FLUKE®

Hart Scientific®

9011

High-Accuracy Dual-Well Calibrator User's Guide

Rev. 612501

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Rev. 612501

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1 Before You Start

1.1 Introduction

The Hart Scientific 9011 High-Accuracy Dual-Well Calibrator may be used as a portable instrument or bench top temperature calibrator for calibrating thermocouple and RTD temperature probes. Calibrations may be done over a range of –30°C to 670°C (–22°F to 1238°F). Temperature display and setability resolution is 0.1 degrees.

The instrument features:

- Rapid heating and cooling
- Hot and cold blocks in a single unit
- RS-232 interface capability
- Switch hold test

Built in programmable features include:

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

The temperature is accurately controlled by Hart's digital controller. The controller uses a precision platinum RTD as a sensor that controls the well temperature with a triac driven heater or thermoelectric devices (TED).

The LED front panel continuously shows the current well temperature of both hot and cold blocks. The temperature may be set, using the control buttons, to any desired temperature within the instrument's range. Multiple fault protection devices insure user and instrument safety and protection.

This dry-well calibrator was designed for portability, low cost, and ease of operation. Through proper use, the instrument will provide continued accurate calibration of temperature sensors and devices. The user should be familiar with the safety guidelines and operating procedures of the calibrator as described in the instruction 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.

Table1 *International Electrical Symbols*

Symbol	Description
	AC (Alternating Current)
	AC-DC
	Battery
	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-TIC Australian EMC Mark
	The European Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) mark.

1.3 Safety Information

Use this instrument only as specified in this manual. Otherwise, the protection provided by the instrument may be impaired. Refer to the safety information in the Warnings and Cautions sections below.

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.

GENERAL

- **DO NOT** use this instrument in environments other than those listed in the User’s Guide.
- Inspect the instrument for damage before each use. **DO NOT** use the instrument if it appears damaged or operates abnormally.
- Follow all safety guidelines listed in the user’s manual.
- Calibration Equipment should only be used by Trained Personnel.
- If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.
- Before initial use, or after transport, or after storage in humid or semi-humid environments, or anytime the dry-well has not been energized for more than 10 days, the instrument needs to be energized for a "dry-out" period of 2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1. If the product is wet or has been in a wet environment, take necessary measures to remove moisture prior to applying power such as storage in a low humidity temperature chamber operating at 50°C for 4 hours or more.

- **DO NOT** use this instrument for any application other than calibration work. The instrument was designed for temperature calibration. Any other use of the instrument may cause unknown hazards to the user.
- Completely **unattended operation is not recommended.**
- Overhead clearance is required. **DO NOT** place the instrument under a cabinet or other structure. Always leave enough clearance to allow for safe and easy insertion and removal of probes.
- If the instrument is used in a manner not in accordance with the equipment design, the operation of the dry-well may be impaired or safety hazards may arise.
- This instrument is intended for indoor use only.

BURN HAZARDS

- **DO NOT** turn the instrument upside down with the inserts in place; the inserts will fall out.
- **DO NOT** operate near flammable materials.
- Use of this instrument at **HIGH TEMPERATURES** for extended periods of time requires caution.
- **DO NOT** touch the well access surface of the instrument.
- The block vent may be very hot due to the fan blowing across the heater block of the dry-well.
- The temperature of the well access is the same as the actual display temperature, e.g. if the instrument is set to 375°C and the display reads 375°C, the well is at 375°C.
- For top loading dry-wells, the top sheet metal of the dry-well may exhibit extreme temperatures for areas close to the well access.
- The air over the well can reach temperatures greater that 200°C for high temperature (400°C and higher) dry-wells. **Note:** Probes and inserts may be hot and should only be inserted and removed from the instrument when the instrument is set at temperatures less than 50°C. Use extreme care when removing hot inserts.
- **DO NOT** turn off the instrument at temperatures higher than 100°C. This could create a hazardous situation. Select a set-point less than 100°C and allow the instrument to cool before turning it off.
- The high temperatures present in dry-wells designed for operation at 300°C and higher may result in fires and severe burns if safety precautions are not observed.

ELECTRICAL SHOCK

- These guidelines must be followed to ensure that the safety mechanisms in this instrument will operate properly. This instrument must be plugged into a 115 VAC, 60Hz (230 VAC, 50Hz optional), AC only electric outlet. The power cord of the instrument is equipped with a three-pronged

grounding plug for your protection against electrical shock hazards. It must be plugged directly into a properly grounded three-prong receptacle. The receptacle must be installed in accordance with local codes and ordinances. Consult a qualified electrician. **DO NOT** use an extension cord or adapter plug.

- If supplied with user accessible fuses, always replace the fuse with one of the same rating, voltage, and type.
- Always replace the power cord with an approved cord of the correct rating and type.
- **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.

1.3.2 ⚠ CAUTIONS

- Always operate this instrument at room temperature between 41°F and 122°F (5°C to 50°C). Allow sufficient air circulation by leaving at least 6 inches (15 cm) of clearance around the instrument.
- Component lifetime can be shortened by continuous high temperature operation.
- **DO NOT** apply any type of voltage to the display hold terminals. Applying a voltage to the terminals may cause damage to the controller.
- **DO NOT** use fluids to clean out the well. Fluids could leak into electronics and damage the instrument.
- **Never introduce any foreign material** into the probe hole of the insert. Fluids, etc. can leak into the instrument causing damage.
- **DO NOT** change the values of the calibration constants from the factory set values. The correct setting of these parameters is important to the safety and proper operation of the calibrator.
- **DO NOT** slam the probe sheath in to the well. This type of action can cause a shock to the sensor and affect the calibration.
- The instrument and any thermometer probes used with it are sensitive instruments that can be easily damaged. Always handle these devices with care. **DO NOT** allow them to be dropped, struck, stressed, or overheated.
- The Factory Reset Sequence (see Section , Troubleshooting) should be performed only by authorized personnel if no other action is successful in correcting a malfunction. You must have a copy of the most recent Report of Calibration to restore the calibration parameters.
- **DO NOT** operate this instrument in an excessively wet, oily, dusty, or dirty environment. Always keep the well and inserts clean and clear of foreign material.
- The dry-well 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 instrument in an upright position to prevent the probe sleeves from dropping out. The convenient handle allows for hand carrying the instrument.

- If a mains supply power fluctuation occurs, immediately turn off the instrument. Power bumps from brown-outs could damage the instrument. Wait until the power has stabilized before re-energizing the instrument.
- Allow for probe expansion inside the well as the block heats.
- Most probes have handle temperature limits. Be sure that the probe handle temperature limit is not exceeded in the air above the instrument.

1.4 Authorized Service Centers

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

Fluke Corporation, Hart Scientific Division

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

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

Fluke Nederland B.V.

