HART SCIENTIFIC
A Fluke Company

9122A
Dry-Well Calibrator
User's Guide

Revision 291901

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Revision 291001

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1 Before You Start

1.1 Symbols Used

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

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

Symbol	Description
	Canadian Standards Association
	Australian EMC Mark
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.

1.2 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.

1.2.1  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 re-

quirements 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 700°C and the display reads 700°C, the well is at 700°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.
- For compliance with IEC 1010-1, it is recommended that the cutout mode always be set to the manual mode requiring user intervention to reset the instrument.

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.

1.2.2 ⚠ Cautions

- **DO NOT** leave the sleeve(s) in the instrument for prolonged periods. Due to the high operating temperatures of the instrument, the sleeves should be removed after each use and buffed with a Scotch-Brite® pad or emery cloth. (See Maintenance, Section 11.)
- 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. Overhead clearance is required. **DO NOT** place unit under any structure.

- 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 12.1, 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.
- The probe and the block may expand at different rates. Allow for probe expansion inside the well as the block heats. Otherwise, the probe may become stuck in the well.
- Most probes have handle temperature limits. Be sure that the probe handle temperature limit is not exceeded in the air above the instrument. If the probe handle limits are exceeded, the probe may be permanently damaged.

1.3 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
83 Clemenceau Avenue
#15-15/06 Ue Square
239920
SINGAPORE

Phone: +65-737-2922
Telefax: +65-737-5155
E-mail: antng@singa.fluke.com

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

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

2 Introduction

The Hart Scientific 9122A Dry-Well (Figure 1) Calibrator may be used as a portable instrument or bench top temperature calibrator for calibration of multiple thermocouple and RTD temperature probes.

The dry-well calibrator features four interchangeable aluminum-bronze probe sleeves with four ¼-inch diameter fixed wells. The temperature is accurately controlled by Hart's hybrid analog/digital controller with a serial port and optionally an IEEE-488 port.

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 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 calibrator's multiple fault protection devices insure user and instrument safety and protection.

Figure 1 *Top View of 9122A*

The 9122A dry-well calibrator was designed for portability, moderate cost, and ease of operation. Through proper use the instrument should 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.

3 Specifications and Environmental Conditions

3.1 Specifications

Range	50°C–700°C (95°F–1712°F)	
Accuracy (center well)	±0.10°C ≤ 300°C ±0.30°C at 660°C	
Stability†	±0.01°C at 100°C ±0.02°C at 300°C ±0.05°C at 660°C	
Well to Well Uniformity	**All Wells:** ±0.05°C at 100°C ±0.12°C at 300°C ±0.45°C at 660°C	**Drilled Wells:** ±0.025°C at 100°C ±0.1°C at 300°C ±0.3°C at 660°C
Test Wells	9 wells: 4 3/4" dia. x 6" deep for interchangeable inserts and 5 1/4" dia x 6" deep wells.	
Computer Interface	RS-232 interface included with 9930 Interface-*it* for Windows® control software (IEEE-488 optional)	
Heating Time to Max‡	75 minutes (typical)	
Resolution	0.01°C or °F resolution	
Display	LED, °C or °F, user selectable	
Size	13.5" H x 8" W x 12" D (343 x 203 x 305 mm)	
Weight	25 lb. (11.3 kg)	
Power	115 VAC (±10%), 50/60 Hz, 1,000 Watts; 230 VAC (±10%), 50/60 Hz, 1,000 Watts	
AmbientTemperature	5–50°C (40–120°F)	
Controller	Hybrid analog/digital controller with data retention	
Fault Protection	Sensor burnout protection, over temperature thermal cut-out, electrical fuses	
Fuse Rating	115 V: 10 A F (fast acting) 250 V 230V: 5 A F (fast acting) 250 V	
Safety	Conforms to EN61010-1 Conforms to CAN/CSA C22.2 No.1010.1 UL3111 and ANSI/ISA-S82.01	

†Stability is two times the standard deviation.
‡Heating and cooling times may be affected by line voltage and ambient temperatures.

3.2 Environmental Conditions

Although the instrument has been designed for optimum durability and trouble-free operation, it must be handled with care. The instrument should 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°C to 50°C (41°C to 122°F)

- ambient relative humidity: maximum 80% for temperatures < 31°C decreasing linearly to 50°% at 40°C
- pressure: 75kPa - 106kPa
- mains voltage within ± 10% of nominal
- vibrations in the calibration environment should be minimized
- altitude less than 2000 meters
- indoor use only

3.3 Warranty

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

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

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

To exercise this warranty, the purchaser must forward the product after calling or writing a Hart Authorized Service Center (see Section 1.3, on page 6). 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 MECHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE. HART SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSS WHETHER IN CONTRACT, TORT, OR OTHERWISE.

4 Quick Start

4.1 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:

- 9122A Dry-well
- 2154, 2156, 2157, and 2159 Inserts; 1/8", 3/16", 1/4", and 3/8" Bronze/Aluminum
- Power Cord
- User's Guide
- Tongs (insert removal tool)
- Well and sleeve cleaning kit (Model 2037)
- 9930 Interface-*it* Software and User's Guide

4.2 Set-up

Place the calibrator on a flat surface with at least 6 inches of free space around the instrument. *Overhead clearance is required.* ***DO NOT*** *place the unit under any structure.* Plug the power cord into a grounded mains outlet. Observe that the nominal voltage corresponds to that indicated on the back of the calibrator.

Carefully insert the probe sleeve into the well. Probe sleeves should be of the smallest hole diameter possible still allowing the probe to slide in and out easily. Sleeves of various sizes are available from Hart Scientific. The well must be clear of any foreign objects, dirt, and grit before the sleeve is inserted. The sleeve is inserted with the two small tong holes positioned upward.

Turn on the power to the calibrator by toggling the power switch on. 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. After using the calibrator, allow the well to cool by setting the temperature to 25°C and waiting for the instrument to reach temperature before turning the instrument off.

4.3 Power

Plug the dry-well power cord into a mains outlet of the proper voltage, frequency, and current capability. Refer to Section 3.1, Specifications, for the power details. Turn the dry-well on using the rear panel "POWER" switch. The dry-well will turn on and begin to heat to the previously programmed temperature set-point. The front panel LED display will indicate the actual dry-well temperature.

4.4 Setting the Temperature

Section 7.3 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 "EXIT" twice 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 cycle indicator, a two color LED, will also indicate on (red and heating) or off (green and cooling). The displayed well temperature will gradually change until it reaches the set-point temperature. The well may require 5 to 60 minutes to reach the set-point depending on the span. Another 5 to 10 minutes is required to settle within 1°C of the set-point and 20 to 30 minutes to stabilize to within 0.1°C. Ultimate stability may take an hour or more of stabilization time.

4.5 Changing Display Units

The 9122A can display temperature in Celsius or Fahrenheit. The temperature units are shipped from the factory set to Celsius.To change to Fahrenheit or back to Celsius:

1. While displaying temperature press "SET" 3 times.

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

3. Press the "SET" button to store the change.

4. Press "EXIT" to return to displaying temperature.

5 Parts and Controls

The user should become familiar with the dry-well calibrator and its parts.

5.1 Back Panel

Refer to Figure 2 on page 15.

Power Cord - At the rear of the calibrator is the removable power cord inlet that plugs into an IEC grounded socket.

Fuses - The unit is equipped with the appropriate fuse for the voltage. Refer to Section 3.1, Specifications, on page 11 for details. The fuses should never be replaced with one of a different type, current, or voltage rating.

Power Switch - The power switch is located on the power entry model (PEM). The PEM also houses the fuses and the dual voltage selector. The PEM and heater voltage switch allow the unit to be field switched for 115 VAC or 230 VAC operation (see Section 3.1, Specifications, for power details). See Section 6.2 for instructions on changing the input voltage.

Heater Voltage Switch - The heater voltage switch can be switched between 115 VAC and 230 VAC. This switch setting must match the PEM setting. See Section6.2 for instructions on changing the input voltage.

Serial Port - A DB-9 connector is present on all units for interfacing the calibrator to a computer or terminal with serial RS-232 communications.

Figure 2 *Back Panel*

IEEE-488 Port - (optional) This connector is for interfacing the calibrator to an IEEE (GPIB) bus for control and communications.

Display Hold - The two terminals may be used to test a switch or cut-out with the calibrator.

Fan - The fan inside the calibrator runs continuously when the unit is being operated to provide cooling for the instrument. Slots at the top and around the four corners of the calibrator are provided for airflow. The area around the calibrator must be kept clear to allow adequate ventilation.

5.2 Front Panel

See Figure 3 on page 16.

