9112 Calibration Furnace

User Manual

Hart Scientific

CE

Rev. 770601

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WARNING

To ensure the safety of operating personnel, and to avoid damage to this equipment:

DO NOT operate this unit without a properly grounded, properly polarized power cord.

DO NOT connect this unit to a non-grounded, non-polarized outlet.
DO USE a ground fault interrupt device.

WARNING

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.

WARNING

This unit contains ceramic fiber or other refractories, which can result in the following:

May be irritating to skin, eyes, and respiratory tract.

May be harmful if inhaled.

May contain or form cristobalite (crystalline silica) with use at high temperatures (above 1600°F) which can cause severe respiratory disease.

Possible cancer hazard based on tests with laboratory animals. Animal studies to date are inconclusive. No human exposure studies with this product have been reported.

Service personnel coming into contact with these materials should take proper precautions when handling them. Before maintaining this equipment, read the applicable MSDS (Material Safety Data Sheets).

WARNING

HIGH TEMPERATURES PRESENT
in this equipment
FIRES AND SEVERE BURNS
may result if personnel fail to observe safety precautions.

WARNING

To ensure the safety of personnel, and to avoid damage to equipment:

DO NOT use this unit for any application other than calibration work.

DO NOT use this unit in environments other than those listed in the user's manual.

Continuous use of this equipment at high temperatures for extended periods of time requires caution.

Completely **unattended high temperature operation is not recommended** for safety reasons.

Components and heater lifetimes can be shortened by continuous high temperature operation. Follow all safety guidelines listed in the user's manual.

WARNING

CALIBRATION EQUIPMENT SHOULD ONLY BE USED BY TRAINED PERSONNEL.

Table of Contents

1 Introduction

The Model 9112 Calibration Furnace was designed specifically for calibrating PRT's, fiber optic sensors and thermocouples at higher temperature ranges up to 1100°C. The furnace utilizes an equilibration block capable of making comparison measurements on multiple probes. The standard equilibration block is sized for 1/4 inch probes, however, custom options are possible. Temperature stability is better than ±0.1°C throughout the range and the gradient between wells at full insertion is less than 0.5°C (±0.25°C).

The temperature control system utilizes a digital controller with a Type K thermocouple control sensor.

An RS-232 interface is optional. The controller displays the set temperature and the actual temperature simultaneously. The display shows temperature to the nearest degree in °C or °F(normally shipped in °C, may be changed to °F). The temperature is set with convenient up and down buttons on the front panel.

Sensors being calibrated as well as the furnace itself are protected from excessive temperature with an over-temperature cut-out. The cut-out is easily adjusted from the front panel. This device is relay operated and protects against the possibility of thermal runaway due to a shorted solid state relay which controls the heaters.

2 Specifications and Environmental Conditions

2.1 Specifications

Table 1. Specificatins

Operating Range	300°C to 1100°C
Stability	300°C ±0.05°C 500°C ±0.05°C 700°C ±0.1°C 1000°C ±0.1°C 1100°C ±0.1°C
Uniformity	300°C ±0.05°C 500°C ±0.08°C 700°C ±0.2°C 1000°C ±0.25°C 1100°C ±0.3°C
Stabilization Time	Typically 2 house midrange, slower at low temperature end (4 hours), faster at high temperature end
Heater Power	3700 Watts High 925 Watts Low
Power Requirements	230 VAC (±10%), 50/60 Hz, 20 A
Outside Dimensions	18” H x 14.25”W x 26”D (457mm x 362mm x 660mm)
Weight	72.5 lbs

2.2 Environmental Conditions

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

The instrument operates safely under the following conditions:

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

2.3 Warranty

The 9112 Metrology furnace is covered by a 1 year warranty that takes effect 10 days after the product is shipped. The manufacturer will provide parts and labor without charge for repair or replacement of the instrument due to defects in material or workmanship. The warranty will not apply if the product has not been used according to the instruction manual or has been tampered with by the user. For service or assistance, please contact the manufacturer.

