 Freeze Point Realization

9.1 General

This discussion assumes SPRT calibrations at the copper point. Other freeze points are similar.

Successful copper point realization requires a cell of the following specifications:

- The purity of copper: 99.9999%
- The reproducibility: 5 mK
- The expanded uncertainty: 30 mK†
- The outer diameter of the cell: 48 mm

†The expanded uncertainty was evaluated at the level of two standard deviations (95% confidence)

9.2 How to Realize the Freezing Point of Copper

1) *Melting the Cell: Switch* on the power to the furnace from the front panel. The ramp rate of the furnace should not be set too high. Set the ramp rate of the instrument should be set such that the furnace heats from ambient (approximately 25°C) to 550°C in no less than 2.5 hours and an additional 1-1.5 hours to reach 1084°C. The final step from 1084°C to 1090°C should take approximately 20 minutes. The ramp rates are programmable from the controller. Use a working high temperature platinum resistance thermometer or a Type S (Type R) thermocouple to monitor the temperature in the cell. When the copper sample begins to melt, the temperature stops rising and remains almost constant during the melting process. Write down the resistance or EMF indicated by the working thermometer at the melting point for future reference.

2) As soon as the copper sample is melted completely, set the furnace at a temperature of about 3°C higher than the freezing point. Maintain a stable temperature for 20 minutes. Then let the temperature of the furnace decrease at a rate of 0.2 to 0.3°C per minute until the temperature indicated by the working thermometer stops decreasing and starts to rise. This indicates that freezing has started. Usually the copper may super cool by an amount approximately 1°C or more before the start of freezing. Take the working thermometer out of the furnace and put the thermometer or thermocouple to be calibrated into the furnace. Meanwhile, maintain the temperature of the furnace at a temperature between 0.5 and 1.0°C lower than the freezing point.

3) *Initiating the Freeze and Making Measurements: The* freezing curve usually lasts more than 4 hours and the temperature in the first half of the freezing curve is usually stable within 0.2 mK or 0.3 mK. If the temperature of the furnace is closer to the freezing point, a longer freezing point can be obtained. A freezing curve longer than 10 hours or more is not difficult to obtain if the temperature of the furnace is carefully controlled.

   The first thermometer to be calibrated should not be preheated. The cold thermometer enhances the rate of freezing at the beginning of freezing, i.e. "induces" the freezing.

   Take the average of several thermometer resistance or thermocouple voltage readings over a period of about 10 minutes. This average is the resistance or voltage at the freezing point of copper $R_{Cu.}$ Several probes can be calibrated during one freezing curve.

   Since a cold thermometer absorbs a large amount of heat which shortens the freezing curve greatly, subsequent thermometers to be calibrated should be preheated to a temperature very near the freezing point before inserting each into the copper cell. Another advantage of preheating is that the equilibrium time in the cell may be shortened by nearly one-half, i.e. from about 20 minutes to 10 minutes.

   Preheat the thermometers for 20 minutes or so near the freezing point. Preheating the thermometers for too long is unnecessary and should not be done. The thermometer sensors could possibly be contaminated if they remain in metal wells for a long period of time.

4) SPRT *Annealing: The* rapid cooling from the freezing point of copper to room temperature introduces extra crystal defects - vacancies in the platinum wire of the thermometer - resulting in a noticeable increase in resistance at the triple point of water (R_{tp}). Sometimes a change larger than the equivalent of 30 mK can be observed. An appropriate annealing gets rid of these defects and returns the R_{tp} to the equilibrium value. Anneal the thermometer at 700°C for 2 hours in a clean furnace and then cool it from 700°C to 450°C over 3 hours. An alternative annealing procedure is to anneal at 970°C for 30 minutes and then cool at a constant rate to 500°C over a period of 4 hours. After annealing the thermometer, take it out of the furnace and cool it to room temperature in air. Measure the R_{tp} and calculate the resistance ratio W_{Cu}:

$$W_{Cu} = \frac{R_{Cu}}{R_{tp}}$$

A thermocouple does not need to be annealed after calibration at the freezing point of copper.