Figure 3 *Front Panel*

Controller Display - The digital display is an important part of the temperature controller because it not only displays set and actual temperatures but also displays 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.

Setting the control temperature is done directly in degrees of the current scale. It can be set to one-hundredth 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 set parameters to the displayed value.

DOWN – Used to decrement the displayed value of parameters.

UP – Used to increment the displayed value.

EXIT – Used to exit from a menu. When EXIT is pressed any changes made to the displayed value will be ignored if you have not pressed the SET button first.

Control Indicator - The Control Indicator is a two color light emitting diode. This indicator lets the user visually see the ratio of heating to cooling. When the indicator is red the heater is on, and when it is green the heater is off.

5.3 Constant Temperature Block Assembly

See Figure 4 below.

5.3.1 Constant Temperature Block

The “Block” is made of aluminum-bronze and provides a relatively constant and accurate temperature environment in which the sensors that are to be calibrated are inserted. five fixed diameter holes are provided with adequate clearance for 0.25 inch diameter sensors. Four 0.75 inch diameter holes are provided that may be used for sensors of that size or sleeved down with various sized probe sleeves. Heaters surround the block and have a tapered heat density to compensate for heat loss out of the top. A high-temperature platinum RTD is imbedded to sense the temperature of the block. The entire assembly is insulated and isolated from the exterior sheet-metal and circuit board, and grounded to earth ground.

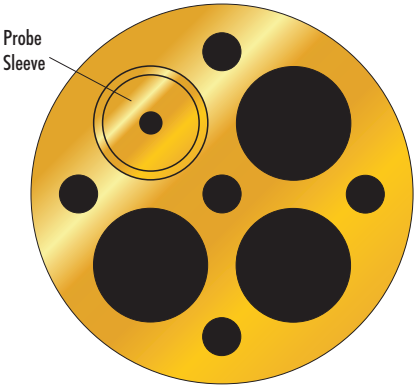


Figure 4 *Constant Temperature Block Assembly*

5.3.2 Probe Sleeves and Tongs

The calibrator is supplied with four (1/8, 3/16, 1/4 and 3/8-inch) aluminum-bronze probe sleeves for insertion into the calibrator well and tongs for removing the sleeves. Probe sleeves of various internal hole sizes are available to allow the user's probe to fit snugly into the well whatever the diameter of the probe.

Standard Probe Sleeve Sizes

Model Number	Size
2152	Blank insert
2153	1/16'' insert
2154	1/8'' insert
2155	5/32'' insert
2156	3/16'' insert
2157	1/4'' insert
2158	5/16'' insert
2159	3/8'' insert
2160	1/2'' insert
2161	5/8'' insert
2162	1 user specified hole
2163	2 user specified holes

5.3.3 Well and Sleeve Cleaning Kit (Model 2037)

The calibrator is supplied with a cleaning kit for removing oxidation or foreign material from the inserts and calibrator wells. Oxidation will grow on the metal block and inserts over time and can cause the inserts to stick in the wells or cause probes to stick in the inserts. Hart recommends using the cleaning kit regularly to remove any excess oxidation. See instructions provided inside the kit.

6 General Operation

6.1 Calibrator Set-Up

Place the calibrator on a flat surface with at least 6 inches of free space around the instrument. Plug the power cord into a grounded mains outlet. Observe that the nominal voltage corresponds to that indicated on the back of the calibrator.

Gently insert the probe sleeve into the well. The well must be clear of any foreign objects, dirt and grit before the sleeve is inserted. The sleeve is inserted with the two small tong holes positioned upward. The probe sleeve should be of the smallest hole size possible while allowing the probe to slide in and out easily allowing for thermal expansion. Sleeves of various sizes are available from the manufacturer.

Turn on the power to the calibrator by toggling the switch at the rear of the instrument to the “l” (on) position. The fan will begin circulating air through the instrument. After a brief self test the controller should begin normal operation showing the well temperature. The block will heat or cool until it reaches the programmed set-point.

6.2 Switch to 230 V Operation

To change the mains voltage, perform the following steps.

1. Unplug the unit from the power source.
2. Insert a flat-headed screwdriver into the slot on the power entry module (PEM).
3. Remove the fuse holder from the PEM.
4. Change the fuses to the appropriate current rating for the voltage (see Section 4, Safety Guidelines).
5. The power cord may need to be changed to mate with the appropriate 230 VAC or 115 VAC socket. Some options are listed.
   - 230 VAC Europe – 10A approved cord with CEE 717 plug
     US – 15A approved cord with a NEMA 6-15 straight blade plug
   - 115 VAC US – 15A approved cord with a NEMA 5-15 plug
6. Ensure the PEM and heater switch match voltage settings.

6.3 Setting the Temperature

Section 7.3 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 “EXIT” twice 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 cycle indicator, a two color LED, will also indicate on (red and heating) or off (green and cooling). The displayed well temperature will gradually change until it reaches the set-point temperature. The well may require 5 to 75 minutes to reach the set-point depending on the span. Another 5 to 10 minutes is required for the temperature to stabilize.

6.4 Calibrating Probes

The dry-well block provides a constant temperature environment in which probes may be compared. The probes inserted into the block may be compared to the well temperature displayed on the front panel of the calibrator. The probes should be inserted the full depth of the well since the temperature at the bottom of the well will most closely agree with the displayed temperature.

For greater accuracy the probes may be compared to a reference thermometer inserted into the block. The reference thermometer may be inserted into one hole while the probes to be calibrated are inserted into another. The drawback to this method is that because of temperature variations throughout the block there may be a small temperature difference between one hole and another causing errors.

Using the same hole for the reference thermometer and the test probe may have better results. This however requires switching the probes which takes more time. One must allow a few minutes after inserting the probes for the temperature to stabilize before making measurements. Because of temperature variations along the length of the well, best results are obtained when comparing probes of similar construction and inserting them the same depth into the well.

7 Controller Operation

This section 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, set the cut-out set-point, and program the probe calibration parameters, operating parameters, serial and IEEE-488 interface configuration, and controller calibration parameters. Operation of the primary functions is summarized in the flowchart in Figure 5 on page 22.

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

7.1 Well Temperature

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

100.00 C	*Well temperature in degrees Celsius*

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

7.2 Reset Cut-out

If the over-temperature cut-out has been triggered then the temperature display will alternately flash “CUt-oUt”.

CUt-oUt	*Indicates cut-out condition*

The message will continue to flash until the operator intervenes and resets the instrument.

The cut-out has two modes — manual reset and automatic reset. (See Section 7.9.2.2.) The mode determines how the cut-out is reset which allows the instrument to heat up again.With manual reset mode the cut-out must be reset by the operator after the temperature falls below the set-point. When in automatic mode, the cut-out will reset itself as soon as the temperature is lowered below the cut-out set-point. The unit is set in manual mode at the factory.

