FLUKE ®

Hart Scientific ®

# 6055

## Calibration Bath User's Guide

Rev. 5A1102

## Limited Warranty & Limitation of Liability

Each product from Fluke Corporation, Hart Scientific Division ("Hart") is warranted to be free from defects in material and workmanship under normal use and service. The warranty period is one year for the Calibration Bath. The warranty period begins on the date of the shipment. Parts, product repairs, and services are warranted for 90 days. The warranty extends only to the original buyer or end-user customer of a Hart authorized reseller, and does not apply to fuses, disposable batteries or to any other product which, in Hart's opinion, has been misused, altered, neglected, or damaged by accident or abnormal conditions of operation or handling. Hart warrants that software will operate substantially in accordance with its functional specifications for 90 days and that it has been properly recorded on non-defective media. Hart does not warrant that software will be error free or operate without interruption. Hart does not warrant calibrations on the Calibration Bath.

Hart authorized resellers shall extend this warranty on new and unused products to end-user customers only but have no authority to extend a greater or different warranty on behalf of Hart. Warranty support is available if product is purchased through a Hart authorized sales outlet or Buyer has paid the applicable international price. Hart reserves the right to invoice Buyer for importation costs of repairs/replacement parts when product purchased in one country is submitted for repair in another country.

Hart's warranty obligation is limited, at Hart's option, to refund of the purchase price, free of charge repair, or replacement of a defective product which is returned to a Hart authorized service center within the warranty period.

To obtain warranty service, contact your nearest Hart authorized service center or send the product, with a description of the difficulty, postage, and insurance prepaid (FOB Destination), to the nearest Hart authorized service center. Hart assumes no risk for damage in transit. Following warranty repair, the product will be returned to Buyer, transportation prepaid (FOB Destination). If Hart determines that the failure was caused by misuse, alteration, accident or abnormal condition or operation or handling, Hart will provide an estimate or repair costs and obtain authorization before commencing the work. Following repair, the product will be returned to the Buyer transportation prepaid and the Buyer will be billed for the repair and return transportation charges (FOB Shipping Point).

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Since some countries or states do not allow limitation of the term of an implied warranty, or exclusion or limitation of incidental or consequential damages, the limitations and exclusions of this warranty may not apply to every buyer. If any provision

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# Figures and Tables

# 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.

***Table 1*** *International Electrical Symbols*

| Symbol | Description |
|---|---|
|  | AC (Alternating Current) |
|  | AC-DC |
|  | Battery |
|  | CE Complies with European Union Directives |
|  | DC |
|  | Double Insulated |
|  | Electric Shock |
|  | Fuse |
|  | PE Ground |
|  | Hot Surface (Burn Hazard) |
|  | Read the User's Manual (Important Information) |
|  | Off |
|  | On |

| Symbol | Description |
|---|---|
|  | Canadian Standards Association |
| CAT II | OVERVOLTAGE (Installation) CATEGORY II, Pollution Degree 2 per IEC1010-1 refers to the level of Impulse Withstand Voltage protection provided. Equipment of OVERVOLTAGE CATEGORY II is energy-consuming equipment to be supplied from the fixed installation. Examples include household, office, and laboratory appliances. |
|  | C-TIC Australian EMC Mark |

## 1.2 Safety information

***DISCLAIMER:*** *Fluke Corporation, Hart Scientific Division manufactures baths for the purpose of temperature calibration. Baths used for applications other than calibration are used at the discretion and sole responsibility of the customer. Hart Scientific cannot accept any responsibility for the use of baths for any application other than temperature calibration.*

Use this instrument only as specified in this manual. Otherwise, the protection provided by the instrument may be impaired.

The following definitions apply to the terms "Warning" and "Caution".

- "Warning" identifies conditions and actions that may pose hazards to the user.
- "Caution" identifies conditions and actions that may damage the instrument being used.

### 1.2.1 ⚠ Warnings

To avoid personal injury, follow these guidelines.

**GENERAL**

- Appropriate personal safety protection should be worn by the operator at all times while using the bath.
- Hart Scientific does not recommend that user's drain the salt from the bath. Hart Scientific provides the service of draining salt from the bath. If draining the bath salt is necessary, contact an Authorized Service Center (see Section 1.3) for an RMA and instructions on returning the bath. Insure that the control probe is removed from the bath before the salt solidifies. Solidification in the bath can take up to several days. If the control probe is not removed before shipping the bath, the control probe may be damaged during shipping and the Service Centers assume no liability for damage incurred during shipping.

- **DO NOT** use the instrument for any application other than calibration work. The instrument was designed for temperature calibration. Any other use of the unit may cause unknown hazards to the user.
- **DO NOT** use the unit in environments other than those listed in the user's guide.
- DO NOT overfill the bath. Overflowing extremely hot fluid may be harmful to the operator. See Section 7.5, Filling the bath, for specific instructions.
- 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 instrument has not been energized for more than 10 days, the instrument needs to be energized for a "dry-out" period of 2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1. If the product is wet or has been in a wet environment, take necessary measures to remove moisture prior to applying power such as storage in a low humidity temperature chamber operating at 50°C for 4 hours or more.
- DO NOT operate high temperature baths (500°C) near flammable materials. Extreme temperatures could ignite the flammable material.
- 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.
- The instrument is intended for indoor use only.
- Ensure that you check the appropriate OSHA and local fire code regulations for proper equipment required to suppress a fire for the Salt utilized in the bath.

**BURN HAZARD**

- High temperatures may be present in this equipment. Fires and severe burns may result if personnel fail to observe safety precautions.
- Ensure the bath **DOES NOT** contain any water and has been completely dried prior to filling with salt. Any trapped water can cause a steam explosion resulting in personal injury. If the bath has recently been filled with water, ensure the inside of the drain tube is dry prior to filling the bath with salt.
- When immersing any object in the bath, ensure that you are not introducing anything into the bath that will react with the bath salt. Ensure that probes are **DRY** and free of contaminants. Read the MSDS (Material Safety Data Sheet) for the salt used. If you are still unsure if the material you are going to introduce into the bath will react with the salt, refer to

the individual MSDS sheets for the three components that make up the salt.

- The bath is provided with an access cover. The cover should remain on the bath whenever possible. Operating the bath without the access cover reduces stability, increases out gassing of fluids, and increases the possibility of personal injury or fire hazard.
- When removing probes from the bath **DO NOT** wipe probes down with a paper towel. If the bath setpoint is high, the salt can cause the paper towel to ignite in your hand. Provide a safe surface and situation for the probes to cool prior to cleaning the salt from the probes.
- The bath generates extreme temperatures. Precautions must be taken to prevent personal injury or damage to objects. Probes may be extremely hot when removed from the bath. Cautiously handle probes to prevent personal injury. Carefully place probes on a heat resistant surface or rack until they are at room temperature.
- Be extremely careful when filling the bath with salt and bringing it up to temperature. Salt expands with temperature. It is easy to add salt, but extremely dangerous to remove hot molten salt because the bath is over filled. **DO NO**T fill the bath above the indicated fill line when the stirring is on. It will overflow.

**ELECTRICAL HAZARD**

- These guidelines must be followed to ensure that the safety mechanisms in this instrument will operate properly. This instrument must be plugged into an outlet as stated in the specifications of this guide. 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.
- **DO** use a ground fault interrupt device. This unit contains a liquid. A ground fault device is advised in case liquid is present in the electrical system and could cause an electrical shock.
- Always replace the power cord with an approved cord of the correct rating and type. If you have questions, contact an Authorized Service Center (see Section 1.3).
- High voltage is used in the operation of this equipment. Severe injury or death may result if personnel fail to observe the safety precautions. Before working inside the equipment, turn off the power and disconnect the power cord.
- Keep all combustible materials away from the bath when using salt. Operate the bath on a heatproof surface such as concrete. Provide a means of safety for containing any spill, which may occur.

**BATH SALT**

- Salt used in this unit may produce noxious or toxic fumes under certain circumstances. Consult the fluid manufacturer's MSDS (Material Safety Data Sheet). Proper ventilation and safety precautions must be observed.
- The unit is equipped with a soft cutout (user settable firmware) and a hard cutout (set at the factory). Check the flash point, boiling point, or other fluid characteristic applicable to the circumstances of the unit operation. Ensure that the soft cutout is adjusted to the fluid characteristics of the application. Failing to set the cutout to the limits of the bath fluid can result in fire hazards and personal injury.

### 1.2.2 ⚠ Cautions

- Always operate this instrument at room temperature between 41°F and 104°F (5°C to 40°C). Allow sufficient air circulation by leaving at least 6 inches (15 cm) of clearance around the instrument.
- **DO NOT** overfill the bath. Overflowing liquid may damage the electrical system. Be sure to allow for thermal expansion of the fluid as the bath temperature increases. See Section 7.5, Filling the bath, for specific instructions.
- Read Section 5, Bath Use, before placing the unit into service.
- **DO NOT** change the values of the bath calibration constants from the factory set values. The correct setting of these parameters is important to the safety and proper operation of the unit.
- Only authorized personnel should perform the Factory Reset Sequence if no other action is successful in correcting a malfunction. You must have a copy of the most recent Report of Test to restore the test parameters.
- **DO NOT** operate this instrument in an excessively wet, oily, dusty, or dirty environment.
- The bath is a precision instrument. Although it has been designed for optimum durability and trouble free operation, it must be handled with care. Position the bath before the tank is filled with salt.
- Most probes have handle temperature limits. Be sure that the probe handle temperature limit is not exceeded in the air above the instrument.
- 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.
- DO ensure the salt is cleaned from the probes prior to immersing the probe in the next bath. Clean your probe between each bath to avoid contamination between bath fluids.
- Under filling the bath may reduce the bath performance and may possibly damage the bath.
- When calibrating PRTs always follow correct calibration procedure and calibrate from high temperatures to low temperatures with the appropriate

triple point of water checks. Never immerse a wet or cold PRT into a bath filled with hot fluid. Severe damage to the PRT may result as well as personal injury to the calibration technician.

- This bath is not designed to be portable. Therefore, moving the bath once it has been installed should be kept to a minimum. **NEVER MOVE A BATH THAT IS FULL OF HOT FLUID.** This action could be extremely dangerous and could result in personal injury to the person moving the bath. The fluid can splash causing injury or if the bath tips, the hot fluid could cause damage to the surrounding area and personnel.
- If the bath must be moved, allow the salt to solidify and cool. Care must be used when moving the bath with the fluid solidified in the bath. The control probe can easily be damaged. Four people are required to safely move the bath.
- The control probe must be inserted through the lid into the bath fluid and plugged into the socket at the back of the bath. **DO NOT** operate the bath without the control probe properly inserted and attached. The bath will not operate correctly without the control probe. Injury to operating personnel and permanent damage to the bath could occur.

