FLUKE®

Hart Scientific®

9260

Mini Fixed-Point Cell Furnace Users' Guide

Rev. 611902

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Rev. 611902

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1 Before You Start

1.1 Introduction

The 9260 is a specialized furnace for the realization of certain defining fixed-points of the International Temperature Scale of 1990 (ITS-90). This furnace is intended for Calibration Laboratory use and not for field applications. The 9260 permits simplified realization of either freezing or melting curves. Internal programming of the micro-processor controller provides preprogrammed scan rates, set-points for each step in the process, dwell timing, and indication that the next step is ready. ITS-90 points including Indium, Tin, Zinc, and Aluminum are included. In addition, one other user-defined point may be selected. User defined non-ITS 90 fixed-points are useful for specific applications.

The 9260 furnace is available in 115 VAC (±10%) 60 Hz or 230 VAC(±10%) 50 Hz models.

The 9260 furnace may also be used as a dry-well calibrator or as a temperature comparator. Pre-drilled inserts are available from Hart Scientific for this application.

Built in programmable features include:

- Temperature scan rate control
- Fixed-point programming
- Eight set-point memory
- Adjustable readout in °C or °F

The temperature is accurately controlled by Hart's hybrid analog/digital controller. The controller uses a precision, platinum RTD as a sensor and controls the well temperature with a solid state relay (triac) driven heater.

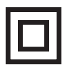
The LED front display panel continuously shows the current well temperature. The temperature may be easily set with the control buttons to any desired temperature within the specified range. The furnace's multiple fault protection devices insure user and instrument safety and protection.

The 9260 furnace was designed for high accuracy calibrations using comparison measurements or fixed-point calibration methods and for ease of operation. Through proper use, the instrument will continuously provide accurate calibration of temperature sensors and devices. The user should be familiar with the safety guidelines and operating procedures of the furnace as described in this user manual.

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
	Hot Surface (Burn Hazard)
	Read the User's Manual (Important Information)
	Off
	On
	Canadian Standards Association

Symbol	Description
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-Tick mark)	C-TIC Australian EMC 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.
- **HIGH TEMPERATURES PRESENT** in this equipment **FIRES AND SEVERE BURNS** may result if personnel fail to observe safety precautions.
- **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.**
- Components and heater lifetimes can be shortened by continuous high temperature operation.
- The instrument can generate extreme temperatures. Precautions must be taken to prevent personal injury or damage to objects. Probes may be extremely hot when removed from the instrument. Cautiously handle probes

to prevent personal injury. Always use the special comparison block tongs that are supplied with the furnace to remove the comparison block or cell basket. Carefully place probes on a heat resistant surface or rack until they are at room temperature. Never place any objects other than the comparison blocks, cell basket, or cells supplied with the furnace into the well.

- Use only grounded AC mains supply of the appropriate voltage to power the instrument. The furnace requires 11 amps maximum at 115 VAC (±10%),60 Hz and 6 amps maximum at 230VAC (±10%), 50 Hz.
- 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.

- Operate the instrument in room temperatures between 5-45°C (41-113°F). Allow sufficient air circulation by leaving at least 6 inches of space between the furnace and nearby objects. Overhead clearance needs to allow for safe and easy insertion and removal of probes for calibration.
- The furnace is a precision instrument. Although it has been designed for optimum durability and trouble free operation, it must be handled with care. Always carry the unit in an upright position to prevent the comparison blocks from falling out. Keep the well of the instrument clean and clear of any foreign matter. Do not operate near flammable materials.
- **DO NOT** use fluids to clean out the well.
- **DO NOT** move the furnace with the fixed-point cells inside. They can be easily broken.
- Before initial use, after transport, and anytime the instrument has not been energized for more than 7 days, the instrument needs to be energized for a "dry-out" period of 1-2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1.
- The instrument is equipped with operator accessible system fuses. If a fuse blows, it may be due to a power surge or failure of a component. Replace the fuse once. If the fuse blows a second time, it is likely caused by failure of a component. If this occurs, contact 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 instrument. Power bumps from brown-outs and black-outs can damage the instrument. Wait until the power has stabilized before re-energizing the instrument.

1.4 Hart Scientific Authorized Service Centers

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

Hart Scientific, Inc.

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

The 9260 specifications are detailed in Table 2 and the Mini Cell specifications are detailed in Table 3.

Table 2 *9260 Specifications*

Operating Range	50°C to 680°C (122°F to 1256°F)
Ambient Temperature	5°C to 45°C (41°F to 113°F)
Accuracy	±0.2°C 50°C to 300°C ±0.3°C 300°C to 450°C ±0.5°C 450°C to 680°C
Stability	± 0.03°C to 300°C ± 0.05°C above 300°C
Well-to-Well Gradient	±0.02°C (±0.036°F)
Melting/Freezing Point Duration	6 to 10 hours typical
Vertical Gradients	Top and bottom zones adjustable by offset
Resolution	0.01°C or °F
Display Scale	°C or °F, switchable
Comparison Block	Blank block, two multi-hole blocks, and custom blocks available
Fault Protection	Sensor burnout and short protection, over temperature thermal cut-out
Heater	1200 W maximum - adjustable top and bottom zones
Heating Time	Approximately 1.25 hours, 25°C to 680°C
Cooling Time	Approximately 10.5 hours, 680°C to 100°C
Stabilization Time	15 minutes nominal
Immersion Depth	229 mm (9”)
Power Requirements	115 VAC (±10%), 60 Hz, 11 amps maximum, 10 amps nominal 230 VAC (±10%), 50 Hz, 6 amps maximum, 5 amps nominal
Exterior Dimensions	250 mm L x 203 mm W x 489 mm H (10” x 8” x 19.25”)
Weight	20.5 kg with comparison block (45 lb)

Table 3 *Mini Cell Specifications*

			Expanded Uncertainty – Using 9260 Furnace	
Model	Fixed Point	Temperature	Six 9's Cell	Five 9's Cell
5914	Indium	156.5985°C	2 mK	5 mK
5915	Tin	231.928°C	3 mK	5 mK
5916	Zinc	419.527°C	4 mK	7 mK
5917	Aluminum	660.323°C	10 mK	12 mK

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 - 45°C (41 - 113°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

2.3 Warranty

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

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

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

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

For service or assistance, please contact an Authorized Service Center.

Hart Scientific, Inc.

799 East Utah Valley Drive

American Fork, UT 84003-9775

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E-mail: support@hartscientific.com

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 Quick Start

3.1 Unpacking

Unpack the instrument carefully and inspect it for any damage that may have occurred during shipment. If there is shipping damage, notify the carrier immediately.

Verify that the following components are present:

- 9260 Furnace
- Inner-Melt Heater
- Power Cord
- Manual
- Comparison Blocks (optional)
- Cell Basket
- Cell Basket Lid
- Basket Removal Tool
- Thermal Shunt
- Top Insulation
- Cell Pad Insulation

3.2 Setup

Place the furnace on a flat surface with at least 6 inches of free space around and 18 inches above the instrument. Install the power cord into the power entry module on the underside of the furnace. Plug the power cord into a grounded mains outlet. Verify that the nominal voltage corresponds to that indicated on the back of the instrument.

Carefully insert the comparison blocks or cell baskets into the well. (**DO NOT** drop them into the well.) Comparison block holes should be of the smallest diameter possible while still allowing the probe to slide in and out easily. Various hole sizes are available from Hart Scientific. The well must be clear of any foreign objects, dirt and grit before the comparison block is inserted. See Section 4.7 for more details.

Turn on the power to the instrument by toggling the switch on the power entry module located underneath the front of the furnace. The fan should begin quietly blowing air through the instrument and the controller display should illuminate after 3 seconds. After a brief self-test the controller should begin normal operation. If the unit fails to operate please check the power connection.

The display will begin to show the well temperature and the well heater will start operating to bring the temperature of the well to the set-point temperature.

3.3 "Dry-out" Period

Before initial use, after transport, and anytime the instrument has not been energized for more than 10 days, the furnace will need 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 IEC 1010-1.

3.4 Power

Plug the instrument power cord into a mains outlet of the proper voltage, frequency, and current capability. Typically this will be 11 amps maximum at 115 VAC (±10%), 60 Hz [6 amps maximum at 230 VAC (±10%), 50 Hz]. Turn the instrument on using the "POWER" switch underneath the unit. The instrument will turn on and begin to heat to the previously programmed temperature set-point. The front panel LED display will indicate the actual instrument temperature.

3.5 Setting the Temperature

Section 5.3 explains in detail how to set the temperature set-point on the furnace using the front panel keys. The procedure is summarized here.

(1) Press "SET" twice to access the set-point value.

(2) Press "UP" or "DOWN" to change the set-point value.

(3) Press "SET" to program in the new set-point.

(4) Press "EXIT" to return to the temperature display.

When the set-point temperature is changed the controller will switch the well heater on or off to raise or lower the temperature. The displayed well temperature will gradually change until it reaches the set-point temperature. The well may require 10 to 75 minutes to reach the set-point depending on the span and the scan rate. Another 15 minutes is required to stabilize within ±0.1°C of the set-point. Ultimate stability may take 15 to 20 minutes of stabilization time.

3.6 Changing Display Units

The instrument can display temperature in Celsius or Fahrenheit. The instrument is shipped from the factory set to Celsius. To change to Fahrenheit or back to Celsius there are two ways:

Press "SET" and "UP" simultaneously. This will change the display units.

or

Press the "SET" key three times from the temperature display to show

Un = C	*Press the "UP" or "DOWN" key to change units.*

Press “SET” to store changes.

4 Parts and Controls

The user should become familiar with the 9260 furnace parts. Successful use of the instrument is dependent upon knowledge of important components and their proper use.

4.1 Bottom Panel

The bottom panel consists of the removable power cord inlet, the power entry module (PEM) and power switch, and the fan. See Figure 1.

1. The removable power cord inlet is located underneath the furnace and plugs into an IEC grounded socket.

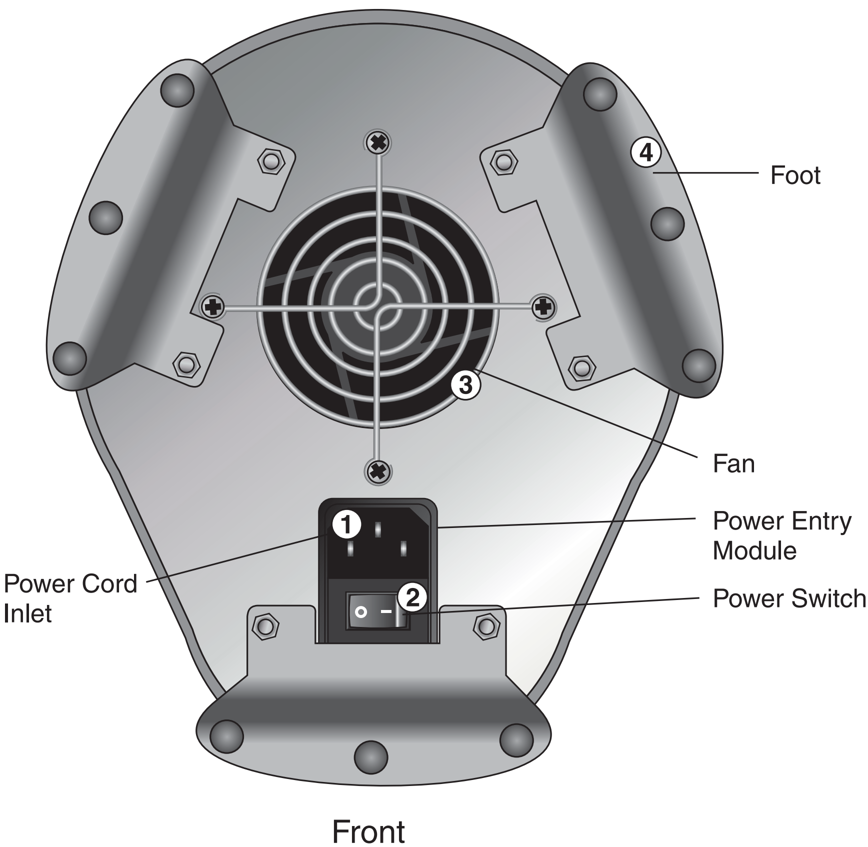

Figure 1 *Bottom Panel*

2. The power switch is located on the power entry module (PEM). The PEM also houses the fuses. Models are available for either 115 VAC (±10%) 60 Hz or 230 VAC (±10%) 50 Hz operation.