Customer Support Services
Science Park Eindhoven 5108
5692 EC Son
NETHERLANDS

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

Fluke Int'l Corporation

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

CHINA

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

Fluke South East Asia Pte Ltd.
Fluke ASEAN Regional Office
Service Center
60 Alexandra Terrace #03-16
The Comtech (Lobby D)
118502
SINGAPORE

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

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

- Model Number
- Serial Number
- Voltage
- Complete description of the problem

2 Specifications and Environmental Conditions

2.1 Specifications

	Hot Block	Cold Block
Range	50°C to 670°C (122°F to 1238°F)	–30°C to 140°C (–22°F to 284°F)
Accuracy	±0.2°C at 50°C ±0.4°C at 400°C ±0.65°C at 600°C	±0.25°C (insert wells) ±0.65°C (fixed wells)
Stability	±0.02°C at 100°C ±0.06°C at 600°C	±0.02°C at –30°C ±0.04°C at 140°C
Uniformity	±0.2°C (±0.05°C typical)	±0.05°C (insert wells) ±0.25°C (fixed wells)
Well Depth	6" (152 mm)	4.875" (124 mm)
Heating Time to Max.	30 minutes	15 minutes
Cooling Times	120 minutes from 660°C to 100°C	30 minutes from 140°C to –30°C
Well Inserts	1 interchangeable well accommodates multi-hole insert	1 interchangeable well accommodates multi-hole insert, plus four outer wells, 1/4", 1/4", 3/16", and 1/8"
Computer Interface	RS-232 interface included with Model 9930 Interface-*it* control software	
Power	115 VAC (±10%), 8.8 A or 230 VAC (±10%), 4.4 A, switchable, 50/60 Hz, 1150 W	
Size	11.5" H x 15.5" W x 10.5" D (292 x 394 x 267 mm)	
Weight	36 lb. (16.4 kg)	
NIST-Traceable Certificate (8 points)	Data at 50°C, 100°C, 200°C, 300°C, 400°C, 500°C, 600°C, and 660°C	Data at –30°C, 0°C, 25°C, 50°C, 75°C, 100°C, 125°C, and 140°C
Safety	OVERVOLTAGE (Installation) CATEGORY II, Pollution Degree 2 per IEC1010-1	
Fault Protection	Sensor burnout protection, over-temperature cutout, and electrical fuses	
Fuses	115 V: 10 A F (Hot), 4 A T (Cold), 250 VAC 230 V: 5 A F (Hot), 3.15 A T (Cold), 250 VAC	

†Using same type of probes

2.2 Environmental Conditions

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

The instrument operates safely under the following conditions:

- temperature range: 5–50°C (41–122°F)

- ambient relative humidity: 15–50%
- pressure: 75kPa–106kPa
- mains voltage within ±10% of nominal
- vibrations in the calibration environment should be minimized
- altitudes less than 2000 meters
- indoor use only

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 (see Section 1.4). The Service Centers assume NO risk for in-transit damage.

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 dry-well 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:

- 9011 Dry-well
- Power Cord
- User's Guide with Report of Calibration
- 2 inserts
- Insert removal tool
- RS-232 Cable
- 9930 Interface-*it* Software

3.2 Set-up

Place the calibrator on a flat surface with at least 6 inches of free space around the instrument. Always leave enough clearance in front of the instrument to allow for safe and easy insertion and removal of probes. Plug the power cord into a grounded mains outlet. Observe that the nominal voltage corresponds to that indicated on the calibrator.

3.3 Power

Plug the instrument power cord into a mains outlet of the proper voltage, frequency, and current capability. Refer to Section 2.1, Specifications, for the power details.

Turn on the power to the calibrator by toggling both power switches on within three seconds of each other. The fans should begin blowing air through the instrument and both controller displays 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.

NOTE: *If more than three seconds elapse, 'ICL' (Interconnect Link) appears on the display. Press any front control panel button to eliminate the 'ICL' message. The hot block serial commands are not available unless both power switches were turned on within three seconds of each other.*

The display shows the well temperature and the well heater brings the temperature of the well to the set-point temperature.

After using the calibrator, allow the well to cool by setting the temperature to 25°C and waiting 1/2 hour before turning the instrument off.

3.4 Setting the Temperature

Section 6.2 explains in detail how to set the temperature set-point on the calibrator 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 and hold "EXIT" to return to the temperature display.

When the set-point temperature is changed the controller switches the well heater on or off to raise or lower the temperature. The displayed well temperature gradually changes until it reaches the set-point temperature. The well may require considerable time to reach the set-point depending on the span. Additional time is required to stabilize within ±0.1°C of the set-point.

4 Parts and Controls

The user should become familiar with the dry-well calibrator and its parts (See Figures 1, 2, and 3).

4.1 Rear Panel

Power Cord - The removable power cord (not shown), attaches to the back side of the instrument. It plugs into a standard 115 VAC (optional 230 VAC) grounded socket.

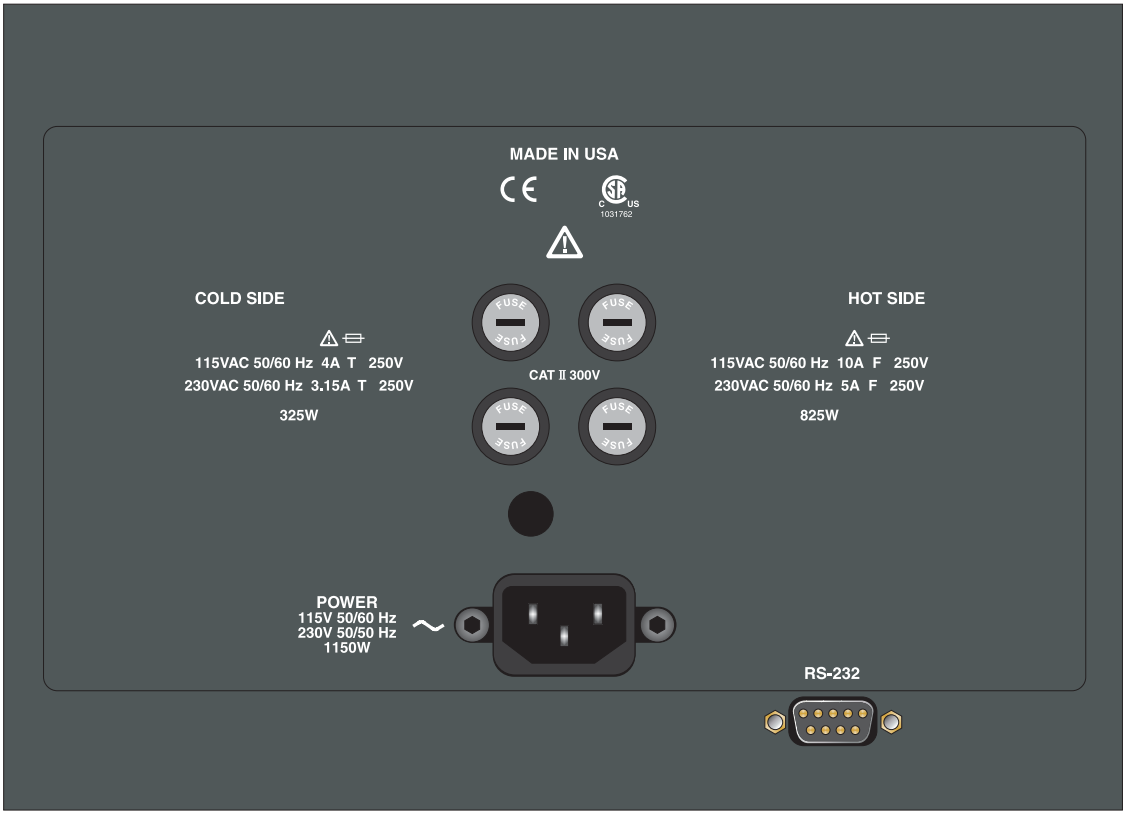


Figure 1 *Back Panel*

RS-232 - The RS-232 serial port provides a means for connecting the instrument to a computer or a printer using the included serial cable.

Fan - The fans inside the instrument are controlled by the controller and vary in speed. Slots at the top and bottom of the instrument are provided for airflow.

The area around the calibrator must be kept clear to allow adequate ventilation. The air is directed from the bottom to the top and may be hot. Allow 6 inches of open space around the calibrator to allow adequate ventilation.

