FLUKE®

Hart Scientific®

9114
Freeze Point Furnace

User' Guide

Rev. 661601

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Figures and Tables

1 Before You Start

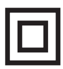
1.1 Introduction

The Hart Scientific 9114 furnace is designed for use with metal freeze point cells in a primary temperature standards application. The furnace provides a way to melt the ultra pure metal contained in the cell, initiate a freeze, and then sustain the freezing plateau for a length of time. The furnace is capable of utilizing freeze point cells from Indium (156.5985°C) through Aluminum (660.322°C). The furnace consists of a 3-zone equilibration block employing digital control electronics. The furnace can be connected to a computer system utilizing an RS-232 serial port or optional IEEE-488 interface.

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
	Fuse
	PE Ground

Symbol	Description
	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.

- This unit contains ceramic fiber or other refractories, which can result in the following:
  May be irritating to skin, eyes, and respiratory tract.
  May be harmful if inhaled.
  Service personnel coming into contact with these materials should take proper precautions when handling them.
  Before maintaining this equipment, read the applicable MSDS (Material Safety Data Sheets).
- **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.
- The 9114 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.
- 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.
- Follow all safety guidelines listed in the user's manual.
- Calibration Equipment should only be used by Trained Personnel.

1.3.2 ⚠ CAUTIONS

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

- THE VERTICAL GRADIENT IS CRITICAL TO THE SAFETY OF THE CELL. ENSURE THE VERTICAL GRADIENT IS WITHIN SPECIFICATION + 0.05°C INSIDE A FIXED POINT CELL PRIOR TO REALIZING A FIXED POINT. SEE SECTION 5.16.3, NULLING THE ZONE CONTROLLERS, ON PAGE 36.
- 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.

- Operate the instrument in room temperatures between 5–50°C (41–122°F). Allow sufficient air circulation by leaving at least 6 inches of space between the furnace and nearby objects. Nothing should be placed over the top of the furnace. The furnace should not be placed under cabinets or tables. Extreme temperatures can be generated out the top of the well. If the furnace is equipped with cooling coils, use cold water circulation when the furnace is used above 500°C. (for specifics see Section 3.5, Plumbing.)
- The furnace should be level for operation. Level the furnace at installation by adjusting the levelers on the bottom.
- 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.
- Use only grounded AC mains supply of the appropriate voltage to power the instrument. The furnace requires a maximum 15 amps at 230V (±10%), 50/60 Hz.
- Before initial use, after transport, and anytime the furnace has not been energized for more than 7 days, the instrument needs to be energized for a "dry-out" period of 1–2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1.
- The system fuses are located behind the door. (For CE, all fuses are located inside the electrical cover.)
- The heater fuses are located inside the electrical cover. If a fuse blows, it may be due to a power surge or failure of a component. Replace the fuse once. If the fuse blows a second time, it is likely caused by failure of a component. If this occurs, contact an Authorized Service Center. Always replace the fuse with one of the same rating, voltage, and type. Never replace the fuse with one of a higher current rating.
- If a main supply power fluctuation occurs, immediately turn off the furnace. Power bumps from brownouts and blackouts can damage the instrument. Wait until the power has stabilized before re-energizing the furnace.
- 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.
- The unit is equipped with a large metal heating block. It takes a long time for the unit to completely cool.
- The unit is equipped with a 20A 250V plug. If the plug is changed to meet building requirements be sure that it is rated for at least 20A 220V.

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

Table 2. *Specifications*

Temperature Range	100 to 680°C
Temperature Stability	±0.030°C or better
Temperature Gradients	less than ±0.3°C
Set-point Accuracy	±0.5°C
Set-point Resolution	0.01°C
Display Resolution	0.01°C
Cut-out Accuracy	±5°C
Heater Power	End Zones = 1000 watts each (@ 230 VAC nom.) Primary Zone = 1500 watts
Exterior Dimensions	Height: 33 inches Width: 24 inches Front to back: 16 inches
Power Requirements	230 VAC (±10%), 50/60 Hz, 1 Phase, 22 Amps maximum
Weight	203 Lbs

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:

- temperature range: 5-50°C (41-122°F)
- ambient relative humidity: 15-50%
- pressure: 75kPa-106kPa
- mains voltage within ±10% of nominal
- vibrations in the calibration environment should be minimized
- altitude does not effect the performance or safety of the unit

If the unit is operating at temperatures above 500°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 3.5, Plumbing)

2.3 Warranty

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

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

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

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

For service or assistance, please contact an Authorized Service Center (see Section 1.4).

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

3 Installation

3.1 Unpacking

Verify that the following components are present:

- Furnace
- Radiation Guard
- Fixed Point Basket
- Fixed Point Basket Lid
- Fixed Point Basket removal tool
- Extra Insulation:
    - Paper for the fixed point cell
    - Small circles for fixed point basket
    - Miscellaneous for packing around the fixed point cell

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 keep it from rocking.

3.3 "Dry-out" Period

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

3.4 Power

The 9114 furnace requires a maximum 15 amps of current at a nominal 230 VAC (±10%), 50/60 Hz. The furnace is supplied with a 14-gauge, 2-conductor plus ground cable and connector. Since building electrical installations may vary, the connector and cable may be removed at the furnace back panel and another used so long as it is rated for the specified current and voltage. (See Figure 4, Back Panel on page 16.)

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.

3.5 Plumbing

The cooling coils are accessible from the back panel of the 9114 chassis (See Figure 4, Back Panel on page 16). 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.

3.6 Leveling

Levelers are provided on each corner at the base of the furnace. Adjust the furnace to level leaving at least 6mm (1/4") space under the frame for airflow through the chassis.

3.7 Gas Purge

A gas purge port is available at the rear of the furnace. The gas purge is used to initiate the tin point freeze. The port is a 6mm (1/4") barbed fitting. Use 6mm (1/4") ID plastic tube to attach to clean compressed air. A regulator/flow meter combination like used with welding is ideal. The flow meter should be capable of 75 CFH.

3.8 ⚠ Vertical Gradients

Prior to using the furnace to realize any fixed points, utilize the procedure outlined in Section 5.16.3, Nulling the Zone Controllers, on page 36 to check the vertical gradient.

4 Parts and Controls

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 is the primary controller, which is regularly used during operation of the furnace. Beneath the primary controller is the power switch. The zone controllers are the least often used and are located behind a hinged door under the power switch. System fuses are located behind the door. Heater fuses are located inside the unit.