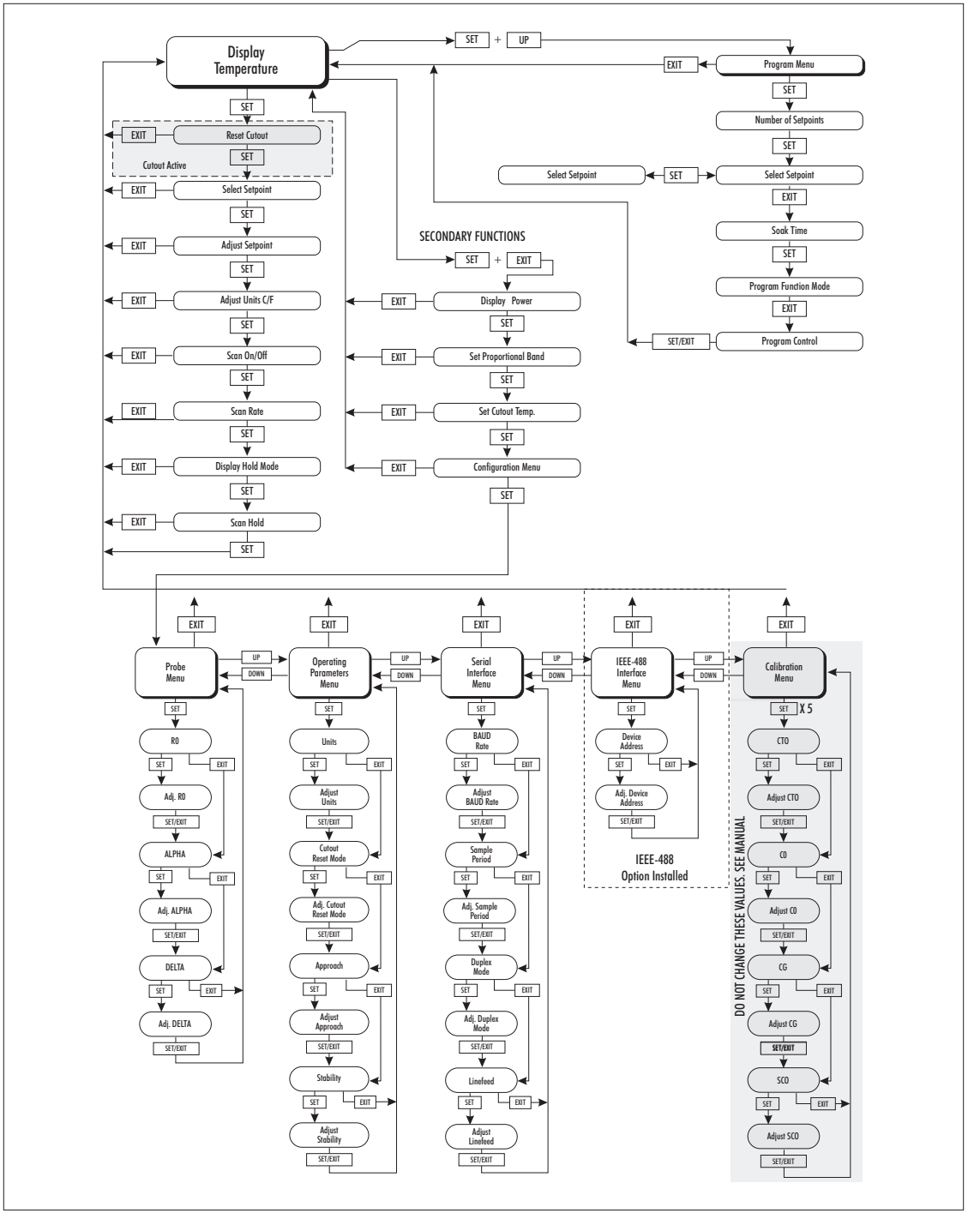


Figure 5 *Controller Function Flowchart*

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 when the cut-out is active press the "SET" button.

SET *Access cut-out reset function*

The display will indicate the reset function.

rESEt P *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.

7.3 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. The safety cut-out should be properly adjusted to help prevent this occurrence.

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

7.3.1 Programmable Set-points

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

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

100.00 C *Well temperature in degrees Celsius*

SET *Access set-point memory*

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

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

4. 400.0

New set-point memory 4, 400.0°C

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

Accept selected set-point memory

7.3.2 Set-point Value

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

C 400.00

Set-point 4 value in °C

Press “UP” or “DOWN” to adjust the set-point value. If the set-point value need not be changed then press “EXIT” to resume displaying the well temperature.

C 420.00

New set-point value

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

Accept new set-point value

7.4 Adjust Units

This instrument can display temperature in °C or °F. The temperature units are set at the factory to °C. To change the display units between °C and °F, access the units display from the temperature display by pressing “SET” 3 times.

Un=C

Current temperature units

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

Un=F

New unit selection

Press “ SET” to accept the new selection or press “EXIT” to ignore the new selection and return to displaying temperature.

7.5 Scan

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

7.5.1 Scan Control

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

`ScAn=OFF` *Scan function off*

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

`ScAn=On` *Scan function on*

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

SET *Accept scan setting*

7.5.2 Scan Rate

The next function in the main menu is the scan rate. The scan rate can be set from 0.1 to 10.0°C/min. The maximum scan rate however is actually limited by the natural heating or cooling rate of the instrument. This scan rate is often less than 10.0°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 C per minute, 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*

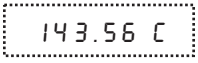
7.6 Display Hold

The 9122A has a display hold function which allows action of an external switch to freeze the displayed temperature and stop the set-point from scanning. This is useful for testing thermal switches and cut-outs. This section explains the functions available for operating the display hold feature. An example follows showing how to set up and use the hold feature to test a switch.

Ferrites should be used when connecting a thermal switch to the Switch Hold. See Section 12.2.2, Using Clamp-on Ferrites, for details.

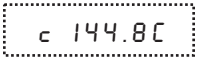
7.6.1 Hold Temperature Display

When the hold feature is enabled you can easily switch the display between the normal temperature display and the hold temperature display by simply pressing the “UP” or “DOWN” buttons. The hold temperature display shows the hold temperature on the right and the switch status on the left. For the status “c” means the switch is closed and “o” means the switch is open. The status flashes when the switch is in its active position (opposite the normal position). The hold temperature shows what the temperature of the well was when the switch changed from its normal position to its active position. While the switch is in the normal position the hold temperature will follow the well temperature. Operation of the hold temperature display is outlined below.



Well temperature display

Access hold display



Switch status and hold temperature

Note that the hold function display is not accessible if the function mode is set to “OFF”.

To return to the normal well temperature display press “DOWN” or “EXIT”.

7.6.2 Mode Setting

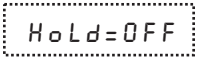
The temperature hold feature has three modes of operation. In the normally-closed (n.c.) mode, the hold temperature display freezes when the switch opens. In the normally-open (n.o.) mode, the hold temperature display freezes when the switch closes. Whenever the switch is in the normal position the hold temperature follows the well temperature.

There is also an automatic mode. In this mode the normal position is set to whatever the switch position is when the set-point is changed. For example, if the switch is currently open when the set-point is changed, the closed position

then becomes the new active position. The normal position will be set automatically under any of the following conditions, (1) a new set-point number is selected, (2) the set-point value is changed, (3) a new set-point is set through the communications channels, or (4) the ramp-and-soak program is running and automatically steps to the next set-point in the sequence. The automatic mode is useful for repetitive tests of the opening and closing temperatures of a switch.

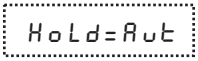
The temperature hold feature can also be disabled by setting the mode to "OFF".

The operating mode of the temperature hold is set in the primary menu after the scan rate setting.

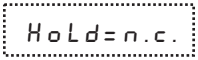


Hold mode set to off

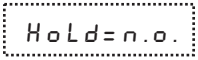
To change the mode press "UP" or "DOWN".



Automatic mode



Normally closed mode



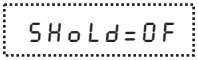
Normally open mode

Press "SET" to accept the displayed setting.

7.6.3 Scan Hold

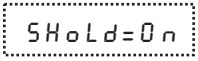
In addition to controlling the hold temperature display, a switch can also control set-point scanning by enabling the scan hold function. When the switch changes from its normal position to its active position scanning will stop. For the scan hold to be effective scanning must be enabled and the scan rate should be set to a relatively low value (see Sections 7.5.1 and 7.5.2).

The scan hold is set in the primary menu after the temperature hold mode setting.



Scan hold set to off

To change the mode press "UP" or "DOWN".



Scan hold set to on

Press "SET" to accept the displayed setting.

7.6.4

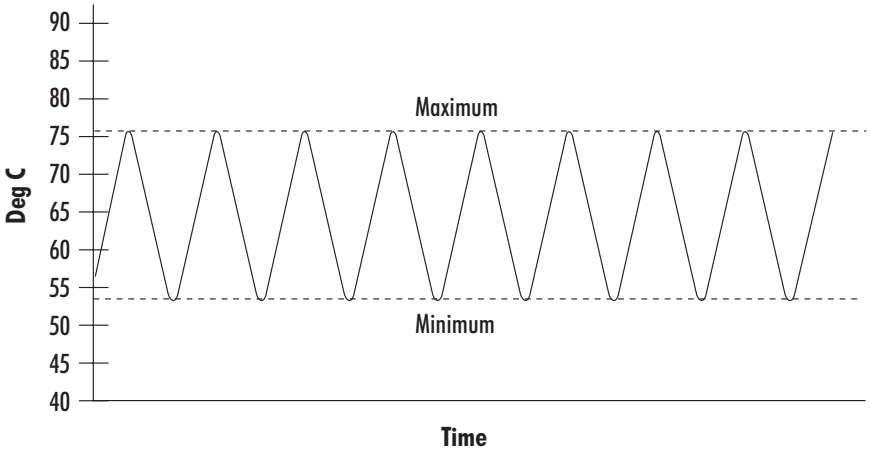


Figure 6 *Switch Test Data*

Switch Wiring

The thermal switch or cut-out is wired to the calibrator at the two terminals at the back of the dry-well calibrator labeled “DISPLAY HOLD”. The switch wires may be connected to the terminals either way. Internally the black terminal connects to ground. The red terminal connects to +5V through a 10 kΩ resistor. The calibrator measures the voltage at the red terminal and interprets +5V as open and 0V as closed.