Fuse Holders - On the rear panel are four user accessible fuse holders.

***WARNING**: Always leave enough clearance to allow for safe and easy installation and removal of probes.*

4.2 Front Panel

Power Switches - The power switches for both controllers are located on the front panel of the instrument. The switches are either on or off. The on position is for normal operation. The off position disconnects power to the entire unit.

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

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

***Figure 2** Front Panel*

Setting the control temperature is done directly in degrees of the current scale. It can be set to one-tenth of a degree Celsius or Fahrenheit.

The functions of the buttons are as follows:

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.

4.3 Top Panel

Well Block - The well block openings are located on the top of both the cold and hot sides. These openings are for insertion of interchangeable inserts. The inserts are designed to accept probes of varying diameters. For insert details see Section 4.4, Constant Temperature Block Assembly.

Display Hold - One set of Display Hold connectors are available for each block. These connectors allow external switches to be connected and controlled by the instrument.

4.4 Constant Temperature Block Assembly

The contant temperature block assemblies provide a relatively constant and accurate temperature environment for sensors to be calibrated. High-temperature platinum RTDs imbedded in the block assemblies senses and control the temperature of the blocks. Inserts for use in the constant temperature block assemblies are shown in Figure 3.

Warning: *The air over the constant temperature block assembly can reach temperatures greater that 200°C for high temperature (400°C and higher) dry-wells. Probes and inserts may be hot and should only be inserted and removed from the instrument when the instrument is set at temperatures less than 50°C. Use extreme care when removing hot inserts.*

Insert "A" has six holes that accept probe diameters of 1/16", 1/8, 3/16, 1/4", 3/8", and 1/2".

Insert "B" has six holes, two of each that accept probe diameters of 3/16", 1/4", and 3/8".

Insert "C" has six holes (cold) or eight holes (hot) that accept probe diameters of 1/4".

Insert "D" has six holes, two that accept probe diameter of 3 mm, two that accept probes of 4 mm diameter, and two that accept probes of 6 mm diameter.

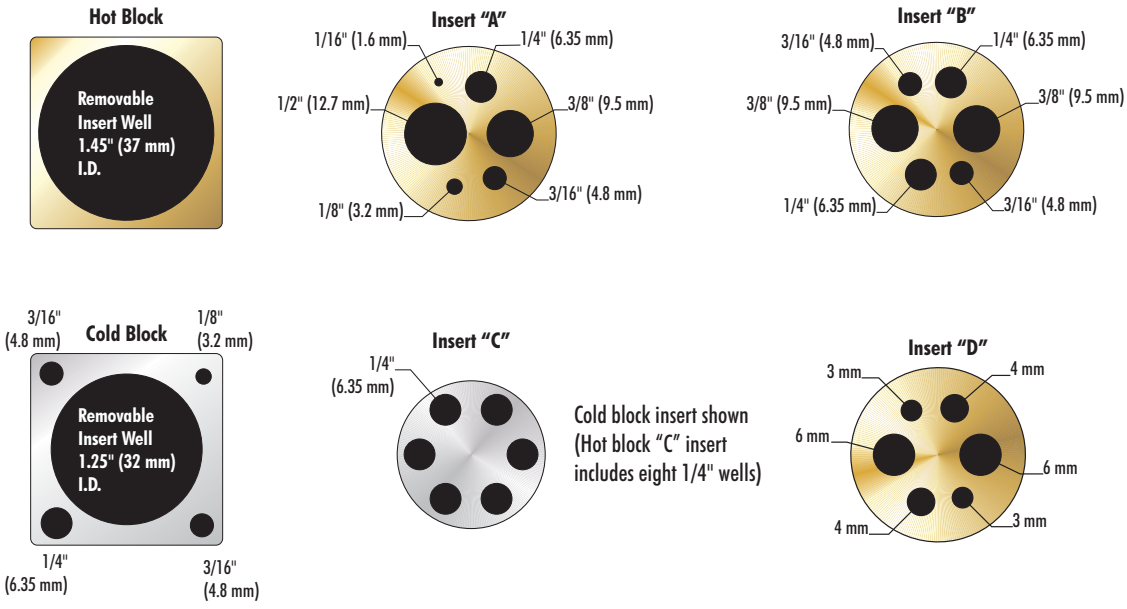


Figure 3 *Interchangeable Insert Options*

5 General Operation

5.1 Setting the Temperature

Section 6.2 explains in detail how to set the temperature set-point on the calibrator 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.

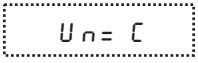
(4) Press and hold “EXIT” to return to the temperature display.

When the set-point temperature is changed the controller switches the well heater on or off to raise or lower the temperature. The displayed well temperature gradually changes until it reaches the set-point temperature. The well requires considerable time to reach the set-point depending on the span. Additional time is required to stabilize within ±0.1°C of the set-point.

5.2 Changing Display Units

This instrument can display temperature in Celsius or Fahrenheit. The temperature units are shipped from the factory set to Celsius.

1 - Press “SET” three times from the temperature display to show



2 - Press “UP” or “DOWN” to change units.

3 - Press “SET” to save the setting or “EXIT” to continue without changing the setting.

6 Controller Operation

This chapter discusses in detail how to operate the dry-well temperature controller using the front control panel. Using the front panel key-switches and LED display the user may monitor the well temperature, set the temperature set-point in degrees C or F, monitor the heater output power, adjust the controller proportional band, and program the calibration parameters, operating parameters, and serial interface configuration. Operation of the functions and parameters are shown in the flowchart in Figure 4 on page 20. This chart may be copied for reference.

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

6.1 Well Temperature

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

100.00C *Well temperature in degrees Celsius*

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

6.2 Temperature Set-point

The temperature set-point can be set to any value within the range and with 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 the set-point memory and adjusting the set-point value.

6.2.1 Programmable Set-points

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

To set the temperature, 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.