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3 Safety Guidelines

- Operate the instrument in room temperatures between 5-50°C (41-122°F). Allow sufficient air circulation by leaving at least 6 inches of space between the furnace and nearby objects. Frontal clearance needs to allow for safe and easy insertion and removal of probes for calibration.
- The furnace is a precision instrument. Although it has been designed for optimum durability and trouble free operation, it must be handled with care. The instrument should not be operated in wet, oily, dusty or dirty environments. It is important to keep the well of the instrument free of any foreign matter. Do not operate near flammable materials.
- **DO NOT** use fluids to clean out the well.
- The furnace generates extreme temperatures. Precautions must be taken to prevent personal injury or damage to objects. Probes may be extremely hot when removed from the furnace. Cautiously handle probes to prevent personal injury. Carefully place probes on a heat resistant surface or rack until they are at room temperature.
- Use only a grounded AC mains supply of the appropriate voltage to power the instrument. The furnace requires 20 amps at 230 VAC (±10%), 50/60 Hz.
- Before initial use, after transport, and anytime the furnace has not been energized for more than 10 days, the instrument needs to be energized for a “dry-out” period of 1-2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1.
- The instrument is not equipped with easily accessible fuses. The fuses are located inside the control drawer. We do not recommend replacing the fuses without calling Hart Scientific Customer Service first.
- If a mains supply power fluctuation occurs, immediately turn off the furnace. Power bumps from brown-outs and black-outs can damage the instrument. Wait until the power has stabilized before re-energizing the furnace.
- The unit is not considered portable. Once installation is complete, the unit should not be moved unnecessarily. If the unit must be moved, wait until the unit is cooled to less than 100°C. It is advisable that two people lift the unit carefully by placing their hands underneath the control drawer. Lift simultaneously being careful not to tip the unit. **Be sure that the block is removed before moving the unit. The quartz glass liner is extremely fragile.**

4 Installation

4.1 Unpacking & Inspection

The furnace has been carefully packed for safe shipment by traditional means. Unpacking should be done carefully. Check carefully for all parts. If any damage has occurred, you should notify the shipper immediately and make the appropriate claim.

The equilibration block assembly has been packed separately in order to protect the quartz tube from breakage during shipment. The block assembly should not be installed into the furnace until it has been placed in its final location.

Verify that the following components are present:

- Furnace
- 2 - Thermocouples
- Equilibration Block Assembly (2 pieces)
- Diskette
- Manual

4.2 Location

The furnace is intended to be installed into any typical calibration facility environment. The best results from the furnace are realized if the temperature fluctuations in the room are not excessive. A minimum of 6 inches free air space around the furnace must be allowed. This air space allows air exchange to occur and safely remove excess heat from the furnace.

WARNING

This furnace is intended for high temperature use and consequently a fire danger exists. Keep away from flammable materials and keep fire extinguishing equipment near by.

Extremely humid environments may require startup on low heat after long periods of disuse.

4.3 “Dry-out” Period

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

4.4 Power

The furnace utilizes a ground AC supply of 230 VAC(±10%), 20 amps, single phase, 50/60 HZ. An eight foot 14 AWG, 2 conductor with ground, power cord is provided.

4.5 Equilibration Block Assembly Installation

After the furnace has been installed and permanently located, the equilibration block assembly may be inserted. Carefully insert the block assembly into the tube with its insulation packing per Figure 1 on page 16. Extreme care should be taken installing the Equilibration Block since it is very heavy and the quartz tube is very fragile. A 1/8 to 1/4 inch air gap between the front access plate and the front panel of the furnace is required in order to prevent the front panel from getting too hot. Care must be taken to prevent dirt, insulation, or anything else from getting between the block and the quartz tube or it might break during heat up due to thermal expansion differences. The fit between the block and the tube is typically loose in order to accommodate this expansion.

WARNING

If the furnace must be moved for any reason, remove the block assembly to prevent breakage of the quartz tube.

4.6 Probe Installation

Install the temperature control and over temperature cut-out probes from the back as shown in Figure 1 on page 16 and Figure 3 on page 18. Insert the probes carefully to the depth shown in order to insure that the sensor is properly located in the equilibration block. The control probe should be inserted through the guard cover first so that the cover can be properly installed afterward. Position the rear guard block as shown and then insert the insulation (ceramic fiber, see MSDS in the Appendix) being careful not to bend the probe sheath. The insulation should generally

block air movement in and out of the back of the quartz tube. Install the Guard Cover to prevent physical contact with parts that become dangerously hot when in use. Be sure to connect the probes properly on the rear panel.

5 Parts and Control

5.1 Front View

See Figure 2 on page 17.

5.1.1 Temperature Controller

The temperature controller is a full PID microprocessor based instrument as indicated. The controller is set to cover the range of 0 to 1100°C and features two LED type displays. The upper display normally indicates the actual temperature while the lower display indicates the set temperature. The displays are also utilized in setup and alarm functions. Other indicators include the OP1 and OP2 indicator lights. The OP1 indicator lights when the heater is on. The OP2 is not functional in this unit. The “R” indicator lights during programmed ramping. The “M” indicator flashes if the sensor fails. If the sensor opens, the heaters shuts off.

The up and down Temperature Adjustment arrow keys are the only temperature controllable controls normally used. A quick single stroke increments or decrements the temperature setting. Holding the buttons down causes a gradual acceleration of the temperature setting. These same buttons are used to adjust other parameters in conjunction with the “PAR” button.