10 Calibration Procedure

⚠ ***CAUTION:*** *The vertical gradient needs to be checked before calibrating the furnace. Checking the vertical gradient insures that the sodium heat-pipe is working properly.*

⚠ ***CAUTION:*** *DO NOT change the value of the calibration parameter Delta. Delta is set to at the factory (to the value of 1.6) for optimum performance of the furnace.*

The user may want to calibrate the furnace to improve the temperature set-point accuracy. Calibration is done by adjusting the controller probe calibration constants R0 and ALPHA so that the temperature of the furnace as measured with a standard thermometer 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 furnace.

10.1 Two Point Calibration Procedure

In some instances the user may want to calibrate the controller to improve the temperature set-point accuracy. Calibration is done by adjusting the controller probe calibration constants R_0 and ALPHA so that the process temperature, as measured with a standard thermometer, agrees more closely with the set-point. The thermometer used must be able to measure the temperature with higher accuracy than the desired accuracy of the system.

1. The two set-points that should be used for the calibration are 800°C and 1060°C, since they are used at the factory to calibrate the furnace.

2. Set the controller to the low set-point. When the calibrator reaches the set-point and is stable (< 0.1°C change in 15 minutes), take a reading from the reference thermometer. Sample the set-point resistance by holding down the SET key and pressing the DOWN key. Write these values down as T_1 and R_1 respectively.

3. Repeat step 2 for the second set-point recording it as T_2 and R_2.

4. Using the recorded data, calculate new values for R_0 and ALPHA parameters using the equations given below:

10.1.1 Compute R_0 & ALPHA:

$$a_1 = T_1 + 1.6\left[\frac{T_1}{100}\right]\left[1 - \frac{T_1}{100}\right]$$

$$a_2 = T_2 + 1.6\left[\frac{T_2}{100}\right]\left[1 - \frac{T_2}{100}\right]$$

$$rzero = \frac{R_2 a_1 - R_1 a_2}{a_1 - a_2}$$

$$alpha = \frac{R_1 - R_2}{R_2 a_1 - R_1 a_2}$$

$\mathbf{T_{1\text{-}2}}$ - Measured temperature using thermometer.

$\mathbf{R_{1\text{-}2}}$ - Value of R from display of furnace (Press SET and DOWN at the same time.)

where

$\mathbf{T_1}$ and $\mathbf{R_1}$ are the measured temperature and resistance at 800.0 °C

$\mathbf{T_2}$ and $\mathbf{R_2}$ are the measured temperature and resistance at 1060.0 °C

5. Program the new values for R_0 (rzero) and ALPHA (alpha) into the instrument.

10.1.2 Accuracy & Repeatability

1. Check the accuracy of the calibrator at various points over the calibrated range.

2. If calibrator does not pass specification at all set-points, repeat the **Calibration Procedure**.

11 Maintenance

The calibration 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 split on or inside the equipment, 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 cut-out should be checked every 6 months to see that it is working properly. In order to check the user selected cut-out, follow the controller directions (Section 6) for setting the cut-out.
- **Adjustment of Temperature Uniformity:** Vertical uniformity should be measured in a freeze point cell just below the melting point of the cell. The vertical temperature uniformity in the cell should be within the limit specified in Section 2.1, Specifications, for a distance of 10.2 cm (4 in) upwards from the bottom of the central well (See Figure 30 on page 74). A periodic check of the temperature uniformity using a Type R or Type S thermocouple is recommended at least once every year. If the vertical gradient is not within the limit specified in Section 2.1, Specifications, the heat pipe may not be functioning properly. Contact an Authorized Service Center.

