FLUKE ®

Hart Scientific ®

7007

Calibration Bath
User Manual

Rev. 612402

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Rev. 612402

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1 Before You Start

1.1 Introduction

The Hart Scientific Model 7007 Calibration Bath is a highly stable constant temperature liquid bath. It has been designed for calibrating liquid and glass thermometers or other types of long thermometers against a known temperature standard such as a Standard Platinum Resistance Thermometer (SPRT).

The 7007 calibration bath provides the following features:

- A deep fluid tank (test well is 9 inches in diameter and has 24 inches of fluid depth).
- It provides a highly temperature stable low gradient environment typically a nominal stability of ±0.0005°C with water. 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 and glass thermometers without needing to compensate for stem effect.
- The bath provides two calibration modes: Temperature Control Mode and 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 Temperature Drift Mode bypasses the controller with heater power manually controlled by a variable transformer.

1.2 Symbols Used

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

Table 1 *International Electrical Symbols*

Symbol	Description
∼	AC (Alternating Current)
≂	AC-DC
	Battery
CE	CE Complies with European Union Directives

Symbol	Description
	DC
	Double Insulated
	Electric Shock
	Fuse
	PE Ground
	Hot Surface (Burn Hazard)
	Read the User's Manual (Important Information)
	Off
	On
	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
	The European Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) mark.

1.3 Safety Information

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

The following definitions apply to the terms "WARNING" and "CAUTION".

- "WARNING" identifies conditions and actions that may pose hazards to the user.

- "CAUTION" identifies conditions and actions that may damage the instrument being used.

1.3.1 ⚠ WARNINGS

To avoid personal injury, follow these guidelines.

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

Use only a grounded AC mains supply of the appropriate voltage to power the bath. The bath requires 15 amps at 230 VAC (±10%), 60 Hz.

DO NOT connect this unit to a non-grounded, non-polarized outlet.

DO use a ground fault interrupt device.

EXTREMELY COLD TEMPERATURES PRESENT in this equipment. **FREEZER BURNS AND FROSTBITE** may result if personnel fail to observe safety precautions.

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

Fluids used in this bath 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.**

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 fluid. This action could be extremely dangerous and could result in personal injury to the person moving the bath. If the bath is going to be placed in an area where it needs to be moved frequently, a special cart can be designed to accommodate the bath making the bath much more portable. Hart sells carts designed for these baths. However, even with a cart the bath should not be moved full of fluid. The fluid can splash causing injury or if the bath and cart tip, the fluid could cause damage to the surrounding area and personal injury to personnel.

Follow all safety guidelines listed in the user's manual.

Calibration Equipment should only be used by Trained Personnel.

1.3.2 ⚠ CAUTIONS

To avoid possible damage to the instrument, follow these guidelines.

Operate the bath in room temperatures between 5-50°C (41-122°F). Allow sufficient air circulation by leaving at least 6 inches of space between the bath and nearby objects. Overhead clearance needs to allow for safe and easy insertion and removal of probes for calibration.

If the bath is used at higher temperatures where fluid vaporization is significant, a fume hood should be used.

The bath is a precision instrument. Although it has been designed for optimum durability and trouble free operation, it must be handled with care. The instrument should not be operated in excessively dusty or dirty environments. Do not operate near flammable materials.

Before initial use, after transport, and anytime the instrument has not been energized for more than 10 days, the bath needs to be energized for a "dry-out" period of 1-2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1.

The bath is equipped with operator accessible fuses. If a fuse blows, it may be due to a power surge or failure of a component. Replace the fuse once. If the fuse blows a second time, it is likely caused by failure of a component part. If this occurs, contact an Authorized Service Center. Always replace the fuse with one of the same rating, voltage, and type. Never replace the fuse with one of a higher current rating.

If a mains supply power fluctuation occurs, immediately turn off the bath. Power bumps from brown-outs and black-outs can damage the compressor. Wait until the power has stabilized before re-energizing the bath.

If the bath must be moved, be sure to drain the fluid to prevent any injury. The side of the bath with the compressor is heavier than the tank side. To safely move the bath, two people are required.

1.4 Authorized Service Centers

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

Fluke Corporation, Hart Scientific Division

799 E. Utah Valley Drive

American Fork, UT 84003-9775

USA

Phone: +1.801.763.1600

Telefax: +1.801.763.1010

E-mail: support@hartscientific.com

Fluke Nederland B.V.

Customer Support Services

Science Park Eindhoven 5108

5692 EC Son

NETHERLANDS

Phone: +31-402-675300

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

Fluke Int'l Corporation
Service Center - Instrimpex
Room 2301 Sciteck Tower
22 Jianguomenwai Dajie
Chao Yang District
Beijing 100004, PRC
CHINA

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

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

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

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

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

2 Specifications and Environmental Conditions

2.1 Specifications

Power Required	230 VAC (±10%), 60 Hz, 15 Amps max.
Operating Range	–5 to 110°C
Temperature Stability	±0.001°C @ 0°C (methanol) ±0.0005°C @ 25°C (water) ±0.001°C @ 100°C (oil @ 5 cs)
Temperature Uniformity	±0.002°C max
Controller Accuracy	±1.0°C
Test Well Area	9 inches dia X 24 inches deep
Refrigeration	Single stage; ¼ Hp R-134a air cooled condenser. Adjustable cooling temperature and capacity.
Heater	Electrical, 5 positions; 230 VAC (±10%) line 1=off, 2=300, 3=600, 4=950, and 5=1300
Boost Heater	700 watts
Heat Transfer Liquid	Fluids compatible with stainless steel may be used.
Exterior Dimensions	Height 54" X Width 30.5" X FB 19.5"
Weight	156 Lbs.