## 1.3 Authorized Service Centers

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

**Fluke, Hart Scientific Division**

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

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

**Fluke Nederland B.V.**

Customer Support Services
Science Park Eindhoven 5108
5692 EC Son
NETHERLANDS

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

**Fluke Int'l Corporation**

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

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

**Fluke South East Asia Pte Ltd.**

Fluke ASEAN Regional Office
Service Center
60 Alexandra Terrace #03-16
The Comtech (Lobby D)
118502
SINGAPORE

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

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

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

# 2 Introduction

The 6055 Calibration Bath is a highly stable constant temperature salt bath. It has been designed for calibrating liquid-in-glass thermometers or other types of long thermometers against a known temperature standard such as a Standard Platinum Resistance Thermometer (SPRT).

The 6055 calibration bath provides the following features:

- A deep fluid tank (test well is 3.88 inches in diameter and has 17 inches of fluid depth).
- A highly temperature stable low gradient environment typically a nominal stability of ±0.005°C with salt. The fluid is well stirred and environmentally protected to minimize gradients.
- The fluid level is near the top of the test well to facilitate calibration of liquid-in-glass thermometers without needing to compensate for stem effect.
- The bath provides two calibration modes; temperature control mode and temperature drift mode. The temperature control mode uses a hybrid digital and analog PI controller with lock in amplifier design. The temperature and other functions are selected with the four button keypad to a hundredth of a degree and finer with a digital vernier adjustment. The Drift mode bypasses the controller with heater power manually controlled by the variable transformer.

# 3 Specifications and environmental conditions

## 3.1 Specifications

| | |
|---|---|
| **Range** | 200 °C to 550 °C (392 °F to 1022 °F) |
| **Stability** | ± 0.003 °C at 200 °C (salt)<br>± 0.010 °C at 550 °C (salt) |
| **Uniformity** | ± 0.005 °C at 200 °C (salt)<br>± 0.010 °C at 550 °C (salt) |
| **Temperature Setting** | Digital display with push-button entry |
| **Set-Point Resolution** | 0.01 °C, high resolution 0.00018 °C |
| **Display Temperature Resolution** | 0.01 °C |
| **Digital Setting Accuracy** | ± 1 °C |
| **Digital Setting Repeatability** | ± 0.01 °C |
| **Heaters** | 260 to 2080 W |
| **Working Area** | 107 mm diameter (4.2 in), 432 mm deep (17 in), removable SST lid, special viewing channel for LIG sighting |
| **Wetted Parts** | 304 stainless steel |
| **Power** | 230 V ac (± 10 %), 50/60 Hz, 15 A |
| **Volume** | 19.8 liters, 43 kg of bath salt (5.2 gal, 95 lb) |
| **Size** | 57.2 cm D x 77.5 cm W x 152.4 cm H (22.5 x 30.5 x 60 in) |
| **Weight** | 70.8 kg (156 lb) |
| **Distance from Line of Sight to Top of Fluid** | 15.9 mm (5/8 in) |
| **Safety** | OVERVOLTAGE (Installation) CATEGORY II, Pollution Degree 2 per IEC1010-1 |

## 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:

- ambient temperature range: 5–50°C (41–122°F)
- ambient relative humidity: maximum 80% for temperature <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

# 4 Installation

***CAUTION:*** *READ SECTION 5 ENTITLED BATH USE before placing the bath in service. Incorrect handling can damage the bath and void the warranty.*

This section provides the steps required to set up and operate the 6055 bath. This section should be used as a general overview and reference and not as a substitute for the remainder of the manual. Please read Sections5 through7 carefully before operating the bath.

***WARNING:*** *Never move a bath that is full of "hot" fluid. This action is extremely dangerous and can result in personal injury and possible damage to the surrounding area.*

The bath comes on a cart. This cart is for ease of operation, but in no way implies that the bath is portable. This bath is extremely dangerous when filled with salt. Follow the safety guidelines set forth in the *Before you start* section.

The bath should never be picked up with liquid salt in the tank. If the bath needs to be picked up, allow the salt to solidify and cool. Four people are needed to safely lift the bath. Lift the bath where the bath and the cart meet.

***CAUTION:*** *Use caution as this bath is top heavy.*

## 4.1 Unpacking

Unpack the bath 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:

- 6055 Bath
- Control Probe
- Power Cord
- Immersion Heater
- Report of Test
- Carousel (optional)

## 4.2 Comments concerning the use of salt

***CAUTION:*** *Do not use the control heaters to melt granular salt when filling the bath. The control heaters can be damaged if used in such a manner. Use the immersion heater (with a power of about 1000 watts) to melt the salt. Do not turn the POWER on until the tank is 3/4 full of melted salt.*

## 4.3 Bath environment

The Model 6055 bath is a precision instrument that must be located in an appropriate environment. The location should be free from drafts, extreme temperatures, extreme temperature changes, and dirt. Use the levelers to ensure that the bath is level. Allow free air space around the bath to allow surface heat to convect away freely. A fume hood should be used for ventilation of fumes.

Because the bath is designed for operation at high temperatures, keep all flammable and meltable materials away from the bath. Although the bath is well insulated, top surfaces do become hot. Beware of the danger of accidental fluid spills.

If used at high temperatures, a fume hood should be used to remove any vapors given off by hot bath fluid.

## 4.4 "Dry-out" period

The melting period for salt serves as a "dry-out" period for the heaters of this bath. During this time period all of the safety requirements of the IEC 1010-1 **CAN NOT** be assumed to be met.

## 4.5 Power

Plug the bath power cord into a mains outlet of the proper voltage, frequency, and current capability as stated in the Specifications. Set the "HEATER" switch on the front panel to position "LOW" and turn the bath on using the front panel "POWER" switch. The bath turns on and begins to heat or cool to reach the previously programmed temperature set-point. The front panel LED display indicates the actual bath temperature.

## 4.6 Setup

The probe used with the Model 6055 is a precision PRT sensor. The probe should not be bent or damaged in any way. Plug the probe into the probe connector on the rear panel of the bath.

Plug the stirrer into the receptacle marked "STIRRER POWER" located on the rear panel of the bath. This receptacle is switched on with the instruments control after the instrument reaches 200°C.

## 4.7 Setting the temperature

In the following discussion and throughout this manual 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.

To view or set the bath temperature set-point proceed as follows. The front panel LED display normally shows the actual bath temperature.

| | |
|---|---|
| 100.00 C | *Bath temperature display* |

When “SET” is pressed the display shows the set-point memory that is currently being used and its value. Eight set-point memories are available.

| | |
|---|---|
| SET | *Access set-point selection* |
| 1. 150.0 | *Set-point 1, 150.0 °C currently used* |

Press “SET” to select this memory and access the set-point value.

| | |
|---|---|
| SET | *Access set-point value* |
| C 150.00 | *Current value of set-point 1, 150.00°C* |

Press “UP” or “DOWN” to change the set-point value.

| | |
|---|---|
| UP | *Increment display* |
| C 160.00 | *New set-point value* |

Press “SET” to accept the new value and display the vernier value. The bath begins heating or cooling to the new set-point.

| | |
|---|---|
| SET | *Store new set-point, access vernier* |
| 0.00000 | *Current vernier value* |

Press “EXIT” and the bath temperature will be displayed again.

| | |
|---|---|
| EXIT | *Return to the temperature display* |
| 100.00 C | *Bath temperature display* |

The bath heats or cools until it reaches the new set-point temperature. Set the heater switch to position "HIGH" to allow the bath to more quickly reach a higher temperature. The "HIGH" setting may be necessary to reach higher temperatures and control at high temperatures.

When setting the set-point temperature be careful not to exceed the temperature limit or the bath fluid. The over-temperature cut-out should be correctly set to prevent this from happening. See Section 8.8.

To obtain optimum control stability adjust the proportional band as discussed in Section 8.7.

# 5 Bath Use

***CAUTION:*** *READ THIS SECTION before placing the bath in service. Incorrect handling can damage the bath and void the warranty.*

The information in this section is for general information only. It is not designed to be the basis for calibration laboratory procedures. Each laboratory will need to write their own specific procedures.

## 5.1 General

Be sure to select the correct fluid for the temperature range of the calibration. Bath fluids should be selected to operate safely with adequate thermal properties to meet the application requirements. Also, be aware that some fluids expand and could overflow the bath if not watched. Refer to General Operation, Section 7, for information specific to fluid selection and to the MSDS sheet specific to the fluid selected. Generally, baths are set to one temperature and used to calibrate probes only at that single temperature. This means that the type of bath fluid does not have to change. Additionally, the bath can be left energized reducing the stress on the system.

The bath generates extreme temperatures. Precautions must be taken to prevent personal injury or damage to objects. Probes may be extremely hot or cold when removed from the bath. Cautiously handle probes to prevent personal injury. Carefully place probes on a heat/cold resistant surface or rack until they are at room temperature. It is advisable to wipe the probe with a clean soft cloth or paper towel before inserting it into another bath. This prevents the mixing of fluids from one bath to another. If the probe has been calibrated in liquid salt, carefully wash the probe in warm water and dry completely before transferring it to another fluid. Always be sure that the probe is completely dry before inserting it into a hot fluid. Some of the high temperature fluids react violently to water or other liquid mediums. Be aware that cleaning the probe can be dangerous if the probe has not cooled to room temperature. Additionally, high temperature fluids may ignite the paper towels if the probe has not been cooled.

For optimum accuracy and stability, allow the bath adequate stabilization time after reaching the set-point temperature.

## 5.2 Comparison calibration

Comparison calibration involves testing a probe (unit under test, UUT) against a reference probe. After inserting the probes to be calibrated into the bath, allow sufficient time for the probes to settle and the temperature of the bath to stabilize.

One of the significant dividends of using a bath rather than a dry-well to calibrate multiple probes is that the probes do not need to be identical in construction. The fluid in the bath allows different types of probes to be calibrated at

the same time. However, stem effect from different types of probes is not totally eliminated. Even though all baths have horizontal and vertical gradients, these gradients are minimized inside the bath work area. Nevertheless, probes should be inserted to the same depth in the bath liquid. Be sure that all probes are inserted deep enough to prevent stem effect. From research at Hart Scientific, we suggest a general rule-of-thumb for immersion depth to reduce the stem effect to a minimum: 15 x the diameter of the UUT + the sensor length. **Do not submerge the probe handles.** If the probe handles get too warm during calibration at high temperatures, a heat shield could be used just below the probe handle. This heat shield could be as simple as aluminum foil slid over the probe before inserting it in the bath or as complicated as a specially designed reflective metal apparatus.

When calibrating over a wide temperature range, better results can generally be achieved by starting at the highest temperature and progressing down to the lowest temperature.

Probes can be held in place in the bath by using probe clamps or drilling holes in the access cover. Other fixtures to hold the probes can be designed. The object is to keep the reference probe and the probe(s) to be calibrated as closely grouped as possible in the working area of the bath. Bath stability is maximized when the bath working area is kept covered.

In preparing to use the bath for calibration start by:

- Placing the reference probe in the bath working area.
- Placing the probe to be calibrated, the UUT, in the bath working area as close as feasibly possible to the reference probe.

## 5.3 Calibration of multiple probes

Fully loading the bath with probes increases the time required for the temperature to stabilize after inserting the probes. Using the reference probe as the guide, be sure that the temperature has stabilized before starting the calibration.