  A properly operating heat pipe will keep the area around the cell or test area uniform in temperature. However, the open end of the pipe can allow some heat loss that can cause a gradient inside. Thermal shunts and insulation are intended to inhibit this loss. On the other hand, the heat pipe requires some heat loss at its top to promote condensation of the sodium vapor. The balance may be adjusted by adjusting the amount of insulation between the plates of the reflectors of the assembly that covers the access

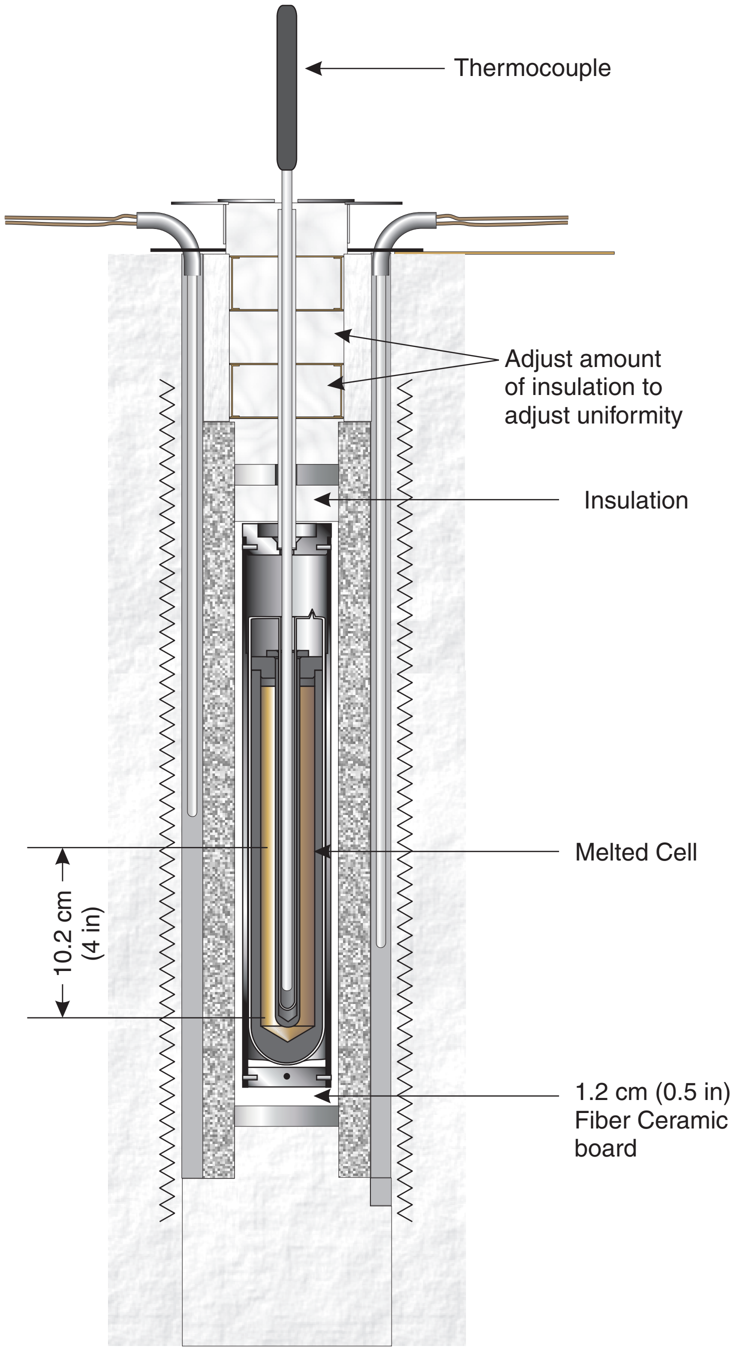


Figure 30. *Testing Uniformity*

opening. The fiber ceramic insulation provided may be added or removed to do this. Generally the bottom position must be filled and additional spaces above may be filled as required.