2.2 Environmental Conditions

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

The instrument operates safely under the following conditions:

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

2.3 Warranty

The 7007 bath is covered by a 1 year warranty that takes effect 10 days after the product is shipped. The manufacturer will provide parts and labor without charge for repair or replacement of the instrument due to defects in material or workmanship. The warranty will not apply if the product has not been used according to the instruction manual or has been tampered with by the user. For service or assistance, please contact an Authorized Service Center

3 Quick Start

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

This section gives a brief summary of the steps required to set up and operate the 7007 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 Sections 5 through 7 carefully before operating the bath.

3.1 Unpacking

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

Verify that all components are present:

- 7007 Bath
- Controller Probe
- Access Hole Cover
- Manual

If you are missing any item, please an Authorized Service Center.

3.2 Set Up

Set up of the bath requires careful unpacking and placement of the bath, filling the bath with fluid, installing the probe and connecting power. Consult Section 5 for detailed instructions for proper installation of the bath. Be sure too place the bath in a safe, clean, and level location.

Fill the bath tank with an appropriate liquid. For operation at moderate bath temperatures, clean distilled water works well. Carefully pour the fluid into the bath tank through the access hole cover above the tank and avoid spilling any fluid. The fluid must not exceed heights of 1/2 inch below the bath lid.

The control probe must be inserted through the lid into the bath and plugged into the socket at the back of the bath.

3.3 Power

Plug the bath power cord into a mains outlet of the proper voltage, frequency, and current capability. Typically this will be 230 VAC (±10%), 60 Hz, 15 A. If the power connector provided is not used, attach the brown, blue, and green wires, according to code, to an adequately sized connector of your choice. Be sure the green ground wire is properly connected as well.

Set the "HEATER" switch on the front panel to position "LOW" and turn the bath on using the front panel "POWER" switch. The bath will turn on and begin to heat or cool to reach the previously programmed temperature set-point. The front panel LED display will indicate the actual bath temperature.

3.4 Quick Start

With the bath fluid in the bath and the control probe in place, the bath is ready to be turned on. When switched on, the stirring motor, the controller displaying the bath temperature, and the heater will come on. Set the **Heating** switch to position 1 (the first position CW from off) and set the **Drift Adjust Control** to 100%.

Now set the bath to the desired temperature using the buttons to set the temperature controller. This is accomplished by pressing the SET button and then using the UP and DOWN buttons to reach the desired set temperature. Once the set point desired is displayed, press the SET button to set the bath to the new temperature and then press the EXIT button to return to the temperature display (refer to Figure 7 the Controller Operation Flowchart). The bath will heat to the set temperature and begin to control. For temperatures under 45°C, turn on the cooling and set the cooling temperature to 5 -10 degrees below the set temperature. Allow several minutes for the bath to stabilize at the control set-point.

The heater power switch should be set to the lowest position necessary to provide adequate power to control, generally position 1. The higher setting and the boost heater may be switched on to bring the bath up to higher temperatures quickly. The Boost must be switched off and the control heater set down when the temperature is reached.

To achieve optimum control stability the proportional band may require adjustment. The ideal proportional band setting varies with temperature, heater setting, and fluid type.

3.5 Setting the Temperature

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

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

24.68 C	*Bath temperature display*

When "SET" is pressed the display will show the set-point memory that is currently being used and its value. Eight set-point memories are available.

SET — *Access set-point selection*

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

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

SET — *Access set-point value*

`C 25.00` — *Current value of set-point 1, 25.00°C*

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

UP — *Increment display*

`C 30.00` — *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*

`24.73 C` — *Bath temperature display*

The bath will heat or cool 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 of the bath fluid. The over-temperature cut-out should be correctly set to prevent this from happening. See Section 8.8.

If operating the bath below 45 °C set the COOLING power switch to ON. The cooling temperature may require adjustment to provide the proper amount of cooling.

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

If the **Temperature Drift** mode is desired, select that position after adjusting the **Drift Adjust** to 0% to eliminate jumps in temperature, then adjust to the anticipated heating position. Use a bridge and strip chart recorder or other adequate means to establish the desired temperature drift rate as the **Drift Adjust** control is adjusted upward. Select the number **1** control heater position for the minimum amount of heat and add heat in increments with positions **2**, **3** and **4** as needed.

4 Installation

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

This bath is not designed to be portable. Therefore, moving the bath once it has been installed should be kept to a minimum.

⚠ ***WARNING:*** *Never move a bath that is full of fluid. This action could be extremely dangerous and could result in personal injury to the person moving the bath.*

If the bath is going to be placed in an area where it will need to be moved frequently, a special cart can be designed to accommodate the bath making the bath much more portable. Hart sells carts designed for these baths. However, even with a cart the bath should not be moved full of fluid. The fluid can splash causing injury or if the bath and cart tip, the fluid could cause damage to the surrounding area and personal injury to personnel.

If the bath must be moved, be sure to drain the fluid to prevent any injury. The side of the bath with the compressor is heavier than the tank side. To safely move the bath, two people are required.

4.1 Bath Environment

The model 7007 bath is a precision instrument that must be located in an appropriate environment. The location should be free from drafts, extreme environmental temperatures and temperature changes, dirt, etc.