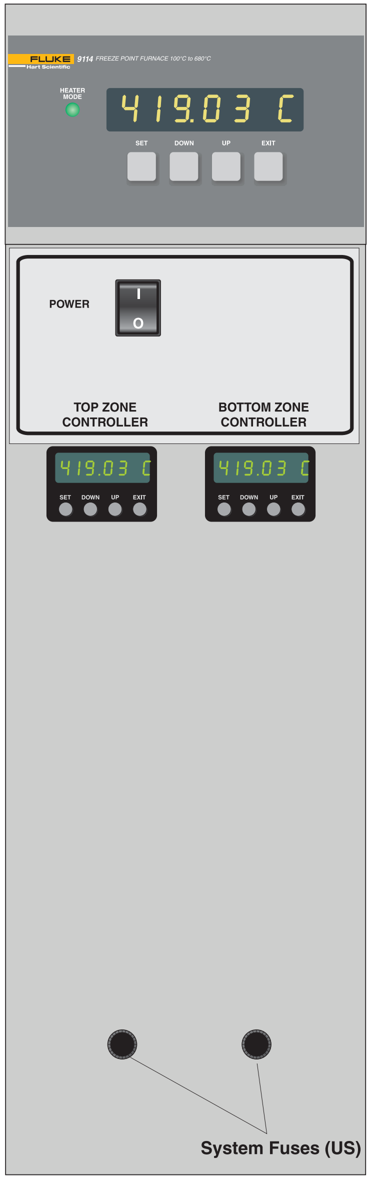


Figure 1. *Front Control Panel (cover door removed)*

4.1.1 Primary Controller

The primary controller controls the center zone to which the end zones are slaved; and, therefore, has overall control of the furnace. This sloped panel is located on the upper right portion of the furnace with its controls and display convenient to the user (see Figure 1). The controller itself is a hybrid analog/digital device utilizing the high stability of analog circuitry with the flexibility of a microprocessor interface and digital controls.

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

(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 and to access and set other operating and calibration parameters.

A brief description of the functions of the buttons follows:

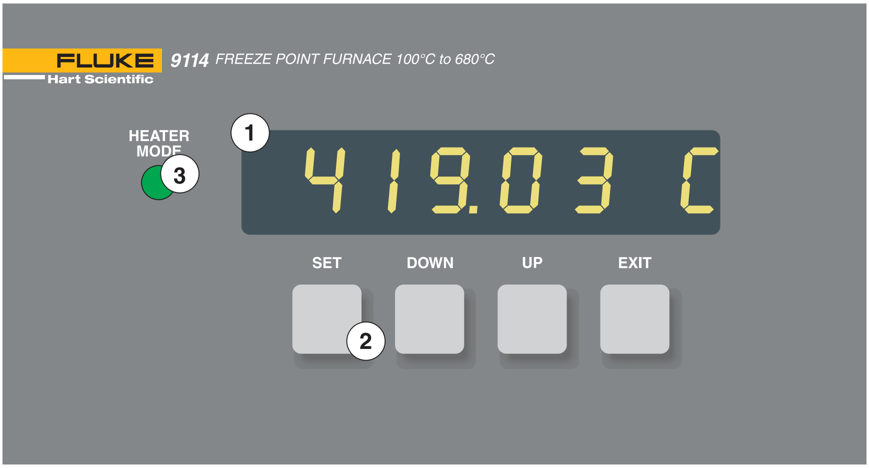


Figure 2. *Primary Controller*

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 of temperature and settable parameters.

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

(3) The control indicator is a two color light emitting diode. This indicator lets the user visually see the ratio of heating to cooling. When the indicator is red the heater is on and when it is green the heater is off and the furnace is cooling.

4.1.2 Fuses

System fuses are located on the front panel behind the door. (For units required to meet CE requirements, the system fuses are internal.) Heater fuses are located inside the unit. There are two fuses per heater, one for each hot leg of a 230 VAC circuit in case a heater should become grounded.

4.1.3 ⚠ Zone Controllers

The controllers for the top and bottom zones of the equilibration block are located under the covered panel. They are slaved to the primary zone of the furnace with differential thermocouples. Their controls are utilized in setting the proper vertical gradient in the primary zone. See Section 5.16.3, Nulling the Zone Controllers.

4.2 Furnace Core

The furnace core consists of the heater block, heaters, control sensors, pre-heat wells, and inert gas inlet. Each of these is described below.

4.2.1 Heater Block

The furnace core contains a heated aluminum-bronze cylindrical block with a hole in the center that receives the metal freeze point cell and its supporting canister, see Figure 3 on page 14. The block is physically divided into three zones: the top end zone, the bottom end zone, and the center or primary zone. The end zones are intended to thermally guard the primary zone from heat loss out the ends hence reducing the longitudinal temperature gradient. To promote an even freeze throughout the freeze point cell and to consequently maximize the duration of the freeze, minimize this gradient.

4.2.2 Heaters

The control energy to the equilibration block is provided by means of electrical heaters that are attached to the block. AC line current is time modulated to the heaters by means of solid state relays or triacs. The heaters are wound in a bi-fliar fashion to minimize inductance. The primary heater is wound over the entire length of the block while the end zone heaters are wound only on the top and bottom ends and provide only the heat required to equalize the end temperature to that of the center zone.

The block is suspended in the cabinet and insulated to minimize heat loss. Aluminum housing containing the block assembly is isolated from the outer cabinet by an air space. Water cooling coils are attached to this housing to minimize the heating of the laboratory environment.

4.2.3 Control Sensors

A three-zone control system requires several sensors to maintain temperature control. All of the sensors are in inconel sheaths and inserted into the top of the block just under the top cover of the furnace. This scheme allows the sensors to be removed and replaced easily. The top cover is clipped into place and comes off by applying upward pressure.

4.2.3.1 Differential Thermocouples

The end zones are slaved to the primary zone by means of differential thermocouples. Each end zone has one Type K or Type H thermocouple differentially connected to a reference thermocouple in the center zone. A fifth Type K or Type N thermocouple is utilized as an independent over temperature cut-out sensor.