- **Check of the Controller Set-point Accuracy:** This test is carried out in a metal freeze point cell where the metal has been completely melted. Prepare the furnace in the same fashion as though a freeze plateau would be conducted up to the point that the metal sample is melted. This example illustrates measurements made near the silver point:
  - Set the temperature of the furnace at 964°C and allow it to stabilize as would be done in preparation for a freeze. Measure the EMF of a thermocouple inserted into the cell. Compare the measured EMF to one taken at the M.P. or F.P. The actual temperature, *t*, in the cell can be calculated by using the following equation:

$$t = 961.78°\mathrm{C} + \frac{E_1 - E_0}{0.0114\,\mathrm{mV}/°\mathrm{C}}$$

where E_1 is the measurement EMF and E_0 is the EMF at the M.P. (961.78°C is the M.P. temperature of copper for this example) and 0.0114mV/°C is the sensitivity of a Type S thermocouple near the M.P. of silver.

For example, the measured EMF E_1=9.1502 mV, the EMF at the M.P. E_0=9.1481 mV, the actual temperature in the furnace.

$$t = 961.78 + \frac{9.1502 - 9.1481}{0.0114} = 961.96°\mathrm{C}$$

Since *t*=964.0°C = the actual set-point, the error, if any, is very small. If the error is larger than 1°C, you can make an adjustment to the set-point.

12 Troubleshooting

If problems arise while operating the 9116A, this section provides some suggestions that may help you solve the problem.

12.1 Troubleshooting

Below are several situations that may arise followed by suggested actions to take for fixing the problem.

Problem	Causes and Solutions
The heater indicator LED stays red but the temperature does not increase	The display does not show "cutout" nor displays an incorrect instrument temperature, but the controller otherwise appears to operate normally. The problem may be either insufficient heating or no heating at all. One or more burned out heaters or blown heater fuses may also cause this problem. If the heaters seem to be burned out, contact an Authorized Service Center (see Section 1.4) for assistance.
The controller display flashes "Cut-out" and the heater does not operate	The display flashes "Cut-out" alternately with the process temperature. If the process temperature displayed seems grossly in error, consult the following problem: 'The display flashes "Cut-out " and an incorrect process temperature'. Normally, the cutout disconnects power to the heater when the instrument temperature exceeds the cutout set-point causing the temperature to drop back down to a safe value. If the cutout mode is set to "AUTO", the heater switches back on when the temperature drops. If the mode is set to "RESET", the heater only comes on again when the temperature is reduced and the cutout is manually reset by the operator, see Section 6.9 Cutout. Check that the cutout set-point is adjusted to 10 or 20°C above the maximum instrument operating temperature and that the cutout mode is set as desired. If the cutout activates when the instrument temperature is well below the cutout set-point or the cutout does not reset when the instrument temperature drops and it is manually reset, then the cutout circuitry or the cutout thermocouple sensor may be faulty or disconnected. Contact an Authorized Service Center (see Section 1.4) for assistance.