Further information about the controller operation can be obtained from the temperature controller installation and operation manual.

5.1.2 Over Temperature Cut-out

The over temperature cut-out is located on the left side of the control panel. The controls include a temperature limit adjustment control knob calibrated in Celsius and a “temperature limited” indicator light. The cut-out is adjustable by the user within the temperature range of the furnace with divisions shown every 25°C. The indicator light turns on when the set limit is reached and automatically resets when the temperature has dropped about 20 degrees.

The cut-out is provided to allow the user to set the maximum furnace temperature to a point within the safe range of sensor(s) being calibrated and to protect the furnace from exceeding its own safe operating range. Limiting the top end also helps extend the life of the heaters.

The cut-out controls a relay which is wired in series with the heater circuit. The cut-out is provided as a safety backup in case the solid state relay driven by the temperature controller fails (shorts) causing thermal runaway.

5.1.3 Power and Heater Switches

The power switch is located just left of the temperature controller. The top is pressed inward to turn the unit on. Note: The internal fans are wired ahead of the switch so that they stay on until the unit is cooled even though the main power may have been turned off. This way the outer surfaces of the enclosure are not heated to dangerous levels from stored heat.

The heater switch provides two levels of power to the heaters. The LOW position switches the two furnace heaters into a series circuit while the HIGH position connects them in parallel. The low heat generally provides the highest stability while the HIGH position reduces the time spanning from a lower to a higher temperature.

5.2 Heater Assembly

The heater is made of a fiber ceramic insulating material with heating elements imbedded. The heater is made in two halves, each with a separate heating element. The heating elements are wired to the heating power switch so as to switch between series and parallel circuits allowing HIGH and LOW heating positions.

The heater is primarily a radiating device and is rated for a maximum furnace operating temperature of 1100°C. Realize, however, that the higher the operating temperature the lower the lifetime of the heater. Limiting the number of hours at the extreme high end of the temperature range to only the time required for calibrations increases the longevity of your furnace heating element. Likewise, using the LOW heat position reduces the watt density of the heater and increases lifetime.

5.2.1 Equilibration Block Assembly

The equilibration block assembly consists of 1) the test well, 2) access tubes and endplate, 3) the front and rear guard blocks, 4) insulation on each end and 5) the