7.6.5 Switch Test Example

This section describes a possible application for the display hold feature and how the instrument is set up and operated.

Suppose you have a thermal switch which is supposed to open at about 75°C and close at about 50°C and you want to test the switch to see how accurate and repeatable it is. You can use the display hold feature and the ramp and soak feature (described in detail in the next section) to test the switch. Measurements can be made by observing the display or, preferably, by collecting data using a printer or computer connected to the RS-232 port. To set up the test do the following steps.

1. Connect the switch wires to the terminals on the back of the dry-well and place the switch in the well.

2. Enable set-point scanning by setting the scan to “ON” in the primary menu (see Section 7.5.1).

3. Set the scan rate to a low value, say 1.0°C/min. (see Section 7.5.2). If the scan rate is too high you may lose accuracy because of transient temperature gradients. If the scan rate is too low the duration of the test may be longer than is necessary. You may need to experiment to find the best scan rate.

4. Set the hold mode to automatic (see Section 7.6.2).

5. Set the scan hold to “ON” (see Section 7.6.3).

6. Set the number of program set-points to 2 in the program menu (see Section 7.7.1).

7. Set the first program set-point to a value below the expected lower switch temperature, say 40°C, in the program menu (see Section 7.7.2).

8. Set the second program set-point to a value above the expected upper switch temperature, say 90°C.

9. Set the program soak time to allow enough time to collect a number of data points, say 2 minutes (see Section 7.7.3).

10. Set the program function to mode 4 so that the instrument will cycle between the 2 set-points repeatedly (see Section 7.7.4).

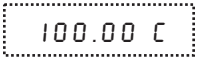
11. Start the program (see Section 7.7.5).

12. Collect data on a computer connected to the RS-232 port. Refer to Section 8 for instructions on configuring the RS-232 communications interface. The data may appear as shown in Figure 6. The maximum and minimum are the switch temperatures.

7.7 Ramp and Soak Program Menu

The ramp and soak program feature of the 9122A 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. A flowchart of the ramp and soak program menu is shown in Figure 5.

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



Well temperature

Access program menu

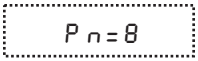
Program menu

Press “SET” to enter the program menu

Enter program menu

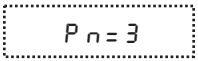
7.7.1 Number of Program Set-points

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.



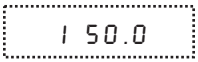
New number of program set-points

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

Save new setting

7.7.2 Set-points

The next parameters are the program set-points.



First set-point

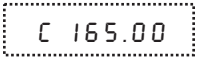
Use the "UP" or "DOWN" buttons to select any of the set-points.

Third set-point

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

Set-point value

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



New set-point value

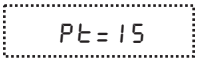
Press "SET" to save the new set-point value.

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

Continue to next menu function

7.7.3 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 will be 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. The stability requirement can be set in the parameter menu as explained in Section 7.9.2.4. The default is 0.1°C.



Soak time in minutes

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

PŁ=5	*New soak time*

Press “SET” to continue.

SET	*Save new setting*

7.7.4 Program Function Mode

The next parameter is the program function or cycle mode. There are four possible modes which determine whether the program will scan up (from set-point 1 to *n*) only or both up and down (from set-point *n* to 1), and also whether the program will stop 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

PF=1	*Program mode*

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

PF=4	*New mode*

Press “SET” to continue.

SET	*Save new setting*

7.7.5 Program Control

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

Pr=OFF	*Program presently off*

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

Pr=ŚŁArŁ	*Start cycle from beginning*

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

SET *Activate new command.*

7.8 Secondary Menu

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

7.8.1 Heater Power

The temperature controller controls the temperature of the well by pulsing the heater on and off. The total power being applied to the heater is determined by the duty cycle or the ratio of heater on time to the pulse cycle time. This value may be estimated by watching the red/green control indicator light or read directly from the digital display. By knowing the amount of heating the user can tell if the calibrator is heating up to the set-point, cooling down, or controlling at a constant temperature. Monitoring the percent heater power will let the user know how stable the well temperature is. With good control stability the percent heating power should not fluctuate more than ±1% within one minute.

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

100.00 C *Well temperature*

SET + EXIT *Access heater power in secondary menu*

12 Pct *Heater power in percent*

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

7.8.2 Proportional Band

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

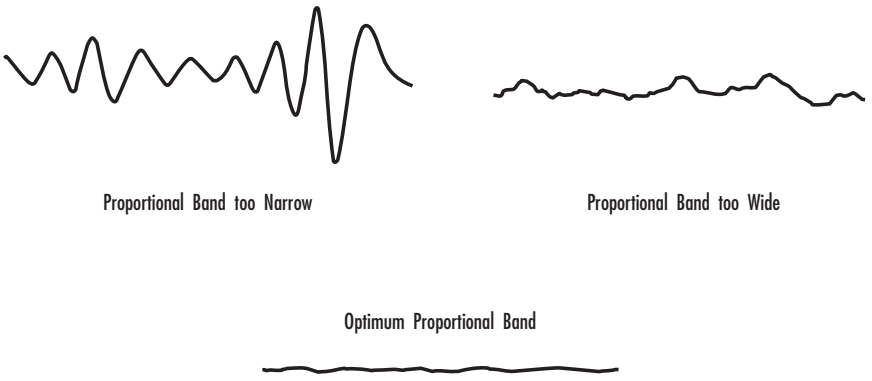


Figure 7 *Well temperature fluctuation at various proportional band settings*

The temperature stability of the well and response time depend on the width of the proportional band. See Figure 7. If the band is too wide the well temperature will deviate 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 may be altered by the user if he desires to optimize the control characteristics for a particular application.

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

SET + EXIT *Access heater power in secondary menu*

12 PcE *Heater power in percent*

SET *Access proportional band*

Pb= 4.71C *Proportional band setting*

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

Pb=10.00C *New proportional band setting*

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

SET *Accept the new proportional band setting*

7.8.3 Cut-out

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

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

The cut-out set-point may be accessed within the secondary menu. Press “SET” and “EXIT” to enter the secondary menu and show the heater power. Then press “SET” twice to access the cut-out set- point.

SET + EXIT *Access heater power in secondary menu*

12 Pct *Heater power in percent*

SET *Access proportional band*

Pb= 4.01C *Proportional band setting*

SET *Access cut-out set-point*

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

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

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

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

Accept cut-out set-point

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

7.9 Controller Configuration

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

7.9.1 Probe Parameters

The probe parameter menu is indicated by,

PrObE *Probe parameters menu*

Press “SET” to enter the menu. The probe parameters menu contains the parameters, R0, ALPHA, and DELTA, which characterize the resistance-temperature relationship of the platinum control sensor. These parameters may be adjusted to improve the accuracy of the calibrator. This procedure is explained in detail in Sectioin 10.

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

7.9.1.1 R0

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

7.9.1.2 ALPHA

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

7.9.1.3 DELTA

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

7.9.2 Operating Parameters

The operating parameters menu is indicated by,

PAr	*Operating parameters menu*

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

7.9.2.1 Temperature Scale Units

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

UnitS	*The temperature scale units selection is the first function in the operating parameters menu.*

Press “SET” to view the current setting.

Un= C	*Scale units currently set*

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

Un= F	*New units selected*

Press “SET” to accept the new selection and move to the next parameter. Press “EXIT" to ignore the new selection and move to the next parameter..

7.9.2.2 Cut-out Reset Mode

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

The parameter is indicated by,

CtorSt	*Cut-out reset mode parameter*

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

CtoSt	*Cut-out set for manual reset (default)*

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

CtoAuto	*Cut-out set for automatic reset*

Warning: *For compliance with IEC 1010-1, it is recommended that the cutout mode always be set to the manual mode requiring user intervention to reset the instrument.*

7.9.2.3 Approach

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

APPr	*Approach parameter*

Press “SET” to access the parameter setting.

APP=12	*Current approach value setting*

Press “UP” or “DOWN” to increment/decrement the value.

APP=3	*New value setting*

Press “SET” to accept the new setting and move to the next parameter. Press “EXIT” to ignore the new setting and move to the next parameter.

7.9.2.4 Soak Stability

The soak stability controls the required stability of the well temperature for the soak time (see Section 7.7.3). The stability is in degrees Celsius. The default is 0.5°C. This value can be changed in the parameter menu.

StAb	*Soak stability parameter*

Press “SET” to access the stability adjustment parameter.

4.98	*Current soak stability parameter value*

Press “UP” or “DOWN” to adjust the value.

3.00	*New value setting*

Press “SET” to accept the new value setting and return to the top of the Operating Parameters Menu. Press “EXIT” to discard the new setting and return to the top of the menu.