3. The cooling fan inlet is at the bottom of the unit. The cooling air circulating through the furnace keeps the electronics and the chassis cool. Keep the area immediately around the furnace clear to allow adequate ventilation.

4. Three feet support the chassis permitting air space for the fan and access to the power entry module and power switch.

4.2 Front Panel

The front panel contains the digital display and the controller keypad. See Figure 2.

1. The digital display is an important part of the temperature controller because it not only displays set and actual temperatures but also displays various instrument functions, settings, and constants. The display shows temperatures in units according to the selected scale °C or °F.

2. The four button controller keypad allows easy setting of the set-point temperature. The control buttons (SET, DOWN, UP, and EXIT) are used to set the instrument temperature set-point, access and set other operating parameters, and access and set calibration parameters.

Setting the control temperature is done directly in degrees of the current scale and can be set to 0.01 of a degree Celsius or Fahrenheit.

The functions of the buttons are as follows:

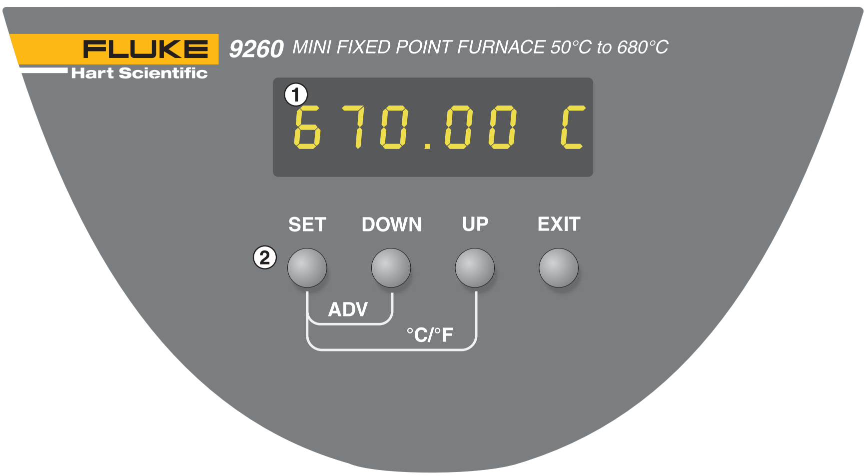

Figure 2 *Front Panel*

SET - Used to display the next parameter in the 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 a function and to skip to the next function. Any changes made to the displayed value are ignored. Holding "EXIT" for about 1/2 a second returns control to the main display.

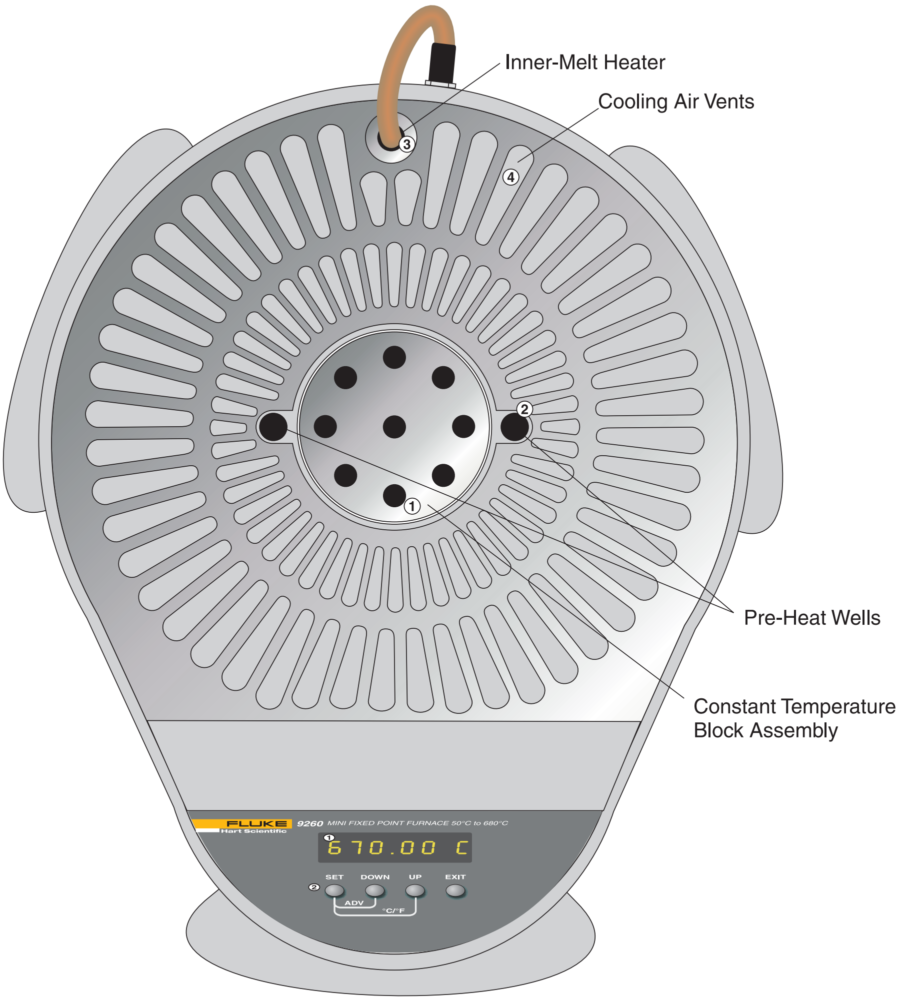

Figure 3 *Top Panel*

4.3 Top Panel

The primary feature of the top of the unit is the access to the temperature-controlled block. The top panel consists of the constant temperature block assembly, the pre-heat wells, the inner-melt heater, and cooling air vents. See Figure 3.

1. The constant temperature block assembly is where the cell basket containing the fixed-point cell is inserted. Or, when the furnace is used as a temperature comparator, where the pre-drilled inserts are placed for inserting the thermometers. The block assembly is made of a special aluminum-bronze alloy that is resistant to the temperatures that the furnace is capable of reaching.

   Heaters surround the cell in order to provide uniform heat. The 9260 features adjustable top and bottom zone heaters that help to keep the temperature uniform over the entire fixed-point cell. These zone heaters add heat to each end of the block where more heat is lost to ambient.

   A high-temperature platinum resistance thermometer is imbedded into the wall of the block to sense and control the temperature of the block. This entire assembly is insulated and suspended in the airflow of the fan to remove lost heat and to keep the chassis cool.
2. The thermometer pre-heat wells are located on either side of the block access well. Thermometers are pre-heated in these wells prior to insertion into the cell in order to conserve its latent energy.
3. The inner-melt heater is a low-power heater that creates an inner liquid layer next to the reentrant tube of the fixed-point cell during the melting curve process. This inner-melt heater is controlled automatically by the microprocessor when using the program mode, or may be used manually with the switch in back. When not in use, the inner-melt heater is stored in the well at the back of the unit to prevent it from causing any damage.
4. The cooling air vents in the top of the unit permit heated air to exit the unit. ***Care must be taken not to touch these vents while the furnace is at high temperatures or burns may result.***

CAUTION: *Areas on the top of the furnace may be very hot due to hot air blowing upward. Please use caution.*

4.4 Rear Panel

The rear panel consists of the inner-melt heater connector, the inner-melt heater switch, and the serial port. See Figure 4.

1. The inner-melt heater plugs into the rear of the furnace into the connector provided. Be sure it is plugged in during operation.

Figure 4 *Rear Panel*

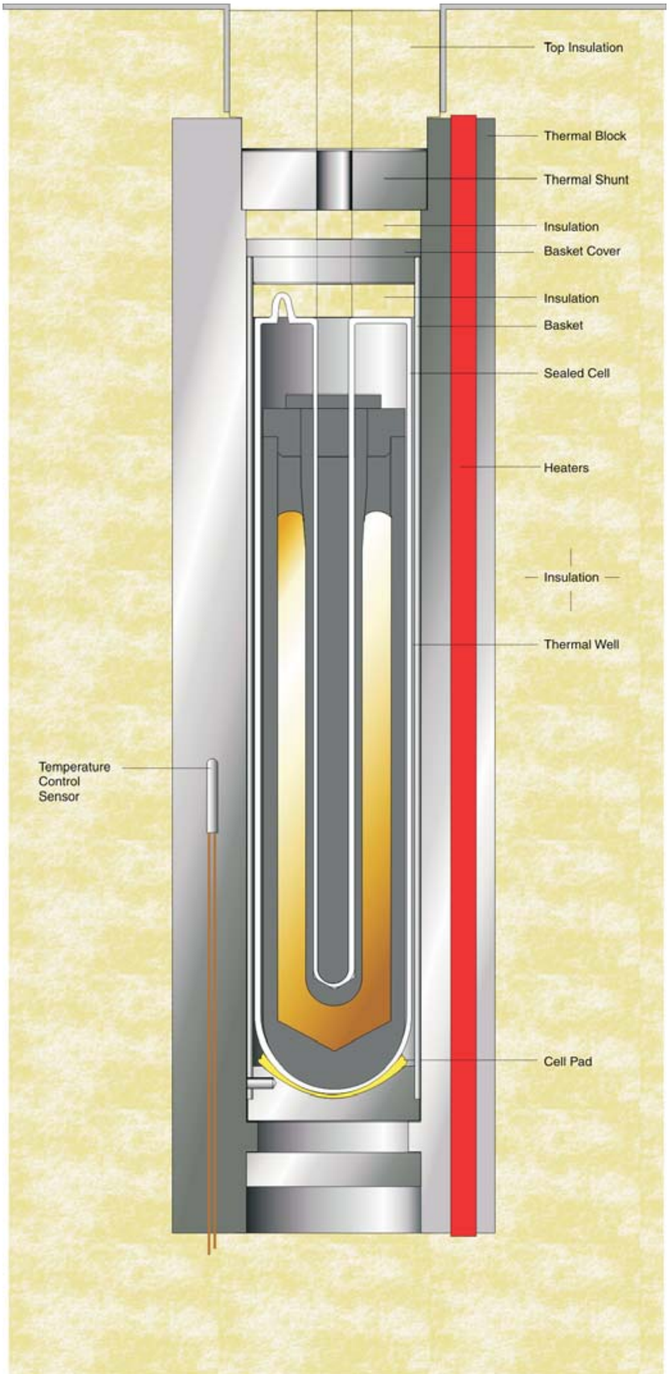

Figure 5 *Thermal Block Assembly*

2. The inner-melt heater switch can be set to “MANUAL ON” position or “AUTO” position. The microprocessor has control when the switch is in the “AUTO” position.
3. The serial port is a DB-9 male connector for interfacing the instrument to a computer or terminal RS-232 communications.

4.5 Thermal Block Assembly

The thermal block assembly is shown in Figure 5 and described below.

4.5.1 Thermal Block

The thermal block is specifically designed to contain the sealed cell and basket containment assembly. This design permits the uniformity to be tuned carefully for best performance and cell safety. Heaters in the perimeter of the aluminum-bronze cylinder provide heat as dictated by the temperature controller. A PRT sensor in the block monitors the block temperature and provides feedback to the controller. Forced airflow around the assembly keeps the outside of the furnace cool.

4.5.2 Heaters

The block assembly is heated by up to 1200 watts of heat. There are 3 heated zones; the main zone heaters heat the entire length of the block and the top and bottom zones heat their respective ends. The end zone heating compensates for losses out of the unheated ends. These heaters are adjusted to provide the required temperature uniformity within the cell itself. The adjustments are made by way of the keypad.

4.5.3 Basket

The sealed cell is positioned within the basket which allows the cell to be easily inserted and removed and contains all materials should the cell be broken. The top and bottom parts of the basket are made of aluminum-bronze and provide thermal shunting across the top and bottom as well. The lid and basket are removed separately with the tongs provided. A cell-pad in the bottom of the basket helps to cushion the cell from the metal bottom.

4.5.4 Thermal Shunt

A disk of aluminum-bronze in the top of the thermal well above the basket provides heat transfer across the top of the cell and to the thermometer itself. The effectiveness of the heat transfer to the thermometer is dependent on its fit to the shunt. Measurements at the aluminum point may be affected by heat conducted up the thermometer stem.