100.00C *Well temperature in degrees Celsius*

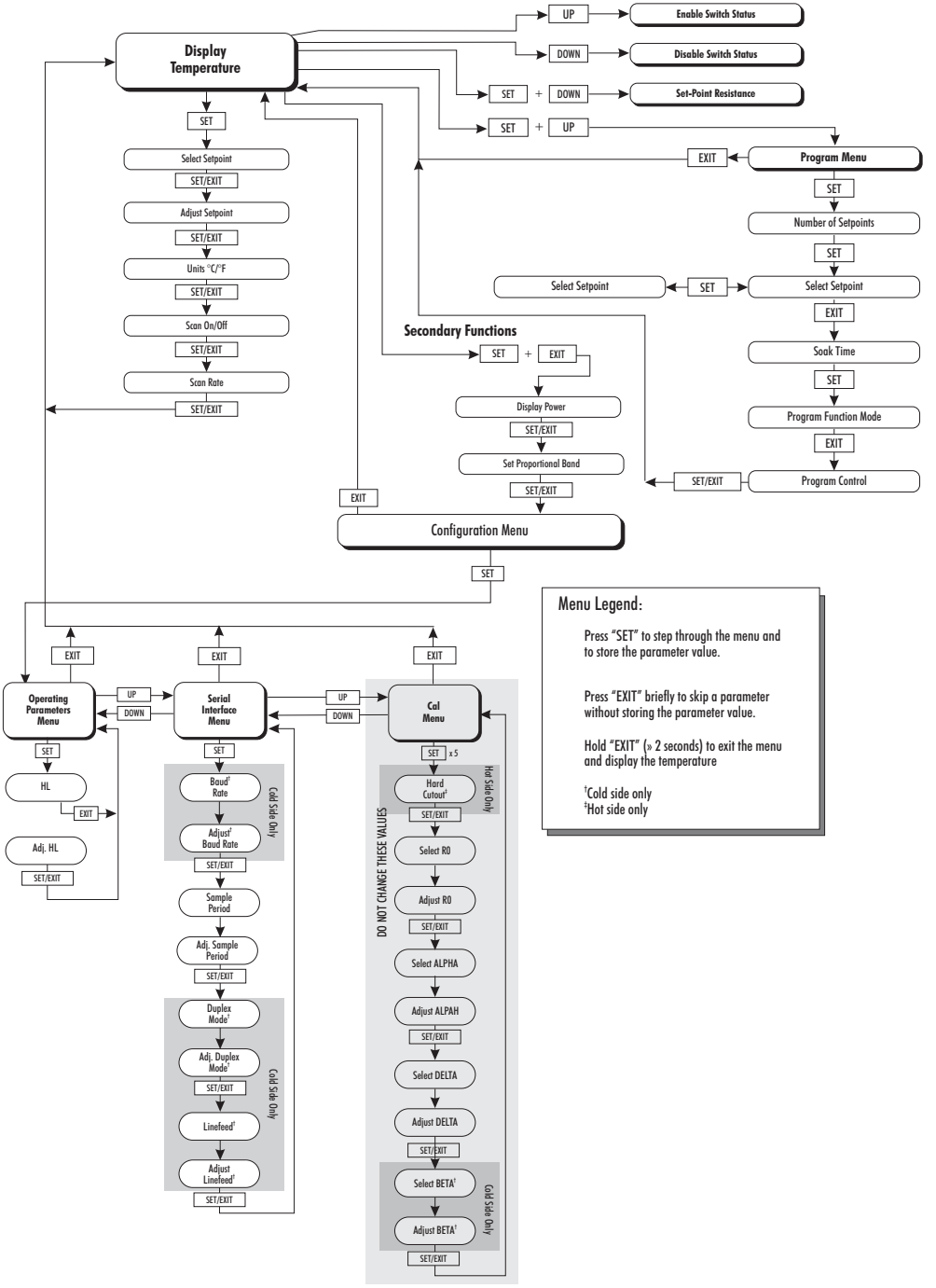


Figure 4 *Controller Operation Flow Chart*

SET *Access set-point memory*

1 100. *Set-point memory 1 location, 100°C currently used*

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

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

Press “SET” to accept the new selection and access the set-point value. Press “EXIT” to continue and to ignore any changes.

SET *Accept selected set-point memory*

6.2.2 Set-point Value

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

4 200. *Set-point 4 value in°C*

If the set-point value does not need to be changed, press and hold “EXIT” to resume displaying the well temperature. To change the set-point value, press “SET” and then “UP”.

220.00 *New set-point value*

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

SET *Accept new set-point value*

6.2.3 Temperature Scale Units

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

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*

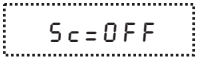
Press “SET” to accept the new units or “EXIT” to cancel.

6.3 Scan

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

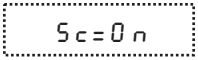
6.3.1 Scan Control

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



Current scan setting

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



Scan function on

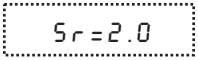
Press "SET" to accept the present setting and continue.

Accept scan setting

6.3.2 Scan Rate

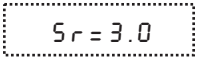
The scan rate can be set from 0.1 to 50.0°C/min. The maximum scan rate, however, is actually limited by the natural heating or cooling rate of the instrument. This rate is often less than 50°C/min, especially when cooling.

The scan rate function appears in the main menu after the scan control function. The scan rate units are in degrees Celsius per minute, regardless of the selected units.



Current scan rate setting in °C/min

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



New scan rate

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

Accept scan rate

6.4 Temperature Display Hold

There are two sets of display hold terminals located on the top of the 9011, one for the cold side and one for the hot side. The display hold terminals are used for testing thermal switches.

CAUTION: *Do not apply any type of voltage to the display hold terminals. Applying a voltage to the terminals may cause damage to the controller.*

6.4.1 Switch Status

Connect the thermal switch to the display hold terminals on the either the hot or cold side. To enable the Switch Status while displaying the temperature, press "UP" on the hot or cold side. The letter "o" (switch open) or "c" (switch closed) appears to the left of the display and flashes when it changes states. When the Switch Status is enabled, the displayed temperature does not show the hundredth place or the units. (For example, if the switch is open and the temperature is 25°C, "o 25.0" is displayed.) To disable the Switch Status, press the "DOWN" key.

When the Switch Status is displayed, the Display Hold is also enabled, allowing the operator to view the temperature at which the switch changed states and the status of the thermal switch.

When the thermal switch changes states the controller does the following.

1. Displays the temperature at which the switch changed states.
2. Flashes the new switch status.
3. The controller continues in the above state until either the thermal switch is returned to its original state or the set-point temperature changes.

Note: This feature is a useful to quickly monitor thermal switch state changes with a rough idea of accuracy but is not accurate when compared with the displayed temperature. Enable Scan Hold (see Section 6.4.2, Scan Hold) to improve the accuracy.

The following example demonstrates the use of Switch Status using the Display Hold terminals.

Example 1

With the instrument displaying 25°C, set the set-point to 100°C and enable the Switch Status by pressing "UP". When the thermal switch changes states at say 50°C, the displayed temperature shows 50°C and the status flashes "o or c", while the block continues to 100°C. The display remains at the switched temperature and "o or c" continues to flash until the switch changes status or a new set-point is set.

6.4.2 Scan Hold

To enable scan hold, first enable Switch Status/Display Hold and the Scan Control (see Section 6.3.1, Scan Control)prior to setting the set-point temperature.

Scan Hold is similar to Switch Status/Display Hold but instead of displaying the temperature at which the thermal switch changes status, it sets a new set-point temperature to the current temperature at which the thermal switch

changed states. This feature allows for minimal block temperature scanning times and improved accuracy.

Example 2:

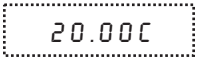
With the instrument displaying 25°C, set the set-point to 100°C and enable the Scan Hold feature. When the thermal switch changes states at 50°C, the controller automatically sets a new set-point of 50°C and the status flashes either "o or c".

Note: There is a delay between the displayed temperature and the actual temperature of the thermal switch. To achieve better accuracy when the thermal switch is tripped, the scan rate should be set for a slower time. The slower the scan rate the more time required to perform a test. The operator must determine the optimal scan rate for the specific application.

6.5 Ramp and Soak Program Menu

The ramp and soak program feature allows the user to program a number of set-points and have the dry-well automatically cycle between the temperatures, holding at each for a determined length of time. The user can select one of four different cycle functions.

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



Well temperature

Access program menu

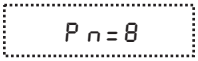
Program menu

Press "SET" to enter the program menu

Enter program menu

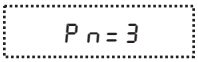
6.5.1 Number of Program Set-points

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



Number of program set-points

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



New number of program set-points

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

SET *Save new setting*

6.5.2 Set-points

The next parameters are the program set-points.

1 25 *First set-point*

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

3 10 *Third set-point*

Press “SET” to change the set-point.

10.00 *Set-point value*

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

13.50 *New set-point value*

Press “SET” to save the new set-point value.