# 6 Parts and controls

This section describes the Front Panel, the Power Panel, and the Back Panel of the 6055.

The Front Panel, located just left of the bath, consists of the Controller Panel (Figure 1) and the Power Panel (Figure 2).

## 6.1 Controller panel

The Controller Panel includes: 1) the digital LED display, 2) the control buttons and 3) the control indicator light.

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

2) The control buttons (SET, DOWN, UP, and EXIT) are used to set the temperature set-point, access and set other operating parameters, and access and set calibration parameters.

   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.

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

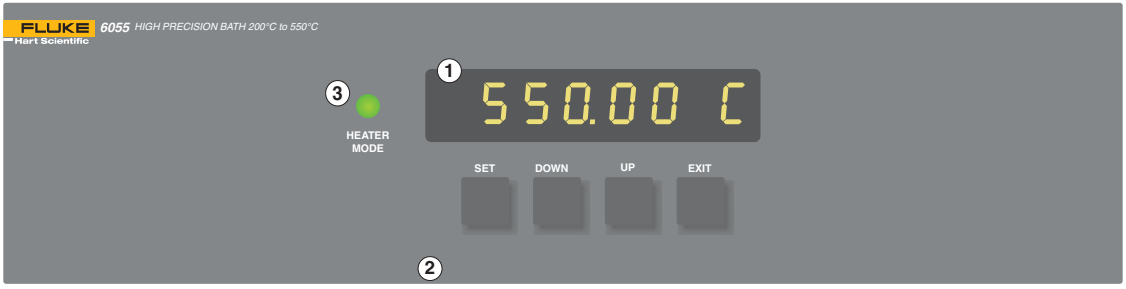



***Figure 1*** *Controller panel*

## 6.2 Power panel

The Power Panel (Figure 2) controls include: 1) the power switch and indicator, 2) the boost heater and indicator, 3) the mode select switch and indicators, 4) the control heating select switch, and 5) the drift adjust control.

1) The "ON/OFF" power switch powers up the bath. The switch is a DPST type that opens both legs of the ac mains power source. A red indicator light shows that power is on.

2) The boost heating provides an additional 900 watts for rapidly changing between temperatures. The boost heating indicator shows whether the boost heater is on or off. The boost heater is powered through the temperature controller triac to prevent exceeding the desired set temperature. The boost heater indicator flashes when the set temperature has been reached as a reminder to turn it off for control.

3) The mode select switch selects between the Temperature Control and Temperature Drift modes. The indicator light shows which mode is functioning. The Temperature Control position selects the temperature controller panel. In Temperature Drift mode, the heater control is via the Drift Adjust control and the heating select switch.

4) The control heating switch selects the control heater power positions; off through 4. Select the lowest reasonable value for normal control condi-

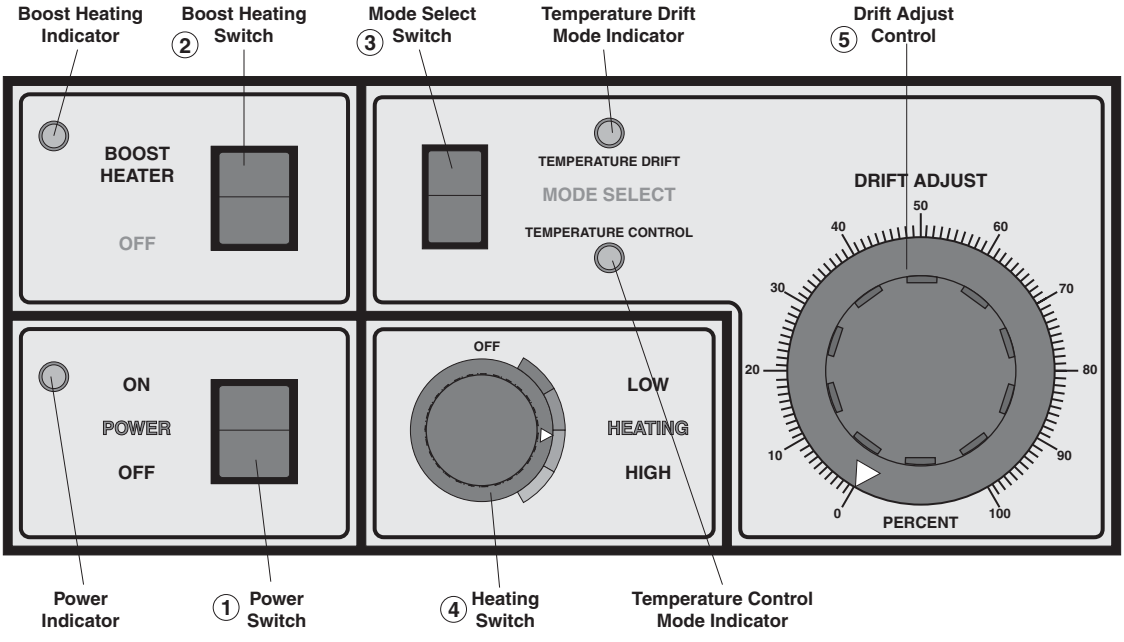



***Figure 2*** *Power panel*

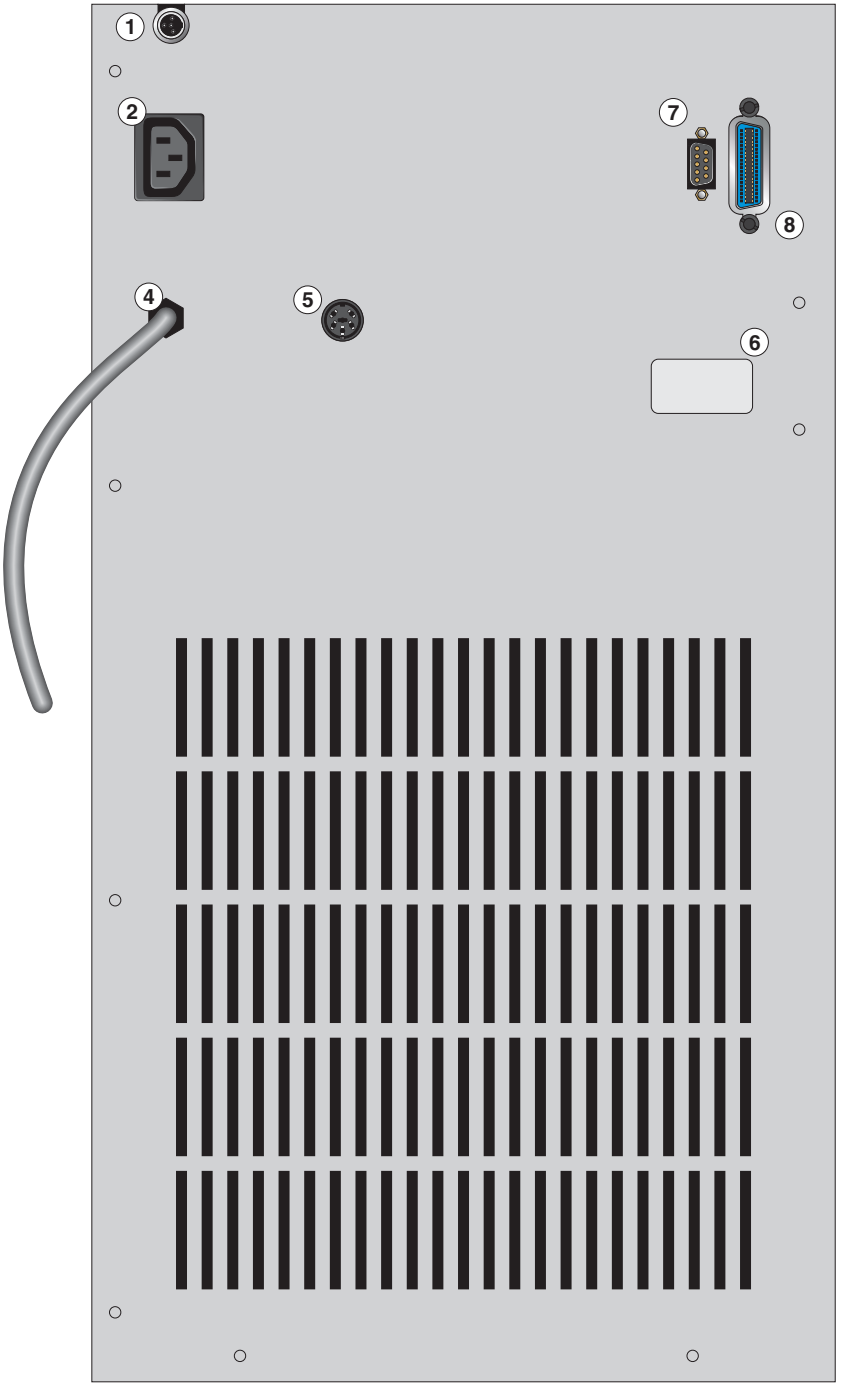



***Figure 3*** *Back panel*

tions depending on bath temperature. The switch simply adds more heaters into the circuit until the desired power is attained. Position 2 is variable using the Drift Adjust control.

5) The drift adjust control is a variable transformer that adjusts the position 1 control heater through 0 to 100% of its power range. The additional power required for higher temperatures may be added in steps by selecting heating 2, 3, 4, etc. Positions 2 + 3 + 4 + 5 will not achieve the maximum possible temperatures. Boost + 2 is the next increment. Boost + 2 + 3 and so on can be used as required.

## 6.3 Back panel

The Back Panel (Figure 3) includes: 1) the probe connector, 2) the stirrer power outlet, 4) the power cord, 5) the heater power connector, 6) the serial number, 7) optional RS-232 connector, and 8) optional IEEE-488 GPIB connector.

1) The probe connector on the back panel is used for the temperature controller probe.

2) The stirrer power connection provides ac power to the stirring motor and cooling fan.

3) The system fuses are internal (one fuse for each leg of the ac mains power). Only replace fuses with those of the same rating and type.

4) The power cord.

5) The heater power outlet supplies power to the control and boost heaters that are attached to the top plate of the bath tank. The connector allows the assembly to be easily removed if required.

6) The serial number is located at the top right corner of the back panel. When consulting with an Authorized Service Center, refer to the serial number.

7) Optional DB-9 connector for interfacing the instrument to a computer or terminal with a serial RS-232 cable.

8) Optional GPIB connector for interfacing the instrument to a computer or terminal using IEEE-488 communications.

# 7 General operation

The components, features and operational theory of the Model 6055 calibration bath are described in this section.

The Model 6055 calibration bath is shown in block diagram form in Figure 4 on page 24. This diagram illustrates the primary features of the bath system and their function, which are described as follows.

## 7.1 Two modes of temperature control

There are two modes of temperature control available with the Model 6055. The Temperature Control mode or the Temperature Drift mode may be selected by a switch on the front panel.

### 7.1.1 Temperature control mode

The Temperature Control Mode uses a hybrid digital/analog PI temperature controller with a lock-in-amplifier. The bath stability is very high with this controller. The temperature is selected using the four button keypad on the front panel. Temperatures from 150 to 550°C may be selected directly to a hundredth of a degree. Finer adjustment is available using the vernier adjustment. Accuracy of the setting is typically ±0.5°C or better.