4.5.5 Insulation

The entire block assembly is surrounded by fiber-ceramic insulation. A removable portion above the cell permits the cell to be inserted and removed.

4.5.6 Temperature Control Sensor

The temperature control sensor is a high quality PRT with 4 leads. Accuracy is calibrated into the unit. Zero resistance, alpha, and delta coefficients of the Calendar-Van Dusen equation permit linearization over the desired temperature range.

4.6 Mini Fixed-point Cells

Mini Fixed-point Cells (Figure 6) utilize physical properties of a substance to provide well established temperatures. The sample in the cell is placed into a condition of multiple phases at a melting or freezing temperature or at a triple-point temperature. While the sample substances are in this condition they can exhibit very stable constant temperatures for long periods of time. Properly used, the temperatures provided by these constants of nature are extremely precise and repeatable. The International Temperature Scale of 1990 (ITS-90) is based on these principles. The ITS-90 temperatures defined at the freezing points of Indium, Tin, Zinc, and Aluminum are among these and are achievable with the Hart Scientific 9260 Furnace.

In order to achieve the ITS-90 temperatures and maintain long flat plateaus, the substance samples (metals in this case) must be very pure. Typically 6 nines purity is best. Sometimes 5 nines purity is used for the lower price but at the cost of higher uncertainty and shorter plateaus. The 9260 furnace utilizes a sealed mini-cell construction. The construction of the mini-cell follows the pattern of the full size cell. The high-purity sample is contained within a graphite crucible. The graphite is free of contaminants and will not react with the metal maintaining the metal purity. This material is all hermetically sealed within a silica glass (quartz) envelope. The internal atmosphere is high purity argon. In order to immerse the test thermometer into the high accuracy temperature zone of the cell, a reentrant well is provided in the center of the cell.

These cells are manufactured in the same careful manner as their larger full size counterparts. The certified high purity metal sample must maintain its purity throughout the process of manufacture and use of the cell. To accomplish this, high purity materials must be used for all the other components of the cell. After fabrication of each component, it must be treated to remove any impurities that may have been added during the process. The components are assembled in a clean environment and never touched directly by hand. After the components have been assembled and the silica glass permanently sealed, all of the air is evacuated out while the cell is melted. Numerous cycles of vacuum and purging with high purity argon are finally completed when the evacuation port is sealed leaving approximately one atmosphere pressure of argon in the cell at the freezing point of the sample.

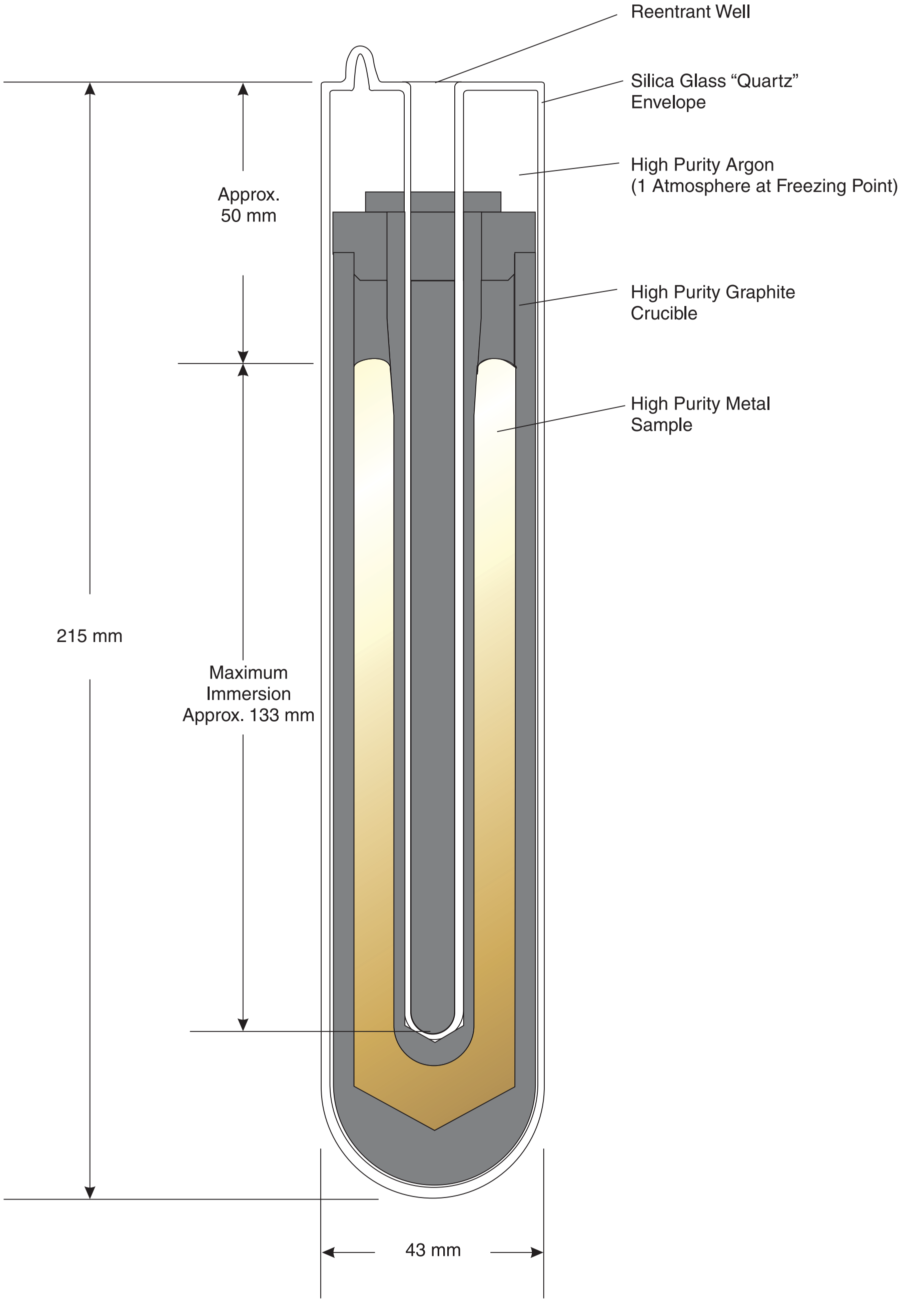

Figure 6 *Typical Sealed Mini Fixed-Point Cell*

Temperature corrections must be made to the reading to account for actual cell pressure and for hydrostatic pressure. During manufacturing, the cell is sealed with argon near the 1 atmosphere pressure. At that time the actual pressure is measured. With that pressure a small temperature correction can be calculated.

The hydrostatic pressure, created by the mass of the sample itself, depresses the temperature of the reading. Since different cell designs and thermometer designs translate to different immersion depths, the practice is to calculate and correct for the error. Figure 6 illustrates the maximum immersion depth within the mini-cell. The actual immersion depth is taken to the center of the sensor element of the thermometer. This depth will vary and the thermometer manufacturer may need to be consulted. Approximations can be made for typical types of thermometers since the hydrostatic error is small anyway and may be negligible for some requirements. Refer to the cell manual for the equations and constants that need to be applied.

Due to the fragile nature of the fixed-point cells, extra care must be taken during use and handling. Do not handle it with bare hands, use clean cotton gloves or equivalent. Make sure anything that comes in contact with the cell is clean. To remove contaminants, wipe the cell down with a clean cloth and pure alcohol. Quartz glass is subject to a process called devitrification. The glass will break down at high temperatures during this process. Oils in the skin and other contaminants can initiate or accelerate this process.

Contaminants introduced to the reentrant well of the cell from unclean thermometers can cause the same problem. In addition, some types of metals can contaminate the platinum sensor in a quartz SPRT at high temperatures (650°C and up). Clean all thermometers prior to testing.

4.7 Comparison Blocks

The 9260 furnace can function either as a calibrator or as a comparator. As a calibrator, the calibration of the controller provides the reference temperature. As a comparator, a reference thermometer value is compared to the values of the units under test. A smaller uncertainty is obtainable with the comparison method. Comparison blocks are available as options to the furnace.

4.7.1 Block Well Sizes

Three standard comparison blocks are available. See Figure 7. Model 3160-2-provides 9 wells with clearance for 1/4-inch diameter thermometers. Model 3160-3 is a combination of wells providing access for a variety of popular sizes. Model 3160-1 is a blank block that can be drilled by the user to any desired sizes.

4.7.2 Comparison Block Assembly

Comparison blocks provide a uniform temperature between multiple thermometers. For accurate results, the thermometers must fit closely inside the well.

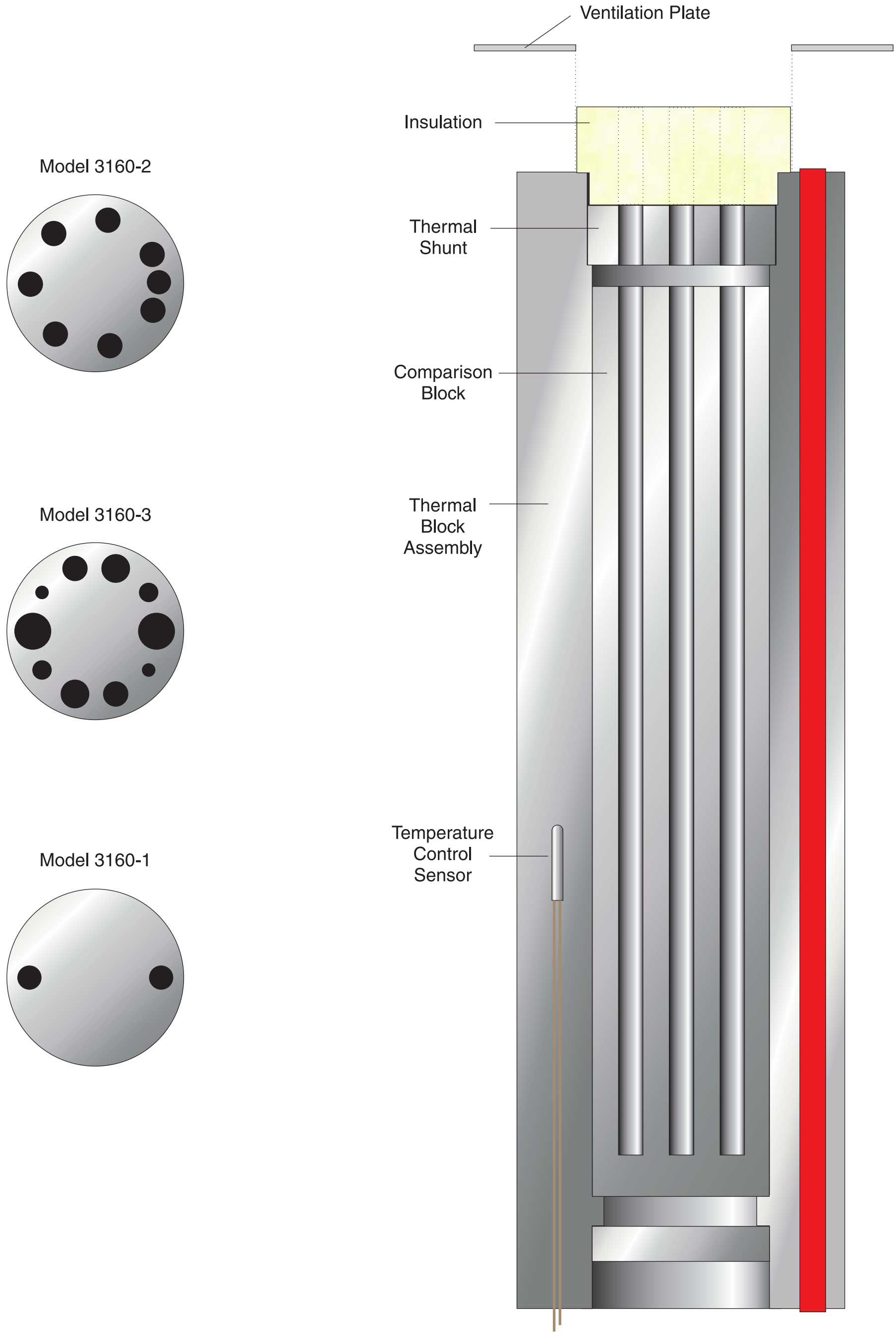

Figure 7 *Comparison Blocks*

The comparison block assembly is comprised of three components, the comparison block, the thermal shunt, and the top insulation.