Problem	Causes and Solutions
The display flashes "Cut-out" and an incorrect process temperature	The problem may be that the controller's voltmeter circuit is not functioning properly. A problem with the thermocouple probe, the cutout operation, or the cutout circuitry may cause the cutout to remain in this condition. Check that the thermocouple probe is plugged into the controller and wired correctly. Check that the probe temperature is well below the programmed set-point. If not then reset the cutout temperature to a value well above the probe temperature or wait for the temperature to cool well below the cutout set-point. If the cutout is set for manual reset mode then after the temperature cools the user must also manually reset the cutout according to the directions in this manual under Section 6.9, Cutout. If the probe is not connected to the controller, plug in the appropriate thermocouple probe into the cutout probe socket. A nearby large static discharge may also affect data in memory. Verify that the parameters on the Report of Test are accurate. Cycle the power off, disconnect the instrument from AC, and then restart the instrument. The controller may need to be reset using the Factory Reset Sequence listed below, but should only be performed if a current Report of Test is available, since performing the Factory Reset Sequence sets all controller parameters to default. **Factory Reset Sequence.** Hold the SET and EXIT buttons down at the same time while powering up the instrument. The instrument display shows '-init-', the model number, and the firmware version. Each of the controller parameters and calibration constants must be reprogrammed. The values can be found on the Report of Test that was shipped with the instrument.
The displayed process temperature is in error and the controller remains in the cooling or heating state at any set-point value	Possible causes may be either a faulty control probe or erroneous data in memory. The probe may be disconnected, shorted, or burned out. Check that the probe is connected properly. If wired properly, the probe may be checked with an ohmmeter to see if it is open or shorted. The probe is a platinum 4-wire Din 43760 type. The resistance should read 0.2 to 2.0 ohms between pins 1 and 2 on the probe connector and 0.2 to 2.0 ohms between pins 3 and 4. It should read 10 [at 0°C (32°F)] to 50 ohms [at 1100°C (32°F)] between pins 1 and 4 depending on the temperature of the instrument. If the probe appears to be defective, contact an Authorized Service Center (see Section 1.4) for assistance. If the problem is not the probe, erroneous data in memory may be the cause. Re-initialize the memory as discussed in the problem 'The display flashes "Cut-out" and an incorrect process temperature'. If the problem remains, the cause may be a defective electronic component.

Problem	Causes and Solutions
The controller controls or attempts to control at an inaccurate temperature	The controller operates normally except when controlling at a specified set-point. At this set-point, the temperature displayed does not agree with the temperature measured by the user's reference thermometer to within the specified accuracy. This problem may be caused by an actual difference in temperature between the points where the control probe and thermometer probe measure temperature, by erroneous instrument calibration parameters, or by a damaged control probe. Check that the thermometer probe and control probe are both fully inserted into the instrument to minimize temperature gradient errors. Check that the calibration parameters are all correct according to the Report of Test. If not, re-program the constants. Check that the control probe has not been struck, bent, or damaged. The instrument may be out of calibration, therefore it may be necessary to perform the calibration procedure explained in the calibration section of this manual.
The controller shows that the output power is steady, but the process temperature is unstable	Possible cause is an improper proportional band setting. If the instrument temperature does not achieve the expected degree of stability when measured using a thermometer, try adjusting the proportional band to a narrower width as discussed in Section 6.8, Proportional Band.
The controller alternately heats for a while then cools	The instrument is not stable and the duty cycle is not constant. The proportional band being too narrow typically causes this oscillation. Increase the width of the proportional band until the temperature stabilizes as discussed in Section 6.8, Proportional Band.
The controller erratically heats then cools, control is unstable	If both the instrument temperature and output power do not vary periodically but in a very erratic manner, the problem may be excess noise in the system. Noise due to the control sensor should be very small. However, if the probe has been damaged or has developed an intermittent short or open, erratic behavior may exist. Check for a damaged probe or poor connection between the probe and controller. Intermittent shorts in the heater or controller electronic circuitry may also be a possible cause. Contact an Authorized Service Center (see Section 1.4, on page 5) for assistance.
The controller does not maintain controller parameters or parameters are reset each time the power to the unit is removed	**Note:** Before performing the memory check, you need to record the controller calibration parameters (found in the CAL menu of the instrument) and any user-adjusted parameters that you have changed (such as the programmable set points and proportional band). **Memory Check** Doing a memory check is the easiest way to verify the ability of the battery to maintain controller parameters. 1. Power off the instrument. 2. Disconnect the instrument from AC power for 10 seconds. 3. Reconnect the AC power and power on the instrument. 4. If the display shows InIT and/or the cycle count shows a low number such as 0002, the battery is spent and should be replaced. Contact an Authorized Service Center for assistance. 5. After replacing the battery, you must reprogram the calibration and user-adjustable parameters into the controller.