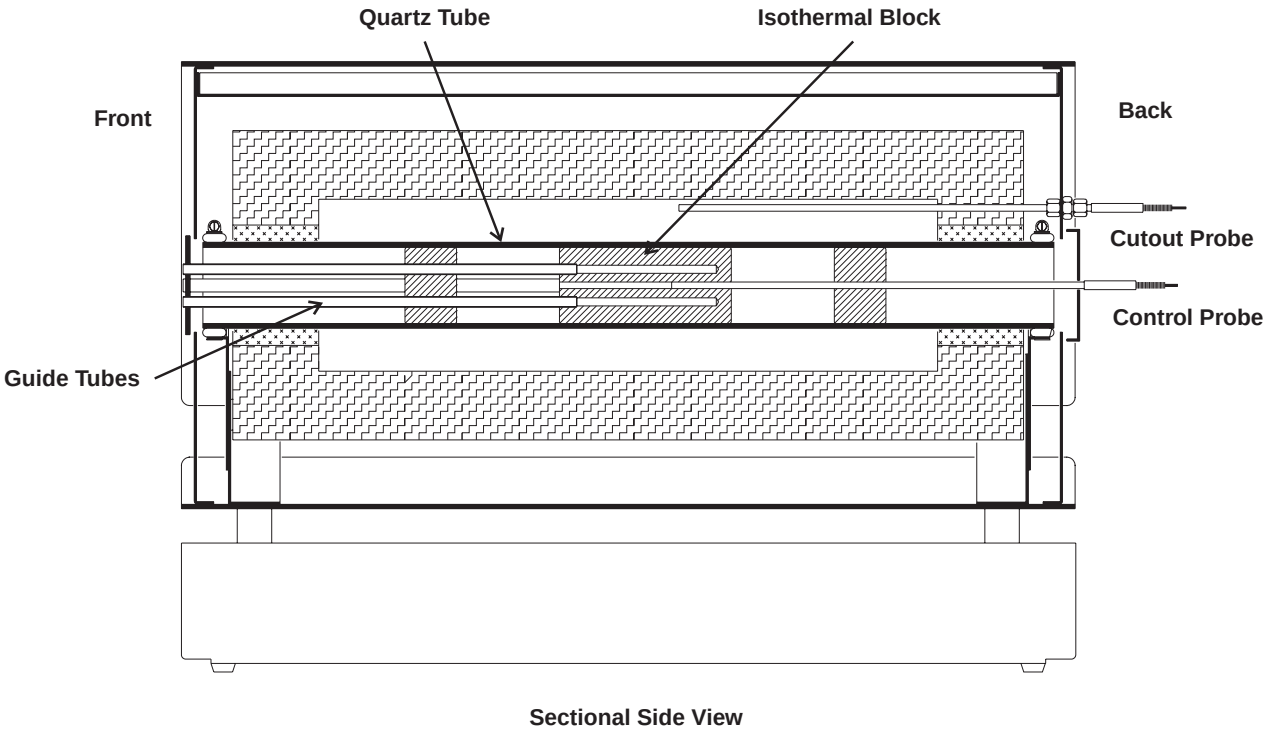

Figure 1. Side View

center block. The center block is intended to stabilize the temperature fluctuations and to conduct heat between the test wells in order to equalize them. The guard blocks shunt heat to the various probes to reduce heat loss out the ends. The whole assembly is supported by a quartz tube. All heated materials are quartz, ceramic fiber, or INCONEL (alloy 600).

5.2.2 Temperature Control and Cut-out Sensor

The temperature control sensor is a Type K Thermocouple as indicated. This sensor is grounded to the INCONEL sheath which is 3/16 inch in diameter and 16 inches long. Its location in the block is important and can cause the gradient in the block to move back and forth as the probe is moved back and forth. The probe is normally inserted as shown in Figure 1.

The cut-out sensor is the same as the control sensor except in length, 12 inches instead of 16 inches long. This sensor is inserted through a fitting into the space between the heating element and the quartz tube. Its location here helps prevent the heater elements from overheating thus prolonging their life.

The sensor connectors are provided on the rear panel of the furnace for connecting the control and cut-out thermocouples sensors. They are Type K miniature connectors and allow for ease of system assembly and sensor replacement.

5.3 Back View

See Figure 3 on page 18.