The controller pulses AC current to the control heaters in a time modulated fashion to compensate for heat gains and losses to the system. A two color LED on the control panel glows red when the heaters are on and glows green when they are off and cooling is taking place. (Note: The cooling required for control is supplied through heat loss to ambient).

The temperature control probe uses a 100 ohm PRT. Plug the probe into the rear of the control unit.

The heaters are internal to the tank. They are arranged electrically to provide the 4 control heating positions plus an off position. The additional boost heating position is accessed from a separate switch on the control panel.

### 7.1.2 Temperature drift mode

When using the Temperature Drift mode, the heater may be set manually to allow the temperature to drift very slowly (a few millidegrees C per minute) over the desired range. This allows the control noise to be eliminated although greater skill is required in making calibrations. The heater power is adjusted by means of a variable transformer located on the control panel. It allows position one of the heater selection switch to be continually variable from 0 to 100%. Positions 2, 3, 4 and Boost add their full value of heat incrementally to the adjusted value of position 1.

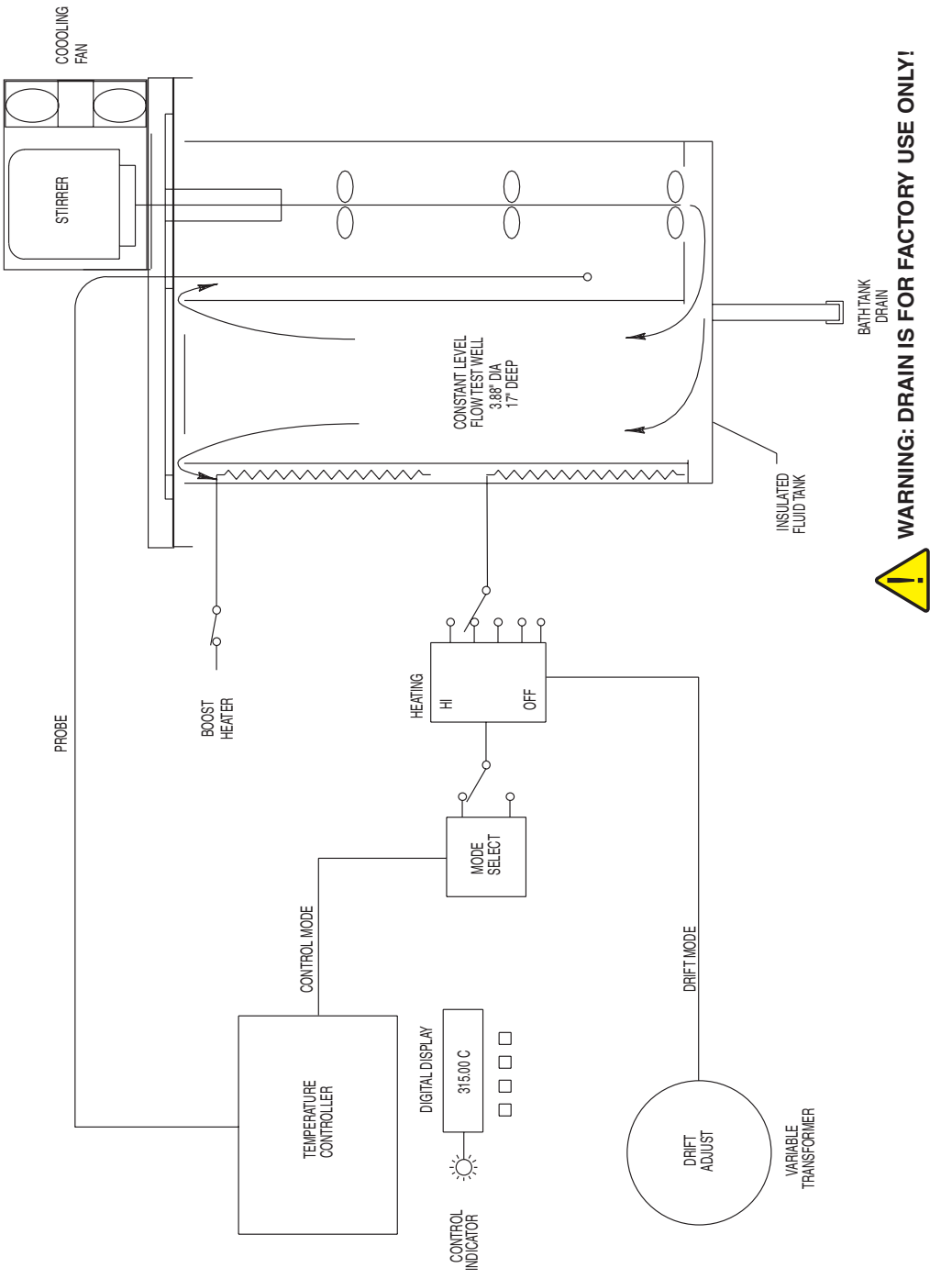



***Figure 4*** *System diagram*

## 7.2 Bath fluid

Heat transfer salt works with the 6055 bath up to 550°C. Other fluids **SHOULD NOT** be used with the 6055 bath.

## 7.3 Fluid system

The fluid system consists of the insulated tank, the stirrer assembly, the drain, the overflow test well, and the fluid. The heaters and probe, which are part of the control system, are physically internal to the tank.

The tank and other wetted parts are made of stainless steel. The stirrer is attached to the tank top plate of the bath and its motor receives additional cooling from a fan to keep from overheating and to increase the lifetime at high bath temperatures. The stirrer directly drives three 2-inch diameter stirring propellers. The down draft from the propellers forces the fluid through the overflow test well. The stirring motor plugs into the rear of the control unit. (See Figure 5 on page 26.)

The over-flow test well serves to provide a constant depth of fluid at an essentially constant height near the well opening. Variations in fluid volume due to thermal expansion and evaporation do not effect measurements within reasonable volume ranges. The fluid expelled from the tank is controlled to flow past the control heaters first before entering the main tank for thermal management.

***WARNING:*** *The drain is for factory use only.*

## 7.4 Fluid Drain

The drain on the bottom of the bath (see Figure 4 on page 24) is ***for factory use only.*** During operation of the bath the drain plug must be screwed on tightly.

## 7.5 Filling the bath

The bath is shipped dry. Check inside of the test well for foreign matter and remove it to avoid interference with operation.

### 7.5.1 Using heat transfer salt

#### 7.5.1.1 The first salt load

Salt comes in small bead or granular form which is initially pink in color. Approximately 70 pounds are required for the installation.

The following procedure is required if the bath is empty and will be filled with bead or granular salt.

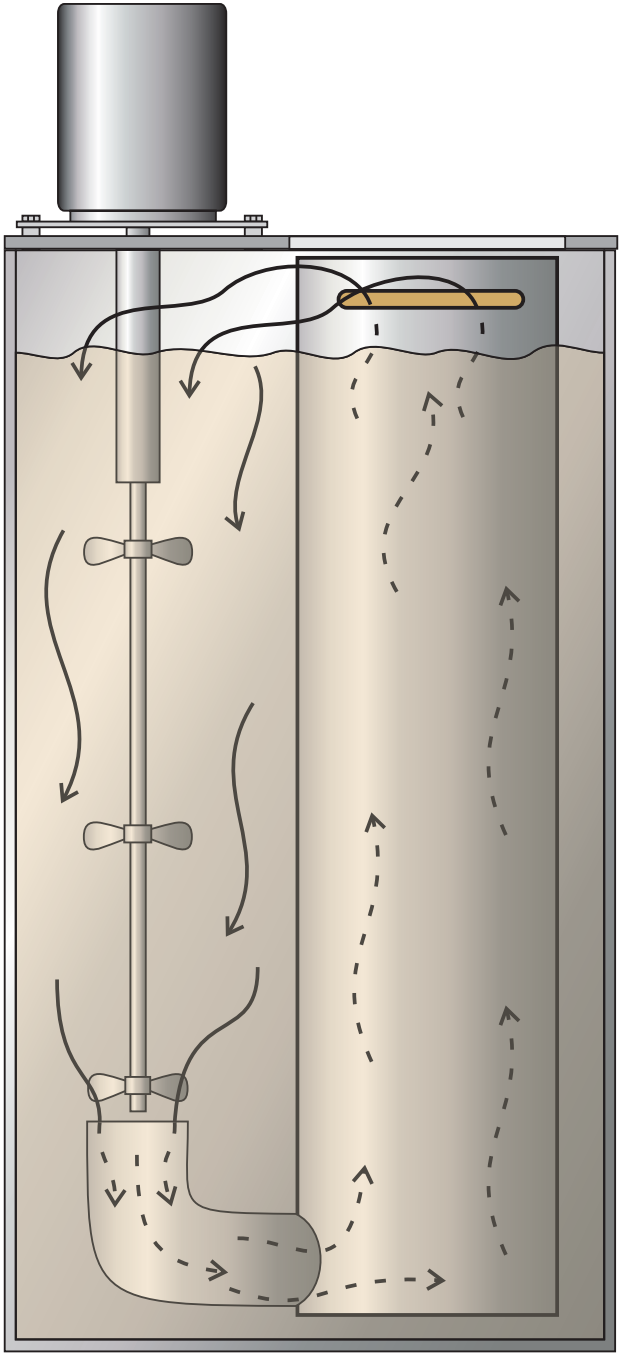


***Figure 5*** *System diagram*

- Use an immersion heater (with a power of about 1000 watts) to melt the salt.
- **Do not use the control heaters to melt the granular salt or they will be damaged.**
- Inspect the drain to be sure it is fully sealed.
- Insert the immersion heater into the test well and fill the remaining space with the granular salt.
- As the salt melts, it will run into the main tank. As this occurs continually fill the test well with more salt.

***CAUTION:*** *Danger of serious burns exists. Use extreme care and use appropriate safety equipment.*

As this process continues and the tank is nearing its full level, turn the POWER switch ON and set the temperature to about 200°C with the MODE SELECT switched to TEMPERATURE CONTROL. The stirrer will not turn on until the bath has actually reached the cut in temperature of 175 to 225°C. The melting point of the salt is about 150°C. Increase the temperature of the main tank and add more salt until the salt depth reaches about 3.5 inches from the tank top plate at 250°C (without pumping).

#### 7.5.1.2 Melting the salt

The following process is to be followed to melt salt in a bath which has previously had salt installed and has cooled.

- Turn on the unit and set the temperature to the desired starting point (at least 200°C).
- Turn the heater to the maximum position of 4 and turn on the boost heater.
- The controller will limit the duty cycle of the heaters to 25% until the salt reaches about 200°C.
- As the heat expands the solid salt, you will hear some cracking noises which should not cause concern.
- When the stirrer cut in temperature is reached the stirrer will turn on and begin to pump the molten salt into the test well.
- If the thermometer holding fixture was removed previously, it may be replaced at this time.
- The bath is now ready for operation.