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

EXIT *Continue to next menu function*

6.5.3 Program Soak Time

The next parameter in the program menu is the soak time. This is the time, in minutes, for which each of the program set-points is maintained after settling before proceeding to the next set-point. The duration is counted from the time the temperature settles to within a specified stability.

Pt=15 *Soak time in minutes*

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

Pt=5 *New soak time*

Press “SET” to continue.

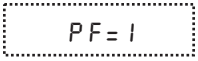
SET *Save new setting*

6.5.4 Program Function Mode

The next parameter is the program function or cycle mode. There are four possible modes which determine whether the program scans up (from set-point 1

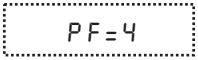
to n) only or both up and down (from set-point n to 1), and also whether the program stops after one cycle or repeat the cycle indefinitely. The table below shows the action of each of the four program mode settings.

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



Program mode

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



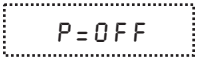
New mode

Press "SET" to continue.

Save new setting

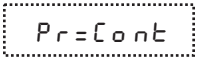
6.5.5 Program Control

The final parameter in the program menu is the control parameter. Three options are available for controlling the ramp and soak program. The options are "GO" (start the program from the beginning), "Cont" (continue the program from where it was when it was stopped), or "OFF" stop the program.



Program presently off

Use "UP" or "DOWN" to change the program state.



Start cycle from beginning

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

Activate new command.

6.6 Set-point Resistance

The set-point resistance is the resistance the instrument is trying to make the control sensor achieve and is calculated in the firmware using the set-point temperature. This value is not directly adjustable but is recalculated when the set-point temperature is changed. The set-point resistance is used to perform a calibration adjustment using the Callendar-Van Dusen R versus T curve fit. The

instrument must be at temperature and stable prior to taking the set-point resistance reading.

To display the Set-point Resistance, press “SET” and “DOWN” simultaneously when the temperature is displayed. When the “SET” and “DOWN” buttons are released the temperature is again displayed.

99.222	*Current set-point resistance setting is displayed*

6.7 Secondary Menu

Functions which are used less often are accessed within the secondary menu. The secondary menu is accessed by pressing “EXIT” while holding down “SET” and then releasing both. The first function in the secondary menu is the heater power display.

6.8 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 calibrator is heating up to the set-point, cooling down, or controlling at a constant temperature. Monitoring the percent heater power, allows the user to 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 “EXIT” while holding down “SET” and then release both. The heater power is displayed as a percentage of full power.

100.00C	*Well temperature*
SET + EXIT	*Access heater power in secondary menu*
SEC	*Flashes SEC for secondary menu and then displays the heater power*
12.0P	*Heater power in percent*

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

6.9 Proportional Band

In a proportional controller such as this, the heater output power is proportional to the well temperature over a limited range of temperatures around the set-point. This range of temperature is called the proportional band. At the bottom of the proportional band, the heater output is 100%. At the top of the proportional band, the heater output is 0 to 100 (hot side) and –100 to 100 (cold side). 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 is because the power output changes very little with temperature and the controller cannot respond very well to changing conditions or noise in the system. If the proportional band is too narrow, the temperature may swing back and forth because the controller overreacts to temperature variations. For best control stability, the proportional band must be set for the optimum width.

The proportional band width is set at the factory and printed on the Report of

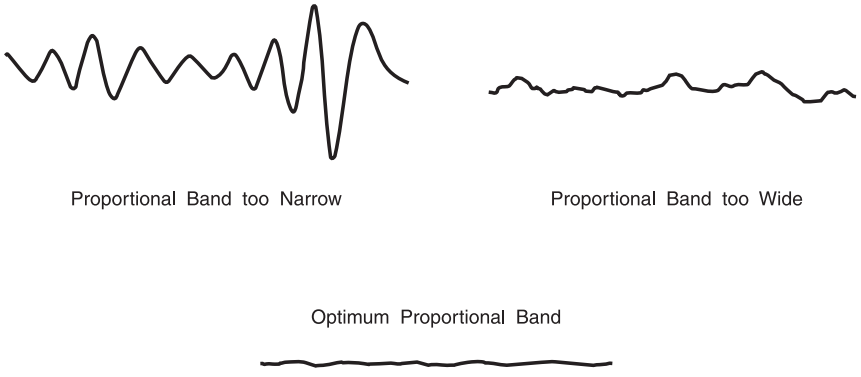


Figure 5 *Temperature fluctuations at various proportional band settings*

Calibration. The proportional band width may be altered by the user if desired 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 is accessed within the secondary menu. Press "EXIT" while holding down "SET" and then releasing both to enter the secondary menu and show the heater power. Then press "SET" to access the proportional band.

SET + EXIT *Access heater power in secondary menu*

SEC	*Flashes SEC for secondary menu and then displays the heater power*
12.0P	*Heater power in percent*
SET	*Access proportional band*
ProP	*Flashes ProP and then displays the setting*
4.1	*Proportional band setting*

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

10.0	*New proportional band setting*

To accept the new setting press “SET”. Press “EXIT” to continue without storing the new value.

SET	*Accept the new proportional band setting*

6.10 Controller Configuration

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

6.11 Operating Parameters

The operating parameters menu is indicated by,

PAr	*Operating parameters menu*

The operating parameters menu contains the High Limit parameter.

6.12 High Limit

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

HL	*Flashes* HL *and then displays the setting*
H=375	*Current High Limit setting*

Press "UP" or "DOWN" to adjust the setting.

H=300	*New High Limit setting*

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

SET	*Accept the new High Limit setting*

6.13 Serial Interface Parameters

Note: Both sides of the 9011 must be turned on within three seconds of one another for the serial communications to function on the hot side. If "ICL" is displayed on either the hot or the cold side of the instrument, the serial port is not controlled by the hot side. If "ICL" is displayed and control is desired from only the front panel, press any button ("SET", "UP", "DOWN", or "EXIT") to remove "ICL" from the display and control the instrument from the front panel buttons only.

This instrument has two controllers, one for the hot side and one for the cold side. The cold side controller acts as the master for the serial communications and the hot side controller acts as the slave.

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

SErIAL	*Serial RS-232 interface parameters menu*

Press "SET" to enter the menu. The serial interface parameters menu contains parameters which determine the operation of the serial interface. The parameters in the menu are - BAUD rate, sample period, duplex mode, and linefeed.

6.13.1 Baud Rate (cold side only)

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

The baud rate parameter is indicated by,

bAUd	*Flashes* bAUd *for one second and then displays the setting*
2400 b	*Current baud rate*

The baud rate of the serial communications may be programmed to 300, 600, 1200, **2400** (default), 4800, or 9600 baud. Use “UP” or “DOWN” to change the baud rate value.

4800 b	*New baud rate*

Press “SET” to accept the new setting or “EXIT” to abort the operation and skip to the next parameter in the menu.

6.13.2 Sample Period (hot and cold sides)

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

SPEr	*Flashes for one second and then the serial sample period setting is displayed*
SA=1	*Current sample period (seconds)*

Adjust the value by using “UP” or “DOWN”.

SA=60	*New sample period*

Press “SET” to accept the new setting or “EXIT” to abort the operation and skip to the next parameter in the menu.

6.13.3 Duplex Mode (cold side only)

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 master controller via the serial interface are immediately executed and echoed or transmitted back to the device of origin. With half duplex the commands are executed but not echoed. The duplex mode parameter is indicated by,

dUPL	*Flashes for one second and then the serial duplex mode setting is displayed*
d=FULL	*Current duplex mode setting*

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

d=HALF	*New duplex mode setting*

Press "SET" to accept the new setting or "EXIT" to abort the operation and skip to the next parameter in the menu.