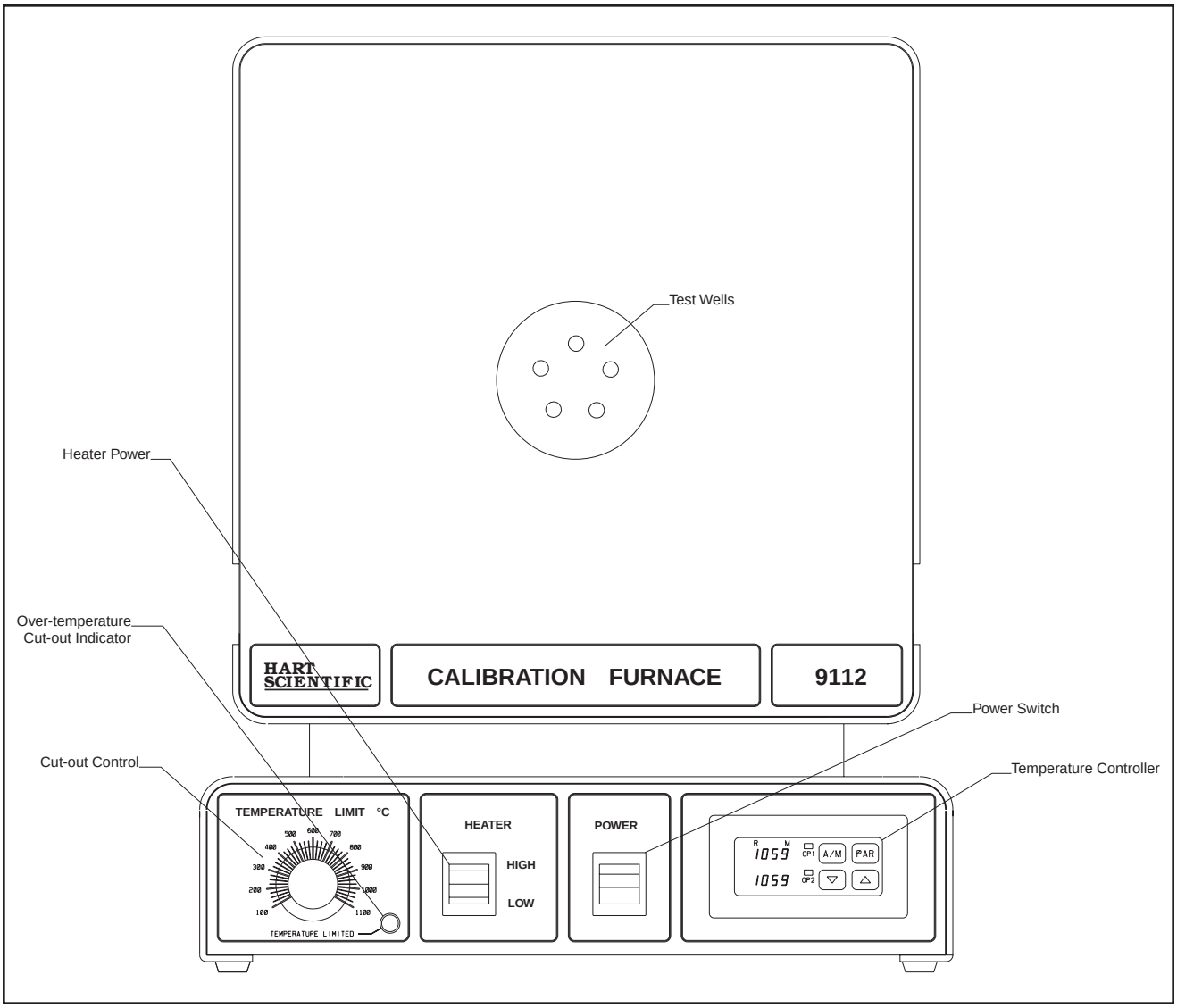

Figure 2. Front View

5.3.1 The Power Cable

The furnace is provided with a 14 gauge two conductor with ground power cable. The user must provide a connector to meet the needs of the installation. Be sure to follow electrical codes and ground the green conductor appropriately. The hot wires are white and black.

5.3.2 Nomenclature

The nomenclature on the rear panel of the furnace provides important information to the user in case service is required. The nomenclature includes the manufacturer, manufacturer location, model number, and serial number specific to this unit. Refer to the model and serial numbers whenever service is required.

5.3.3 Fuses

Two 20 amp fuses are used to protect the system, one for each leg of the 230 VAC power. The fuses are located inside the control cabinet. If the furnace fails to operate, check these first.

A 1 amp fuse is located inside the control cabinet for the controller.