4.7.2.1 Comparison Block

The comparison block is carefully lowered to the bottom of the thermal block well with the tongs provided. **DO NOT drop the block into the well. Damage to the furnace may result. Small changes to the furnace calibration may result as well.**

4.7.2.2 Thermal Shunt

Just above the comparison block is a ledge in the thermal block itself. The thermal shunt is lowered into the thermal well until it rests on this ledge. The insertion wells must match the comparison block. This block conducts heat from the thermal block of the furnace in order to reduce stem conduction along the thermometer. Heat loss from stem conduction will reduce the accuracy of the measurement.

4.7.2.3 Top Insulation

A fiber ceramic pad of insulation is provided with the comparison block. This insulation helps the thermal shunt by keeping it closer to the furnace temperature. After it is inserted, poke holes through it to match the comparison block.

5 Controller Operation

This section discusses in detail how to operate the furnace temperature controller using the front control panel. By using the front panel key-switches and LED display, the user may monitor the well temperature, adjust the set-point temperature in degrees C or F, monitor the heater output power, adjust the controller proportional band, and program the operating parameters, program parameters, serial interface configuration, and the controller calibration parameters. Operation of the functions and parameters is shown in the flowchart in Figure 8 on page 28. This chart may be copied for reference.

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

5.1 Well Temperature

The digital LED display on the front panel allows direct viewing of the actual well temperature. This temperature value 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 then the temperature display will alternately flash,

Cut-out	*Indicates cut-out condition*

The 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 will reset itself as soon as the temperature is lowered below the cut-out set-point. With 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”) then the display will flash “cut-out” until the user resets the cut-out. To access the reset cut-out function press the “SET” button.

SET	*Access cut-out reset function*

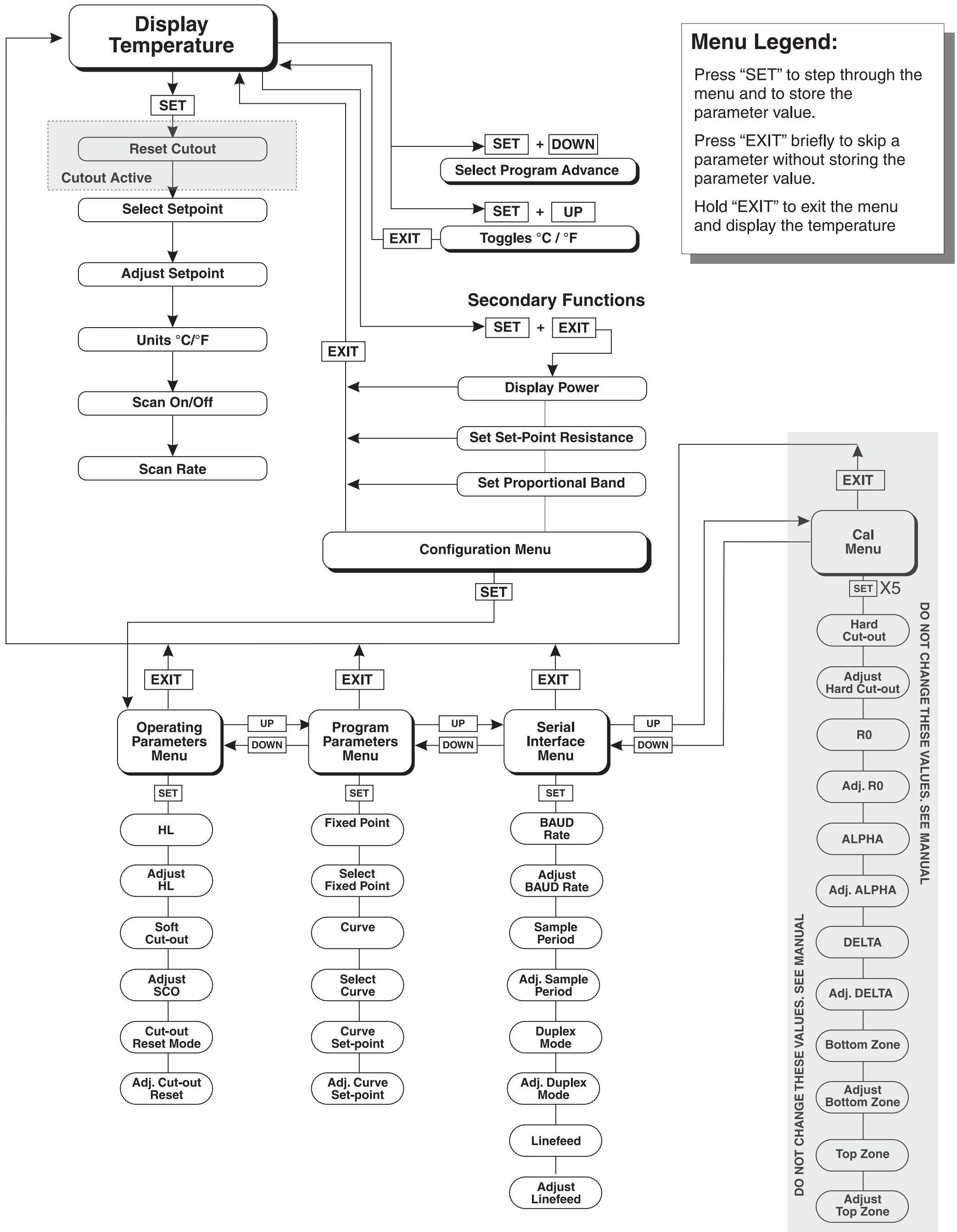

Figure 8 *Flow Chart*

The display will indicate the reset function.

rESEt ?	*Cut-out reset function*

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

SET	*Reset cut-out*

This will also switch 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 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 selecting one of the eight (8) set-points in memory and then adjusting the set-point value.

5.3.1 Programmable Set-points

The controller stores eight (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, 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.	*Set-point memory 1, 100.0°C currently used*

To change the set-point memory to another preset value press “UP” or “DOWN”.

4. 300.	*New set-point memory 4, 300.0°C*

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

SET	*Accept selected set-point memory*

NOTE: *Pressing "SET" at this point turns off the program mode if it is on.*

5.3.2 Set-point Value

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

4 200.	*Set-point value in °C*

If the set-point value is correct, hold "EXIT" to resume displaying the well temperature. Press "UP" or "DOWN" to adjust the set-point value.

220.00	*New set-point value*

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

SET	*Accept new set-point value*

5.4 Temperature Scale Units

The temperature scale units of the controller can be 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*

5.5 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.

5.5.1 Scan Control

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

`Sc=OFF` *Scan function off*

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

`Sc=On` *Scan function on*

Press “SET” to accept the present setting and continue.

[SET] *Accept scan setting*

5.5.2 Scan Rate

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

5.6 Program Advance

The program advance function allows the user to step through the maintain, freeze, and melt operations of the fixed-point realization. They are explained in detail in Section 8, 7 on Fixed-Point Realization.

[SET] + [DOWN] *Access program advance*

`AdV` *“Adv” flashes*

`MAINT` *Displays one of the functions MAINT, FREEZE, MELT, or STOP*

Press “UP” or “DOWN” to view the desired function.

[SET] *Accepts the new the operation*

5.7 Temperature Scale Units

To toggle between °C and °F, press the "SET" and "UP" keys simultaneously when the temperature is displayed.

5.8 Secondary Menu

Functions which are used less often are accessed within the secondary menu. Pressing "SET" and "EXIT" simultaneously and then releasing accesses the secondary menu. The first function in the secondary menu is the heater power display. (See Figure 8 on page 28.)

5.9 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. By knowing the amount of heating the user can tell if the instrument is heating up to the set-point, cooling down, or controlling at a constant temperature. Monitoring the percent heater power lets the user know the stability of the well temperature. 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	*Well temperature*
SET + EXIT	*Access heater power in secondary menu*
SEC	*Flashes*
12.0 P	*Heater power in percent*

To exit out of the secondary menu press "EXIT" and hold for a brief moment. To continue on to the proportional band setting function press "EXIT" momentarily or "SET".

5.10 Set-point Resistance

The set-point resistance is the resistance of the temperature sensor at the current temperature. Allow the temperature to stabilize at the desired set-point before taking its resistance. In order to calibrate the furnace temperature, the set-point resistance must be displayed.

Press “SET” and “EXIT” to enter the secondary menu and show the heater power. Then press “SET” twice to access the set-point resistance

SET + EXIT *Access heater power in secondary menu*

SEC *Flashes “SEC” and then displays the heater power setting*

12.0 P *Heater power in percent*

SET *Access set-point resistance*

rS *Flashes “rS” (Set-point Resistance) and then displays the setting*

160.095 *Resistance in ohms*

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

The proportional band width is set at the factory to about 5.0°C. The proportional band width may be altered by the user to optimize the control characteristics for a particular application.

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

SET + EXIT *Access heater power in secondary menu*

Display	
SEC	*Flashes "SEC" and then displays the heater power setting*
12.0 P	*Heater power in percent*

SET *Access set-point resistance*

Display	
r S	*Flashes "r S" (Set-point Resistance) and then displays the setting*
160.095	*Resistance in ohms*

SET

Display	
ProP	*Flashes "ProP" and then displays the setting*
5.0	*Proportional band setting*

To change the proportional band press "UP" and "DOWN".

Display	
4.0	*New proportional band setting*

To store the new setting press "SET". Press "EXIT" to continue without storing the new value.

SET *Accept the new proportional band setting*

5.12 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 proportional band function by pressing "SET". "ConFiG" flashes and then the name of the first parameter menu "PAR" is displayed.Pressing "SET" again enters the first of four groups of configuration parameters: operating parameters, program parameters, serial interface parameters, and calibration parameters. The groups are selected using the "UP" and "DOWN" keys and then pressing "SET". (See Figure 8 on page 28)

5.13 Operating Parameters

The operating parameters menu is indicated by,

Display	
PAr	*Operating parameters menu*

Press “SET” to enter the menu. The operating parameters menu contains the High Limit (HL) parameter, the Soft Cut-out parameter, and the Cut-out Reset mode parameter.

5.13.1 High Limit

The High Limit parameter adjusts the upper set-point temperature. The factory default and maximum are set to 680°C. For safety, a user can adjust the High Limit parameter down so the maximum temperature set-point is restricted.

Display	Description
HL	*Flashes “HL” (High Limit parameter) and then displays the setting*
H=680	*Current HL setting*

Adjust the HL parameter using “UP” or “DOWN”

Display	Description
H=600	*New High Limit setting*

Press “SET” to accept the new High Limit parameter and to access the Soft Cut-out parameter.

5.13.2 Soft Cut-out

The next parameter in this menu is the Soft Cut-out. The Soft Cut-out parameter is used by the controller to shut down the unit during over-temperature conditions. If the temperature of the unit is ever greater than the Soft Cut-out temperature the controller shuts itself down and displays, alternately, “SCtOut” and "Err 8".

Display	Description
SoFtCo	*Flashes “SoFtCo” (Soft Cut-out parameter) and then displays the setting*
705	*Current value*

Adjust this parameter by using “UP” or “DOWN”.

Display	Description
700	*New Soft Cut-out setting*

Press “SET” to accept the new parameter and to access the Cut-out Reset Mode.

5.13.3 Cut-out Reset Mode

The final parameter in this menu is the 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 must be manually reset by the operator.

CtorSt	*Flashes "CtorSt" (Cut-out reset mode parameter) and then displays the setting*
Auto	*Current setting*

To change to manual reset mode press "UP" or "DOWN".

rSt	*New Cut-out reset for manual reset*

Press "SET" to accept the new parameter.

5.14 Program Parameters

The program parameters menu is indicated by,

ProG	*Program parameters menu*

Press "SET" to enter the menu. The Program parameters menu contains the fixed-point parameter, the curve parameter, and the curve temperature parameter.

5.14.1 Fixed-point

The first parameter in this menu is the Fixed-point parameter.The Fixed-point parameter allows the user to select the fixed-point metal. The available options are In (Induim), Sn (Tin), Zn (Zinc), Al (Aluminum), or Other.