The surface where the bath is placed must be level.

If used at higher temperatures where fluid vaporization is significant, a fume hood should be used.

4.2 "Dry-out" Period

Before initial use, after transport, and any time the instrument has not been energized for more than 10 days, the bath needs to be energized for a "dry-out" period of 1-2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1.

4.3 Bath Preparation and Filling

The 7007 bath is not provided with a fluid. Various fluids are available from Hart Scientific and other sources. Depending on the desired temperature range, any of the following fluids, as well as others, may be used in the bath:

- Water
- Ethylene Glycol/Water
- Methanol
- Mineral Oil
- Silicone Oil

Fluids are discussed in detail in Section 7.3.

Remove the access hole cover from the bath and check the tank for foreign matter (dirt, remnant packing material, etc.). Use clean unpolluted fluid. Carefully fill the bath through the access hole cover to a level that allows for stirring and thermal expansion. The fluid should never exceed a height of 1/2" below the top of the tank. Carefully monitor the bath fluid level as the bath temperature rises to prevent overflow or splashing. Remove excess fluid if necessary and with caution if the fluid is hot.

Be careful to prevent bath fluid from spilling on the stirring motor while filling.

CAUTION: *Underfilling may reduce bath performance and may possibly damage the bath heater.*

4.4 Probe

Inspect the bath controller probe. This probe should not be bent or damaged in any way. Reasonable caution should be used in handling this probe as it contains a precision thermistor sensor. If damaged, the probe can be replaced. Contact Hart Scientific Customer Service for assistance.

4.5 Power

With the bath power switch off, plug the bath power cord into a mains outlet of the proper voltage, frequency, and current capability. Typically this will be 230 VAC (±10%), 60 Hz, 15 A. If the power connector provided is not used, attach the brown, blue, and green wires, according to code, to an adequately sized connector of your choice. Be sure the green ground wire is properly connected as well.

Be sure the stirring motor power cord is plugged into the "STIRRER" socket at the back of the bath.

5 Bath Use

READ BEFORE PLACING THE BATH IN SERVICE

The information in this section is for general information only. It is not designed to be the basis for calibration laboratory procedures. Each laboratory needs to write their 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 8, 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. 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 make sure that the temperature has stabilized before starting the calibration.

6 Parts and Controls

This section describs the Controller Panel, the Power Panel, the Back Panel, and the Refrigeration Control Panel of the 7007.

The Front Control Panel, which is located just left of the bath, has two sections. The upper section is the Controller Panel (Figure 1) and the lower is the Power Panel (Figure 2) section.

6.1 Front Controller Panel

The Controller Panel includes the following features: 1) the digital display, 2) the four button keypad and 3) the control indicator.

1) The digital display is an important part of the temperature controller because it not only displays set and actual temperatures but also displays various 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.

Setting the control temperature is done directly in degrees of the current scale and can be set to one-hundredth of a degree Celsius.

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 are ignored.

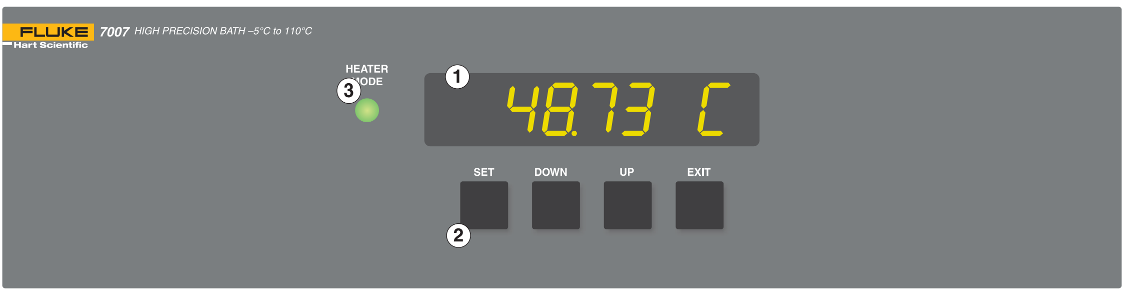

Figure 1 *Control Panel*

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.

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 **POWER** (On-Off) switch powers up the bath. The switch is a DPST type that opens both legs of the 230 volt power source. A red indicator light shows that power is on.

2) The **BOOST HEATING/COOLING** switch selects between the refrigeration cooling and a boost heater which provides an additional 700 watts, 230 VAC (±10%) for slewing between temperatures. The Boost Heating Indicator (red) 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. The Cooling Indicator (green) indicates whether the refrigeration cooling system is on. The center OFF position allows both functions to be off. The refrigeration cooling is generally not used at temperatures above about 45 degrees.