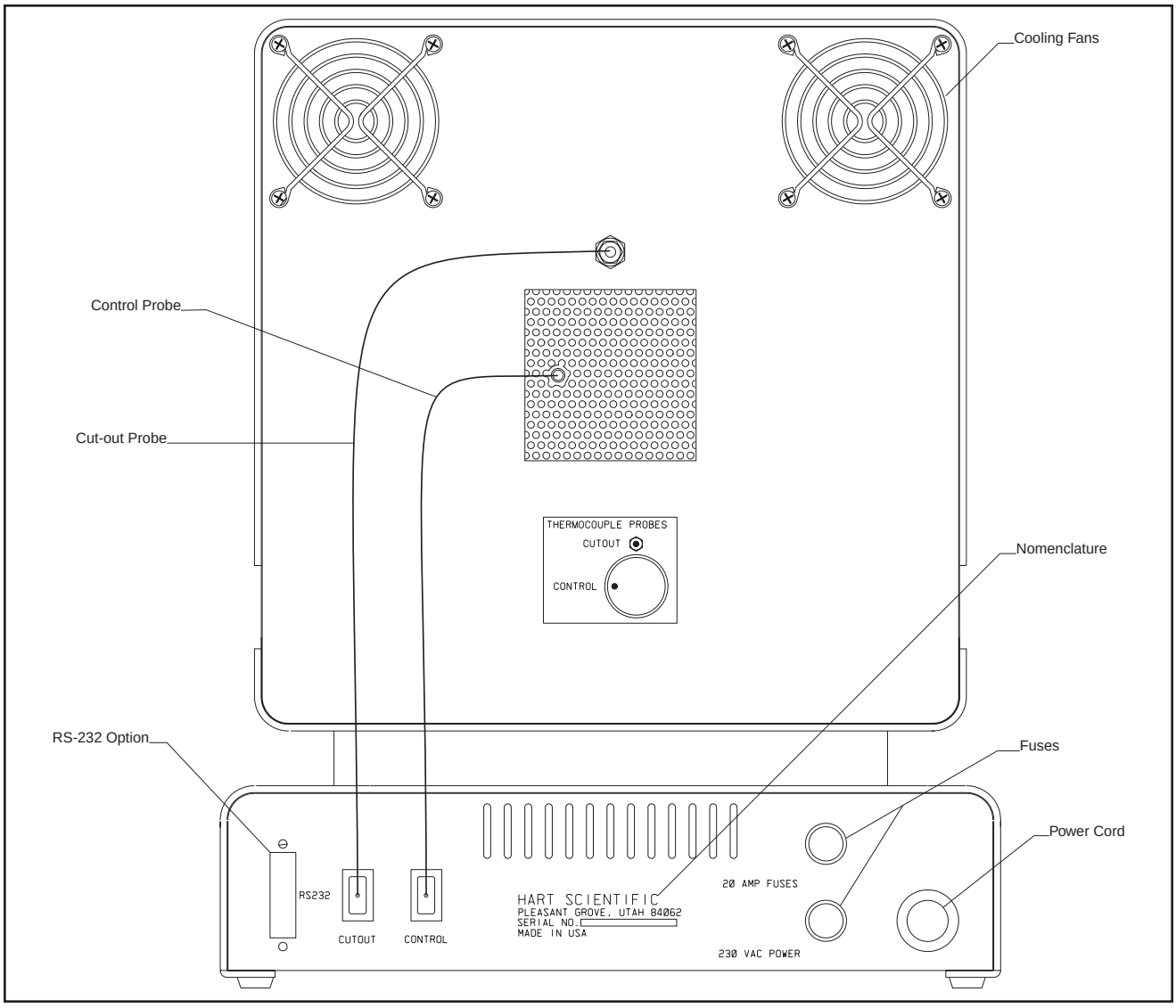

Figure 3. Back View

6 Operation

6.1 Overview

The Model 9112 is basically a temperature controlled furnace utilizing a full PID micro-processor based temperature controller with a Type K thermocouple temperature sensor. The temperature controller sends a time proportional signal to the solid state relay which regulates the current to the heater. The heater power can be switched to HIGH or LOW power positions. The object of the temperature control is the equilibration block with test wells containing the reference probe and the sensors to be calibrated inside. The block provides a thermal mass which tends to stabilize the temperature and reduce the gradients between the test wells. The user settable "over-temperature cut-out" can open the heater circuit with a relay if the safe temperature for the test probe or for the furnace is exceeded. The enclosure is designed to limit the heat seen by the various components of the furnace as well as the user. The control section is in a separate cabinet below the furnace heat preventing damage or accuracy errors. The furnace part of the cabinet contains ventilation holes as well as two fans controlled by the thermostat. This cooling capability prevents the surface of the enclosure from getting dangerously hot. In the event that the fans should fail, a second thermostat is installed in the cabinet which shuts down the furnace heaters if the cabinet exceeds a safe temperature.

6.2 Operating the Furnace

Operating the Model 9112 is straight forward once you have grasped all the important principles.

Temperature selection is accomplished by using the up and down arrow keys on the front of the temperature controller. The lower display indicates the new temperature setting while the upper display shows the actual temperature. When scanning from one temperature to another, notice that the temperature controller seems to be ahead of the equilibration block temperature. This difference is because the temperature control sensor is near the outside of the block and it takes some time for the heat to conduct into the center. Depend on an external temperature monitor to establish when the equilibration block has reached the desired temperature and achieved stability.

The actual temperature indication made by the temperature controller is not intended to be a calibration reference, but to merely provide a general indication of the furnace temperature. NIST traceable standard thermometers are available and should be used in making comparison measurements. For less stringent measurements you may make a calibration of the controller and control probe at particular temperature points and use that with reasonable accuracy for a time.

Use the heater power switch in HIGH heat position for rapid scanning between temperatures and switch to LOW for controlling when possible (to 900°C).

WARNING

Take care that all sensors used as references or being calibrated in the furnace are capable of withstanding the desired temperature range to be used.

WARNING

Take extreme care in handling hot probes. The extreme temperatures generated in a furnace of this type can cause serious personal injury. Do not touch them on external surfaces of the furnace or set them on any other surfaces unable to withstand those temperatures. A fire hazard exists. Do not touch the access tube end plate or severe burns can result.

Some kind of metal and/or ceramic fiber surface or container should be used to set the hot probes on to prevent injury, damage, and fire.

For best results, all reference or sample probes should be inserted into the full depth of the well. At this position the stability is the highest and the gradient the lowest. Each user should satisfy themselves as to what the uncertainties are in terms of stability and gradients between the test wells. Variations in equipment, probe size, configuration, etc affect these important factors. A solid (unstirred) mass such as in a furnace is subject to heat losses from the probe stem which varies from probe to probe and temperature to temperature. Typically, stabilities are less than ±0.1°C and can be as little as ±0.015°C at 500°C. Similarly, gradients between the measuring cells can range from ±0.2°C to well under ±0.1°C. For calibrations that must be less than full insertion into the test well, make your own compari-

sons between the reference and test cell at that depth to establish the uncertainties.

The furnace can be used throughout the temperature range of 300 to 1100°C. Lower temperatures are sluggish however. High integrating values are required to maintain controller stability (1200 sec) at the lower temperatures. Around 100°C the control and cut-out probes need to be reserved. This allows response for the sensor since the cut-out probe is near the heater. Be sure to put them back for higher temperatures. Expect some offset from the indicated temperature and the actual temperature. Stability and gradients between test wells are similar at higher temperatures but time to stability is much longer.