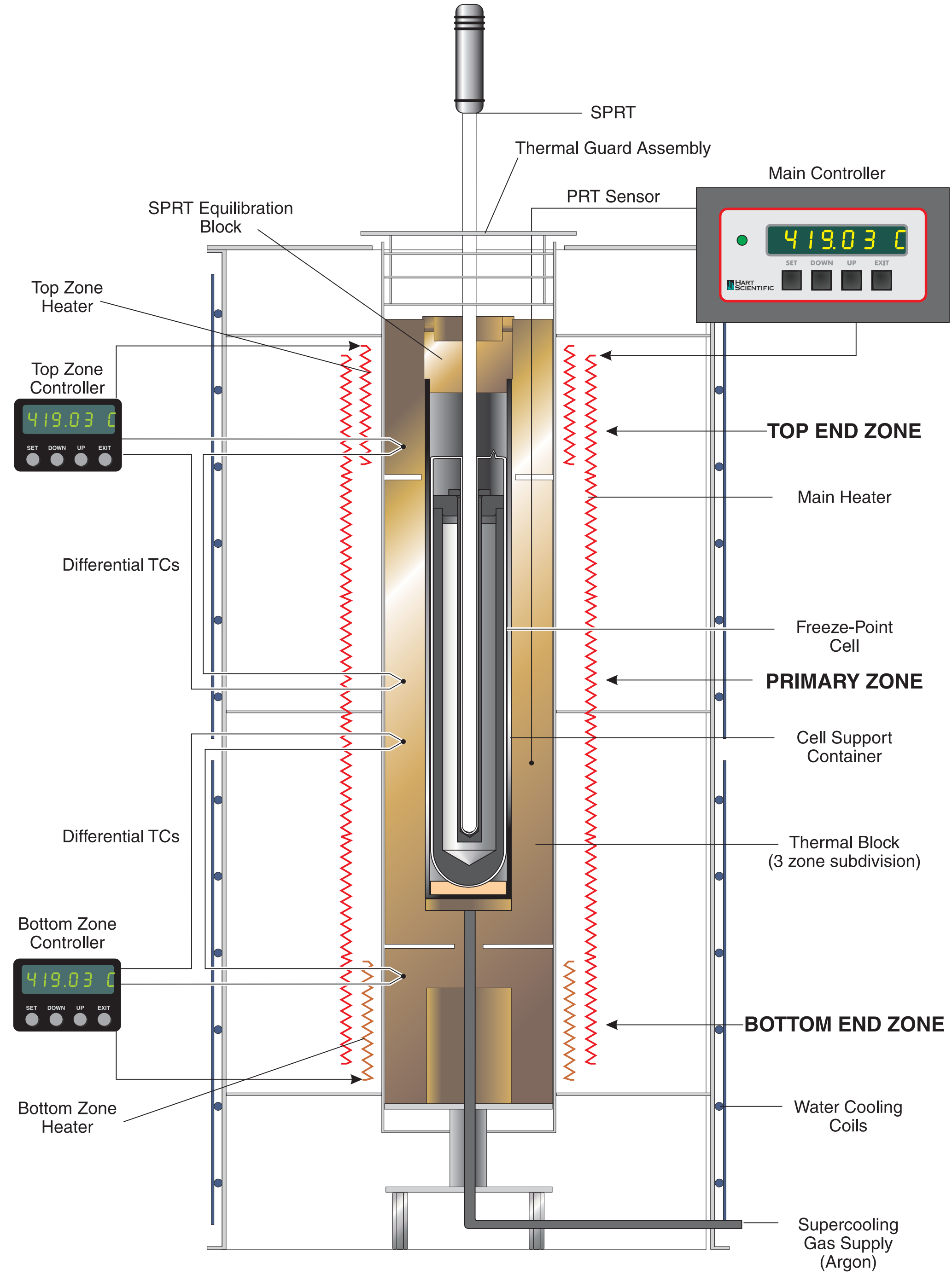


Figure 3. *9114 Heater Block Assembly*

4.2.3.2 High Temperature PRT

A high temperature PRT is used as the control sensor for the primary zone. A PRT provides higher repeatability, sensitivity, and accuracy than a thermocouple. A 100 ohm 385 DIN curve type is used.

4.2.4 Pre-Heat Wells

The furnace block contains three holes or wells which extend through the top cover and into the block for the purpose of preheating the probes or SPRT's to be calibrated in the freeze point cell. Preheating these thermometers extends the duration of the freeze by not using up valuable latent heat energy to bring the thermometers up to freeze point temperature. The diameter of the holes is 8mm (0.312 inches).

The pre-heat holes should not be used at the aluminum point. Scientific investigation has shown that contamination of the SPRT platinum sensor may occur at temperatures as low as 500°C. An annealing furnace should be implemented to ensure against contamination at the aluminum point. Use of an annealing furnace also allows for the slow cool down of the SPRT at temperatures above 500°C.

4.2.5 Inert Gas Inlet

Argon gas can be blown through the bottom of the freeze point cell well and past the cell assembly to cool it down quickly enough to initiate supercooling of a tin point cell. The "Gas Port" at the rear of the furnace is connected to the inlet point of the block.

4.3 Thermometer Cooling Wells

There are three holes along the rear of the top deck of the furnace. These have an inside diameter of about 8mm (5/16") and extend down into the air space inside of the furnace. Thermometers or probes may be placed inside these wells for cooling to air temperature after removal from the furnace or 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 4 on page 16.

1. The exhaust fan allows air circulation around the electrical components. Be sure to keep this fan free of foreign objects that could hinder airflow.

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 6 starting on page 41 for details.)

3. An optonal IEEE-488 interface is available. See Section 6 for details.

4. The power cord is a non-removable cord of AC voltage [230 VAC (±10%)].

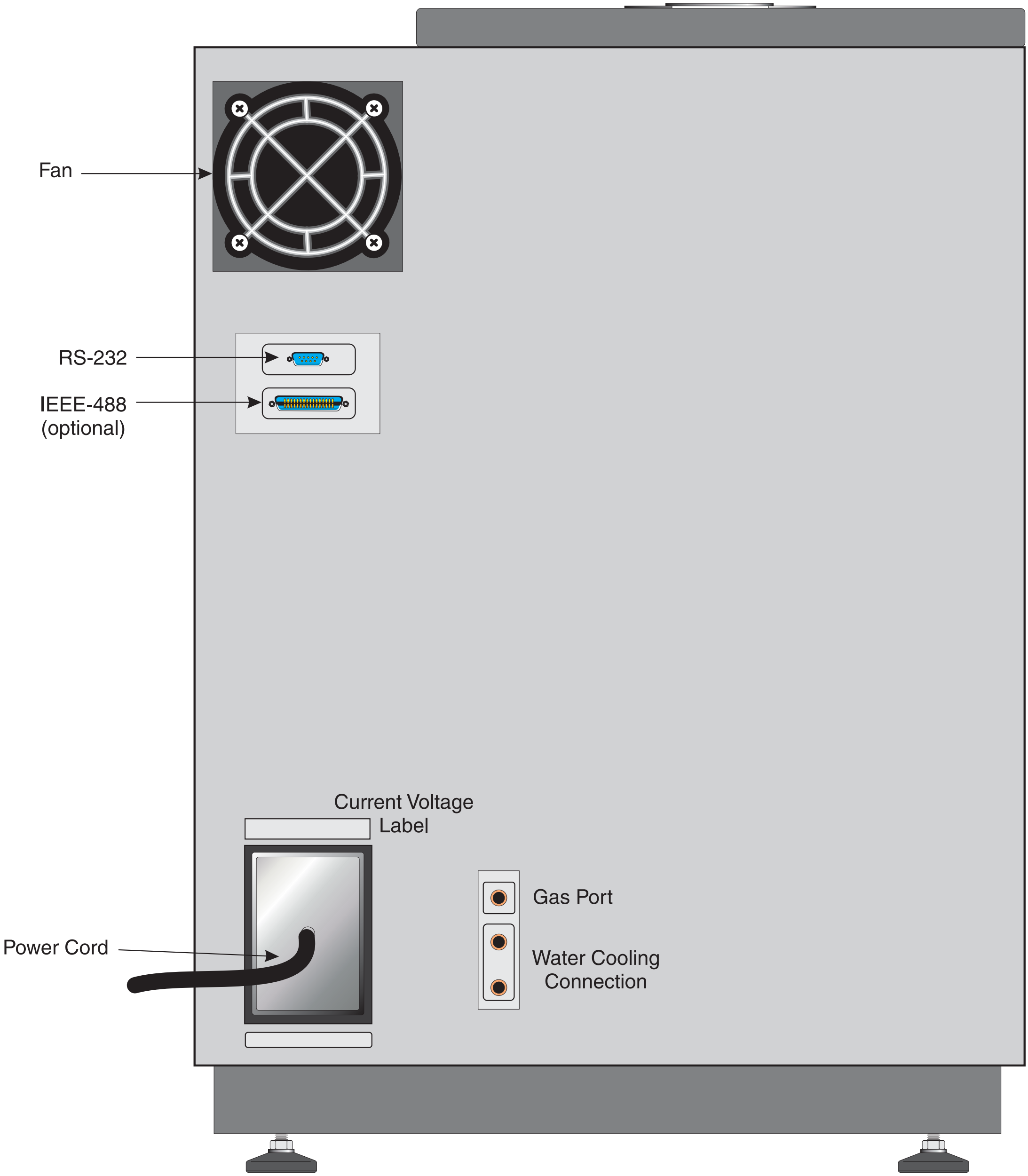


Figure 4. *Back Panel*

5. The cooling water ports are provided for connecting to cooling water to reduce the heat load. See Section 3.5, Plumbing, for details.