7.9.3 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.

7.9.3.1 Baud Rate

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

The baud rate parameter is indicated by,

bAUd	*Serial baud rate parameter*

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

1200 b	*Current baud rate*

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

2400 b	*New baud rate*

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

7.9.3.2 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, for instance, then the instrument will transmit the current measurement over the serial interface approximately every five seconds. The automatic sampling is disabled with a sample period of 0. The sample period is indicated by,

SAnPLE	*Serial sample period parameter*

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

SA= 1	*Current sample period (seconds)*

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

SA= 60	*New sample period*

7.9.3.3 Duplex Mode

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

dUPL	*Serial duplex mode parameter*

Press “SET” to access the mode setting.

dUP=FULL	*Current duplex mode setting*

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

dUP=HALF	*New duplex mode setting*

7.9.3.4 Linefeed

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

LF	*Serial linefeed parameter*

Press “SET” to access the linefeed parameter.

LF= On	*Current linefeed setting*

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

LF= OFF	*New linefeed setting*

7.9.4 IEEE-488 Parameters

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

IEEE	*IEEE-488 parameters menu*

Press “SET” to enter the menu.

7.9.4.1 IEEE-488 Address

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

AddrESS	*IEEE-488 interface address*

Press “SET” to access the address setting.

Add= 22	*Current IEEE-488 interface address*

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

Add= 15	*New IEEE-488 interface address*

7.9.4.2 Termination

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

EOS	*IEEE-488 termination*

Press “SET” to access the termination setting.

EOS=Cr	*Present IEEE-488 termination*

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

EOS=LF	*New termination selection*

Use “SET” to save the new selection.

7.9.5 Calibration Parameters

The user has access to the calibration constant CTO. This value is set at the factory and must not be altered. The correct value is important to the proper and safe operation of the calibrator. Access to this parameters is available to the user so that in the event the controller’s memory fails the user may restore the value to the factory setting.

***Caution**: DO NOT change the value of the calibration constant from the factory set value. The correct setting of this parameter is important to the safety and proper operation of the calibrator.*

The calibration parameters menu is indicated by,

CAL	*Calibration parameters menu*

Press “SET” five times to enter the menu.

7.9.5.1 CTO

Parameter CTO sets the calibration of the over-temperature cut-out. This is not adjustable by software but is adjusted with an internal potentiometer. For the 9122A dry-well calibrator this parameter should read between 710 and 750.

7.9.5.2 SCO

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

8 Digital Communication Interface

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

With a digital interface the instrument may be connected to a computer or other equipment. This allows the user to set the set-point temperature, monitor the temperature, and access any of the other controller functions, all using remote communications equipment. Communications commands are summarized in Table 2 on page 47.

8.1 Serial Communications

The calibrator is equipped 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 7, Controller Operation, with the exception of the baud rate setting.

8.1.1 Wiring

The serial communications cable attaches to the calibrator through the DB-9 connector at the back of the instrument. Figure 8 shows the pin-out of this connector and suggested cable wiring. In order to elimnate noise, the serial cable should be shielded with a low resistance between the connector (DB-9) and the shield.

RS-232 Cable Wiring for IBM PC and Compatibles

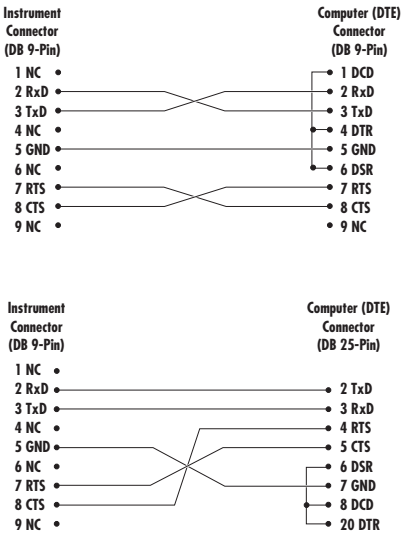


Figure 8 *Serial Cable Wiring Diagram*

8.1.2 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. The serial interface parameters menu is outlined in Figure 5.

To enter the serial parameter programming mode first press “EXIT” while pressing “SET” and release to enter

the secondary menu. Press “SET” repeatedly until the display reads “ProbE”. This is the menu selection. Press “UP” repeatedly until the serial interface menu is indicated with “SErIAL”. Finally press “SET” to enter the serial parameter menu. In the serial interface parameters menu are the BAUD rate, the sample rate, the duplex mode, and the linefeed parameter.

8.1.2.1 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 9122A serial communications may be programmed to 300, 600, 1200, or 2400 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.

8.1.2.2 Sample Period

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

8.1.2.3 Duplex Mode

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

8.1.2.4 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”.

8.1.3 Serial Operation

Once the cable has been attached and the interface set up properly the controller will immediately begin 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 8.3. All commands are ASCII character strings terminated with a carriage-return character (CR, ASCII 13).

8.2 IEEE-488 Communication

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

8.2.1 Setup

To use the IEEE-488 interface first connect an IEEE-488 standard cable to the back of the calibrator. Next set the device address. This parameter is programmed within the IEEE-488 interface menu. The IEEE-488 interface parameters menu is outlined in Figure 5.

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

8.2.1.1 IEEE-488 Interface Address

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

8.2.2 IEEE-488 Operation

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

8.3 Interface Commands

The various commands for accessing the calibrator functions via the digital interfaces are listed in this section (see Table 2). These commands are used with both the RS-232 serial interface and the IEEE-488 GPIB interface. In either case the commands are terminated with a carriage-return character. The interface makes no distinction between upper and lower case letters, hence either may be used. Commands may be abbreviated to the minimum number of letters which determines a unique command. A command may be used to either set a parameter or display a parameter depending on whether or not a value is sent with the command following a "=" character. For example "s"<CR> will return the current set-point and "s=150.00"<CR> will set the set-point to 150.00 degrees.

In the following list of commands, characters or data within brackets, "[" and "]", are optional for the command. A slash, "/", denotes alternate characters or data. Numeric data, denoted by "n", may be entered in decimal or exponential notation. 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 2 *Interface 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			Instrument Range
Read scan function	sc[an]	sc	scan: {ON or OFF}	scan: ON	
Set scan function:	**sc[an]=on/of[f]**				ON or OFF
Turn scan function on	sc[an]=on	sc=on			
Turn scan function off	sc[an]=of[f]	sc-of			
Read scan rate	sr[ate]	sr	srat: 999.99 {C or F}/min	srat: 10.0 C/min	
Set scan rate to *n* degrees per minute	sr[ate]=*n*	sr=5			.1 to 10°C
Read display temperature hold status	hm[ode]	hm	hm: {OFF or AUTO or NO or NC}		
Set display temperature hold mode:	**hm[ode]=OF[F]/AU[TO]/NO/NC**				OFF or AUTO or NO or NC
Set hold mode to off	hm[ode]=OF[F]	hm=of			
Set hold mode to automatic	hm[ode]=AU[TO]	hm=auto			
Set hold mode to normally open	hm[ode]=NO	hm=no			
Set hold mode to normally closed	hm[ode]=NC	hm=nc			
Read sample and hold	sh[old]	sh	shold:{ON or OFF}	shold:ON	
Set sample and hold	**sh[old]=on/of[f]**	sh			
Set sample and hold on	sh[old]=on	sh=on			
Set sample and hold offf	sh[old]=off	sh=off			
Read temperature	t[emperature]	t	t: 9999.99 {C or F}	t: 55.69 C	
Read hold status	ho[ld]	ho	hold:{closed or open}, 9999.99 {C or F}	ho: open, 75.0 C	
Secondary Menu					
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			Depends on Configuration
Read cut-out setting	c[utout]	c	c: 9999 {C or F}	c: 620 C	
Set cut-out setting:	**c[utout]=n/r[eset]**				
Set cut-out to *n* degrees	c[utout]=n	c=500			Temperature Range
Reset cut-out now	c[utout]=r[eset]	c=r			
Read heater power (duty cycle)	po[wer]	po	p%: 9999	po: 1	
Ramp and Soak Menu					
Read number of programmable set-points	pn	pn	pn: 9	pn: 2	
Set number of programmable set-points to *n*	pn=*n*	pn=4			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