## 7.6 Stirring

Stirring of the bath salt is very important for stable temperature control. The salt must be mixed well for good temperature uniformity and fast controller response. The stirrer is precisely adjusted for optimum performance.

## 7.7 Power

Power to the bath is provided by an AC mains supply as specified in the specifications. Power to the bath passes through a filter to prevent switching spikes from being transmitted to other equipment.

To turn on the bath switch the control panel power switch to the "ON" position. The stir motor will turn on, the LED display will begin to show the bath temperature, and the heater will turn on or off until the bath temperature reaches the programmed set-point.

When powered on the control panel display will briefly show a four digit number. This number indicates the number of times power has been applied to the bath. Also briefly displayed is data which indicates the controller hardware configuration. This data is used in some circumstances for diagnostic purposes.

# 8 Controller operation

This section discusses in detail how to operate the bath temperature controller using the front control panel. Using the front panel key switches and LED display the user may monitor the bath 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, optional serial and IEEE-488 interface configuration, and controller calibration parameters. Operation of the primary functions is summarized in Figure 6.

## 8.1 Bath temperature

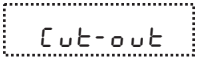
The digital LED display on the front panel allows direct viewing of the actual bath temperature. This temperature value is what is normally shown on the display. The units, C or F, of the temperature value are displayed at the right. For example,


*Bath temperature in degrees Celsius*

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

## 8.2 Reset cut-out

If the over-temperature cut-out has been triggered then the temperature display will alternately flash,




*Indicates cut-out condition*

The message continues to flash until the temperature is reduced and the cut-out is reset.

The cut-out has two modes — automatic reset and manual reset. The mode determines how the cut-out is reset which allows the bath to heat up again. When in automatic mode, the cut-out resets itself as soon as the temperature is lowered below the cut-out set-point. With manual reset mode the cut-out must be reset by the operator after the temperature falls below the set-point.

When the cut-out is active and the cut-out mode is set to manual (“reset”) then the display flashes "Cut-out" until the user resets the cut-out. To access the reset cut-out function press the “SET” button.


*Access cut-out reset function*

The display indicates the reset function.

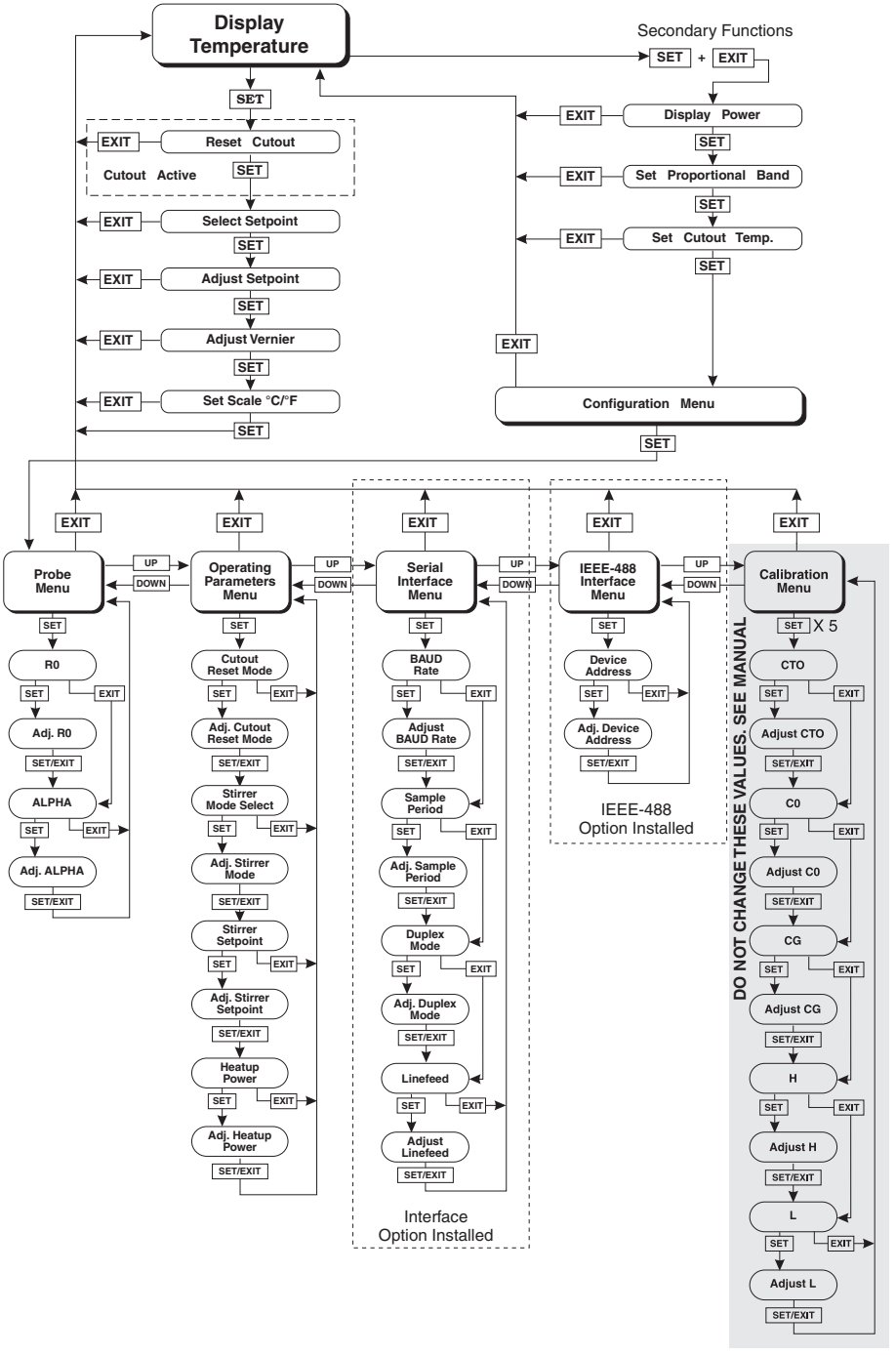



***Figure 6*** *Controller operation flowchart*

rESEt ?  *Cut-out reset function*

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


*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 continues to flash “cut-out”. The bath temperature must drop a few degrees below the cut-out set-point before the cut-out can be reset.

## 8.3 Temperature set-point

The bath temperature can be set to any value within the range as given in the specifications with a high degree of resolution. The temperature range of the particular fluid used in the bath must be known by the operator and the bath should only be operated well below the upper temperature limit of the liquid. In addition, the cut-out temperature should also be set below the upper limit of the fluid.

Setting the bath temperature involves three steps: (1) select the set-point memory, (2) adjust the set-point value, and (3) adjust the vernier, if desired.

### 8.3.1 Programmable set-points

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

To set the bath 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.

25.00 C  *Bath temperature in degrees Celsius*


*Access set-point memory*

1. 25.0  *Set-point memory 1, 25.0°C currently used*

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


*Increment memory*

4. 40.0  *New set-point memory 4, 40.0°C*

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

SET *Accept selected set-point memory*

### 8.3.2 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 40.00 *Set-point 4 value in°C*

If the set-point value need not be changed then press "EXIT" to resume displaying the bath temperature. To adjust the set-point value press "UP" or "DOWN".

UP *Increment display*

C 42.50 *New set-point value*

When the desired set-point value is reached press "SET" to accept the new value and access the set-point vernier. If "EXIT" is pressed instead then any changes made to the set-point will be ignored.

SET *Accept new set-point value*

### 8.3.3 Set-point vernier

The set-point value can be set with a resolution of 0.01°C. The user may want to adjust the set-point slightly to achieve a more precise bath temperature. The set-point vernier allows one to adjust the temperature below or above the set-point by a small amount with very high resolution. Each of the 8 stored set-points has an associated vernier setting. The vernier is accessed from the set-point by pressing "SET". The vernier setting is displayed as a 6 digit number with five digits after the decimal point. This is a temperature offset in degrees of the selected units, C or F.

0.00000 *Current vernier value in°C*

To adjust the vernier press "UP" or "DOWN". Unlike most functions the vernier setting has immediate effect as the vernier is adjusted. "SET" need not be pressed. This allows one to continually adjust the bath temperature with the vernier as it is displayed.

UP *Increment display*

0.00090 *New vernier setting*

Next press “EXIT” to return to the temperature display or “SET” to access the temperature scale units selection.

SET *Access scale units*

## 8.4 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 bath temperature, set-point, vernier, proportional band, and cut-out set-point.

The temperature scale units selection is accessed after the vernier adjustment function by pressing “SET”. From the temperature display function access the units selection by pressing “SET” 4 times.

*Bath temperature*

SET *Access set-point memory*

*Set-point memory*

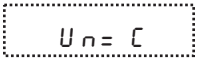
SET *Access set-point value*

*Set-point value*

SET *Access vernier*

*Vernier setting*

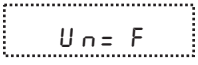
SET *Access scale units selection*



*Scale units currently selected*

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

UP *Change units*



*New units selected*

Press “SET” to accept the new selection and resume displaying the bath temperature.

SET *Set the new units and resume temperature display*

## 8.5 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 6.)

## 8.6 Heater power

The temperature controller controls the temperature of the bath 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 bath is heating up to the set-point, cooling down, or controlling at a constant temperature. Monitoring the percent heater power lets the user know how stable the bath 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.

SET + EXIT *Access heater power in secondary menu*

12 PcE *Heater power in percent*

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

EXIT *Return to temperature display*

## 8.7 Proportional band

In a proportional controller such as this the heater output power is proportional to the bath 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 bath temperature rises the heater power is reduced, which consequently tends to lower the temperature back down. In this way the temperature is maintained at a fairly constant temperature.

The temperature stability of the bath depends on the width of the proportional band. See Figure 7. If the band is too wide the bath 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 propor-

tional band is too narrow the bath 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 optimum proportional band width depends on several factors among which are fluid volume, fluid characteristics (viscosity, specific heat, thermal conductivity), operating temperature, and stirring. Thus the proportional band width may require adjustment for best bath stability when any of these conditions change. Of these, the most significant factors affecting the optimum proportional band width are the fluid viscosity and thermal noise due to difference in temperature between the fluid and ambient. The proportional band should be wider when the fluid viscosity is higher because of the increased response time and also when noise is greater.

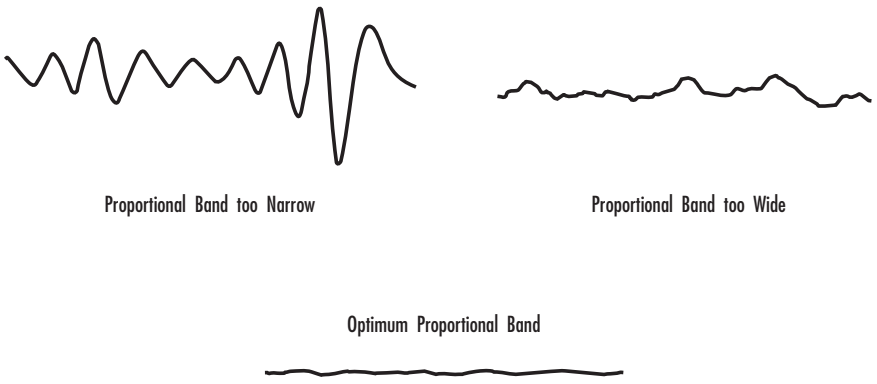



***Figure 7*** *Bath temperature fluctuations at various proportional band settings*

The proportional band width is easily adjusted from the bath front panel. The width may be set to discrete values in degrees C or F depending on the selected units. The optimum proportional band width setting may be determined by monitoring the stability with a high resolution thermometer or with the controller percent output power display. Narrow the proportional band width to the point at which the bath temperature begins to oscillate and then increase the band width from this point to 3 or 4 times wider.