FP	*Flashes "FP" (Fixed-point parameter) and then displays the setting*
In	*Current Fixed-point setting (Indium)*

Adjust the Fixed-point parameter by using "UP" or "DOWN".

Zn	*New Fixed-point setting (Zinc)*

Press "SET" to accept the new Fixed-point parameter and to access the Curve parameter.

5.14.2 Curve

The next parameter in this menu is the Curve parameter. The Curve parameter is selected as either melting or freezing.

CurVE	*Flashes "CurVE" (Curve parameter) and then displays the setting*

MELt	*Current Curve setting*

Adjust this parameter by using “UP” or “DOWN”.

FrEEZE	*New Curve setting*

Press “SET” to accept the new Curve parameter and to access the Curve Temperature parameter.

5.14.3 Curve Temperature

The final set of three parameters in this menu are the Curve Temperature parameters. These parameters set the temperature of the curve set-points.

TEMP	*Flashes “TEMP” (Curve Temperature parameter) and then displays the melt parameter*
MELt	*Flashes “MELt” and then displays the value*
100.00	*Current melt temperature setting*

Adjust this parameter by using “UP” or “DOWN”. Press “SET” to accept the new value and to display the freeze parameter.

SET

FREEZE	*Flashes “FREEZE” and then displays the value*
25.00	*Current freeze temperature setting*

Adjust this set-point by using “UP” or “DOWN”. Press “SET” to accept the new value and to display the maintain parameter

SET

MAint	*Flashes “MAint” and then displays the value*
148.59	*Current maintain temperature setting.*

Adjust this set-point by using “UP” or “DOWN”.

Press “SET” to accept the new value.

5.15 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 which determine the operation of the serial interface. These controls only apply to instruments fitted with the serial interface. The parameters in the menu are: BAUD rate, sample period, duplex mode, and linefeed.

5.15.1 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 of the serial communications may be programmed to 300, 600, 1200, 2400, 4800, or 9600 baud. 2400 baud is the default setting.

bAUd	*Flashes "bAUd" (Serial baud rate parameter) and then displays the setting*
2400 b	*Current baud rate*

Adjust the baud rate by using "UP" or "DOWN".

4800 b	*New baud rate*

Press "SET" to store the baud rate to the new value and to access the Sample Period.

5.15.2 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.

SPEr	*Flashes "SPEr" (Serial sample period parameter) and then displays the setting*
SP=1	*Current sample period (seconds)*

Adjust the value with "UP" or "DOWN".

SP=60	*New sample period*

Press “SET” to store the sample period to the new value and to access the Duplex Mode.

5.15.3 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 instrument 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.

dUPL	*Flashes “dUPL” (Serial duplex mode parameter) and then displays the setting*
d=FULL	*Current duplex mode setting*

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

d=HALF	*New duplex mode setting*

Press “SET” to store the duplex mode to the new value and to access the the Linefeed.

5.15.4 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.

LF	*Flashes “LF” (Serial linefeed parameter) and then displays the setting*
LF=On	*Current linefeed setting*

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

LF=OFF	*New linefeed setting*

Press “SET” to store the new linefeed value.

5.16 Calibration Parameters

The operator of the instrument has access to a number of the calibration constants namely R0, ALPHA, DELTA, top and bottom zone percent heat, and the hard cut-out. These values are set at the factory and must not be altered. The correct values are important to the accuracy and proper and safe operation of the furnace. Access to these parameters is available to the user only so that in the event that the controller 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 manual.

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

The calibration parameters menu is indicated by,

CAL	*Calibration parameters menu*

Press "SET" five times to enter the menu.

The calibration parameters R0, ALPHA, and DELTA characterize the resistance-temperature relationship of the platinum control sensor. These parameters may be adjusted by an experienced user to improve the accuracy of the furnace.

CAUTION: *Care should be exercised when adjusting these parameters since they affect the accuracy of the set-point value. This procedure is explained in detail in Section 8.*

5.16.1 Hard Cut-out

This parameter is the temperature above which the unit shuts down automatically. The parameter is set at the factory to approximately 700°C and cannot be changed by the user.

5.16.2 R_0

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.

5.16.3 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.

5.16.4 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. should have a list of these constants and their settings with manual.

5.16.5 Top and Bottom Zone Percent Heating

The top and bottom zone heaters of the furnace start heating each time the main zone heater turns on. These end zone heaters are adjusted to a percentage of on time compared to the main zone. Each zone is pre-adjusted according to a calibration procedure that provides a low vertical temperature gradient in the thermal block.

5.16.5.1 Bottom Zone

botPCt is the percentage of the main heater value for the bottom zone. Do not adjust this value unless you are following the procedure in Section 8 Calibration Procedure, of this manual. Adjustment values range from 0 to 200 percent.

5.16.5.2 Top Zone

toPPCt is the percentage of the main heater value for the top zone. Do not adjust this value unless you are following the procedure in Section 8 Calibration Procedure, of this manual. Adjustment values range from 0 to 200 percent.

6 Digital Communication Interface

The furnace is capable of communicating with and being controlled by other equipment through the digital serial 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. Communications commands are summarized in Table 4 on page 46.

6.1 Serial Communications

The instrument is installed with an RS-232 serial interface that allows serial digital communications over fairly long distances. With the serial interface the user may access any of the functions, parameters and settings discussed in Section 5 with the exception of the BAUD rate setting.

6.1.1 Wiring

The serial communications cable attaches to the instrument through the DB-9 connector at the back of the instrument. Figure 9 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. If the unit is used in a heavy industrial setting, the serial cable must be limited to ONE METER in length.

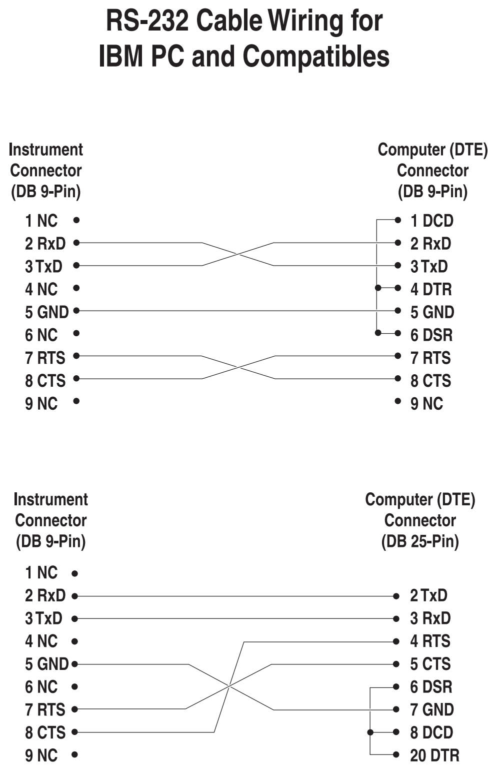

Figure 9 *Serial Cable Wiring*

6.1.2 Setup

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

To enter the serial parameter programming mode first press "EXIT" while pressing "SET" and release to enter the secondary menu. Press "SET" repeatedly until the display reads "PAr". Press "UP" until the serial interface menu is indicated with "SErIAL". Finally press "SET" to enter the serial parameter menu. In the serial interface parameters menu are the BAUD rate, the sample rate, the duplex mode, and the linefeed parameter.

6.1.2.1 Baud Rate

The baud rate is the first parameter in the menu. The display will prompt with the baud rate parameter by showing "bAUd". Press "SET" to choose to set the baud rate. The current baud rate value will then be displayed. The baud rate of the 9260 serial communications may be programmed to 300, 600, 1200, 2400, 4800, or 9600 baud. The baud rate is pre-programmed to 2400 baud. Use "UP" or "DOWN" to change the baud rate value. Press "SET" to set the baud rate to the new value or "EXIT" to abort the operation and skip to the next parameter in the menu.

6.1.2.2 Sample Period

The sample period is the next parameter in the menu and prompted with "SPEr". 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. 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 instrument 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 6.2. All commands are ASCII character strings terminated with a carriage-return character (CR, ASCII 13).

6.2 Interface Commands

The various commands for accessing the instrument functions via the digital interface are listed in this section (see Table 4). These commands are used with the RS-232 serial interface. The commands are terminated with a carriage-return character. The interface makes no distinction between upper and lower case letters, hence either may be used. Commands may be abbreviated to the minimum number of letters 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" <cr> will return the current set-point and "s=150.0" will set the set-point to 150.0 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 will simply be ignored. Backspace (BS, ASCII 8) may be used to erase the previous character. A terminating CR is implied with all commands.

Table 4 *Communications Command Summary*

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Display Temperature					
Read units	u	u	u:{C or F}	u: C	
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 temperature	t	t	t: 9999.99{C or F}	t: 478.03 C	
Set temperature units:	**u[nits]=c/f**				C or F
Set temperature units to Celsius	u[nits]=c	u=c			
Set temperature units to Fahrenheit	u[nits]=f	u=f			
Read scan function	sc[an]	sc	scan: {ON or OFF}	scan: ON	
Set scan function:	**sc[an]=on/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 99.9
Read program control	pc	pc	pc:{[STOP/FREEZE/ME[LT]/MA[INTAIN]}	pc:FREEZE	
Set program control	pc={stop/freeze/me[lt]/ma[intain]}	pc=melt			STOP, FREEZE, MELT or MAINTAIN
Secondary Menu					
Read heater power (duty cycle)	po[wer]	po	po: 999.9	po: 1	
Read proportional band setting	pr[op-band]	pr	pb: 999.9	pb: 15.9	
Set proportional band to *n*	pr[op-band]=n	pr=8.83			0.1 to 100
Read set-point resistance	*sr	*sr	999.999	121.091	
Configuration Menu					
Operating Parameters Menu					
Read high limit	hl	hl	hl: 9999	hl: 925	
Set high limit	hl=n	hl=900			100–1200
Read soft cut-out	cu	cu	cu: 9999.9	cu: 1150	
Set soft cut-out setting:	**cu[tout]=n**				
Set soft cut-out to *n* degrees	cu[tout]=n	cu=500			0.0 to 1150.0
Read cut-out mode	cm[ode]	cm	cm:{xxxx}	cm: AUTO	
Set cut-out mode	cm[ode]=r[eset]/a[uto]				Reset or Auto
Set cut-out to be reset manually	cm[ode]=r[eset]	cm=r			
Set cut-out to be reset automatically	cm[ode]=a[uto]	cm=a			
Program Parameters Menu					
Read fixed-point parameter	fp	fp	fp:{INDIUM, TIN, ZINC,ALUMINUM}	fp:INDIUM	

Communications Command Summary cont.

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Set fixed-point parameter	fp=[INDIUM/TIN/ZINC/ ALUMINUM]	fp=In			INDIUM, TIN, ZINC, ALUMINUM
Read curve parameter	crv	crv	crv:{MELT or FREEZE}	crv:MELT	
Set curve parameter	crv={melt/freeze}	crv=melt			MELT or FREEZE
Read curve temperatures	ps*n*	ps3	ps*n*: 999.99{C or F}	ps1: 480.00 C	
Set curve temperatures	ps*n*=*n*	ps3=100			1 to 3, dependent on program control
Serial Interface Menu					
Read serial sample setting	sa[mple]	sa	sa: 9	sa: 1	
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			
Cal Menu					
Read R_0 calibration parameter	r[0]	r	r0: 999.999	r0: 100.7	
Set R_0 calibration parameter to *n*	r[0]=*n*	r=100.7			98.0 to 104.9
Read Alpha calibration parameter	al[pha]	al	al: 9.999999	al: 0.003865	
Set Alpha calibration parameter to *n*	al[pha]=*n*	al=0.003865			.002 to .006
Read Delta calibration parameter	de[lta]	de	de: 9.99	de: 1.50	
Set Delta calibration parameter	de[lta]=*n*	de=1.37			0 to 3
Read top zone % heating	tpct	tpct	tpct: 999.9	tpct: 200.0	
Set top zone % heating	tpct=*n*	tpct=100			0 to 200
Read bottom zone % heating	bpct	bpct	bpct: 999.9	bpct: 150.0	
Set bottom zone % heating	bpct=*n*	bpct=150.0			0 to 200
These commands are only used for factory testing.					
Miscellaneous (not on menus)					
Read firmware version number	*ver[sion]	*ver	ver.9999,9.99	ver.9260,v1.1	
Read structure of all commands	h[elp]	h	list of commands		
Legend:	[] Optional Command data				
	{} Returns either information				
	n Numeric data supplied by user				
	9 Numeric data returned to user				
	x Character data returned to user				
Note:	When DUPLEX is set to FULL and a command is sent to READ, the command is returned followed by a carriage return and linefeed. Then the value is returned as indicated in the RETURNED column.				