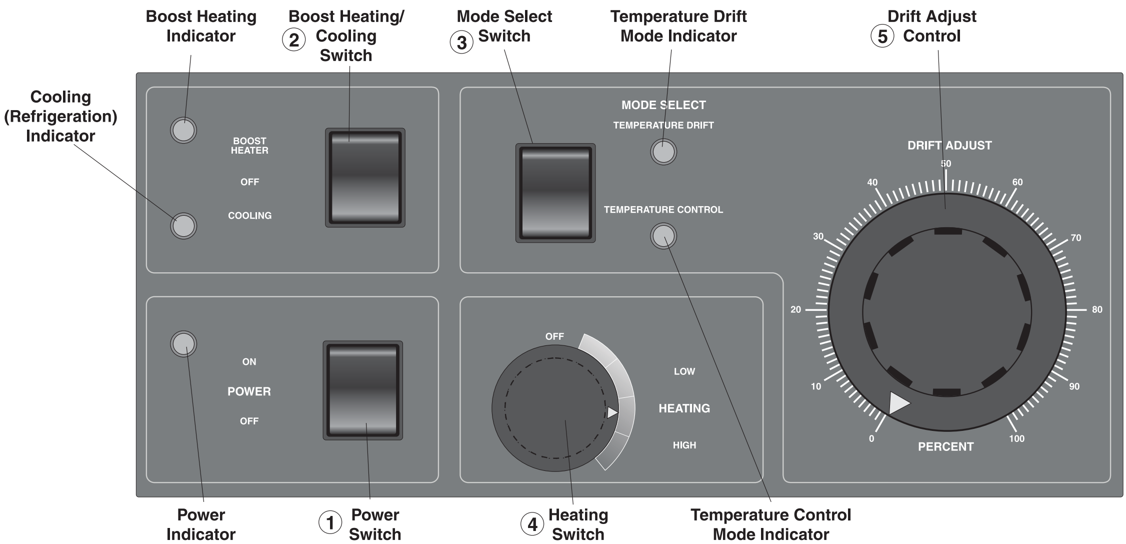

Figure 2 *Power Panel*

3) The **MODE SELECT** switch selects between the Temperature Control and Temperature Drift modes. The lights show which mode is functioning. The Temperature Control position selects the temperature controller to operate and the desired temperature is selected on the controller panel. In the Temperature Drift mode, heater control is via the Drift Adjust control and the Heating select switch.

4) The control **HEATING** switch selects control heater power positions OFF through 4 (clockwise). Select position 1 for normal control conditions. The switch simply adds more heaters into the circuit until the desired power is attained.

5) The **DRIFT ADJUST** control is a variable transformer that adjusts positions 1 and 2 control heater through 0 to 100% of its power range. The additional power required for faster temperature changes may be added in steps by selecting heating positions 2, 3, and 4, as required. However, positions 3 and 4 are not controlled by the drift adjust.

6.3 Rear Panel

The Rear Panel has five different features (see Figure 3). 1) The PROBE connector, 2) STIRRER POWER outlet, 3) SYSTEM FUSES, 4) Electrical Junction Box, and 5) Unit SERIAL NO. notation.

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

2) The STIRRER POWER connection provides 230 VAC to the stirring motor and cooling fan.

3) The SYSTEM FUSES are 15 amp at 230 VAC.

4) The Electrical Junction Box is where the bath is wired to electrical power. The bath requires 230 VAC single phase power.

5) The unit SERIAL NO. is located at the top right corner of the back panel. When consulting with the factory, refer to the serial number.

6.4 Side Panel

The side panel has three features (see Figure 4): 1) the back pressure valve, 2) the cooling temperature regulating valve, and 3) the cooling temp gauge. With the interface option an extra cooling valve (HIGH) is provided.

1) The back pressure valve adjustment is used to control the amount of cooling supplied to the system. This valve reduces the cooling capacity by restricting the flow of refrigerant to the bath, allowing the adjustment of the heating to cooling percentage. Under normal operation the valve should be fully open (counter clockwise).
2) The cooling temperature regulating valve is used to adjust the temperature at which the refrigerant evaporates, which determines cooling effi-