5 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 5.

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.

5.1 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.

5.2 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.**

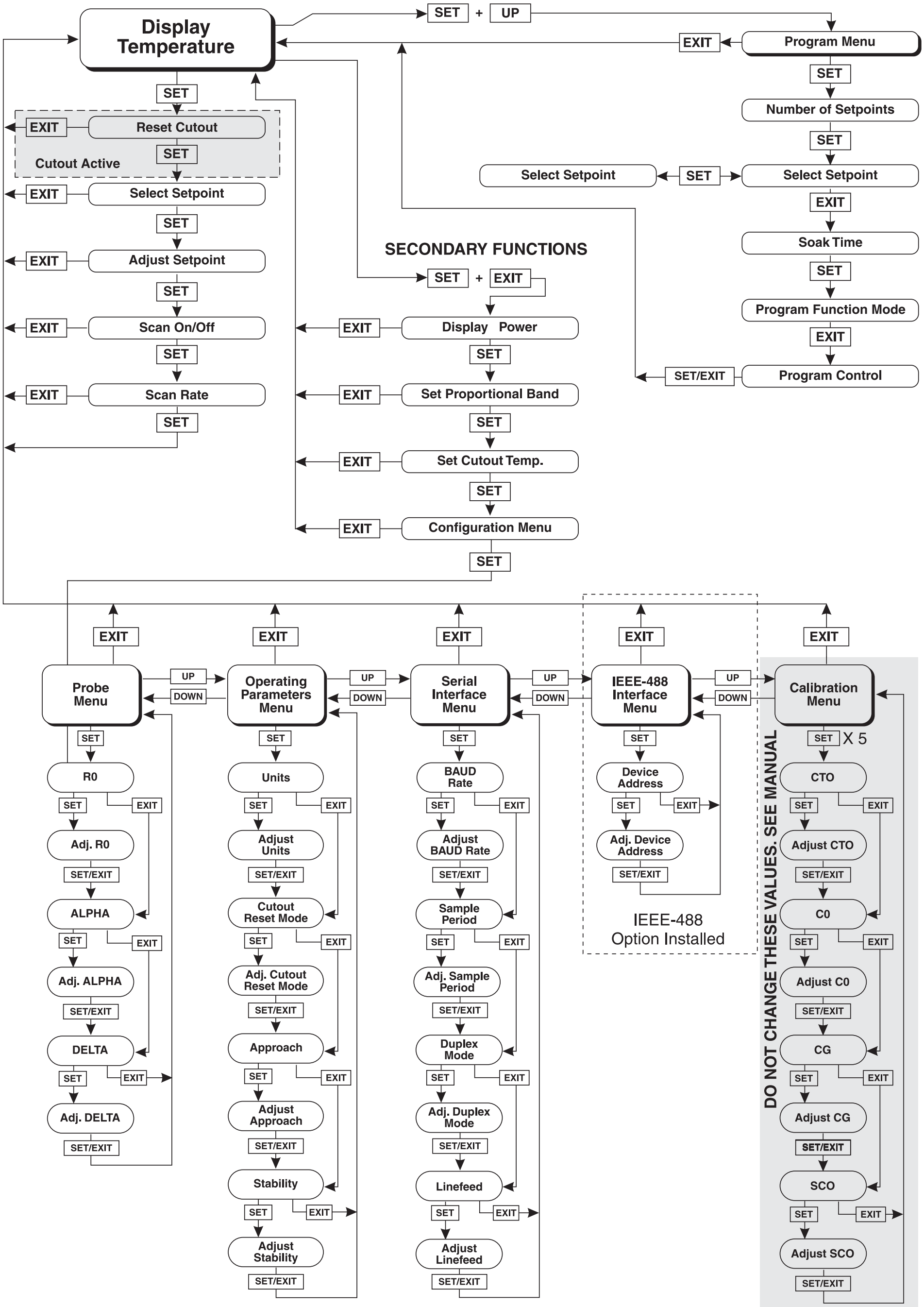


Figure 5. *Controller Flow Chart*

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.

5.3 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.

5.3.1 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. 100.0 *Set-point memory 1, 100.0°C currently used*

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

4. 400.0 *New set-point memory 4, 400.0°C*

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

SET *Accept selected set-point memory*

5.3.2 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 400.00` *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 420.00` *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*

5.4 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.

5.4.1 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*

5.4.2 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*

5.5 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*

5.5.1 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*

5.5.2 Set-points

The next parameters are the program set-points.

`1  50.0` *First set-point*

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

`3 150.0` *Third set-point*

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

`C  150.00` *Set-point value*

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

`C  165.00` *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*

5.5.3 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 5.12.4. 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*

5.5.4 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 3 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 3. *Program mode setting actions*

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

5.5.5 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*

5.6 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 5 on page 20.)

5.7 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".

5.8 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 6. 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.

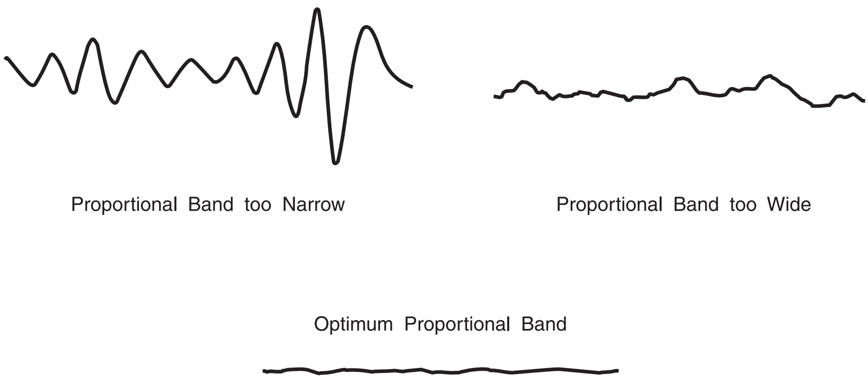


Figure 6. *Proportional Band Settings*

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*

5.9 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.

5.10 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".

5.11 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 8.

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.

5.11.1 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.

5.11.2 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.

5.11.3 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.

5.12 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.

5.12.1 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.

5.12.2 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 automatic mode.

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

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

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

5.12.3 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.