The proportional band adjustment may 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=0.101C *Proportional band setting*

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

DOWN *Decrement display*

Pb=0.060C *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*

## 8.8 Cut-out

As a protection against software or hardware fault, shorted heater triac, or user error, the bath is equipped with an adjustable heater cut-out device that will shut off power to the heater if the bath temperature exceeds a set value. This protects the heater and bath materials from excessive temperatures and, most importantly, protects the bath fluids from being heated beyond the safe operating temperature preventing hazardous vaporization, breakdown, or ignition of the liquid. The cut-out temperature is programmable by the operator from the front panel of the controller. It must always be set below the upper temperature limit of the fluid and no more than 10 degrees above the upper temperature limit of the bath.

If the cut-out is activated because of excessive bath temperature then power to the heater will be shut off and the bath will cool. The bath 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 — automatic reset or manual reset. If the mode is set to automatic, then the cut-out will automatically reset itself when the bath temperature falls below the reset temperature allowing the bath to heat up again. If the mode is set to manual, then the heater will remain disabled until the user manually resets the cut-out.

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

SET + EXIT *Access heater power in secondary menu*

12 Pct *Heater power in percent*

SET *Access proportional band*

Pb=0.101C *Proportional band setting*

SET *Access cut-out set-point*

CO= 210C *Cut-out set-point*

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

DOWN *Decrement display*

CO= 95C *New cut-out set-point*

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

SET *Accept cut-out set-point*

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

## 8.9 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”. The display will prompt with "CONFIG". Press “SET” once more. 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”. See Figure 6.

## 8.10 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 and ALPHA, which characterize the resistance-temperature relationship of the platinum control probe. These parameters may be adjusted to improve the accuracy of the bath. This procedure is explained in detail in Section 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.

### 8.10.1 R0

This probe parameter refers to the resistance of the control probe at 0°C. Normally this is set for 100.000 ohms.

### 8.10.2 ALPHA

This probe parameter refers to the average sensitivity of the probe between 0 and 100°C. Normally this is set for 0.00385°$C^{-1}$.

## 8.11 Operating parameters

The operating parameters menu is indicated by,


*Operating parameters menu*

Press "SET" to enter the menu. The operating parameters menu contains the cut-out reset mode parameter.

### 8.11.1 Cut-out reset mode

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

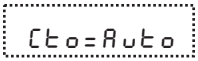
The parameter is indicated by,


*Cut-out reset mode parameter*

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


*Cut-out set for manual reset*

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




*Cut-out set for automatic reset*

### 8.11.2 Stir mode select

This parameter along with the Stirrer Set-point allows the user to set the temperature at which the stirrer motor is activated. This setting is generally used when salt is used for the bath medium. For example, you can set the mode to "auto" and the temperature to 200°C. This allows the stirrer motor to shut off and turn on only when the salt is a liquid (>200°C) preventing the stirrer motor from overheating and damage.

The parameter is indicated by,

| | |
|---|---|
| Str Act | *Stirrer mode selection parameter* |

Press “SET” to access the parameter setting.

| | |
|---|---|
| Str=Auto | *Stirrer is set for automatic activation at the stirrer set-point temperature.* |

To change the setting to **always on** press the “UP” or “DOWN” buttons and then “SET”. When set to "Str=On" the stirrer motor comes on with the bath power regardless of the temperature set in the stirrer set-point parameter.

### 8.11.3 Stir set-point

Allows setting of the temperature above which the stirrer motor will activate when the stirrer activation is set to automatic.

To access the paramter press “SET” from the stirrer activation parameter. Set-point mode selection parameter is indicated by,

| | |
|---|---|
| Str SEt | *Stirrer motor activation set-point parameter* |

Press “SET” to access the parameter value.

| | |
|---|---|
| Str=200 | *Stirrer motor activation set-point* |

Press “UP” or “DOWN” to change the value and then “SET” to enter the new value.

***NOTE:*** *Stir Mode Select defaults to “Auto” each time the power of the bath is cycled off and back on. Therefore, this parameter has to be set each time the bath is powered on if “Str-ON” is the desired mode of operation.*

### 8.11.4 Heat up power

***NOTE:*** *This section applies to controller parameters, not to the High/Low setting of the front panel heater switch.*

This feature helps lengthen the lifetime of the heaters when using heat transfer salt as the bath fluid. The heater power will be limited to less than 30% while the salt is solid at low temperatures to prevent the heaters from overheating. Once the temperature reaches 200°C the heaters can then operate at 100% power.

| | |
|---|---|
| HEAt UP | *Heat up power option* |

Press “SET” to access the parameter value.

| | |
|---|---|
| HU=LO | *Low power heat up mode for heat transfer salt* |
| HU=HI | *High power heat up mode* |

Press "UP" or "DOWN" to change the option and then press "SET" to store the setting.

***NOTE:** When using salt as the fluid be sure to always set this option to LO to maximize the lifetime of the heaters.*

## 8.12 Serial interface parameters

The optional 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 baths fitted with the serial interface. The parameters in the menu are — baud rate, sample period, duplex mode, and linefeed.

### 8.12.1 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 bath 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.

### 8.12.2 Sample period

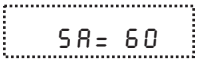
The sample period is the next parameter in the serial interface parameter menu. The sample period is the time period in seconds between temperature measurements transmitted from the serial interface. If the sample rate is set to 5, for instance, the bath transmits the current measurement over the serial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


*Serial sample period parameter*

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


*Current sample period (seconds)*

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



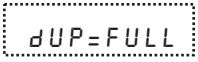

*New sample period*

### 8.12.3 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 bath 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,

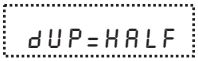

*Serial duplex mode parameter*

Press “SET” to access the mode setting.




*Current duplex mode setting*

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



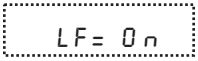

*New duplex mode setting*

### 8.12.4 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,

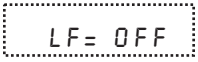

*Serial linefeed parameter*

Press "SET" to access the linefeed parameter.




*Current linefeed setting*

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




*New linefeed setting*

## 8.13 IEEE-488 parameters

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


*IEEE-488 parameters menu*

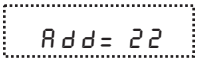
Press "SET" to enter the menu.

### 8.13.1 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,

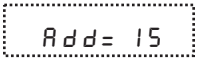

*IEEE-488 interface address*

Press "SET" to access the address setting.




*Current IEEE-488 interface address*

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




*New IEEE-488 interface address*

## 8.14 Calibration parameters

The operator of the bath controller has access to a number of the bath calibration constants, namely CTO, C0, CG, H, and L. These values are set at the factory and must not be altered. The correct values are important to the accuracy and proper and safe operation of the bath. Access to these parameters is available to the user only so that in the event that the controller's memory fails the user may restore these values to the factory settings. The user should have a list of these constants and their settings with the manual.

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

The calibration parameters menu is indicated by,

CAL *Calibration parameters menu*

Press “SET” five times to enter the menu.

### 8.14.1 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 6055 bath this parameter should read between 560 and 570.

### 8.14.2 CO and CG

These parameters calibrate the accuracy of the bath set-point. These are programmed at the factory when the bath is calibrated. Do not alter the value of these parameters. If the user desires to calibrate the bath for improved accuracy then calibrate R0 and ALPHA according to the procedure given in Section 10.

### 8.14.3 H and L

These parameters set the upper and lower set-point limits of the bath. DO NOT change the values of these parameters from the factory set values. To do so may present danger of the bath overheating and causing damage or fire.

# 9 Digital communication interface

If supplied with the option, the 6055 bath is capable of communicating with and being controlled by other equipment through the digital interface. Two types of digital interface are available — the RS-232 serial interface and the IEEE-488 GPIB interface.

## 9.1 Serial communications

The bath may be installed with an RS-232 serial interface that allows serial digital communications over fairly long distances. With the serial interface the user may access any of the functions, parameters and settings discussed in Section7 with the exception of the BAUD rate setting. The serial interface operates with 8 data bits, 1 stop bit, and no parity. The use of a shielded communications cable is recommended.

### 9.1.1 Wiring

The serial communications cable attaches to the bath through the DB-9 connector on the back panel. Figure 8 shows the pin-out of this connector and suggested cable wiring. To eliminate noise, the serial cable should be shielded with low resistance between the connector (DB-9) and the shield.

### 9.1.2 Setup

Before operation, the serial interface of the bath 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 6.

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”

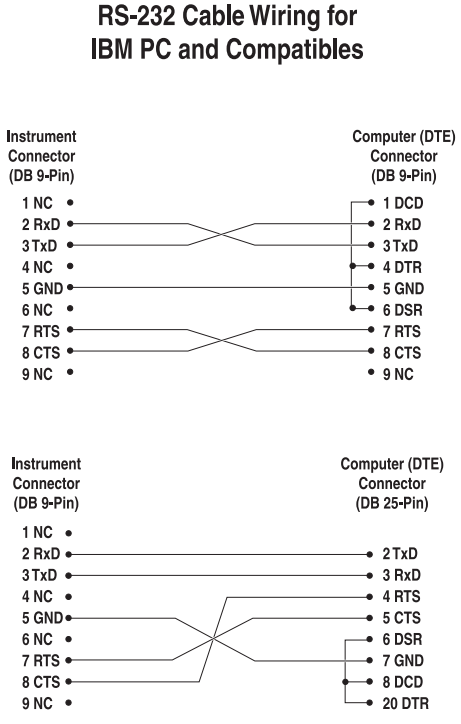



***Figure 8*** *Serial Cable Wiring Diagram*

repeatedly until the serial interface menu is indicated with "SErIAL". Finally press "SET" to enter the serial interface parameters menu. In the serial interface parameters menu are the baud rate, sample rate, duplex mode, and linefeed parameters.

#### 9.1.2.1 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 serial communications may be programmed to 300, 600, 1200, or 2400 baud. The baud rate is pre-programmed to 1200 baud. Use "UP" or "DOWN" to change the baud rate value. Press "SET" to set the baud rate to the new value or "EXIT" to abort the operation and skip to the next parameter in the menu.

#### 9.1.2.2 Sample period

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

#### 9.1.2.3 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 bath 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".