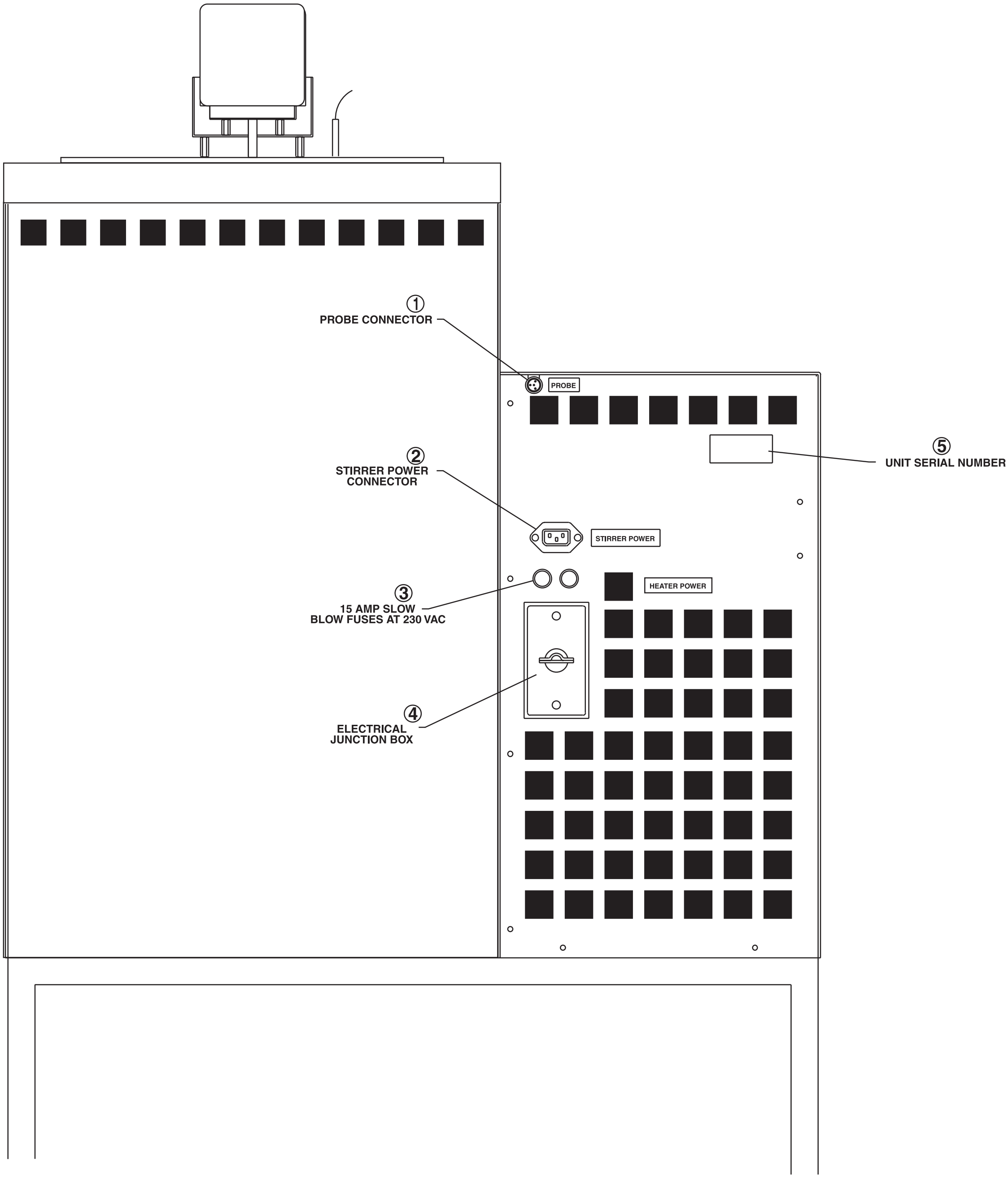

Figure 3 *Rear Panel*

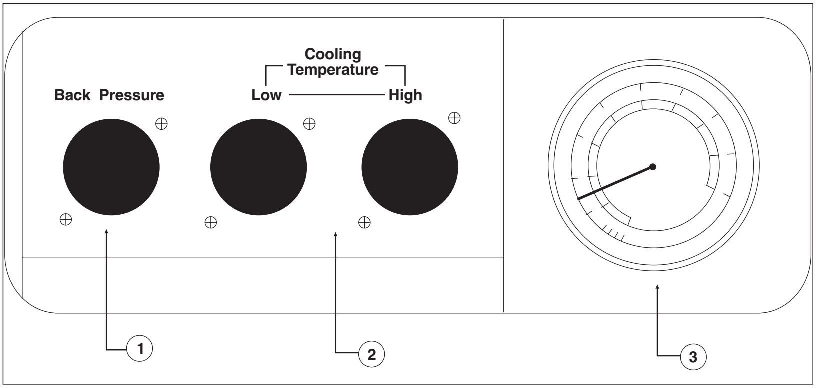

Figure 4 *Side Panel*

ciency. The ideal temperature for operation is about 5-10 degrees Celsius below the desired bath temperature. Refer to the label below the gauge for approximate psi and evaporative temperature settings. The table from the label is reproduced below.

Automated versions have cooling temperature valves in two ranges, High and Low see Section 9.4. For normal operation adjust the Low valve.

For this bath: Control Temperature		Set the Cooling Temp. Valve to this pressure
°C	°F	Nominal Cooling PSIG
–10	14	4.7
–5	23	9.2
0	32	14.5
5	41	20.7
10	50	27.9
15	59	36.1
20	68	45.5
25	77	56.2
30	86	68.4
35	95	82.1
37	98.6	86
DO NOT set the Cooling Pressure above 90 PSIG		

3) The cooling temperature gauge is used to indicate the temperature at which the refrigerant is evaporating. The cooling temperature regulating valve is used to set and then control at this temperature.

7 General Operation

The model 7007 calibration bath is shown in block diagram form in Figure 5 on page 24. The primary features of the bath system and their function are described as follows.

7.1 Two Modes of Temperature Control

Two modes of temperature control are available with the model 7007. 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 control mode uses a hybrid digital/analog PI temperature controller with lock-in-amplifier. The bath stability is very high with this controller. The temperature is selected using a four button keypad on the front panel. Temperatures from –5.00 to 110.00°C may be selected directly to ±0.002 °C. 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.

The temperature control probe uses a linearized thermistor. The thermistor is a totally separate unit for ease of replacement. It is inserted into the top of the bath near the stirring motor as shown and plugs into the rear of the control unit.

The heaters are external 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

In the Temperature Drift mode the heater may be set manually to allow the temperature to drift very slowly (a few milli-°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 are not controlled by the variable transformer. When position 2, 3, or 4 of the heater selection switch is selected, it is controlled by the temperature control mode.