6.13.4 Linefeed (cold side only)

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

LF	*Flashes for one second and then the serial linefeed setting is displayed*
LF=On	*Current linefeed setting*

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

LF=OFF	*New linefeed setting*

Press "SET" to accept the new setting or "EXIT" to abort the operation and skip to the next parameter in the menu.

6.14 Calibration Parameters

The operator of the instrument controller has access to a number of the calibration constants namely the Hard Cutout, R0, ALPHA, DELTA, and BETA. 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 instrument. Access to these parameters is available to the user 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 the instrument 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, proper operation, and performance of the instrument.*

The calibration parameters menu is accessed by pressing "UP" from the serial interface menu and is indicated by the following.

CAL	*Calibration parameters menu*

Press "SET" five times to enter the menu. The calibration parameters menu contains the parameters, Hard Cutout, R0, ALPHA, DELTA, and BETA that characterize the resistance-temperature relationship of the platinum control sensor. These parameters may be adjusted to improve the accuracy of the calibrator.

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

6.14.1 Hard Cutout (hot side only)

This parameter is the temperature above which the unit shuts down automatically and is only adjustable through the hot side. The value of this parameter is set at the factory and **cannot** be changed by the user.

The hard cutout parameter is indicated by,

CutOut	*Flashes for one second and then the hard cutout setting is displayed*
670	*Current hard cutout setting*

Press “EXIT” to continue to the next parameter.

6.14.2 R0

This probe parameter refers to the resistance of the control probe at 0°C. The value of this parameter is set at the factory for best instrument accuracy. The value ranges from 95 to 105. The R0 parameter is indicated by,

r0	*Flashes for one second and then the R0 setting is displayed*
100.014	*Current R0 setting (100.014)*

To change the R0 setting, press “UP” or “DOWN”.

99.999	*New R0 setting*

To accept the new setting, press “SET”. Press “EXIT” to continue without storing the new value.

SET	*Accept the new R0 setting*

6.14.3 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. (The ALPHA value is the displayed value times 10^{-7}.)

ALPHA	*Flashes for one second and then the ALPHA setting is displayed*

38530 *Current ALPHA setting*

To change the ALPHA setting, press "UP" or "DOWN".

38600 *New ALPHA setting*

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

SET *Accept the new ALPHA setting*

6.14.4 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.

dELtA *Flashes for one second and then the DELTA setting is displayed*

1.5070 *Current DELTA setting*

To change the DELTA setting, press "UP" or "DOWN".

1.6320 *New DELTA setting*

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

SET *Accept the new DELTA setting*

6.14.5 BETA (cold side only)

This probe parameter relates to the higher order nonlinearity of the sensor below 0°C. The value is set at the factory for best instrument accuracy.

bEtA *Flashes for one second and then the BETA setting is displayed*

0.111 *Current BETA setting*

To change the BETA setting, press "UP" or "DOWN".

0.100 *New BETA setting*

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

Accept the new BETA setting

7 Digital Communication Interface

This instrument is capable of communicating with and being controlled by other equipment through the digital serial interface.

With a digital serial 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 2 on page 40.

7.1 Serial Communications

The RS-232 serial interface allows serial digital communications over fairly long distances (15.24 meters). With the serial interface the user may access any of the functions, parameters and settings discussed in Section 6, Controller Operation with the exception of the BAUD rate setting. The serial interface operates with eight data bits, one stop bit, and no parity.

7.1.1 Wiring

The serial communications cable attaches to the calibrator through the DB-9 connector on the back of the instrument. Figure 6 shows the pin-out of this connector and suggested cable wiring. To eliminate noise, the serial cable should be shielded with low resistance between the connector (DB9) and the shield.

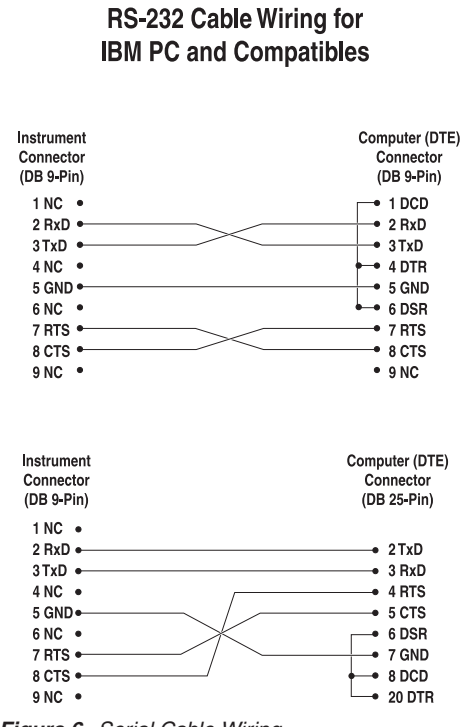


Figure 6 *Serial Cable Wiring*

7.1.2 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 of the cold side controller. The serial interface parameters menu is outlined in Figure 4 on page 20.

To enter the serial parameter menu on the cold side controller, press “EXIT” while holding

down "SET", then release both buttons to enter the secondary menu. Press "SET" repeatedly until the display reads "PAr". Press "UP" once, the serial interface menu is indicated with "SErIAL". Finally press "SET" to enter the serial parameter menu. In the serial parameters menu are the baud rate, the sample period, the duplex mode, and the linefeed parameter.

7.1.2.1 Baud Rate (Cold Side Only)

The baud rate is the first parameter in the menu and is indicated by "BAUd". Press "SET" to choose to set the baud rate. The current baud rate value is displayed. The serial communications baud rate 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 setting. Press "SET" to accept the new setting or "EXIT" to abort the operation and skip to the next parameter in the menu.

7.1.2.2 Sample Period

The sample period is the next parameter in the menu and is indicated by "SPEr". The sample period is the time period in seconds between temperature measurements transmitted from the serial interface. If the sample period 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". Press "SET" to save the new sample rate to the displayed value or "EXIT" to abort the operation and skip to the next parameter in the menu.

7.1.2.3 Duplex Mode

The next parameter is the duplex mode indicated with "dUPL". The duplex mode may be set to half duplex (HALF) or full duplex (FULL). With full duplex any commands received by the controller via the serial interface are immediately executed and 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". Press "SET" to accept the new setting or "EXIT" to abort the operation and skip to the next parameter in the menu.

7.1.2.4 Linefeed

The final parameter in the menu is the linefeed mode and is indicated by "LF". 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". Press "SET" to accept the new setting or "EXIT" to abort the operation and return to the beginning of the serial interface menu.

7.1.3 Serial Operation

The serial communications uses 8 data bits, one stop bit, and no parity. The set-point and other commands may be sent via the serial interface to set the temperature set-point and view or program the various parameters. The interface commands are discussed in Section 7.2. All commands are ASCII character strings terminated with a carriage-return character (CR, ASCII 13).

7.2 Interface Commands

The various commands for accessing the calibrator functions via the digital serial interface are listed in this section (see Table 2 beginning on page 40). These commands are used with the RS-232 serial interface. The commands are terminated with a carriage-return character (CR, ASCII 13). The interface makes no distinction between upper and lower case letters, hence either may be used. Commands may be abbreviated to the minimum number of letters which determines a unique command. A command may be used to either set a parameter or display a parameter depending on whether or not a value is sent with the command following a "=" character. For example, an "s" <CR> returns the current set-point and "s=50.0" <CR> sets the set-point to 50.0 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, ASCII 13) is implied with all commands.