7 Fixed-Point Realization

7.1 General

Either a freezing or melting plateau may be realized. The melting point is faster and easier than the freezing point method and the plateau can last longer. Properly done, accuracy of measurements is nearly the same.

Realizing the fixed-point temperature is a matter of achieving the ITS-90 defined temperature through a careful process. The Hart Scientific Model 9260 furnace features an internally programmed method or a manual method to perform this process.

The internal programming procedure requires the user to:

1. Select the point (Indium, Tin, Zinc, Aluminum or a user programmed point) to be realized.
2. Select either the freezing curve or melting curve mode.
3. The controller then provides pre-programmed scan rates, set-points for each step in the process, dwell times, and an indication that the next step is ready. Some of these pre-programmed conditions can be modified by the user.

Temperature calibration should be checked occasionally to verify the set-point temperatures.

7.2 Installing a Sealed Cell into the Basket

The sealed cell is a very delicate instrument. The quartz glass on the outside of the cell can be easily broken and easily scratched by the harder metal materials into which it is inserted.

CAUTION: *Sealed cells are designed to be kept upright. They should be stored in this position as well. Before inserting the cell be sure it is clean and free of finger oils. Use pure or reagent grade alcohol to clean all pieces. Quartz glass will devitrify breaking down the glass and eventually causing breakage or air leakage to the cell. Clean the basket surfaces as well. Use cotton gloves to handle the basket and cell after cleaning.*

Each cell should have its own basket assembly. Repeated insertion and removal poses an unnecessary risk to the cell. A cell-pad of fiber ceramic fiber or quartz wool should be in the bottom of the basket to pad the cell. This cell-pad should not be too thick so as to prevent proper fitting of the basket cover.

Follow these steps to properly insert the sealed cell. Refer to Figure 5 for location of component detail.

1. Install the cell-pad into the bottom of the basket. Typically a 1/4" (6.35 mm) thick pad is used. It will crush to a thinner dimension as the cell is installed. It ***SHOULD NOT*** be so thick that the basket cover touches the cell at the top. If the pad contains an organic binder, heat the pad to remove it before use.
2. Cut a strip of clean paper approximately 1-inch wide and 1-inch longer than the basket.
3. Insert this paper into the bottom of the basket while it is lying down. At least 1-inch of the paper should be extending out of the basket for easy removal.
4. Temporarily hold the sealed cell sideways with the spherical end toward the basket opening.
5. Carefully insert the cell into the basket sliding it on the paper instead of on the metal basket. When the cell reaches the bottom, return the basket carefully to the upright position.
6. Remove the paper completely.
7. Install a thin insulating pad on top of the cell providing a clearance hole for the thermometer.
8. Check the basket cover fit to ensure that the evacuation port on the top of the cell does not prevent it from fitting flush against the top of the basket.
9. Remove the lid for now.
10. Using the tool provided, carefully lower the basket into the thermal well.
11. Install the basket lid on top of the basket being sure that it is flush against the basket.
12. Install a thin insulation pad on top of the lid with a clearance hole for the thermometer.
13. Install the thermal shunt over the top of the basket fitting it onto the ledge above.
14. Check the alignment.
15. Fit the top insulation above the shunt.
16. Carefully check the thermometer fit all the way to the bottom of the cell. There must not be any significant resistance to insertion.
17. Place a small pad of quartz wool at the bottom of the reentrant well of the cell which will, to some extent, pad the bottom of the well against the thermometers when they are inserted.

CAUTION: *Careless insertion of a thermometer into the well can break the quartz glass at the bottom or even break quartz thermometers.*

CAUTION: *Occasionally remove the thermal shunt and the basket. If there is any resistance to removal, remove oxides with fine grit sandpaper. This is generally only a problem at the aluminum point.*

7.3 Melting Point Realization

Recent improvements of the melting point method have shown that excellent accuracy can also be achieved with this method. With this method, the cell temperature is carefully raised to a temperature just below the melting point. The furnace and cell are allowed to dwell at this temperature for a time to allow temperature equalization throughout the system. The furnace is then raised to a point a few degrees above the melting point for a short time to give melting a good start. The temperature is then dropped to a temperature just above the melting point for the duration of the measuring period. A "melt heater" inside the reentrant well is turned on for a short time creating a second zone of melted sample which is next to the thermometer during measurements. This action permits more accurate measurements and is similar to the technique used with a Triple-point of Water cell.

Measurements are made until the plateau begins to deviate and then the melting must be completed and the process started over.

7.3.1 Melting Point Procedure

The following procedure illustrates the steps required to successfully realize a fixed-point temperature through melting the cell sample. Figure 10 illustrates the process graphically.

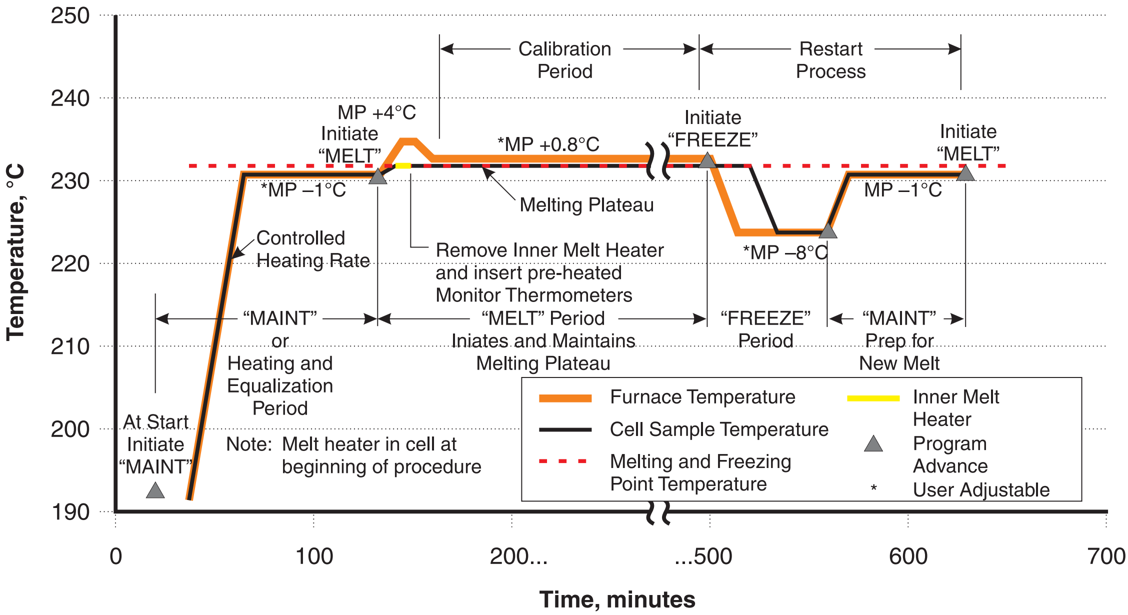

Figure 10 *Melting Point Realization*

7.3.1.1 Preparation

The cell should be carefully loaded into the basket and then into the furnace according to the procedure outlined in Section 8.2, 7.2. Thermometers that are to be inserted into the cell should first be cleaned with pure alcohol. The inner-melt heater should be inserted carefully into the cell.

7.3.1.2 Setting Up The Controller

Setup of the controller consists of selecting the fixed-point and the curve to be used. The setup is in the secondary menu of the controller menus. Access the setup by pressing "SET" and "EXIT". Then press "SET" 4 times and "UP" until "ProC" is displayed. Press "SET". "FP" (fixed-point) flashes and then the current setting is displayed. This setting is the one used on the previous test. Press "UP" or "DOWN" repeatedly to toggle through Indium, Tin, Zinc, Aluminum and Other. When you reach the desired fixed-point press "SET" to select it. Immediately after pressing "SET", "CURVE" flashes and the current setting appears. The available curves are melt and freeze. Use the "UP" or "DOWN" key to select the "MELT" curve. Press "SET" to select it. Following the curve selection, the term "TEMP" flashes on the display followed by adjustments that can be made by the user to the MELT, FREEZE, and MAINTAIN temperatures. ***These adjustments are only for experienced users.*** Press

"EXIT" to exit the program menu and to return to the display temperature. Carefully insert the melt heater into the cell (see Figure 3). Set the heater switch on the rear of the furnace to AUTO. The heater must be clean and carefully inserted into the cell to prevent damage. This should be done before program initiation.

7.3.1.3 Program Initiation

Now that the fixed-point and the melt curve have been selected, the furnace is ready to initiate the program. Advance to the program from the display temperature by pressing "SET" and "DOWN". The term "StOP" appears unless the program is running. The following three steps include "MELt", "MAInt" and "FrEEZE". The step that first appears will be the last step utilized and not necessarily the first step desired. Press the "UP" or "DOWN" keys to view the first step needed which is "MAInt" for the preliminary heating of the cell to just below the melting point. The cell is held at that temperature for a period of time to allow everything to equilibrate to that temperature. Press "SET" to select it. The controller immediately starts heating the cell with its metal sample. The furnace heats at a preprogrammed rate that automatically slows down before the sample reaches the "MAINT" point. Once the furnace has reached that temperature (about 1°C below the melting point), it dwells there for 60 minutes to permit the furnace and metal sample to equilibrate. After the 60 minute period, the display flashes on and off alternately indicating that the cell is now ready to initiate the melt function.

To initiate the melting of the sample, press "SET" and "DOWN" again. Press the "UP" or "DOWN" keys until the term "MELt" is on the display. Press "SET" to select that step and the controller selects a set-point temperature a few degrees above the melting point to begin the sample melting process. The temperature of the furnace slowly scans to about 4°C above the melting point and dwells there for about 8 minutes. At that time the melt heater turns on automatically. This heater melts a thin layer of the sample next to the measurement thermometer increasing the accuracy of this technique. After a few minutes the melt heater automatically turns off and the furnace temperature drops to a temperature just above the melting point of the sample. Remove the melt heater and insert a pre-heated monitor thermometer. When the temperature has stabilized, calibrations may begin. Use the pre-heat wells to heat up the thermometers before inserting them into the cell. This action preserves the latent energy and permits more calibrations during the melting plateau. Allow the thermometers to equilibrate for 20 minutes before making readings. The plateau can last several days depending on how it is used.

When the plateau has ended, the furnace may be turned to about 25°C and turned off or, if desired, the process may be repeated. To repeat the process, press "SET" and "DOWN" and use the "UP" or "DOWN" keys to find the "FrEEZE" step. Select by pressing "SET". The furnace temperature will drop to a temperature 8°C below the freezing point and dwell there as before. The sample will freeze and the temperature will automatically rise to a temperature just below the melting point. The furnace will hold there for a time until the cell and furnace have fully equilibrated. At that time, the display will flash indicating that the cell is ready to begin the melting process again. It is initiated as before by selecting "MELt" step.

7.4 Freezing Point Realization

The freezing point is an established ITS-90 method. This method first entirely melts the metal sample. The furnace temperature is then carefully reduced to a temperature below the freezing point just low enough to induce freezing of the sample. This temperature must be several degrees below the freezing point in order to overcome the sub-cooling of the sample. After recalescense, (initiation of the freeze as observed on a monitor thermometer) the furnace temperature is increased to a temperature just slightly below the freezing point. This action restricts the amount of heat that can flow from the cell, which controls the rate of freezing. High temperature stability and good temperature uniformity permit the temperature to be adjusted closely achieving long freezing plateaus. Long freezing plateaus translate into a larger number of calibrations that can be done during one freeze.

Measurements are made until the plateau begins to deviate and then the freezing must be completed and the process started over.

7.4.1 Freezing Point Procedure

The following procedure illustrates the steps required to successfully realize a fixed-point temperature through freezing the cell sample. Figure 11 illustrates the process graphically.