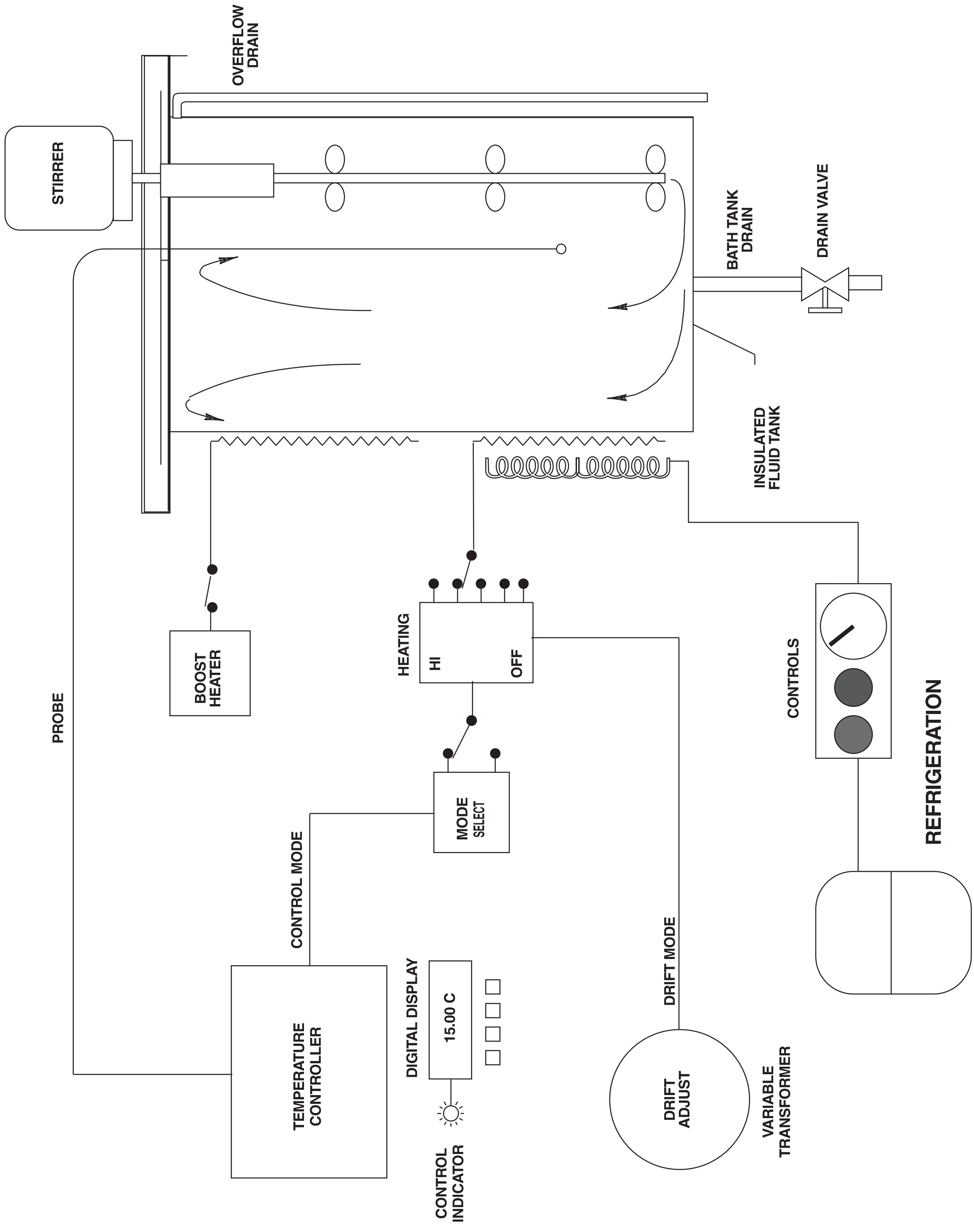

Figure 5 *System Diagram*

7.2 Fluid System

The fluid system consists of the insulated tank, the stirrer assembly, the drain, and the fluid itself. The control heaters and boost heaters are external to the tank. The probe is internal to the tank.

The tank and other wetted parts are made of stainless steel for compatibility with most practical thermostating fluids. The stirrer is attached to the tank top plate of the bath . The stirrer directly drives three 2-inch diameter stirring propellers. The stirring motor plugs into the rear of the control unit. (See Figure 3 on page 20.)

Excess fluid volume due to thermal expansion is controlled with an overflow outlet at the top rear of the tank. The excess fluid exits beneath the bath via a .5 inch diameter tube.

A drain with a valve is provided for convenience in changing the bath fluid. The drain valve is located at the bottom of the bath. (See draining the tank.)

The recommended bath fluid is water for the best stability. Other fluids may be used to extend the temperature range if necessary. Their properties of specific heat, thermal conductivity, flash point and viscosity as well as economy and convenience should be examined and found acceptable.

Attach a tube to the overflow compatible with the temperature and fluid to be used and extend it to an adequate sump.

7.3 Bath Fluid

Many fluids work with the 7007 bath. Choosing a fluid requires consideration of many important characteristics of the fluid. Among these are temperature range, viscosity, specific heat, thermal conductivity, thermal expansion, electrical resistivity, fluid lifetime, safety, and cost.

7.3.1 Temperature Range

One of the most important characteristics to consider is the temperature range of the fluid. Few fluids work well throughout the complete temperature range of the bath. The temperature at which the bath is operated must always be within the safe and useful temperature range of the fluid. The lower temperature range of the fluid is determined by the freeze point of the fluid or the temperature at which the viscosity becomes too great. The upper temperature is usually limited by vaporization, flammability, or chemical breakdown of the fluid. Vaporization of the fluid at higher temperatures may affect temperature stability because of cool condensed fluid dripping into the bath from the lid.

The bath temperature should be limited by setting the safety cut-out so that the bath temperature cannot exceed the safe operating temperature limit of the fluid.