Note: Commands that are preceded by a "C:" or an "H:" access the cold or hot side respectively. If the "C:" or "H:" are not used, the command accesses the cold side. It is highly recommended to always use "C:" or "H:" prefixes to ensure setting or reading a parameter on the correct controller. Responses to commands do not indicate which controller the setting or reading applies to or came from.

Table 2 *Controller Communications Commands*

Command Description	Command Format†	Command Example†	Returned	Returned Example	Acceptable Values
Display Temperature					
Read current set-point	s[etpoint]	s	set: 9999.99 {C or F}	set: 150.00 C	
Set current set-point to n	s[etpoint]=n	s=450			Controller Range
Read temperature unit	u[nits]	u	u:{C or F}	u: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: 999.9 {C or F}/min	srat: 10.0 C/min	
Set scan rate to *n* degrees per minute	sr[ate]=*n*	sr=5			0.1 to 50°C
Read display temperature hold mode	hm[ode]	hm	hmode: AUTO	hmode: AUTO	
Read hold status	ho[ld]	ho	ho:{closed or open}, 9999.9 {C or F}	ho: open, 75.0 C	
Read temperature	t[emperature]	t	t: 9999.9 {C or F}	t: 55.69 C	
Secondary Menu					
Read proportional band setting	pr[op-band]	pr	pb: 999.99999	pb: 15.9	
Set proportional band to *n*	pr[op-band]=n	pr=8.83			Depends on Configuration
Read cutout setting	c[utout]	c	cu: 9999 {C or F}	cu: 620 C, in	
Read heater power (duty cycle)	po[wer]	po	po: 9999.9	po: 1.0	
Ramp and Soak Menu					
Read number of programmable set-points	pn	pn	pn: 9	pn: 2	
Set number of programmable set-points to *n*	pn=*n*	pn=4			2 to 8
Read programmable set-point number *n*	ps*n*	ps3	ps*n*: 9999.99 {C or F}	ps1: 50.00 C	
Set programmable set-point number *n* to *n*	ps*n*=*n*	ps3=50			1 to 8, Instrument Range

Controller Communications Commands continued

Command Description	Command Format†	Command Example†	Returned	Returned Example	Acceptable Values
Read program set-point soak time	pt	pt	ti: 999	ti: 5	
Set program set-point soak time to *n* minutes	pt=*n*	pt=5			0 to 500
Read program control mode	pc	pc	prog: {OFF or ON}	prog: OFF	
Set program control mode:	**pc=g[o]/s[top]/c[ont]**				GO or STOP or CONT
Start program	pc=g[o]	pc=g			
Stop program	pc=s[top]	pc=s			
Continue program	pc=c[ont]	pc=c			
Read program function	pf	pf	pf: 9	pf: 3	
Set program function to *n*	pf=*n*	pf=2			1 to 4
Configuration Menu					
Operating Parameters Menu					
Read high limit	hl	hl	hl:999	hl:126	
Set high limit	hl=n	hl=90			Hot: 25 to 670°C Cold: 25 to 140°C
Serial Interface Menu					
Read serial sample setting	sa[mple]	sa	sa: 999	sa: 1	
Set serial sampling setting to *n* seconds	sa[mple]=*n*	sa=0			0 to 999
Read serial duplex mode (cold side only)	du[plex]	du:	du:{FULL of HALF}	du: FULL	
Set serial duplex mode: (cold side only)	**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			
Read serial linefeed mode (cold side only)	lf[eed]	lf	lf: ON		
Set serial linefeed mode: (cold side only)	**lf[eed]=on/of[f]**				ON or OFF
Set serial linefeed mode to on	lf[eed]=on	lf=on			
Set serial linefeed mode to off	lf[eed]=of[f]	lf=of			
Calibration Menu (WARNING – changing the following calibration values may change the accuracy of the instrument.)					
Read R0 calibration parameter	r[0]	r	r0: 999.999	r0: 100.578	
Set R0 calibration parameter to *n*	r[0]=n	r=100.324			95.0 to 105.0
Read ALPHA calibration parameter	al[pha]	al	al: 9.99999999	al: 0.0038573	

Controller Communications Commands continued

Command Description	Command Format†	Command Example†	Returned	Returned Example	Acceptable Values
Set ALPHA calibration parameter to *n*	al[pha]=n	al=0.0038433			0.0032 to 0.0042
Read DELTA calibration parameter	de[lta]	de	de: 9.99999	de: 1.46126	
Set DELTA calibration parameter to *n*	de[lta]=*n*	de=1.45			1.0 to 1.9
Read BETA calibration parameter (cold side only)	be[ta]	be	be: 9.999	be: 0.342	
Set BETA calibration parameter to *n* (cold side only)	be[ta]=*n*	be=0.342			–25.0 to 25.0
Miscellaneous (not on menus)					
Read firmware version number	*ver[sion]	*ver	ver.9999,9.99	ver.9011,1.11	
Read structure of all commands	h[elp]	h	list of commands		
Read all parameters	all	all	list of parameters and their values		

Legend:
[] Optional Command data
/ Alternate characters or data
{} Returns either information
n Numeric data supplied by user—may be entered in decimal or exponential notation
9 Numeric data returned to user
x Character data returned to user

Note: When DUPLEX is set to FULL and a command is sent to READ, the command is returned followed by a carriage return and linefeed. Then the value is returned as indicated in the RETURNED column.

†Note: Commands that are preceded by a "C:" or an "H:" access the cold or hot side respectively. If the "C:" or "H:" are not used, the command accesses the cold side.

8 Test Probe Calibration

For optimum accuracy and stability, allow the calibrator to warm up for 10 minutes after power-up and then allow adequate stabilization time after reaching the set-point temperature. After completing the test probe calibration procedure, allow the well to cool by setting the temperature to 25°C for one-half hour before switching the power off. Actual use of this instrument should be determined by your applicable Quality Assurance requirements. The following procedure is provided for information only.

8.1 Calibrating a Single Probe

Insert the probe to be calibrated into the test well of the instrument. The probe should fit snugly into the calibrator test well 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 test well. Best results are obtained with the probe inserted to the full depth of the test well. Once the probe is inserted into the test 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 test well, it may be compared to the calibrator display temperature.

CAUTION: *Never allow foreign material into the probe holes of the block. Fluids and other materials can damage the instrument causing binding and damage to your probe.*

8.2 Dry-well Characteristics

There is a temperature gradient vertically in the test well. The heater has been applied to the block in such a way as to compensate for nominal heat losses out of the top of the dry-well. However, actual heat losses vary with design of the thermometer probes inserted into the calibrator and the temperature. For best results, insert probe to full depth of test well.

8.2.1 Stabilization and Accuracy

The stabilization time of the instrument depends on the conditions and temperatures involved. The well requires considerable time to reach the set-point depending on the span. Additional time is required to stabilize within ±0.1°C of the set-point.

Inserting a cold probe into a test well requires another period of stabilizing depending on the magnitude of the disturbance and the required accuracy. For example, inserting a 0.25 inch diameter room temperature probe into a test well 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. It is recommended that typical measurements be made at the desired temperatures with the desired test probes to establish these times.

9 Calibration Procedure

9.1 Calibration Procedure

Calibration of this instrument should be performed at regularly scheduled intervals by qualified authorized personnel in accordance with your company's policy. The following is provided as a basis for developing your own procedure for calibrating this instrument.