5.12.4 Soak Stability

The soak stability controls the required stability of the well temperature for the soak time (see Section 5.5.3). The stability is in degrees Celsius. The default is 0.1°C. This value can be changed in the parameter menu.

5.13 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.

5.13.1 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.

5.13.2 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*

5.13.3 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*

5.13.4 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*

5.14 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.

5.14.1 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*

5.14.2 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.

5.15 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.

5.15.1 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.

5.15.2 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 8.

5.15.3 SCO

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

5.16 End Zone Controllers

The zone controllers have the following features and controls as they pertain to this application.

1) Display: The display of the zone controllers shows the current measured temperature. Since the controllers use differential thermocouples the temperature reading is a measure of the temperature difference between the primary zone and the end zones.

When SET is pressed the display will show the current differential set-point for the respective end zone.

2) Control Buttons: There are four buttons on the controller: SET, UP, DOWN, and EXIT. The up and down buttons are used for adjusting various parameters.

The set button is used to accept parameters after adjusting them and the exit button is used to exit parameter adjusting without saving.

Normally, only the set-point temperature should be adjusted.

These controllers are set at the factory for a nominal gradient and the offsets reported on the report of test.

CAUTION: *BEFORE USING THE FURNACE, check the vertical gradient and adjust the offsets if required to ensure that the vertical gradient is within +0.05°C from the bottom of the cell as described in Section 5.16.3.2.*

5.16.1 Well Temperature

The digital LED display on the front panel allows direct viewing of the differential end zone. 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,

0.4	*Differential end-zone temperature in degrees Celsius*

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

5.16.2 Temperature Set-point

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

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

5.16.2.1 Programmable Set-points

The controller stores 8 set-point temperatures in memory. The set-points can be quickly recalled to conveniently set the instrument 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.

0.2	*Differential end-zone temperature in degrees Celsius*
SET	*Access set-point memory*
1. 0.0	*Set-point memory 1, 0.0°C currently used*

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

`5.   1.4` *New set-point memory 5, 1.4°C*

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

[SET] *Accept selected set-point memory*

5.16.2.2 Set-point Value

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

`+0001.4` *Set-point value in °C*

If the set-point value is correct then press "EXIT" to resume displaying the well temperature. Press "UP" or "DOWN" to adjust the sign of the temperature positive and negative. The sign will be flashing on and off. If the sign is correct press "SET". The first digit of the temperature should now be flashing. Adjust this digit by pressing "UP" or "DOWN".

`1.8` *New set-point value*

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

[SET] *Accept new set-point value*

5.16.2.3 Temperature Scale Units

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

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

`Un = C` *Scale units currently selected*

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

`Un = F` *New units selected*

5.16.3 Nulling the Zone Controllers

The zone nulling process consists of making temperature measurements along the main block, noting gradients, and adjusting the zone controllers to minimize them. Top and bottom zones of the furnace must be balanced to minimize the gradient in the primary zone. The following process is used at Hart Scientific when balancing the zones.

5.16.3.1 Pre-heat Well

Refer to Figure 7 when performing the following process.

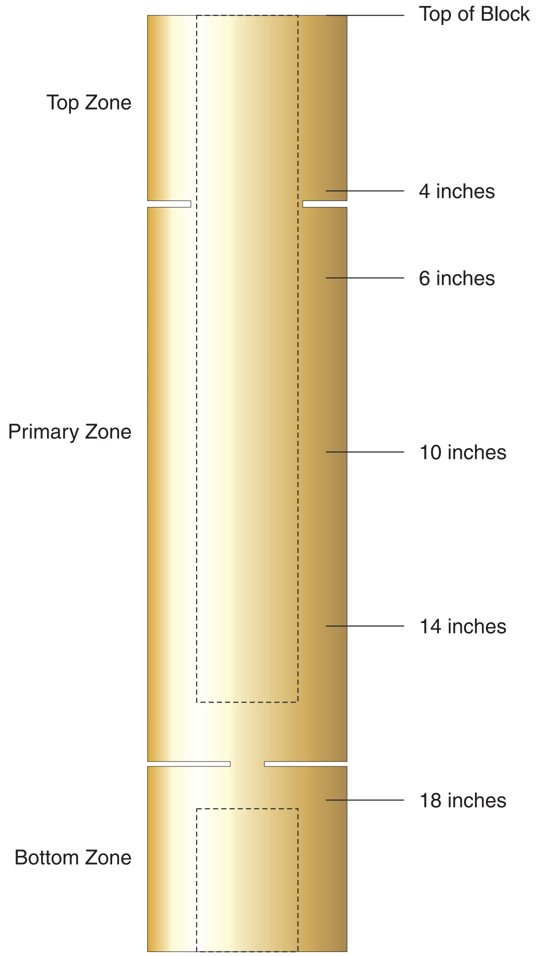


Figure 7 *9114 Furnace Block*

1. Check the temperature and stability of the block at the bottom zone, which is 18 inches from the top (17 inches to the center of the sensor with the PRT.) Use one of the pre-heat holes at 661°C. The well should be blocked so the heat does not escape. Block the well with the standard block, a fixed-point cell below the melting point or insulation. If a

fixed-point cell is used, lower the gradient temperature to at least 5°C below the melting point of the fixed-point.

2. Check the temperature at 14 inches deep. (The bottom end of the primary zone.)
3. Check the temperature and the stability at 10 inches deep. (The center of the primary zone.)
4. Check the temperature at 6 inches deep. (The top of the primary zone.)
5. Check the temperature and the stability at 4 inches deep. (The bottom of the top zone.)

The vertical temperature gradient along the primary zone must be within +0.1°C if a pre-heat hole is used.

If required, adjust the top and bottom zones to improve the gradient in the primary zone. Use the differential temperature difference on the zone controllers. Check the temperatures again and note the changes. (The data may be easier to see if graphed.)

Repeat the process until the vertical gradient is acceptable. (To aid in comparing the data, graph the data from each iteration on the same graph.)

5.16.3.2 Fixed-Point Cell

CAUTION: *The vertical gradient should be checked inside the fixed-point cell prior to realization.*

When the gradient is taken within the cell, the vertical temperature gradient along the bottom 6 inches of the cell must be within +0.05°C. The temperature should be set approximately 5°C below the melting point of the cell while taking the gradient.

1. Insert the cell as if realizing the fixed-point. Set the temperature to approximately 5°C below the melting point of the fixed-point. (When measuring the vertical gradient, keep the cell in its' solid state to guarantee that the cell will not be broken because of a bad gradient.)
2. Insert the quartz glass sheathed SPRT into the cell. Be sure that the SPRT is cleaned with pure alcohol before placing it in the cell.

   Do not use a metal sheathed SPRT to take vertical gradients in a fixed-point cell. The gradient will be affected by stem effect if measured with a metal sheathed SPRT.

   Wait for the unit to stabilize.
3. Take measurements every inch over the bottom 6 inches of the well. The measurements are taken at 2-minute intervals. Ideally, we want to know the vertical gradient over the bottom 6 inches of the cell simultaneously.

Because this is not practical, we have developed a method to provide a satisfactory substitution for simultaneous measurements.