7.3.2 Viscosity

Viscosity is a measure of the thickness of a fluid, how easily it can be poured and mixed. Viscosity affects the temperature stability of the bath. With low viscosity, fluid mixing is better which creates a more uniform temperature throughout the bath. This improves the bath response time which allows it to maintain a more constant temperature. For good control the viscosity should be less than 10 centistokes. 50 centistokes is about the upper limit of allowable viscosity. Viscosities greater than this cause very poor control stability and may also overheat or damage the stirring motor. With oils viscosity may vary greatly with temperature.

When using fluids with higher viscosities the controller proportional band may need to be increased to compensate for the reduced response time. Otherwise the temperature may begin to oscillate.

7.3.3 Specific Heat

Specific heat is the measure of the heat storage ability of the fluid. Specific heat, though to a lesser degree, also affects the control stability and the heating and cooling rates. Generally, a lower specific heat causes slightly better control stability and quicker heating and cooling. With fluids with higher specific heat the controller may require a decreased proportional band to compensate for the decrease in sensitivity of the bath temperature to heat input.

7.3.4 Thermal Conductivity

Thermal conductivity measures how easily heat flows through the fluid. Thermal conductivity of the fluid affects the control stability, temperature uniformity, and probe temperature settling time. Fluids with higher conductivity distribute heat more quickly and evenly improving bath performance.

7.3.5 Thermal Expansion

Thermal expansion describes how the volume of the fluid changes with temperature. Thermal expansion of the fluid used must be considered since the increase in fluid volume as the bath temperature changes may cause overflow. Excessive thermal expansion may also be undesirable in applications where constant liquid level is important. Oils typically have significant thermal expansion.

7.3.6 Electrical Resistivity

Electrical resistivity describes how well the fluid insulates against the flow of electric current. In some applications, such as measuring the resistance of bare temperature sensors, it may be important that little or no electrical leakage occur through the fluid. In this case consider a fluid with very high resistivity.

7.3.7 Fluid Lifetime

Many fluids degrade over time because of evaporization, water absorption, gelling, or chemical breakdown. Often the degradation becomes significant near the upper temperature limit of the fluid.

7.3.8 Safety

When choosing a fluid always consider the safety issues associated. Obviously, where there are extreme temperatures there can be danger to personnel and equipment. Fluids may also be hazardous for other reasons. Some fluids may be considered toxic. Contact with eyes, skin, or inhalation of vapors may cause injury. A proper fume hood must be used if hazardous or bothersome vapors are produced.

⚠ ***WARNING:*** *Fluids at high temperatures. May pose danger from BURNS, FIRE, and TOXIC fumes. Use appropriate caution and safety equipment.*

Fluids may be flammable and require special fire safety equipment and procedures. An important characteristic of the fluid to consider is the flash point. The flash point is the temperature at which there is sufficient vapor given off so that when there is sufficient oxygen present and an ignition source is applied the vapor will ignite. This does not necessarily mean that fire will be sustained at the flash point. The flash point may be either of the open cup or closed cup type. Either condition may occur in a bath situation. The closed cup temperature is always the lower of the two. The closed cup represents the contained vapors inside the tank and the open cup represents the vapors escaping the tank. Oxygen and an ignition source will be less available inside the tank.

Environmentally hazardous fluids require special disposal according to applicable federal or local laws after use.

7.3.9 Cost

Cost of bath fluids may vary greatly, from cents per gallon for water to hundreds of dollars per gallon for synthetic oils. Cost may be an important consideration when choosing a fluid.

7.3.10 Commonly Used Fluids

Below is a description of some of the more commonly used fluids and their characteristics

7.3.10.1 Water

Water is often used because of its very low cost, availability, and excellent temperature control characteristics. Water has very low viscosity and good thermal conductivity and heat capacity which makes it among the best fluids for control stability at low temperatures. Temperature stability is much poorer at higher temperatures because water condenses on the lid, cools and drips into the bath.

Water is safe and relatively inert. The electrical conductivity of water may prevent its use in some applications. Water has a limited temperature range, from a few degrees above 0°C to a few degrees below 100°C. At higher temperatures evaporation becomes significant. Water used in the bath should be distilled or softened to prevent mineral deposits. Consider using an algicide chemical in the water to prevent contamination.

7.3.10.2 Ethylene Glycol

The temperature range of water may be extended by using a solution of 1 part water and 1 part ethylene glycol (antifreeze). The characteristics of the ethylene glycol-water solution are similar to water. Use caution with ethylene glycol since the fluid is very toxic. Ethylene glycol must be disposed of properly.

7.3.10.3 Methanol

Methanol or methyl alchohol is often used at low temperatures below 0°C. Methanol is relatively inexpensive, has good control characteristics, and has a low freeze point. Methanol is very toxic so care must be taken when using and disposing of this fluid.

7.3.10.4 Mineral Oil

Mineral oil or paraffin oil is often used at moderate temperatures above the range of water. Mineral oil is relatively inexpensive. At lower temperatures mineral oil is quite viscous and control may be poor. At higher temperatures vapor emission becomes significant. The vapors may be dangerous and a fume hood should be used. As with most oils mineral oil will expand as temperature increases so be careful not to fill the bath too full that it overflows when heated. The viscosity and thermal characteristics of mineral oil is poorer than water so temperature stability will not be as good. Mineral oil has very low electrical conductivity. Use caution with mineral oil since it is flammable and may also cause serious injury if inhaled or ingested.