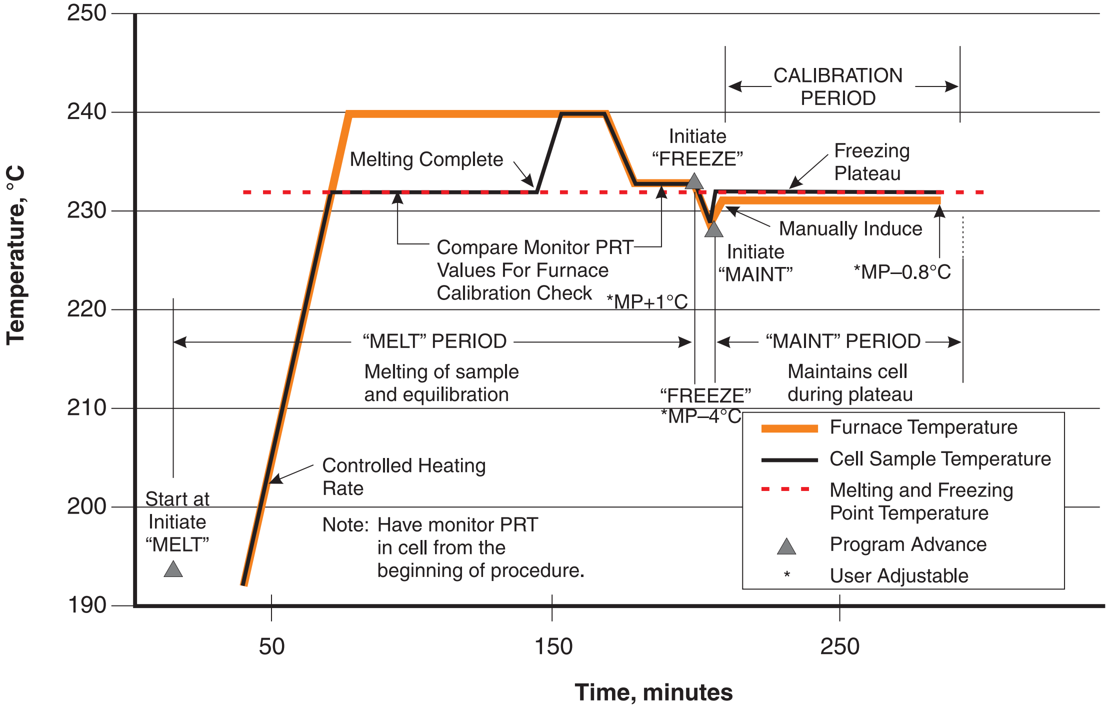

Figure 11 *Freezing Point Realization*

7.4.1.1 Preparation

The cell should be carefully loaded into the basket and then into the furnace according to the procedure previously outlined in Section 8.2, 7.2. Thermometers that are to be inserted into the cell should first be cleaned with pure alcohol. A monitor thermometer should be inserted into the cell to monitor the process from the beginning.

7.4.1.2 Setting Up The Controller

Setup of the controller consists of selecting the mode and fixed-point to be used. The setup is in the secondary menu of the controller menus. Access the program parameters by pressing “SET” and “EXIT” simultaneously. Then press “SET” 4 times and “UP” until the program menu is reached. The word “ProG” is displayed. Press “SET”. “FP” (fixed-point) flashes and then the current setting is displayed. (The metal sample displayed is from the previous test.) Press “UP” or “DOWN” repeatedly to toggle through Indium, Tin, Zinc, Aluminum and Other. When you reach the desired fixed-point press “SET” to select the metal sample to use. Immediately after pressing “SET”, “CURVE” flashes and the current setting "MELt" or "FrEEZE" appears. The terms indicate the first of the two curves, melt or freeze. Use the "UP" or "DOWN" key to view the desired curve, "FrEEZE". Press "SET" to select this curve. Press "EXIT" to exit the program menu and to return to the display temperature.

7.4.1.3 Program Initiation

Now that the fixed-point and the freeze curve have been selected, the furnace is ready to initiate the program. Advance to the program from the display temperature by pressing "SET" and "DOWN". One of three steps of the selected program curve or "StOP" is displayed. The three steps include "MELt", "MAInt" and "FrEEZE". The step that first appears will be the last step utilized and not necessarily the first step desired. Press the "UP" or "DOWN" keys to view the first step needed which is "MELt" for the freezing process. Press "SET" to select it.

***NOTE:** Select stop to turn off the program function. Manually adjusting the set-point also stops the program.*

The controller immediately starts heating the cell. The furnace heats at a pre-programmed rate that automatically slows down before the sample reaches the melting point. Once the furnace has reached the melting temperature (about 8°C above the melting point), it dwells there for 90 minutes to permit the metal sample to melt. The furnace then ramps down automatically to a temperature just above the melting point. The controller holds at that temperature for approximately 20 minutes while everything equilibrates after which the display flashes on and off alternately indicating that the cell is now ready to initiate the freeze. Note: The monitor thermometer temperature can be checked while the sample is melting providing a good check of its accuracy. The control temperature can then be accurately checked during this dwell period.

To initiate the freezing of the metal, press "SET" and "DOWN" again. Press the up and down keys until the term "FrEEZE" is on the display. Press "SET" to select that mode and the controller selects a set-point temperature a few degrees below the freezing point to begin the sample freezing process. This lower temperature is to overcome the super-cooling of the metal sample. The cell temperature must be monitored with the monitor thermometer at this time in order to see when the cell starts to freeze. The freeze is established when the cell temperature begins a sharp rise toward the freezing point (recalesence). Immediately insert a quartz glass rod that is at room temperature for approximately 2 minutes to create a thin layer of frozen metal. This action positions the change of phase right next to the thermometer which is necessary for high accuracy. After removing the tube, press "SET" and "DOWN" again and select "MAInt" to maintain the furnace at a temperature just below the freezing temperature.

With the freeze plateau underway, calibrations can now be made. Use the pre-heat wells to heat up the thermometers before inserting them into the cell preserving the latent energy and permitting more calibrations during the freeze. Allow the thermometers to equilibrate for 20 minutes before making readings.

Calibration must end before the end of the freezing plateau. To continue use, re-melt the sample. Press “SET” and “DOWN”. Select the “MELt” function and the controller will re-melt the sample and the process may be repeated. This function is convenient if the furnace is to be used again early the next day. The sample can be melted overnight and be ready to freeze in the morning.

CAUTIONS: *Use care in handling the metal fixed-point cells. They can be easily broken or contaminated. Keep all items clean. Clean with pure alcohol. Handle with clean cotton gloves or clean paper. Remove any inadvertent finger prints or other contaminants.*

DO NOT *drop the cell or basket into the furnace. Do not drop a thermometer into the cell even a short distance.*

DO NOT *leave quartz thermometers in the preheat wells any longer than necessary to heat to temperature, especially at the aluminum point. Contamination may result.*

DO NOT *insert cells into a hot furnace. Start from near ambient temperatures.*

When all calibrations are complete, manually set the temperature to about 25°C to prevent the furnace from heating unexpectedly the next time it is used. The furnace can be turned off while hot and permitted to cool on its own.

7.5 Test Probe Calibration

For optimum accuracy and stability, allow the furnace to warm up for 10 minutes after power-up and then allow adequate stabilization time after reaching the set-point temperature. After completing operation of the furnace, allow the well to cool by setting the temperature to 25°C and allowing the unit to cool off before switching the power off.

7.5.1 Calibrating a Single Probe

Insert the probe to be calibrated into the well of the instrument. The probe should fit snugly into the comparison block yet should not be so tight that it cannot be easily removed. Avoid any dirt or grit that may cause the probe to jam into the comparison block. Best results are obtained with the probe inserted to the full depth of the well. Once the probe is inserted into the well, allow adequate stabilization time to allow the test probe temperature to settle as described above. Once the probe has settled to the temperature of the well, it may be compared to the furnace display temperature. The display temperature should be stable to within 0.01°C degree for best results.

Never introduce any foreign material into the probe hole of the insert. Fluids etc. can leak into the furnace causing damage to the instrument or binding and damage to your probe.

7.5.2 Furnace Characteristics

There is a temperature gradient vertically in the test well. Heat is applied to the block in such a way as to compensate for nominal heat losses out of the top of the furnace. However, actual heat losses will vary with the design of the thermometer probes inserted into the instrument and the temperature. For best results, insert the probe to the full depth of the well.

***CAUTION: DO NOT** heat the thermometer hub or handle above the rated temperature.*

7.5.2.1 Stabilization and Accuracy

The stabilization time of the instrument depends on the conditions and temperatures involved. Typically the test well will be stable to 0.1°C within 10 minutes of reaching the set-point temperature as indicated by the display. Ultimate stability will be achieved 15 to 20 minutes after reaching the set temperature. Inserting a cold probe into the well requires another period of stabilization depending on the magnitude of the disturbance and the required accuracy. For example, inserting a 0.25 inch diameter room temperature probe into a comparison block at 300°C takes 5 minutes to be within 0.1°C of its settled point and takes 10 minutes to achieve maximum stability.

Speeding up the calibration process can be accomplished by knowing how soon to make the measurement. Test measurements should be made at the desired temperatures with the desired test probes to establish these times.

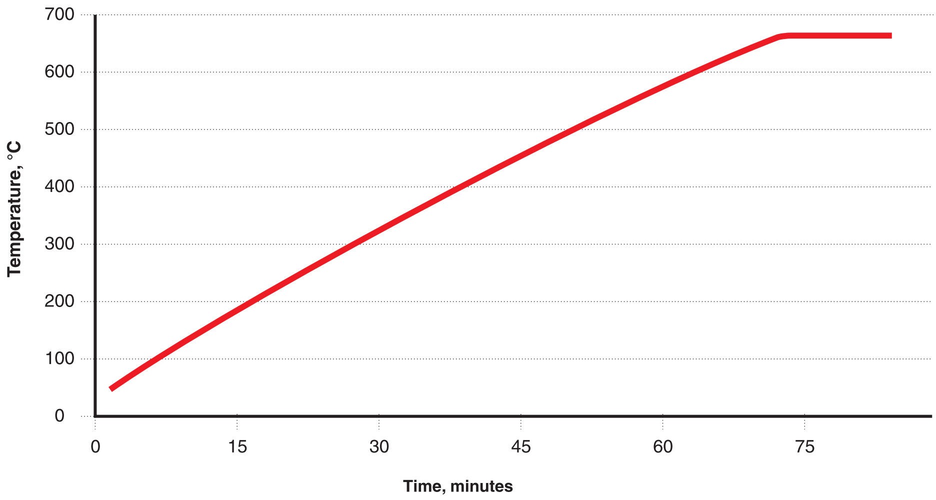

Figure 12 *9260 Comparison Block Heating Up*

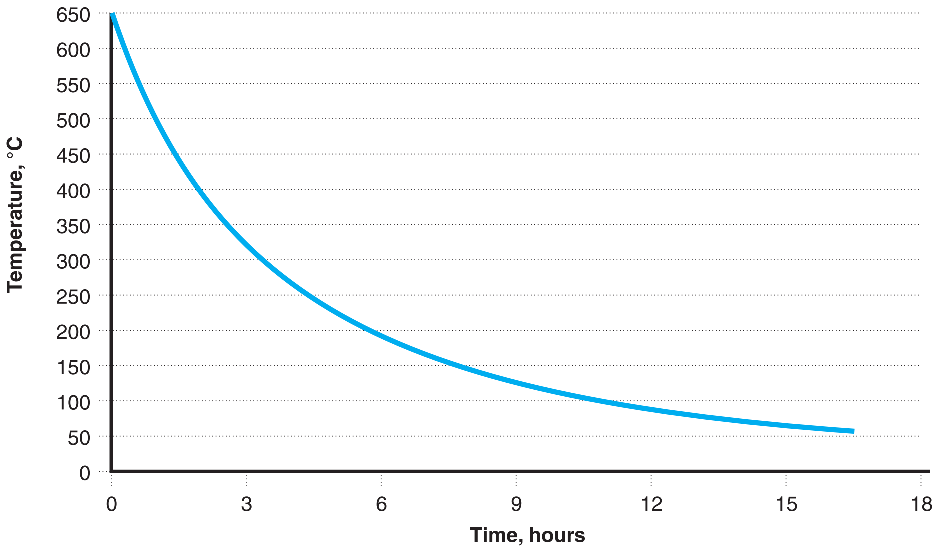

Figure 13 *9260 Comparison Block Cool Down*

8 Furnace Calibration

For optimum performance in realizing melting or freezing points of fixed-point cells, calibration of the 9260 must be maintained. Excessive temperature gradients and inaccurate furnace temperatures can make it difficult to realize melting or freezing points, reduce the length of the melting or freezing plateau, and even possibly damage a fixed-point cell. For best results the vertical temperature uniformity should be kept within 0.2°C over the lower 12 cm (5 in.) and the temperature accuracy should be kept within 0.5°C. The temperature profile and accuracy should be checked often and adjusted as necessary. While the furnace is new consider checking these at least once a month. The following sections explain the temperature profile and temperature accuracy calibration procedures.