Take the measurements twice: once in ascending direction (a_x) and once in descending direction (b_x). Average the two readings. The average is the calculated vertical gradient in the cell. The temperature turn-around point is at 7 inches. The measurement at 7 inches (a_7) is not valid because part of the sensor of the SPRT is out of the metal of the fixed-point cell.

Depth	Ascending Reading	Descending Reading	Average
0	a_0	b_0	$\frac{a_0 + b_0}{2}$
1	a_1	b_1	$\frac{a_1 + b_1}{2}$
2	a_2	b_2	$\frac{a_2 + b_2}{2}$
3	a_3	b_3	$\frac{a_3 + b_3}{2}$
4	a_4	b_4	$\frac{a_4 + b_4}{2}$
5	a_5	b_5	$\frac{a_5 + b_5}{2}$
6	a_6	b_6	$\frac{a_6 + b_6}{2}$
7	a_7		

4. If the gradient is within 0.05°C from the bottom, the furnace is optimized. If the gradient is not within ±0.05°C, repeat the gradient steps.

CAUTION: *The top must be slightly hotter than the bottom in order to ensure that the top of the metal is melted.*

CAUTION: *If the top of the metal is colder and a solid, it forms a solid seal on top of the liquid metal and will break the cell.*

6 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.

6.1 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 5 with the exception of the baud rate setting.

6.1.1 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.

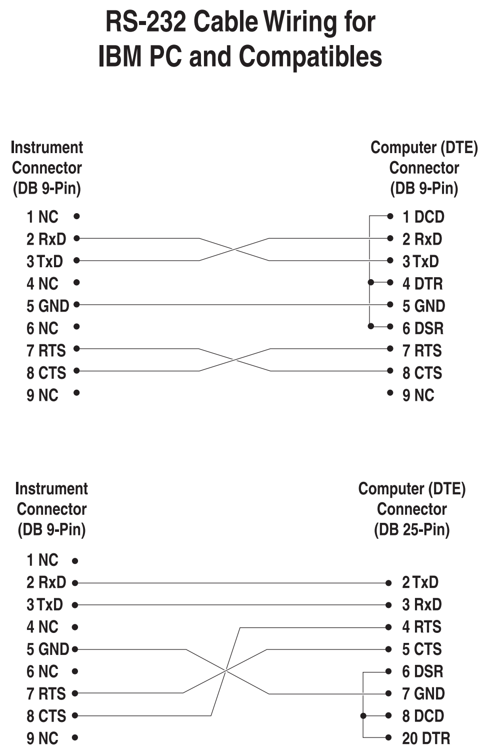


Figure 8. *Serial Cable Wiring*

6.1.2 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.

6.1.2.1 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.

6.1.2.2 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.

6.1.2.3 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".

6.1.2.4 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".

6.1.3 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 6.3. All commands are ASCII character strings terminated with a carriage-return character (CR, ASCII 13).

6.2 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.

6.2.1 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.

6.2.2 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.

6.3 Interface Commands

The various commands for accessing the calibrator functions via the digital interfaces are listed in this section (see Table 4). 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 4. *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.				

7 Freeze Point Realization

CAUTION: Ensure that you have checked the vertical gradient prior to performing any fixed point realization, See Section 5.16.3, Nulling the Zone Controllers, on page 36. Failure to do so will break the fixed point cell.

7.1 General

The procedures for melting and obtaining the freezing point temperatures of metals have been documented in sources such as NBS Special Publication 260-77: “Application of Some Metal SRM’s as Thermometric Fixed Points”, by George T. Furukawa, et.al., NIST Technical Note 1265: “Guidelines for Realizing the International Temperature Scale of 1990”, by Mangum and Furukawa and other sources. This procedure is outlined with respect to the Hart Scientific model 9114 furnace. See the fixed point cell manual for additional information.

7.2 Metal Freeze Point Cell Assembly

The freeze point assembly consists of 1) the metal freeze point cell, 2) the cap, 3) the cell support canister, and 4) the fiber ceramic cushioning. (See Figure 9.)

7.2.1 Metal Freeze Point Cell

The freeze point cell is totally enclosed in either borosilicate glass as with the tin cell or with fused quartz as with the zinc and aluminum cell. The metal sample is six nines pure for high accuracy. The sample is suspended inside a crucible of high purity graphite. The internal atmosphere in argon is one atmosphere pressure at the freeze point.

7.2.2 Cap

The cap provides a supporting mechanism for the entire assembly in the furnace, Figure 9. It attaches to the cell support canister with a twist lock connection. A safety lock is provided by 2 small set screws that prevent undesired rotation and releasing of the canister.

The flange at the top rests on the top of the equilibration block and suspends the cell into the well. The cap has the important function of a thermal shunt between the furnace and the SPRT. The hole in the center of the top is for insertion of the SPRT or other sensor. This feature reduces the gradient along the SPRT. This hole should be checked for fit with the sensors to be used. It should allow contact with the sensor yet allow free movement of the sensor into the cell. Different sizes are available from Hart Scientific or it can be modified to fit. The cap has two 1/4-20 blind threaded holes in which a tool may be threaded in for insertion and removal of the assembly from the furnace. There is also a bail that may alternatively be used to support the assembly.

7.2.3 Cell Support Canister

The canister consists of a metal cylinder closed at the bottom with twist lock grooves at the top to mate with the pins on the cap.

The cell support canister contains the metal freeze point cell and suspends it inside the furnace well. In case the cell should break, the contents remain inside the canister protecting the furnace.

7.2.4 Fiber Ceramic Cushioning

The freeze point cell is cushioned with a pad of fiber ceramic on the bottom. The sides are padded with fiber ceramic paper.

7.3 Installing the Metal Freeze Point Cell

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 causes devitrification or physical breakdown of the fused silica 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. See Figure 9 on page 51.

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

The freeze point cell is first installed into the support canister. The cell must be laid on its side for installation. Use especially gentle handling since there may be considerable stress on the reentrant tube from the weight of the metal sample and graphite crucible. With both the cell and the support canister on their sides, carefully slide the cell into the canister opening and push it against the fiber ceramic cushion on the bottom of the canister. To reduce friction and to prevent scratching the quartz, a strip of paper may be inserted part way into the canister and under the cell during the sliding process. Use very clean paper cut approximately 2 inches wide. Carefully turn the canister and cell upright and remove the entire paper strip. It is helpful to have two people complete the process. Shim the cell with fiber ceramic paper to center it. Always leave enough space around the edge of the cell to enable you to remove it.

Install the cap and rotate to the “locked” position. The cap fits very loosely to prevent binding when oxidized. The 2 pins pull into grooves to help them maintain their position while lowering the assembly into and removing it from the furnace.

Lower the assembly onto the furnace using the basket removal tool provided. Screw the tool into one of the two threaded holes in the cap. Make sure the cap stays in the grooves during the process. Removal of the cell is in reverse of this process.