Interface 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					
Probe Menu					
Read R0 calibration parameter	r[0]	r	r0: 999.999	r0: 100.578	
Set R0 calibration parameter to *n*	r[0]=n	r=100.324			95.0 to 105.0
Read ALPHA calibration parameter	al[pha]	al	al: 9.9999999	al: 0.0038573	
Set ALPHA calibration parameter to *n*	al[pha]=n	al=0.0038433			.00320 to .00420
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
Operating Parameters Menu					
Set temperature units:	**u[nits]=c/f**				C or F
Set temperature units to Celsius	u[nits]=c	u=c			
Set temperature units to Fahrenheit	u[nits]=f	u=f			
Read cut-out mode	cm[ode]	cm	m: {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			
Read approach setting	ap[proach]	ap	ap:9	ap:5	
Set approach setting to *n* degrees C	ap[proach]=*n*	ap=15			0 to 20°C
Read stability	ts	ts	ts:9.9	ts:0.5	
Set soak stability to *n* degrees C	ts=*n*	ts=.1			.01 to 4.99°C
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			

Interface Commands. Continued

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
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			
Read Temperature units	u[nits]	u	u:x	u:C	
Calibration Menu					
These commands are only used for factory testing.					
Read software cut-out mode	*sco	*sco	sco: {ON or OFF}	sco: ON	
Set software cut-out mode:	***sco=ON/OF[F]**				ON or OFF
Set software cut-out mode on	*sco=ON	*sco=on			
Set software cut-out mode off	*sco=OF[F]	*sco=off			
Read setpoint resistance	*sr	*sr	{999.999} ohm	110.222 ohm	
Miscellaneous (not on menus)					
Read firmware version number	*ver[sion]	*ver	ver.9999,9.99	ver.9122,3.54	
Read structure of all commands	h[elp]	h	list of commands		

Legend:

[] Optional Command data

/ 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

9 Test Probe Calibration

For optimum accuracy and stability, allow the calibrator to warm up for 30 minutes after power-up and then allow adequate stabilization time after reaching the set-point temperature. After completing operation of the calibrator, allow the well to cool by setting the temperature to 100°C or less before switching the power off.

9.1 Calibrating a Single probe

Insert the probe to be calibrated into the well of the dry-well calibrator. The probe should fit snugly into the calibrator probe sleeve 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 sleeve. 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, the test probe readout may be compared to the displayed temperature of the calibrator. The display temperature should be stable to within 0.01°C degree for best results.

***Caution**: never allow foreign material into the probe holes of the block or insert. Fluids and other materials can damage the instrument causing binding and damage to your probe.*

9.2 Comparison Calibration

Improved performance can be achieved through characterization of the equipment and the calibration technique to be performed and using a high accuracy reference thermometer for making comparison measurements. For best results, use similar probes for making these measurements. For example, two 0.25 inch diameter probes could be calibrated in the following manner. Select two similar type holes either 0.25 diameter sleeved holes or the fixed holes in the equilibration block. Carefully measure the temperature in both wells, allowing adequate stabilization time between measurements. After noting the difference between them, position both the reference thermometer and the test probe in the same two wells and again allow adequate settling time. The appropriate corrections are then made to represent the differences between the two wells. In this way calibration can be made within hundredths of a degree.

Note that a hot probe moved quickly from one hole to the other will take only about 5 minutes to reach a fully settled temperature.

9.3 Fully Loading the Calibrator

The 9122A temperature calibrator features multiple thermometer test sensor holes allowing increased throughput. Calibrating multiple probes is similar to singles. Comparison to an external reference can improve the results since the additional heat-loss created by the stems of the probes can reduce the temperature at the test sensor locations to a temperature below that indicated on the calibrator display. The amount of the discrepancy will depend on the size and number of probes to be tested as well as the magnitude of the temperature difference to ambient. Recovery time due to insertion of several probes into the calibrator will also increase. If a series of temperatures points are to be measured with the same test probes, it will be faster to leave them in the calibrator as the temperature changes are made.

Caution: *Never introduce any foreign material into the probe hole of the insert. Fluids etc. can leak into the calibrator causing damage to the calibrator or binding and damage to your probe.*

9.4 Dry-well Characteristics

9.4.1 Temperature Gradients

A dry-well type calibrator will have temperature gradients between holes limiting the accuracy of the measurement. These gradients are created by variations

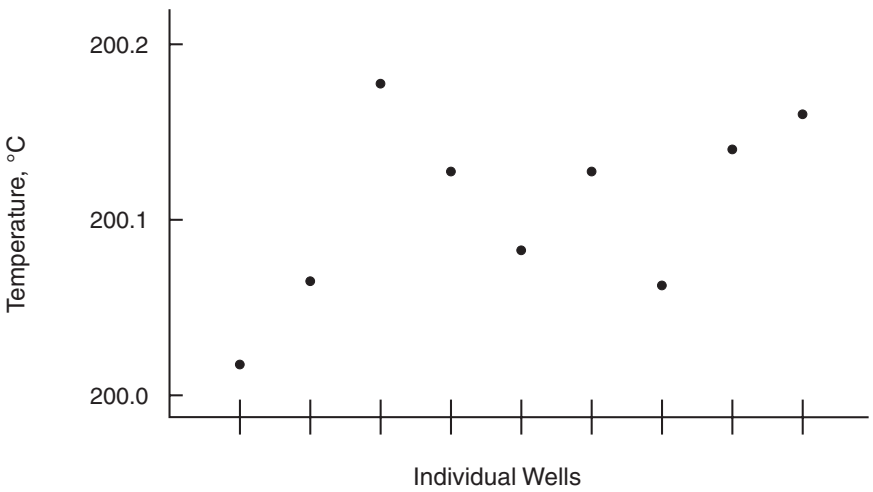


Figure 9 *Hole to Hole Temperature Deviation*

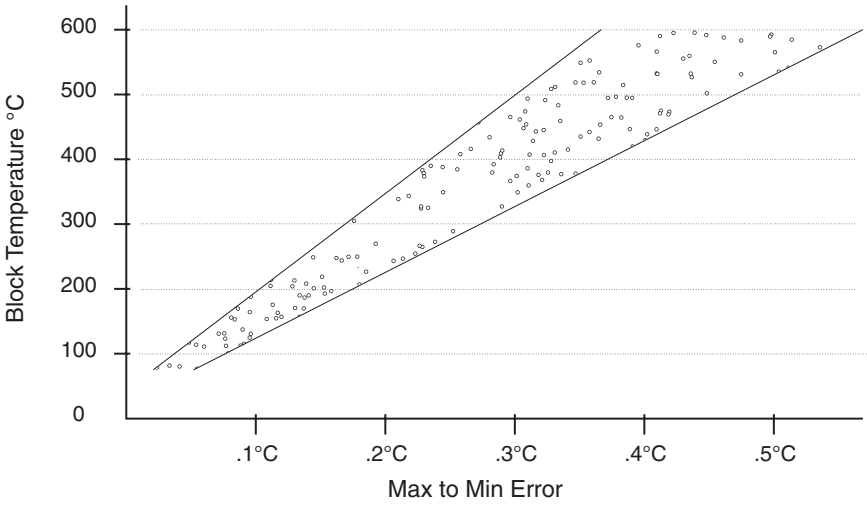


Figure 10 *Hole to Hole Temperature Deviation as a Function of Temperature*

in heat losses and their temperature effect on the block as they are propagated back to the heat source. Figure 9 charts a typical gradient condition as measured with the same thermometer, fully immersed and moved from well to well. This condition will vary somewhat from unit to unit and from temperature to temperature. Figure 10 shows the increase in gradient error as the block temperature is increased.

There is a vertical gradient in the well. The heating device 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 will vary with the number and design of the thermometer probes inserted into the calibrator.

The effect of the various heat loss created gradients can be minimized by making measurements between similar probes as they will create similar heat loss patterns.

9.4.2 Heating and Cooling Rates

Figures 12 and 11 show typical heating cooling rates of the 9122A dry-well calibrator.

You will note that the cooling is relatively slow compared to heating. It is recommended that temperature calibration sequences go from cooler to hotter temperatures to take advantage of this fact.