7 Digital Communication Interface

To control the furnace through a computer connected to the furnace over a serial cable, follow the instructions listed below. The program supplied is a demo program and may be altered by you for your specific needs.

First make the appropriate cable assembly for your computer system. The serial communications cable attaches to the calibrator through the DB-9 connector at the back of the instrument. Figure 4 shows the pinout of this connector and suggested cable wiring. To eliminate noise, the serial cable should be shielded with low resistance between the connector (DB-9) and the shield.

Connect the appropriate connectors to your computer and to the furnace. To communicate with the furnace:

- Load GWBASIC
- Load and then run the program TC847.BAS
- Set the Baud Rate on the Controller of the 9112 to 9600
- Set the address of your furnace to 10 or greater
- Set the temperature or if needed the furnace parameters. A listing of the parameters and their meaning are in the following table.

Table 2. Command Parameters

PV	process value (temperature)
SL	set-point
OP	output power
XP	proportional band
TI	integration time
TD	derivative time

To set a parameter, simply type in the parameter and the value. For example, to set the control temperature to 800°C, type SL=800.

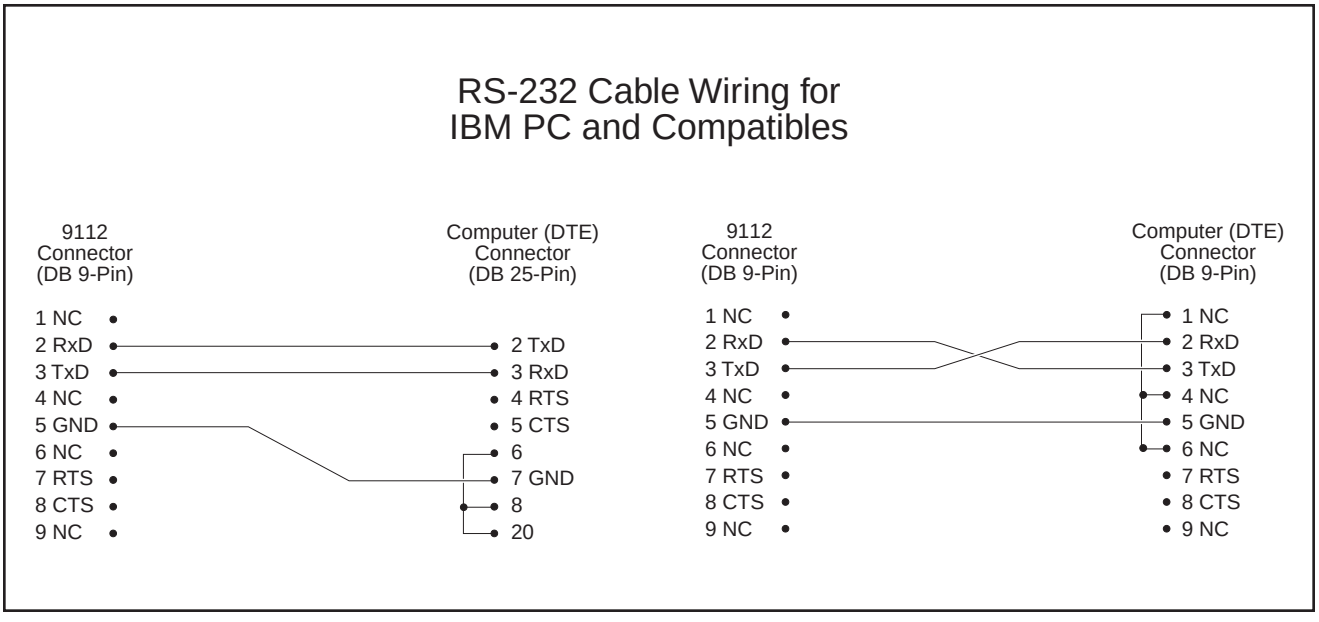

Figure 4. Serial Cable Wiring

8 Maintenance

The calibration instrument has been designed with the utmost care. Ease of operation and simplicity of maintenance have been a central theme in the product development. Therefore, with proper care the instrument should require very little maintenance. Avoid operating the instrument in an oily, wet, dirty, or dusty environment.