9.1.1 Calibration Equipment

Calibration requires a standard thermometer that is adequately accurate and fits properly into one of the reference holes in each of the blocks. Recommended equipment includes a laboratory grade PRT with a length of 230 to 300 mm (9 to 12 inches) and a diameter of 4.76 or 6.35 mm (3/16 or 1/4 inches). The combined accuracy of the PRT and the readout which is used to display the temperature should be 0.025°C or better.

9.1.2 Calibration

The accuracy of the instrument over the full range is determined by the values of the calibration parameters R0, ALPHA, DELTA, and BETA (cold side). The calibration procedure involves measuring the error between the instrument and the reference thermometer at several temperature throughout the range and adjusting the calibration parameters as necessary to reduce the errors to within acceptable limits. The stated accuracy of the instrument can be found in the specification table in Section 2.1. Because of the way the calibration parameters affect the temperature the simplest way to proceed is to measure the errors at 0°C, 100°C, 140°C, and –25°C and adjust R0, ALPHA, DELTA, and BETA (cold side) at each point respectively. Follow these steps:

1. If "as found" data is required, first measure the error at various temperatures throughout the range such as –25, 0, 25, 50, 75, 100, and 140°C. The errors are measured by setting the controller to the desired temperature, allowing the block to reach the temperature and stabilize, and reading the actual temperature of the block with the standard thermometer. If the measured errors are all within acceptable limits, no further action is required and the remainder of this procedure is not necessary. If the accuracy needs to be improved, continue with Step 2.
2. Set the set-point to 0°C and allow adequate time for the block to reach this temperature and stabilize. Adjust the R0 calibration parameter (see Section 6.14.2) to make the block temperature as measured with the standard thermometer match the set-point. The approximate ratio between a change in R0 and a change in temperature at 0°C is about 0.4 to 1. For example, if the block temperature is high by 0.1°C at 0°C, decrease R0 by 0.04.

3. Set the set-point to 100°C and allow adequate time for the block to reach this temperature and stabilize. Adjust the ALPHA calibration parameter (see Section 6.14.3) to make the block temperature as measured with the standard thermometer match the set-point. The approximate ratio between a change in ALPHA and a change in temperature at 100°C is about 0.00004 to 1. For example, if the block temperature is high by 0.1°C at 100°C, decrease ALPHA by 0.000004.

4. Set the set-point to 140°C and allow adequate time for the block to reach this temperature and stabilize. Adjust the DELTA calibration parameter (see Section 6.14.4) to make the block temperature as measured with the standard thermometer match the set-point. The approximate ratio between a change in DELTA and a change in temperature at 140°C is about -1.7 to 1. For example, if the block temperature is high by 0.1°C at 140°C, increase DELTA by 0.17.

5. Set the set-point to –25°C and allow adequate time for the block to reach this temperature and stabilize. Adjust the BETA calibration parameter (see Section 6.14.5) to make the block temperature as measured with the standard thermometer match the set-point. The approximate ratio between a change in BETA and a change in temperature at –25°C is about -50 to 1. For example, if the block temperature is high by 0.1°C at –25°C, increase BETA by 5.0.

6. Repeat Step 1 to ensure the instrument is now accurate throughout the full range.

10 Maintenance

- This 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 calibrator clean and clear of any foreign matter. Do not use fluid to clean out the well.
- Use a commercially available plastic or felt brush, of appropriate diameter for a tight fit without any fluid, to clean the well. Complete the cleaning process by using cotton swabs and air to remove any debris.
- Inserts should be cleaned periodically. For cold dry-wells operating below 0°C, you should always clean the inserts after operating the unit at or below 0°C.
- Use emery cloth or other similar material to clean the outside of the inserts. Ensure that the inserts are wiped clean of any debris loosened in the buffing process. Periodic cleaning of the outside of the inserts ensures easy insertion and removal of the inserts from the well.
- The dry-well calibrator should be handled with care. Avoid knocking or dropping the calibrator.
- Do not slam the probe stems into the well. This type of action can cause a shock to the sensor.
- If a hazardous material is spilt on or inside the equipment, the user is responsible for taking the appropriate decontamination steps as outlined by the national safety council with respect to the material.
- If the mains supply cord becomes damaged, replace it with a cord with the appropriate gauge wire for the current of the instrument. If there are any questions, call an Authorized Service Center (see Section 1.4) for more information.
- Before using any cleaning or decontamination method except those recommended by Hart, users should check with an Authorized Service Center (see Section 1.4) to be sure that the proposed method does not damage the equipment.
- If the instrument is used in a manner not in accordance with the equipment design, the operation of the dry-well may be impaired or safety hazards may arise.

11 Troubleshooting

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

11.1 Troubleshooting Problems, Possible Causes, and Solutions

In the event that the instrument appears to function abnormally, this section may help to find and solve the problem. Several possible problem conditions are described along with likely causes and solutions. If a problem arises, please read this section carefully and attempt to understand and solve the problem. If the problem cannot otherwise be solved, contact an Authorized Service Center (see Section 1.4) for assistance. Be sure to have the instrument's model number, serial number, voltage, and problem description available.

Problem	Possible Causes and Solutions
Incorrect temperature reading	**Incorrect R0, ALPHA, DELTA, or BETA parameters.** Find the value for R0, ALPHA, DELTA, and BETA on the Report of Calibration. Reprogram the parameters into the instrument (see Section 6.14, Calibration Parameters). Allow the instrument to stabilize and verify the accuracy of the temperature reading. **Controller locked up.** The controller may have locked up due to a power surge or other aberration. Initialize the system by performing the Factory Reset Sequence. **Factory Reset Sequence.** Hold "SET" and "EXIT" down at the same time while turning on the instrument. When "BUTTON" is displayed, release "SET" and "EXIT" and immediately press "SET" and "EXIT" again. The instrument displays shows '-init-', the model number, and the firmware version. Each of the controller parameters and calibration constants must be reprogrammed. The values can be found on the Report of Calibration.
The instrument heats or cools too quickly or too slowly	**Incorrect scan and scan rate settings.** The scan and scan rate settings may be set to unwanted values. Check the Scan and Scan Rate settings. The scan may be off (if the unit seems to be responding too quickly). The scan may be on with the Scan Rate set low (if unit seems to be responding too slowly). **Improper line voltage.** Verify that the voltage reading in the bottom of the unit matches the source voltage.
Unstable display	**Wait.** Allow the instrument to stabilize for a few minutes. **Proportional band may be incorrect.** Refer to the proportional band on the Report of Calibration.

Problem	Possible Causes and Solutions
The display shows any error	**Controller problem.** The error messages signify the following problems with the controller. Err 1 - a RAM error Err 2 - a NVRAM error Err 3 - a Structure error Err 4 - an ADC setup error Err 5 - an ADC ready error Err 6 – a defective control sensor Err 7 – a heater error Initialize the system by performing the Factory Reset Sequence describe above.
Temperature cannot be set above a certain point	**Incorrect High Limit parameter.** The High Limit parameter may be set below 150°C. Check this value as described in Section 6.11, Operating Parameters.
"ICL" (Interconnect Link) error or Err 9	**Power on problem.** Both sides of the 9011 must be turned on within three seconds of one another for the serial communications to function on the hot side. If "ICL" is displayed on either the hot or the cold side of the instrument, the serial port does not control the hot side. If "ICL" is displayed and control is desired from only the front panel, press any button ("SET", "UP", "DOWN", or "EXIT") to remove "ICL" from the display and to control the instrument from the front panel buttons.

11.2 CE Comments

11.2.1 EMC Directive

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

11.2.2 Low Voltage Directive (Safety)

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