8.1 Temperature Profile Adjustment

The 9260 Furnace is adjusted at the factory for a flat vertical temperature profile. The temperature profile should be regularly checked and adjusted as necessary to maintain it within about 0.2°C over the bottom 12 cm (5 in.) with a slightly higher temperature toward the top. The following steps explain how to test and adjust the temperature profile. The temperature accuracy should subsequently be calibrated according to Section 8.2 below whenever the zones are adjusted.

8.1.1 Step 1: Measure the profile

The temperature profile should be measured at 660°C or at the highest fixed point with which the furnace is intended to be operated. The furnace should have the fixed-point cell installed and the cell should be completely frozen or melted. Incorrect data will result if the cell is only partially melted or frozen. Use a quartz SPRT and thermometer readout that together provide adequate resolution and stability to allow relative temperature measurements to 0.02°C or better. You must wait until the temperature of the SPRT is stable before recording readings. It may take 20 to 30 minutes after inserting the SPRT before it becomes stable. Measure the temperature at three locations: t1 with the SPRT fully inserted into the well, t2 with the SPRT withdrawn 6 cm (2.5 in.), and t3 with the SPRT withdrawn 12 cm (5 in.). To reduce possible effects of temperature drift repeat the measurements in the following order: t1, t2, t3, t2 again, then t1 again. Wait until the SPRT is stable (about two minutes) before recording each reading. Average the two t1 measurements and the two t2 measurements then compare the temperatures. Temperature t2 relative to t1 should be less than 0.1°C higher or lower. Temperature t3 relative to t1 should be between 0 and 0.2°C higher. If the gradient exceeds these limits adjust the end zones as explained in the next step.

8.1.2 Step 2: Adjust the end zones

The temperature profile can be adjusted by altering the calibration parameters "toPPCt" and "botPCt" in the controller (see Section 5.16.5). Increasing or decreasing the top zone heat by 1% typically increases or decreases t3 relative to t_1 by about 0.1°C at 660°C and increases or decreases t_2 relative to t_1 by about 0.03°C. Likewise, increasing or decreasing the bottom zone heat by 1% typically increases or decreases temperature t_1 relative to t_3 by about 0.1°C at 660°C and increases or decreases temperature t_2 relative to t_3 by about 0.03°C. From these relationships, the following formulas are derived and these can be used to determine new settings for the top and bottom zones to produce a flat gradient with the top only 0.1°C hotter than the bottom.

$$topPct' = topPct + \left(25\frac{\%}{°C}\right)(t_2 - t_1) - \left(17.5\frac{\%}{°C}\right)(t_3 - t_1) + 1.75\%$$

$$botPct' = botPct + \left(25\frac{\%}{°C}\right)(t_2 - t_1) - \left(7.5\frac{\%}{°C}\right)(t_3 - t_1) + 0.75\%$$

For example, t_1 is measured in Step 1 to be 657.71, t_2 is measured to be 657.83, and t_3 is measured to be 658.41. The bottom zone is set at 94% and the top zone is set at 91%. The new settings are calculated as follows.

$$topPct' = 91\% + \left(25\frac{\%}{°C}\right)(657.83°C - 657.71°C) - \left(17.5\frac{\%}{°C}\right)(658.41°C - 657.71°C) + 1.75\% = 84\%$$

$$botPct' = 94\% + \left(25\frac{\%}{°C}\right)(657.83°C - 657.71°C) - \left(7.5\frac{\%}{°C}\right)(658.41°C - 657.71°C) + 0.75\% = 93\%$$

8.1.3 Repeat Step 1 and Step 2 if necessary

After adjusting the end zones repeat Step 1 to check the temperature profile again. If the temperature differences still exceed the recommended limits repeat Step 2 again.

8.2 Temperature Calibration

For best results in realizing freezing or melting points the furnace should be accurate to at least 0.5°C and preferably to 0.3°C. The accuracy should be checked periodically and adjusted if necessary. For small adjustments at one temperature the simplified one-point calibration procedure explained in Section 8.2.1 may be used. For calibration over the entire range of the furnace the three-point calibration procedure explained in Section 8.2.2 should be used. For each procedure a quartz SPRT is needed in a addition to a thermometer readout that together provide an accuracy of 0.1°C or better.

8.2.1 One-point Calibration

This one-point calibration procedure improves the temperature accuracy of the furnace at one point by adjusting the R0 calibration parameter (see Section 5.16.2). It may be used often to ensure the quality of a specific fixed-point realization.

The first step is to measure the furnace temperature at the temperature of interest. The furnace should have the fixed-point cell installed and the cell must be entirely frozen or melted. Measure the temperature with the SPRT fully inserted into the well. Make sure the furnace temperature is stable and make careful and accurate measurements.

The next step is to adjust R0 to make the temperature closer to the set-point. Increasing or decreasing R0 by 0.01Ω increases or decreases the temperature by about 0.025°C at 0°C and about 0.09°C at 650°C. Use the following formula to calculate a new value for R0 to make the temperature closer to the set-point.

$$R0' = R0 - \frac{t_{meas} - t_{sp}}{2.5\frac{°C}{\Omega} + \frac{t_{sp}}{100\Omega}}$$

For example, with the set-point at 655°C the furnace temperature is measured and found to actually be 655.65. R0 is set to 100.124 (ohms). The new value for R0 is calculated as follows.

$$R0' = 100.124\Omega - \frac{655.65°C - 655.00°C}{2.5\frac{°C}{\Omega} + \frac{655°C}{100\Omega}} = 100.052\Omega$$

8.2.2 Three-point Calibration

The first time the furnace is calibrated at the factory it is calibrated over the full range by adjusting the three calibration parameters R0, ALPHA, and DELTA. This full calibration may be repeated periodically to ensure that the furnace is accurate to 0.5°C or better at all temperatures in its range.

Full calibration requires making measurements of the furnace temperature at three widely separated set-points throughout the range of the furnace. Suggested set-points are 50°C, 400°C, and 650°C. The actual temperature of the furnace is measured at these temperatures. As before, the furnace should have the fixed-point cell installed and the cell must be entirely frozen or melted. Measure the temperature with the SPRT fully inserted into the well. Make sure the furnace temperature is stable (wait about 20 minutes after inserting the SPRT) and make careful and accurate measurements. Once the temperatures are obtained, new values for R0, ALPHA, and DELTA can be calculated. The procedure is summarized as follows.

1. Choose three set-points to use in the calibration of the R0 , ALPHA, and DELTA parameters. These set-points are generally 50°C, 400°C, and 650°C but other set-points may be used if desired or necessary.

2. Set the furnace to the low set-point. When the furnace reaches the set-point and the display is stable, wait approximately 15 minutes and then take a reading from the thermometer. Sample the set-point resistance. Write these values down as T_1 and R_1 respectively.
3. Repeat step 2 for the other two set-points recording them as T_2 ,R_2 ,T_3 , and R_3 respectively.
4. Using the recorded data, calculate new values for the R0 , ALPHA, and DELTA parameters using the equations given below.

8.2.3 Compute DELTA

$$A = T_3 - T_2$$

$$B = T_2 - T_1$$

$$C = \left[\frac{T_3}{100}\right]\left[1 - \frac{T_3}{100}\right] - \left[\frac{T_2}{100}\right]\left[1 - \frac{T_2}{100}\right]$$

$$D = \left[\frac{T_2}{100}\right]\left[1 - \frac{T_2}{100}\right] - \left[\frac{T_1}{100}\right]\left[1 - \frac{T_1}{100}\right]$$

$$E = R_3 - R_2$$

$$F = R_2 - R_1$$

$$delta = \frac{AF - BE}{DE - CF}$$

$T_{1\text{-}3}$ are the measured temperatures using the thermometer. $R_{1\text{-}3}$ are the values of R from the display of the 9260. (Press SET and DOWN at the same time.)

T_1 and R_1 are the measured temperature and resistance at 50°C.

T_2 and R_2 are the measured temperature and resistance at 400°C

T_3 and R_3 are the measured temperature and resistance at 650°C

8.2.4 Computer R0 and Alpha

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

$$a_3 = T_3 + delta\left[\frac{T_3}{100}\right]\left[1 - \frac{T_3}{100}\right]$$

$$rzero = \frac{R_3 a_1 - R_1 a_3}{a_1 - a_3}$$

$$alpha = \frac{R_1 - R_3}{R_3 a_1 - R_1 a_3}$$

Delta is the new value of DELTA computed above.

Program the new values for DELTA (delta), R0(rzero), and ALPHA (alpha) into the furnace by: pressing the “SET” and “EXIT” keys simultaneously and then pressing “SET” until R0 is displayed. Press “SET” then use the UP or DOWN keys until the correct numerical setting is displayed. Press “SET” to accept the new value. Continue this process for ALPHA and DELTA.

8.2.5 Accuracy and Repeatability

Check the accuracy of the furnace at various points over the calibrated range. If the furnace does not pass specification at all set-points, repeat the Calibration Procedure.

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, 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.
- It is important to keep the well of the instrument clean and clear of any foreign matter. Do not use fluid to clean out the well.
- The furnace should be handled with care. Avoid knocking or dropping the instrument.
- If the comparison block is dropped, examine the comparison block for deformities before inserting it in the well. If there is any chance of jamming the comparison block in the well, file or grind off the protuberance.
- Do not slam the probe stems into the well. This type of action can cause a shock to the sensor or break the entrant well of a fixed-point cell.
- If a hazardous material is spilt 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 with 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.

10 Troubleshooting

If problems arise while operating the 9260, 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 R0, ALPHA, and DELTA. These numbers can be found on the Report of Calibration that was shipped with the unit.

10.1.2 The unit will not heat or heats at half rate

- Check the fuse. If the fuse is blown the display should be out.
- If the problem continues, contact Hart Scientific Customer Support.

10.1.3 The unit heats slowly

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

NOTE: *When in program mode, the scan rate is automatically set.*

10.1.4 If the display flashes any of the following:

“Err 1” - This error means there is a RAMerror

“Err 2” - This error means there is a NVRAM error

“Err 3” - This error means there is a RAMerror

“Err 4” - This error means there is an ADC set up error

“Err 5” - This error means there is an ADC ready error

- Initialize the system by performing the master reset sequence. If the unit repeats the error code, contact Hart Scientific Customer Sup-port 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-” , “9260" and the version of the software. The unit will need to be reprogrammed for R0, ALPHA, and DELTA in the calibration menu. These

numbers can be found on the Report of Calibration that was shipped with the unit.

10.1.5 If the display flashes any of the following:

"Err 6" - This error means there is a SENSOR error

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

10.1.6 If the display flashes any of the following:

"Err 7" - This error means there is a HtrCTL error

The fan will go on high speed. Initialize the system by performing the master reset sequence. If the unit repeats the error code, turn the unit off and contact Hart Scientific Customer Support for a return authorization and for instructions on returning the unit.

10.2 CE Comments

10.2.1 EMC Directive

Hart Scientific's equipment has been tested to meet the European Electromagnetic Compatibility Directive (EMC Directive, 89/336/EEC). Selection of Light Industrial or Heavy Industrial compliance has been based on the intended use of the instrument. Units designed for use in a calibration laboratory have been tested to Light Industrial Standards. Units designed to be used in the "field" have been tested to both Light Industrial and Heavy Industrial Standards. The Declaration of Conformity for your instrument lists the specific standards to which the unit was tested.

10.2.2 Low Voltage Directive

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