#### 9.1.2.4 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".

### 9.1.3 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 interface operates with 8 data bits, 1 stop bit, and no parity. The set-point and other commands may be sent to the bath via the serial interface to set the bath and view or program the various parameters. The inter-

face commands are discussed in Section 9.3. All commands are ASCII character strings terminated with a carriage-return character (CR, ASCII 13).

## 9.2 IEEE-488 communication (optional)

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

### 9.2.1 Setup and address selection

To use the IEEE-488 interface first connect an IEEE-488 standard cable to the back of the bath.

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

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 bath if necessary to match the address used by the communication equipment by pressing “UP” or “DOWN” and then “SET”.

### 9.2.2 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.

## 9.3 Interface commands

The various commands for accessing the bath controller functions via the digital interfaces are listed in this section (see Table 1). 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=50.00”<CR> will set the set-point (set-point 1) to 50.00 degrees.

***Table 1*** *Interface command summary*

| Command Description | Command Format | Command Example | Returned | Returned Example | Acceptable Values |
|---|---|---|---|---|---|
| **Display Temperature** | | | | | |
| Read current set-point | s[etpoint] | s | set: 9999.99 {C or F} | set: 150.00 C | |
| Set current set-point to n | s[etpoint]=n | s=450 | | | Instrument Range |
| Read vernier | v[ernier] | v | v: 9.99999 | v: 0.00000 | |
| Set vernier to n | v[ernier]=n | v=.00001 | | | Depends on Configuration |
| Read temperature | t[emperature] | t | t: 9999.99 {C or F} | t: 55.69 C | |
| Read temperature units | u[nits] | u | u: x | u: c | |
| **Set temperature units:** | **u[nits]=c/f** | | | | C or F |
| Set temperature units to Celsius | u[nits]=c | u=c | | | |
| Set temperature units to Fahrenheit | u[nits]=f | u=f | | | |
| **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 {x},{xxx} | c: 620 C, in | |
| **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 | po: 9999 | po: 1 | |
| **Configuration Menu** | | | | | |
| **Probe Menu** | | | | | |
| Read R0 calibration parameter | r[0] | r | r0: 999.999 | r0: 100.578 | |
| Set R0 calibration parameter to *n* | r[0]=n | r=100.324 | | | 98.0 to 104.9 |
| Read ALPHA calibration parameter | al[pha] | al | al: 9.9999999 | al: 0.0038573 | |
| Set ALPHA calibration parameter to *n* | al[pha]=n | al=0.0038433 | | | .00370 to .00399 |
| **Operating Parameters Menu** | | | | | |
| Read cut-out mode | cm[ode] | cm | cm: {xxxx} | cm: AUTO | |
| **Set cut-out mode:** | **cm[ode]=r[eset]/a[uto]** | | | | RESET or AUTO |
| Set cut-out to be reset manually- | cm[ode]=r[eset] | cm=r | | | |

*Interface command summary cont.*

| Command Description | Command Format | Command Example | Returned | Returned Example | Acceptable Values |
|---|---|---|---|---|---|
| Set cut-out to be reset automatically | cm[ode]=a[uto] | cm=a | | | |
| Read Stirrer Mode | smod | smod | smod: {xxxx} | smod: AUTO | |
| **Set Stirrer Mode:** | **smod=o/a** | | | | ON or AUTO |
| Set stirrer activation mode to on | smod=o | smod=o | | | |
| Set stirrer activation mode to auto | smod=a | smode=a | | | |
| Read Stirrer Set-Point | sset | sset | sset: 9999.99 {C or F} | sset: 160.00C | |
| Set Stirrer Set-Point to *n* | sset=n | sset=160 | | | instrument range |
| **Serial Interface Menu** | | | | | |
| Read serial sample setting | sa[mple] | sa | sa: 9 | sa: 1 | |
| Set serial sampling setting to *n* seconds | sa[mple]=n | sa=0 | | | 0 to 4000 |
| **Set serial duplex mode:** | **du[plex]=f[ull]/h[alf]** | | | | FULL or HALF |
| Set serial duplex mode to full | du[plex]=f[ull] | du=f | | | |
| Set serial duplex mode to half | du[plex]=h[alf] | du=h | | | |
| **Set serial linefeed mode:** | **lf[eed]=on/of[f]** | | | | ON or OFF |
| Set serial linefeed mode to on | lf[eed]=on | lf=on | | | |
| Set serial linefeed mode to off | lf[eed]=of[f] | lf=of | | | |
| **Calibration Menu** | | | | | |
| Read C0 calibration parameter | *c0 | *c0 | c0: 9 | c0: 0 | |
| Set C0 calibration parameter to *n* | *c0=n | *c0=0 | | | –999.9 to 999.9 |
| Read CG calibration parameter | *cg | *cg | cg: 999.99 | cg: 406.25 | |
| Set CG calibration parameter to *n* | *cg=n | *cg=406.25 | | | –999.9 to 999.9 |
| Read low set-point limit value | *tl[ow] | *tl | tl: 999 | tl: –80 | |
| Set low set-point limit to *n* | *tl[ow]=n | *tl=-80 | | | –999.9 to 999.9 |
| Read high set-point limit value | *th[igh] | *th | th: 999 | th: 205 | |
| Set high set-point limit to *n* | *th[igh]=n | *th=205 | | | –999.9 to 999.9 |
| **Miscellaneous (not on menus)** | | | | | |
| Read firmware version number | *ver[sion] | *ver | ver.9999,9.99 | ver.2100,3.56 | |
| Read structure of all commands | h[elp] | h | list of commands | | |
| Read Heater 1 | f1 | f1 | f1:9 | f1:1 | |
| **Set Heater 1** | **f1=1/0** | | | | **1 or 0** |

*Interface command summary cont.*

| Command Description | Command Format | Command Example | Returned | Returned Example | Acceptable Values |
|---|---|---|---|---|---|
| Set heater 1 to on | f1=*n* | f1=1 | | | |
| Set heater 1 to off | f1=*n* | f1=0 | | | |
| Read Heater 2 | f2 | f2 | f2:9 | f2:0 | |
| **Set Heater 2** | **f2=1/0** | | | | **1 or 0** |
| Set Heater 2 to on | f2=*n* | f2=1 | | | |
| Set Heater 2 to off | f2=*n* | f2=0 | | | |
| Read Heater 3 | f3 | f3 | f3:9 | f3:1 | |
| **Set Heater 3** | **f3=1/0** | | | | **1 or 0** |
| Set Heater 3 to on | f3=*n* | f3=1 | | | |
| Set Heater 3 to off | f3=*n* | f3=0 | | | |
| Read Heater 4 | f4 | f4 | f4:9 | f4:1 | |
| **Set Heater 4** | **f4=1/0** | | | | **1 or 0** |
| Set Heater 4 to on | f4=*n* | f4=1 | | | |
| Set Heater 4 to off | f4=*n* | f4=0 | | | |
| Read Boost Heater | f5 | f5 | f5:9 | f5:1 | |
| **Set Boost Heater** | **f5=1/0** | | | | **1 or 0** |
| Set Boost Heater to on | f5=*n* | f5=1 | | | |
| Set Boost Heater to off | f5=*n* | f5=0 | | | |
| Legend: | [] Optional Command data | | | | |
| | {} Returns either information | | | | |
| | n Numeric data supplied by user | | | | |
| | 9 Numeric data returned to user | | | | |
| | x Character data returned to user | | | | |
| Note: | When DUPLEX is set to FULL and a command is sent to READ, the command is returned followed by a carriage return and linefeed. Then the value is returned as indicated in the RETURNED column. | | | | |

In Table 1, characters or data within brackets, “[” and “]”, are optional for the command. A slash, “/”, denotes alternate characters or data. Numeric data, denoted by “n”, may be entered in decimal or exponential notation. Characters are shown in lower case although upper case may be used. Spaces may be added within command strings and will simply be ignored. Backspace (BS, ASCII 8) may be used to erase the previous character. A terminating CR is implied with all commands.

## 9.4 Power commands

The digital interface is capable of controlling the heating functions so that the bath can be remotely operated at any temperature within the range of the bath. *To allow the interface to control the heating, the front panel controls are disabled by 1) switching the heater control to “OFF”, and 2) switching the boost heater switch to “OFF”*. Otherwise, the interface would not be able to switch these functions off. The 6055 bath has five control functions with the digital interface. These are controls for heaters 1, 2, 3, and 4, each 225 W, and the boost heater which is 900 W. Heater 1 power could be varied with the DRIFT control on the front panel. The boost heater should only be used for quickly heating the bath up to a high temperature and not for controlling at a constant temperature.

Serial commands “F1” through “F5” control the heaters 1 through 4 and the boost heater individually. These commands are used to turn the heaters on or off or to read the states of the heaters. Sending a command with parameter “1” turns the heater on. Parameter “0” turns the heater off. No parameter returns the state, “1” for on or “0” for off. For example “F1=1”<RETURN> turns on heater 1. “F1”<RETURN> (no parameter) will return “f1:1” or “f1:0” depending on whether heater 1 is on or off respectively.

Since unlike the front panel heater control, which turns on multiple heaters to achieve the desired power level, the interface commands control the heaters individually, multiple commands must be issued to set the desired amount of power. Table 2 lists the commands which should be given to set various power

levels. Power is variable with the front panel DRIFT control when heater 1 (F1) is turned on.

***Table 2*** *Power Commands*

| POWER | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| OFF | 0 | 0 | 0 | 0 | 0 |
| 0–225 W LOW | 1 | 0 | 0 | 0 | 0 |
| 225–450 W MEDIUM | 1 | 1 | 0 | 0 | 0 |
| 450–675 W MEDIUM HIGH | 1 | 1 | 1 | 0 | 0 |
| 675–900 W HIGH | 1 | 1 | 1 | 1 | 0 |
| 1800 W BOOST | 1 | 1 | 1 | 1 | 1 |

## 9.5 Heater settings for control

Suggested heater control settings for various ranges are suggested below.

| Range | Controls |
|---|---|
| 150°C–250°C | LOW - Heater 1 on, heaters 2–4 and boost heater off |
| 250°C–350°C | MEDIUM - Heaters 1 and 2 on, heater 3, 4, and boost heater off |
| 350°C–450°C | MEDIUM HIGH - Heaters 1–3 on and heater 4 and boost heater off |
| 450°C–550°C | HIGH - Heaters 1–4 and boost heater on |

# 10 Calibration procedure

In some instances the user may want to calibrate the bath 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 bath as measured with a standard thermometer agrees more closely with the bath set-point. The thermometer used must be able to measure the bath fluid temperature with higher accuracy than the desired accuracy of the bath. By using a good thermometer and carefully following procedure the bath can be calibrated to an accuracy of better than 0.02°C over a range of 100 degrees.