- If the outside of the instrument becomes soiled, it may be wiped clean with a damp cloth and mild detergent. Do not use harsh chemicals on the surface which may damage the paint.
- Be sure that the well of the furnace is kept clean and clear of any foreign matter. **Do not** use fluids to clean out the well.
- If a hazardous material is spilt on or inside the equipment, the user is responsible for taking the appropriate decontamination steps as outlined by the national safety council with respect to the material.
- If the mains supply cord becomes damaged, replace it with a cord with the appropriate gauge wire for the current of the instrument. If there are any questions, call Hart Scientific Customer Service for more information.
- Before using any cleaning or decontamination method except those recommended by Hart, users should check with Hart Scientific Customer Service to be sure that the proposed method will not damage the equipment.
- If the instrument is used in a manner not in accordance with the equipment design, the operation of the furnace may be impaired or safety hazards may arise.
- The over-temperature cut-out should be checked every 6 months to see that it is working properly.

9 Wiring Diagram

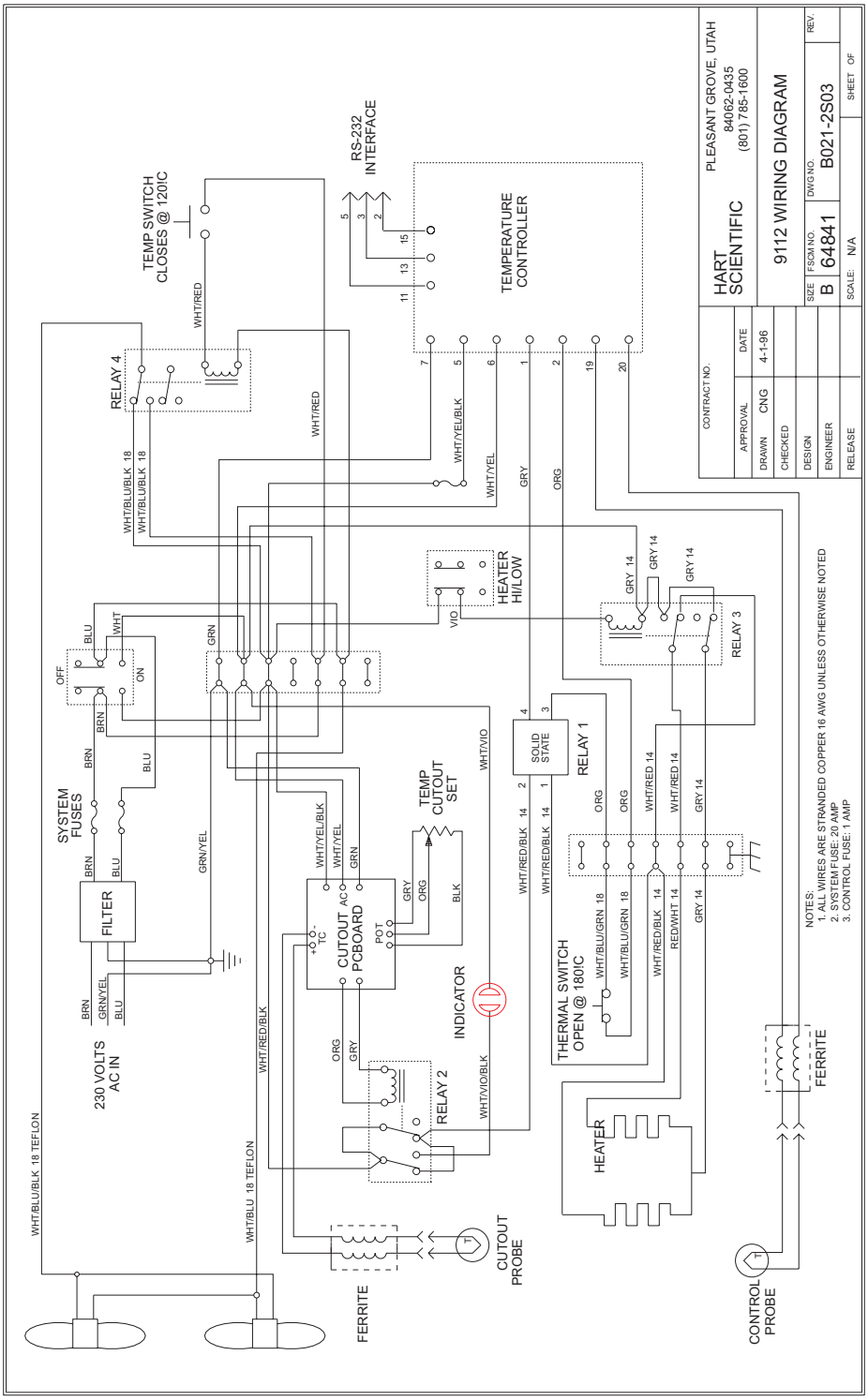

Figure 5. Wiring Diagram

10 Appendix A - Fairfax Material Safety Data Sheet