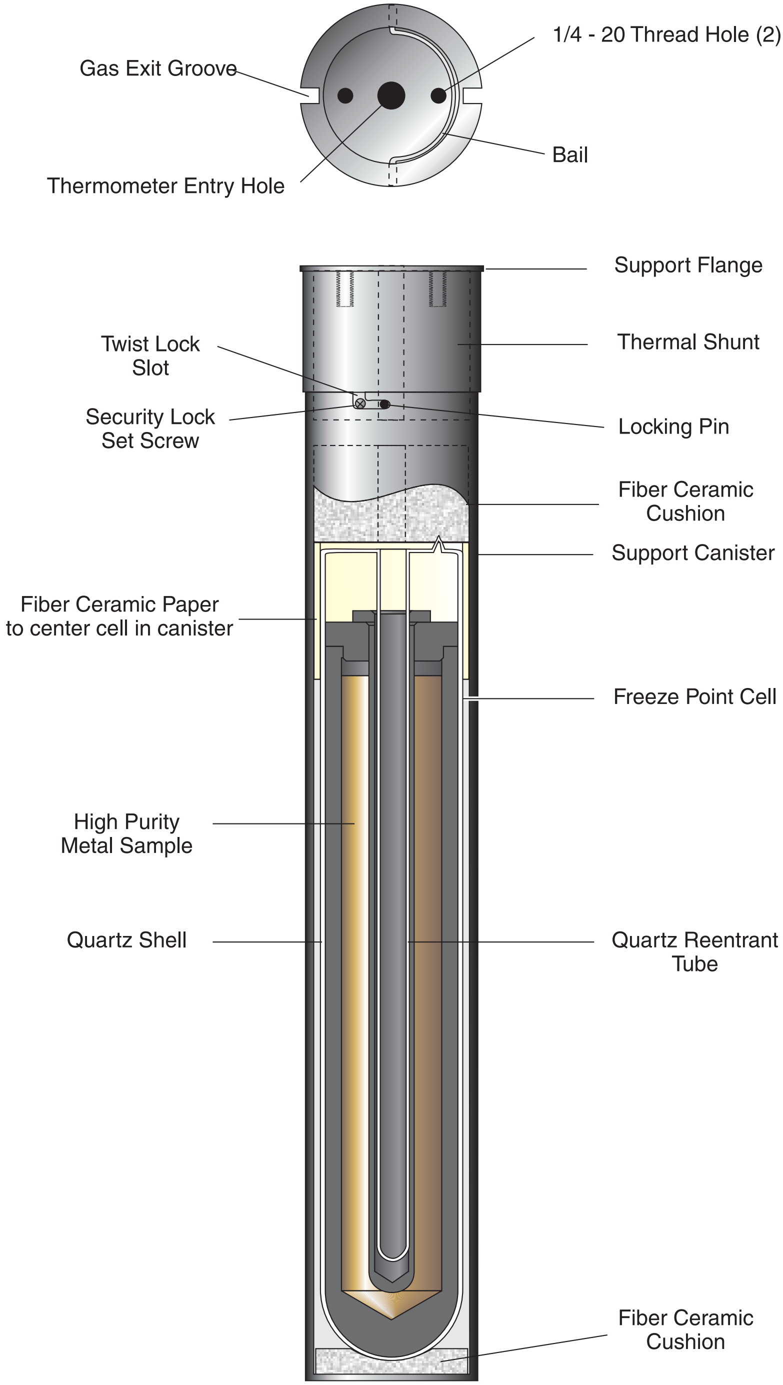


Figure 9. *9114 Freeze Point Cell Containment Vessel*

Once the freeze point cell is properly installed, you are prepared to heat the furnace and realize the freeze point for calibration purposes.

7.4 How to Realize the Freezing Point

7.4.1 General

All of the freezing points except tin are realized in a similar way. The safest way to melt your fixed-point is slowly overnight.

If realizing indium or zinc, set the temperature of the furnace about 5°C higher than the freezing point. After the metal is completely melted, the furnace is set at a stable temperature 1°C or 1.5°C higher than the freezing point overnight. The next morning, the furnace temperature is decreased slowly (0.1°C - 0.15°C).

If realizing the aluminum point, set the temperature to ramp at a rate of 0.5°C/minute (maximum rate of 1°C/minute) to approximately 1-1.5 degrees higher than the melting point. The ramp rate is critical. Melting the aluminum cell too quickly can cause the cell to break. The next morning the furnace temperature is decreased slowly (0.1°C – 0.15°C).

A SPRT is inserted into the cell. The temperature of the metal sample decreases to less than the freezing point before recalescence. The amounts of supercool are different from metal to metal. After recalescence the thermometer is removed from the furnace immediately and a cold fused silica tube is inserted into the fixed point cell for one minute. After that, a SPRT to be calibrated is introduced into the cell, while the furnace is kept at a stable temperature of 1°C below the freezing point. This procedure provides a very stable, long freezing plateau that typically lasts for more than ten hours. The changes in temperature in the first half of the plateau are usually within ±0.2-0.3 mK.

7.4.2 Tin Point

To realize the tin point perform the following steps.

1. Load the tin cell into the cell canister as described. Carefully place the assembly into the furnace and set the furnace temperature to 3 to 5 degrees above the melting temperature. You will find it convenient to set the plateau temperature into a second memory location right away while the temperature is rising. It is advisable to set the cut-out temperature to about 250°C as well.

It will take several hours to melt the tin sample once the melting point has been reached. This procurement can be completed overnight to provide more time for measurements during the day.

***NOTE:** Once the tin is completely melted, make a reference measurement comparing the cell temperature with the set-point temperature. This will help in setting the controller more precisely.*

2.

To begin the freezing process, carefully insert a monitor SPRT into the cell. Reset the furnace temperature to a temperature 0.5 to 1 degree below the tin freezing point.

3. When the monitor SPRT indicates that the tin sample is near the freezing point, it is time to initiate the freeze. Two options are possible to create the “outside nucleated freeze”.
   a. The Hart preferred method is to cool the cell in place with clean compressed air. A “Gas Port” has been provided on the rear of the furnace to allow for this technique. The gas flow is adjusted to about 75 CFH.
   b. **HART DOES NOT RECOMMEND THE FOLLOWING METHOD.** The traditional method is to remove the cell from the furnace and hold it in the air where it may be rapidly cooled. The liquid tin supercools as much as 25°C. As the temperature begins to rise again (as indicated by the SPRT) quickly reinsert the cell into the furnace. The cell may be removed by threading the removal tool into the top of the canister cover. Care must be taken that the tool is turned in far enough to prevent its coming out during removal or reinsertion. Remove the tool after reinsertion of the cell.

CAUTION: *Great care must also be exercised to prevent damage to the tin check standard (SPRT) that is used to monitor the freezing curve during this process.*

4. Freeze a thin mantle around the thermometer well. This is done by successively inserting two fused silica rods from room temperature for about 5 minutes each. In 20 to 30 minutes the monitor SPRT should indicate that the cell has reached its equilibrium temperature.
5. Test SPRT’s should be placed in the pre-heat wells to be brought up to furnace temperature while the monitor SPRT is coming to equilibrium.
6. The monitor SPRT is moved to the pre-heat well after measurement is complete. Move the test SPRT quickly between the pre-heat well and the tin cell to minimize heat loss thus reducing the impact on the cell. The test SPRT will reach equilibrium temperature in about 30 minutes.
7. Successive measurements are made on test SPRTs, cycling each one into the pre-heat well and then to the tin cell.
8. After the final test SPRT, the monitor SPRT is cycled through the pre-heat well and into the tin cell. The reading should be within the desired level of agreement with the initial reading.
9. When the temperature, indicated by a thermometer immersed in the tin sample, reaches the freezing point, a cold gas flow goes upward around the outer surface of the cell until recalescence. After recalescence shut

off the cold gas flow. The furnace is kept at a stable temperature of 1°C below the freezing point.