## 10.1 Calibration points

In calibrating the bath R0 and ALPHA are adjusted to minimize the set-point error at each of two different bath temperatures. Any two reasonably separated bath temperatures may be used for the calibration however best results will be obtained when using bath temperatures which are just within the most useful operating range of the bath. The further apart the calibration temperatures the larger will be the calibrated temperature range but the calibration error will also be greater over the range. If for instance 50°C and 150°C are chosen as the calibration temperatures then the bath may achieve an accuracy of say ±0.03°C over the range 40 to 160°C. Choosing 80°C and 120°C may allow the bath to have a better accuracy of maybe ±0.01°C over the range 75 to 125°C but outside that range the accuracy may be only ±0.05°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 bath to the lower set-point which we will call $t_L$. Wait for the bath to reach the set-point and allow 15 minutes to stabilize at that temperature. Check the bath stability with the thermometer. When both the bath and the thermometer have stabilized measure the bath temperature with the thermometer and compute the temperature error $err_L$ which is the actual bath temperature minus the set-point temperature. If for example the bath is set for a lower set-point of $t_L$=50°C and the bath reaches a measured temperature of 49.7°C then the error is -0.3°C.

Next, set the bath for the upper set-point $t_H$ and after stabilizing measure the bath temperature and compute the error $err_H$. For our example we will suppose the bath was set for 150°C and the thermometer measured 150.1°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 digital 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 100.000 and 0.0038500 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 again to further improve the accuracy.

## 10.4 Calibration example

The bath is to be used between 75 and 125°C and it is desired to calibrate the bath 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 80.00 and 120.00°C. The measured bath temperatures are 79.843 and 119.914°C respectively. Refer to Figure 9 for applying equations to the example data and computing the new probe constants.

$R_0 = 100.000$

ALPHA = 0.0038500

$t_L = 80.00°C$

measured t = 79.843°C

$t_H = 120.00°C$

measured t = 119.914°C

**Compute errors,**

$err_L = 79.843 - 80.00°C = -0.157°C$

$err_H = 119.914 - 120.00°C = -0.086°C$

**Compute $R_0$,**

$$R_0' = \left[ \frac{(-0.086) \times 80.0 - (-0.157) \times 120.0}{120.0 - 80.0} 0.00385 + 1 \right] 100.000 = 100.115$$

**Compute ALPHA,**

$$ALPHA' = \left[ \frac{(1 + 0.00385 \times 120.0)(-0.157) - (1 + 0.00385 \times 80.0)(-0.086)}{120.0 - 80.0} + 1 \right] 0.00385 = 0.0038387$$

***Figure 9*** *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 dirty or dusty environments.

- A battery is used to maintain operating parameters in the unit. All operating parameters, including calibration parameters should be checked on a regular basis to insure accuracy and proper operation of the instrument. See the troubleshooting section for the procedure on checking the status of the battery.
- The bath should be cleaned regularly to prevent a buildup of salt. Use a paint safe cleaning agent on all painted surfaces. Solvents such as Trichloroethylene or Acetone may dull or dissolve the paint. The stainless steel surfaces may be cleaned with solvents as necessary to remove oils.
- The stirring motor should be clean to allow proper cooling. Normally only the outside surfaces require any attention. If the inside of the motor has become heavily loaded with salt, blow it out with compressed air. Follow normal safety procedures when using pressurized gasses.
- Salt expands and contracts with temperature. Be sure that the correct amount of salt is used for the temperature. If the bath is used at a lower temperature and then raised to a higher temperature, some of the molten salt may need to be carefully removed to prevent overflow.
- Periodically check the fluid level in the bath to ensure that the level has not dropped. A drop in the fluid level affects the stability of the bath. Changes in fluid level are dependent upon several factors specific to the environment in which the equipment is used. A schedule cannot be outlined to meet each environmental setting. Therefore, the first year the bath should be checked weekly with notes kept as to changes in bath fluid. After the first year, the user can set up a maintenance schedule based on the data specific to the application.
- Salt requires little maintenance. There is very little evaporation with salt. Periodic fluid level checks are usually sufficient.
- 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. MSDS sheets applicable to all fluids used in the baths should be kept in close proximity to the instrument.
- If the mains supply cord becomes damaged, replace it with a cord with the appropriate gauge wire for the current of the bath. If there are any questions, contact an Authorized Service Center for more information.

- Before using any cleaning or decontamination method except those recommended by Hart, users should check with an 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 bath 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 8.2) for setting the cut-out. Both the manual and the auto reset option of the cut-out should be checked. Set the bath temperature higher than the cut-out. Check to see if the display flashes cut-out and the temperature is decreasing.

***WARNING:*** *When checking the over-temperature cut-out, be sure that the temperature limits of the bath fluid are not exceeded. Exceeding the temperature limits of the bath fluid could cause harm to the operator, lab, and instrument.*

- The constant temperature bath depends upon the certain qualities of the fluid medium in order to maintain a uniform and stable temperature environment.

# 12 Troubleshooting

In the event the bath 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 bath seems faulty or the problem cannot otherwise be solved, then contact an Authorized Service Center for assistance. Opening the unit without contacting an Authorized Service Center may void the warranty.

## 12.1 Troubleshooting

| Problem | Causes and Solutions |
|---|---|
| The heater indicator LED stays red but the temperature does not increase | If the display does not show “cutout” and shows the correct bath temperature, consider the following possibilities:<br>Insufficient heating. Insufficient heating may be caused by the heater power setting being too low, especially at higher operating temperatures. Switching to the higher heater power switch setting, if available, may solve the problem.<br>No heating. This is caused by blown heater fuses and/or burned out heaters. Check the heater fuses to make sure that they are still good. Access the heater fuses by removing the L-shaped panel covering the display electronics. If they are blown, and continue to blow when replaced, the heaters may be shorted. If you suspect that the heaters are shorted or burned out, contact an Authorized Service Center (see Section 1.3) for assistance. |
| The controller display flashes “CUToUT” and the heater does not operate | If the display flashes “CUToUT” alternately with the correct process temperature, check the following:<br>Wrong cutout setting. The cutout disconnects power to the heaters when the bath temperature exceeds the cutout set-point. This causes the bath temperature to drop back down to a safe value. If the cutout mode is set to “AUTO”, the heater switches back on when the temperature drops. If the mode is set to “RESET”, the heater only comes on again when the temperature is reduced and the operator manually resets the cutout. (Refer to Section 8.11.1.)<br>Check that the cutout set-point is adjusted to 10 or 20°C above the desired maximum bath operating temperature and that the cutout mode is set as desired.<br>Continuous cutout. If the cutout activates when the bath temperature is well below the cutout set-point or the cutout does not reset when the bath temperature drops and it is manually reset, the cutout circuitry may be faulty. Try performing the Factory Reset Sequence explained below.<br>Factory Reset Sequence - Hold the “SET” and “EXIT” keys down at the same time while powering up the unit. The display shows “-init”, the model number, and the firmware version. Each of the controller parameters and calibration constants must be re-programmed. The values can be found on the Report of Calibration that was shipped with the instrument. |

| Problem | Causes and Solutions |
|---|---|
| The display flashes "CUToUT" alternately with an incorrect process temperature | Low battery. A problem could exist with the memory back-up battery. If the battery voltage is insufficient to maintain the memory, data may become scrambled causing problems. A nearby large static discharge may also affect data in memory. Access the battery by removing the L-shaped panel covering the display electronics.<br>Corrupt controller memory. If the problem reoccurs after the battery is replaced, initialize the memory by performing a Factory Reset Sequence (described in a previous solution). |
| The controller displays the wrong temperature and the bath continually heats or cools regardless of the set-point value | Defective control probe. The bath control probe may be disconnected, burned out, or shorted. Check first that the probe is connected properly to the socket in the rear of the bath labeled "PROBE".<br>The probe may be checked with an ohmmeter to see if it is open or shorted. The probe is a platinum 4-wire Din 43760 type. The resistance should read 0.2 to 2.0 ohms between pins 1 and 2 on the probe connector and 0.2 to 2.0 ohms between pins 3 and 4. The resistance should read from 100 to 300 ohms between pins 1 and 4 depending on its current temperature.<br>Corrupt controller memory. Initialize the memory by performing a Factory Reset Sequence (described in a previous solution). |
| The controller controls or attempts to control at an inaccurate temperature | If the controller appears to operate normally except that the bath's temperature does not agree with the temperature measured by the user's reference thermometer to within the specified accuracy, consider the following:<br>Erroneous parameters. Check that the calibration parameters are all correct according to the Report of Calibration. If not, reprogram the constants. If the controller does not keep the correct parameters, the memory backup battery may be weak causing errors in data. See "Low Battery" in a previous solution.<br>Poor uniformity. There may be an actual difference between the bath's control probe and the reference thermometer due to excess gradients in the bath. Check that the bath has an adequate amount of fluid in the tank and that the stirrer is operating properly. Also check that the reference thermometer and control probe are both fully inserted into the bath to minimize temperature gradient errors.<br>Defective control probe. Check that the control probe has not been struck, bent, or damaged. Refer to the previous solution for how to check the probe's resistance. |
| The controller shows that it is controlling at the proper temperature, but the bath temperature is unstable | If the bath does not achieve the expected degree of temperature stability when measured using a thermometer, consider the following:<br>Wrong proportional band setting. If the proportional band is set too narrow, the bath will oscillate causing poor stability. In this case, increase the width of the proportional band.<br>If the proportional band setting is too wide, the long-term stability of the bath is affected. In this case decrease the width of the band. (Refer to Section 8.7.)<br>Bath salt is too thick. Make sure that the bath salt used is less than 50 centistokes (10 is ideal) at the temperature at which the bath is controlling. Check the salt manufacturer's specifications.<br>Defective control probe. Check that the control probe has not been struck, bent, or damaged. Refer to the previous solution for how to check the probe's resistance. |
| The controller alternately heats for a while then cools | Wrong proportional band setting. If the proportional band is set too narrow, the bath will oscillate between too much heating and too much cooling causing instability. Increase the width of the proportional band until the temperature stabilizes. (Refer to Section 8.7.) |

| Problem | Causes and Solutions |
|---|---|
| Stir motor does not function | Improper setting or normal operation. See Section 8.11.2, Stir Mode Select, for proper stir mode settings.<br>⚠ **Note:** Stir Mode Select defaults to "AUto" each time the power of the bath is cycled off and back on. Therefore, this parameter has to be set each time the bath is powered on if "Str-ON" is the desired mode of operation.<br>If stir motor still does not function, contact an Authorized Service Center for assistance . |
| The controller does not maintain controller parameters or parameters are reset each time the power to the unit is removed | **Note:** Before performing the memory check,you need to record the controller calibration parameters (found in the CAL menu of the instrument) and any user-adjusted parameters that you have changed (such as the programmable set points and proportional band).<br>**Memory Check**<br>Doing a memory check is the easiest way to verify the ability of the battery to maintain controller parameters.<br>1. Power off the instrument.<br>2. Disconnect the instrument from AC power for 10 seconds.<br>3. Reconnect the AC power and power on the instrument.<br>4. If the display shows InIT and/or the cycle count shows a low number such as 0002, the battery is spent and should be replaced. Contact a Hart Scientific Authorized Service Center for assistance.<br>5. After replacing the battery, you must reprogram the calibration and user-adjustable parameters into the controller. |

## 12.2 Comments

### 12.2.1 EMC Directive

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

### 12.2.2 Low Voltage Directive (Safety)

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