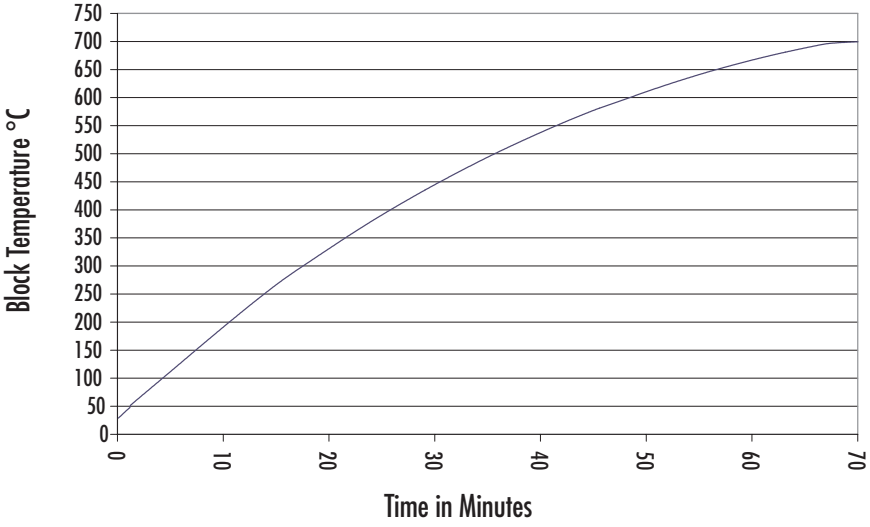


Figure 12 *Heating Rate*

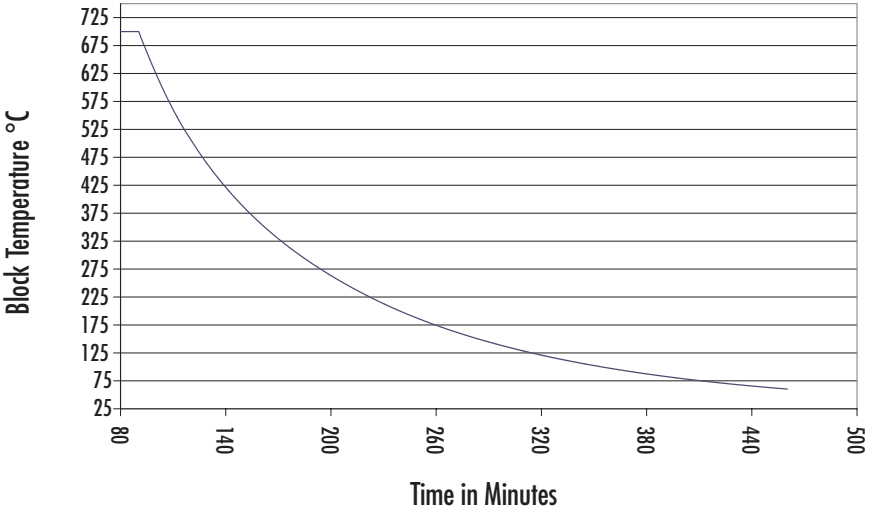


Figure 11 *Typical Cooling Rates*

9.4.3 Stabilization and Accuracy

The stabilization time of the dry-well calibrator will depend on the conditions and temperatures involved. Typically, the displayed well temperature should be

within 0.5 degree of the set-point within 15 minutes after reaching the set-point and within 0.1 degree of its final point of stability within 30 minutes. Figure 13 shows the usable calibration range prior to stabilization. Plots for specific range of interest can be used to allow calibration within a particular specification without having to wait for complete stabilization.

Inserting a cold probe into a well will require another stabilization period depending on the magnitude of the disturbance and the required accuracy. For example, inserting a 0.25 inch diameter room temperature probe into a sleeve at 300°C will take about 5 minutes to be within 0.1°C of its settled point and will take 30 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.

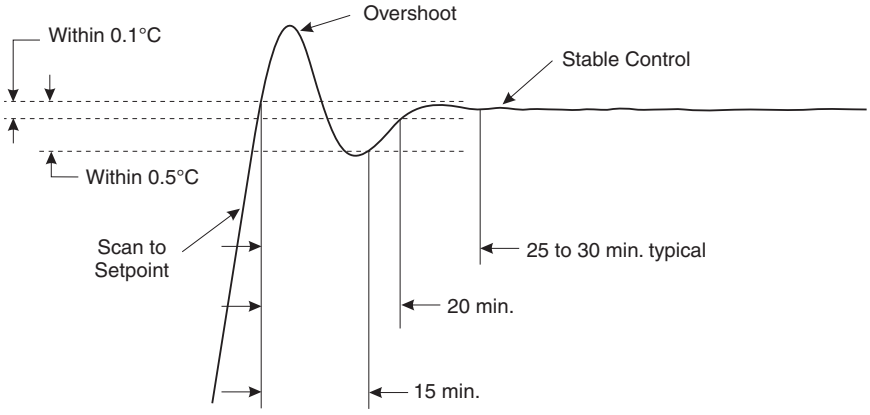


Figure 13 *Useable Calibration Range Prior to Stabilization*

10 Calibration Procedure

Sometimes the user may want to calibrate the dry-well to improve the temperature set-point accuracy. Calibration is done by adjusting the controller probe calibration constants R0 and ALPHA so that the temperature of the dry-well as measured with a standard thermometer agrees more closely with the set-point. The thermometer used must be able to measure the well temperature with higher accuracy than the desired accuracy of the dry-well. By using a good thermometer and carefully following this procedure, the calibrator can be calibrated to an accuracy of better than 0.5°C over a range of 600 degrees.

10.1 Calibration Points

In calibrating the dry-well, R0 and ALPHA are adjusted to minimize the set-point error at each of two different dry-well temperatures. Any two reasonably separated temperatures may be used for the calibration. Improved results can be obtained for shorter ranges when using temperatures that are just within the most useful operating range of the dry-well. The farther apart the calibration temperatures, the larger the calibrated temperature range will be but the calibration error will also be greater over that range. If for instance 150°C and 500°C are chosen as the calibration temperatures then the calibrator may achieve an accuracy of say ±0.2°C over the range 100 to 550°C. Choosing 200°C and 300°C may allow the calibrator to have a better accuracy of maybe ±0.05°C over the range 175 to 325°C but outside that range the accuracy may be only ±0.4°C.

10.2 Measuring the Set-point Error

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

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

10.3 Computing R0 and ALPHA

Before computing the new values for R0 and ALPHA, the current values must be known. The values may be found by either accessing the probe calibration menu from the controller panel or by inquiring through the serial interface. The user should keep a record of these values in case they may need to be restored in the future. The new values R0′ and ALPHA′ are computed by entering the old values for R0 and ALPHA, the calibration temperature set-points t_L and t_H, and the temperature errors err_L and err_H into the following equations,

$$R0' = \left[\frac{err_H\ t_L - err_L\ t_H}{t_H - t_L} ALPHA + 1 \right] R0$$

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

If for example R0 and ALPHA were previously set for 100.2695 and 0.0038319 respectively and the data for t_L, t_H, err_L, and err_H were as given above then the new values R0′ and ALPHA′ would be computed as 100.193 and 0.0038272 respectively. Program the new values R0 and ALPHA into the controller. Check the calibration by setting the temperature to t_L and t_H and measuring the errors again. If desired the calibration procedure may be repeated to further improve the accuracy.

10.4 Calibration Example

The calibrator is to be used between 125 and 325°C and it is desired to calibrate the calibrator as accurately as possible for operation within this range. The current values for R0 and ALPHA are 100.000 and 0.0038500 respectively. The calibration points are chosen to be 150.00 and 300.00°C. The measured well temperatures are 149.943 and 299.814°C respectively. Refer to Figure 14

for applying equations to the example data and computing the new probe constants.

R0 = 100.000

ALPHA = 0.0038500

t_L = 150.00°C

measured t = 149.943°C

t_H = 300.00°C

measured t = 299.814°C

Compute errors,

err_L = 149.943 - 150.00°C = -0.057°C

err_H = 299.814 - 300.00°C = -0.186°C

Compute R0′,

$$R0' = \left[\frac{(-0.186) \times 150.0 - (-0.057) \times 300.0}{300.0 - 150.0} 0.00385 + 1 \right] 100.000 = 99.972$$

Compute ALPHA′,

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

Figure 14 *Calibration Example*

11 Maintenance

- The calibration instrument has been designed with the utmost care. Ease of operation and simplicity of maintenance have been a central theme in the product development. Therefore, with proper care the instrument should require very little maintenance. Avoid operating the instrument in an oily, wet, dirty, or dusty environment.
- 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 the wire brush and cleaning kit provided with the instrument. Ensure that any material removed from the well by the wire brush is either blown from the well with forced air or removed with a soft cloth or “mop” provided.
- This instrument operates at extremely high temperatures and the sleeves can become covered with oxide. If the buildup becomes too thick, it could cause the sleeves to become jammed in the wells. Avoid this build up by buffing the sleeves clean with a Scotch-Brite® pad or emery cloth after each use. DO NOT leave the sleeves in the instrument for prolonged periods without removing them and buffing them clean.
- 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.
- The dry-well calibrator should be handled with care. Avoid knocking or dropping the calibrator.
- If a sleeve should be dropped, examine the sleeve for deformities before inserting it in the well. If there is any chance of jamming the sleeve in the well, file or grind off the protuberance.
- Do not drop 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, contact a Hart Scientific Authorized Service Center for more information.
- Before using any cleaning or decontamination method except those recommended by Hart, users should check with a Hart Scientific Authorized Service Center 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 dry-well may be impaired or safety hazards may arise.
- The over-temperature cut-out should be checked every 6 months to see that it is working properly. In order to check the user selected cut-out, follow the controller directions (Section 7.2) for setting the cut-out. Both the manual and the auto reset option of the cut-out should be checked. Set the instrument temperature higher than the cut-out. Check to see if the display flashes cut-out and the temperature is decreasing.