7.5 Safety Precautions

⚠ ***CAUTION:*** *Sealed cells for freezing points are delicate devices and the fused silica shell is prone to be broken. THE CELL MUST BE HANDLED WITH EXTREME CARE. Never touch the cell with bare hands. When handling the cell, wear cotton gloves.*

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 Furnace Calibration

Sometimes 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 R_0 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. By using a good thermometer and carefully following procedure the calibrator can be calibrated to an accuracy of better than 0.5°C over a range of 662 degrees.

8.1 Calibration Points

In calibrating the furnace, R_0 and ALPHA are adjusted to minimize the set-point error at each of two different furnace temperatures. Any two reasonably separated temperatures may be used for the calibration. Improved results can be obtained for shorter ranges when using temperatures that are just within the most useful operating range of the furnace. The farther apart the calibration temperatures, the larger the calibrated temperature range and the greater the calibration error.

For example, if 150°C and 500°C are chosen as the calibration temperatures, the calibrator may achieve an accuracy of ±0.2°C over the range 100 to 550°C. If 200°C and 300°C are chosen as the calibration temperatures, the calibrator may achieve an accuracy of ±0.05°C over the range 175 to 325°C. Outside this range the accuracy may only be ±0.4°C.

8.2 Measuring the Set-point Error

The first step in the calibration procedure is to measure the temperature errors (including sign) at the two calibration temperatures. First set the calibrator to the lower set-point that we will call t_L. Wait for the well to reach the set-point and allow 30 to 60 minutes to stabilize at that temperature. Check the stability with the thermometer. When both the well and the thermometer have stabilized, measure the temperature with the thermometer and compute the temperature error err_L, which is the actual well temperature minus the set-point temperature. For example, if the calibrator is set for a lower set-point of t_L=200°C and it reaches a measured temperature of 199.7°C then the error is –0.3°C.

Next, set the calibrator for the upper set-point t_H and after stabilizing measure the well temperature and compute the error err_H. This example supposes the calibrator was set for 400°C and the thermometer measured 400.1°C giving an error of ±0.1°C.

8.3 Computing R_0 and ALPHA

Before computing the new values for R_0 and ALPHA, the current values must be known. The values may be found by either accessing the probe calibration menu from the controller panel or by inquiring through the serial interface. The user should keep a record of these values in case they need to be restored in the future. The new values R_0' and ALPHA' are computed by entering the old values for R_0 and ALPHA, the calibration temperatures set-points t_L and t_H, and the temperature errors err_L and err_H into the following equations,

$$R_0' = \left[\frac{err_H\, t_L - err_L\, t_H}{t_H - t_L} ALPHA + 1 \right] R_0$$

$$ALPHA' = \left[\frac{(1 + ALPHA\ t_H)\ err_L - (1 + ALPHA\ t_L) err_H}{t_H - t_L} + 1 \right] ALPHA$$

If for example R_0 and ALPHA were previously set for 100.2695 and 0.0038319 respectively and the data for t_L, t_H, err_L, and err_H were as shown above then the new values R_0' and ALPHA' would be computed as 100.193 and 0.0038272, respectively. Program the new values R_0 and ALPHA into the controller. Check the calibration by setting the temperature to t_L and t_H and measuring the errors again. If desired the calibration procedure may be repeated to further improve the accuracy.

8.4 Calibration Example

If the calibrator is to be used between 125 and 325°C and it is desired to calibrate the calibrator as accurately as possible for operation within this range. The current values for R_0 and ALPHA are 100.000 and 0.0038500 respectively. The calibration points are chosen to be 150.00 and 300.00°C. The measured well temperatures are 149.943 and 299.814°C respectively. Refer to Figure 10 for applying equations to the example data and computing the new probe constants.

R_0 = 100.000

ALPHA = 0.0038500

t_L = 150.00°C

measured t = 149.943°C

t_H = 300.00°C

measured t = 299.814°C

Compute errors,

err_L = 149.943 - 150.00°C = -0.057°C

err_H = 299.814 - 300.00°C = -0.186°C

Compute R_0,

$$R_0' = \left[\frac{(-0.186)\times 1500.0 - (-0.057)\times 300.0}{300.0 - 150.0} 0.00385 + 1\right]100.000 = 99.9723$$

Compute ALPHA,

$$ALPHA' = \left[\frac{(1+0.00385\times 300.0)(-0.057) - (1+0.00385\times 150.0)(-0.186)}{300.0 - 150.0} + 1\right]0.00385 = 0.0038544$$

Figure 10. *Calibration Example*

9 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, wipe it 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 out-lined 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 does 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. In order to check the user selected cut-out, follow the controller directions (Section 5) for setting the cut-out.
- Adjustment of Temperature Uniformity: A periodic check of the temperature uniformity is recommended at least once every year. A suggested procedure is outlined in Section 5.16.3.
- At least once a year check the display accuracy by using a SPRT to measure the well temperature. Compare the measured temperature to the display. If there is more than a 2°C difference, recalibrate the furnace.

10 Troubleshooting

If problems arise while operating the 9114, this section provides some suggestions that may help you solve the problem. A wiring diagram is also included.

10.1 Troubleshooting

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

10.1.1 Incorrect Temperature Reading

Power the unit on and watch the display. If the first number displayed is less than "-0005-", the unit has been re-initialized. The unit needs to be reprogrammed for R_0 and ALPHA. These numbers can be found on the Report of Calibration that was shipped with the unit.

10.1.2 The display is off

Check the fuses. (Internal)

Check that the power cord is plugged in and connected to the unit.

10.1.3 Red LED on display is blank

Check that there is power to the unit.

10.1.4 The unit heats slowly

Check the Scan and Scan Rate settings. The Scan may be on with the Scan Rate set low.

10.1.5 If the controller appears to function properly but the furnace will not heat or heats slowly

Check the internal heater fuses (6 total).

10.1.6 If the display flashes any error code

Initialize the system by performing the master reset sequence. If the unit repeats the error code, contact Hart Scientific Customer Support for a return authorization and for instructions on returning the unit.

Master Reset Sequence - Hold the "SET" and "EXIT" keys down at the same time while powering up the unit. The screen will display "-init-" , "9114" and the version of the software. The unit will need to be reprogrammed for R0 and ALPHA, and in the calibration menu. These numbers can be found on the Report of Calibration that was shipped with the unit.

10.1.7 If the display flashes "–273°C" or "–459°F"

The sensor is disconnected or shorted. Please contact Hart Scientific Customer Support for further instructions.

10.1.8 If the display flashes "cut-out"

The software cut-out is set too low. Check the cut-out setting in the Set-point menu.