12 Troubleshooting

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

In the event that the dry-well 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 dry-well seems faulty or the problem cannot otherwise be solved, contact a Hart Scientific Authorized Service Center (see Section 1.3) for assistance. Be sure to have the instrument model number, serial number, and voltage available.

12.1 Troubleshooting

Problem	Possible Causes and Solutions
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 re-programmed for R0, ALPHA, and DELTA. These numbers can be found on the Report of Calibration that was shipped with the unit.
The display is off	Check the fuses. Check that the power cord is plugged in and connected to the unit.
Red LED on display is blank	Check that there is power to the unit.
The unit heats slowly	Check the Scan and Scan Rate settings. The Scan may be on with the Scan Rate set low.
An "o" or "c" is displayed at the left of the display	The external switch is open causing the displayed temperature to be frozen and keeping the set-point from scanning. Turn the Switch Test off by pressing the "DOWN" button on the front panel.
Error code is displayed	Initialize the system by performing the Master Reset Sequence. If the unit repeats the error code, contact Hart Scientific Customer Support for a return authorization and for instructions on returning the unit. Master Reset Sequence: Hold the "SET" and "EXIT" keys down at the same time while powering up the unit. The screen will display "-init-", the instrument model number 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.
Display flashes "-273° C" or "-459° F"	The sensor is disconnected or shorted. Please contact a Hart Scientific Authorized Service Center for further instructions.

Problem	Possible Causes and Solutions
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.
Display flashes "cut-out"	The software cut-out is set too low. Check the cut-out setting in the Set-point menu.
Temperature readout is not the actual temperature of the well	With the unit stable, slowly rotate the unit. If no change occurs, the unit may need to be calibrated. Contact a Hart Scientific Authorized Service Center. If the display changes more than twice the normal display deviation, another unit in the area could be emitting RF energy. Move the unit to a different location and rotate the unit again. If the temperature is correct in this new area or deviates differently than the first area, RF energy is present in the room. If you have to perform the test in the effected area, use the comparison test to eliminate any possible errors.

12.2 Comments

12.2.1 EMC Directive

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

The instrument was designed specifically as a test and measuring device. Compliance to the EMC directive is through IEC 61326-1 *Electrical equipment for measurement, control and laboratory use – EMC requirements (1998).*

As noted in the IEC 61326-1, the instrument can have varying configurations. The instrument was tested in a typical configuration with shielded RS-232 cables.

12.2.1.1 Immunity Testing

The instrument was tested to the requirements for laboratory locations. Criterion B was used for Radiated RF (IEC 61000-4-3). Therefore, the operation of the instrument may be affected by excessive electromagnetic interference and the instrument may not perform within the normal specification limits in such an environment. Criterion C was used for Electrostatic Discharge (ESD, IEC 61000-4-2). If the instrument is subjected to ESD conditions, the instrument may require the user to cycle the power to return to normal operation.

12.2.1.2 Emission Testing

The instrument fulfills the limit requirements for Class A equipment but does not fulfill the limit requirements for Class B equipment. The instrument was not designed to be used in domestic establishments.

12.2.2 Using Clamp-On Ferrites

When using the Display Hold feature (See Section 7.6, Display Hold), we advise that you place a clamp-on ferrite around the wires of the thermal switch as indicated in Figure 15 on page 65. The instrument was tested in accordance with IEC 61326-1 (1998) which indicates in Section 4 of the IEC Standard that the manufacturer shall provide pertinent information if the emissions exceed required limits of the standard when the instrument is connected to a test object. When a thermal switch is attached to the instrument, the emission limits of the standard may be exceeded through the switch. Therefore, we advise that a ferrite be attached as indicated.

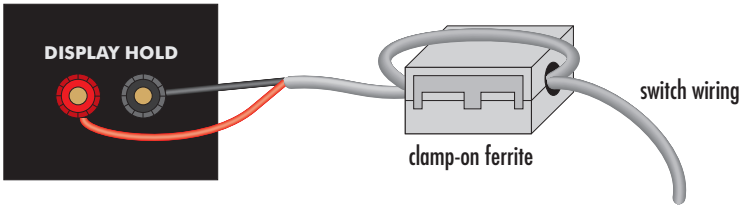


Figure 15 *Using clamp-on ferrites*

12.2.3 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.

12.3 Wiring Diagram

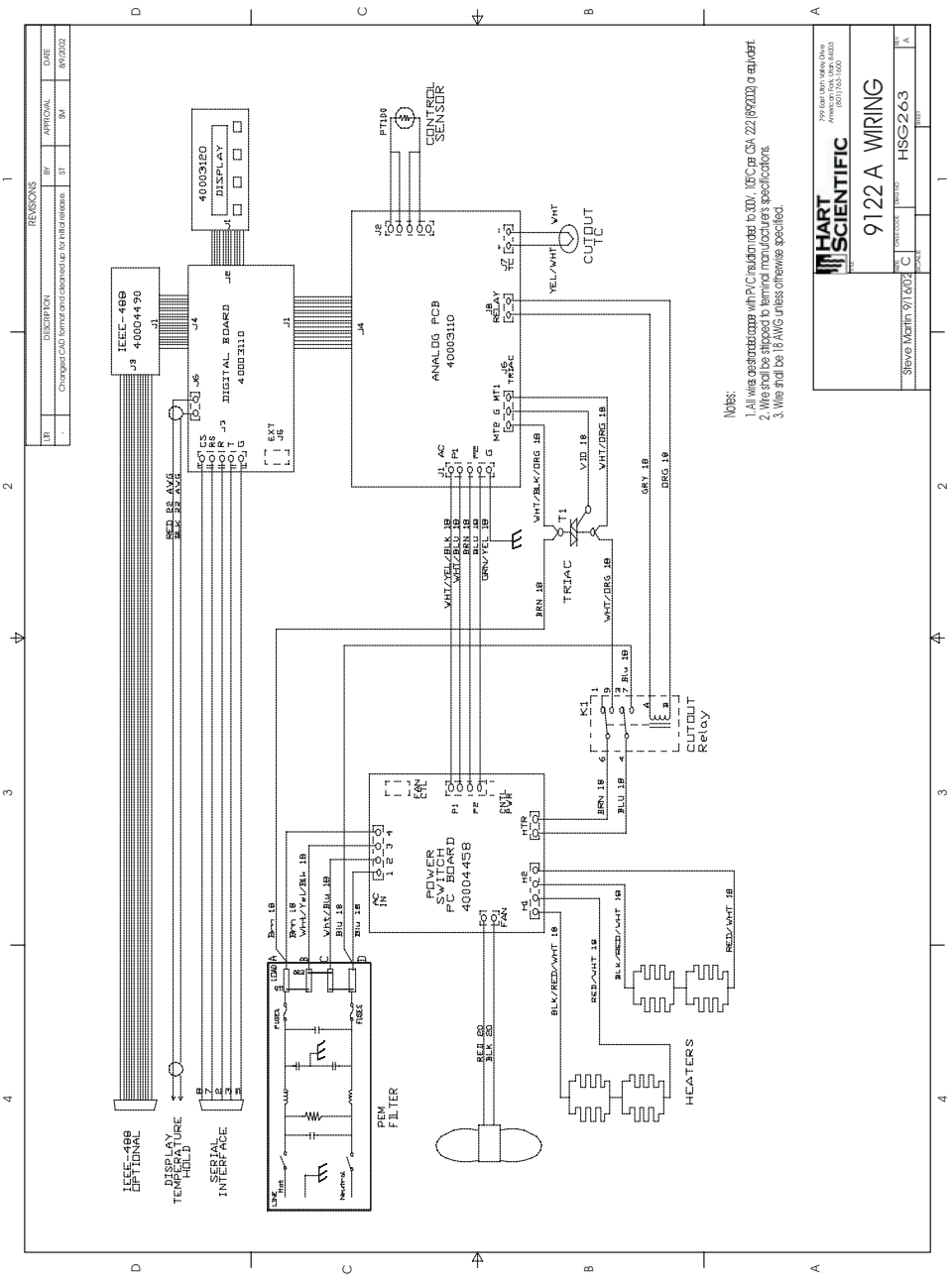


Figure 16 *Wiring Diagram*