7.3.10.5 Silicone Oils

Silicone oils are available which offer a much wider operating temperature range than mineral oil. Like most oils, silicone oils have temperature control characteristics which are somewhat poorer than water. The viscosity changes significantly with temperature and thermal expansion also occurs. These oils have very high electrical resistivity. Silicon oils are fairly safe. These oils are relatively expensive.

7.3.11 Fluid Characteristics Charts

Table 2 and Figure 6 have been created to provide help in selecting a heat exchange fluid media for your constant temperature bath. The charts provide both a visual and numerical representation of most of the physical qualities important in making a selection. The list is not all inclusive, many usable fluids may not have been shown in this listing.

Table 2 *Table of various fluids and their properties*

Fluid (# = Hart Part No.)	Lower Temperature Limit*	Upper Temperature Limit*	Flash Point	Viscosity (centistokes)	Specific Gravity	Specific Heat (cal/g/°C)	Thermal Conductivity (cal/s/cm/°C)	Thermal Expansion (cm/cm/°C)	Resistivity ($10^{12}\Omega$-cm)
Halocarbon 0.8 #5019	–90°C (v)**	70°C (e)	NONE	5.7 @ –50°C 0.8 @ 40°C 0.5 @ 70°C	1.71 @ 40°C	0.2	0.0004	0.0011	
Methanol	–96°C (fr)	60°C (b)	54°C	1.3 @ –35°C 0.66 @ 0°C 0.45 @ 20°C	0.810 @ 0°C 0.792 @ 20°C	0.6	0.0005 @ 20°C	0.0014 @ 25°C	
Water	0°C (fr)	95°C (b)	NONE	1 @ 25°C 0.4 @ 75°C	1.00	1.00	0.0014	0.0002 @ 25°C	
Ethylene Glycol—50% #5020	–35°C (fr)	110°C (b)	NONE	7 @ 0°C 2 @ 50°C 0.7 @ 100°C	1.05	0.8 @ 0°C	0.001		
Mineral Oil	40°C (v)	190°C (fl)	190°C	15 @ 75°C 5 @ 125°C	0.87 @ 25°C 0.84 @ 75°C 0.81 @ 125°C	0.48 @ 25°C 0.53 @ 75°C 0.57 @ 125°C	0.00025 @ 25°C	0.0007 @ 50°C	5 @ 25°C
Dow Corning 200.5 Silicone Oil	–40°C (v)**	133°C (fl, cc)	133°C	5 @ 25°C	0.92 @ 25°C	0.4	0.00028 @ 25°C	0.00105	1000 @ 25°C 10 @ 150°C
Dow Corning 200.10 #5012	–35°C (v)**	165°C (fl, cc)	165°C	10 @ 25°C 3 @ 135°C	0.934 @ 25°C	0.43 @ 40°C 0.45 @ 100°C 0.482 @ 200°C	0.00032 @ 25°C	0.00108	1000 @ 25°C 50 @ 150°C
Dow Corning 200.20 #5013	7°C (v)	230°C (fl, cc)	230°C	20 @ 25°C	0.949 @ 25°C	0.370 @ 40°C 0.393 @ 100°C 0.420 @ 200°C	0.00034 @ 25°C	0.00107	1000 @ 25°C 50 @ 150°C
Dow Corning 200.50 Silicone Oil	25°C (v)	280°C (fl, cc)	280°C	20 @ 25°C	0.96 @ 25°C	0.4	0.00037 @ 25°C	0.00104	1000 @ 25°C 50 @ 150°C
Dow Corning 550 #5016	70°C (v)	232°C (fl, cc) 300°C (fl, oc)	232°C	50 @ 70°C 10 @ 104°C	1.07 @ 25°C	0.358 @ 40°C 0.386 @ 100°C 0.433 @ 200°C	0.00035 @ 25°C	0.00075	100 @ 25°C 1 @ 150°C
Dow Corning 710 #5017	80°C (v)	302°C (fl, oc)	302°C	50 @ 80°C 7 @ 204°C	1.11 @ 25°C	0.363 @ 40°C 0.454 @ 100°C 0.505 @ 200°C	0.00035 @ 25°C	0.00077	100 @ 25°C 1 @ 150°C
Dow Corning 210-H Silicone Oil	66°C (v)	315°C (fl, oc)	315°C	50 @ 66°C 14 @ 204°C	0.96 @ 25°C	0.34 @ 100°C	0.0003	0.00095	100 @ 25°C 1 @ 150°C
Heat Transfer Salt #5001	145°C (fr)	530°C	NONE	34 @ 150°C 6.5 @ 300°C 2.4 @ 500°C	2.0 @ 150°C 1.9 @ 300°C 1.7 @ 500°C	0.33	0.0014	0.00041	1.7 Ω /cm^3

*Limiting Factors — b - boiling point e - high evaporation fl - flash point fr - freeze point v - viscosity — Flash point test oc = open cup cc = closed cup
**Very low water solubility, ice will form as a slush from condensation below freezing.

7.3.11.1 Limitations and Disclaimer

Every effort has gone into making these charts accurate, however, the data here does not imply any guarantee of fitness of use for a particular application. Working near the limits of a property such as the flash point or viscosity limit can compromise safety or serviceability. Sources of information sometimes vary for particular properties. Your company's safety policies as well as personal judgment regarding flash points, toxicity, etc. must also be considered. You are responsible for reading the Material Safety Data Sheets and making a judgment here. Cost may require some compromises as well. Hart Scientific cannot be liable for the suitability of application or for any personal injury, damage to equipment, product or facilities in using these fluids.

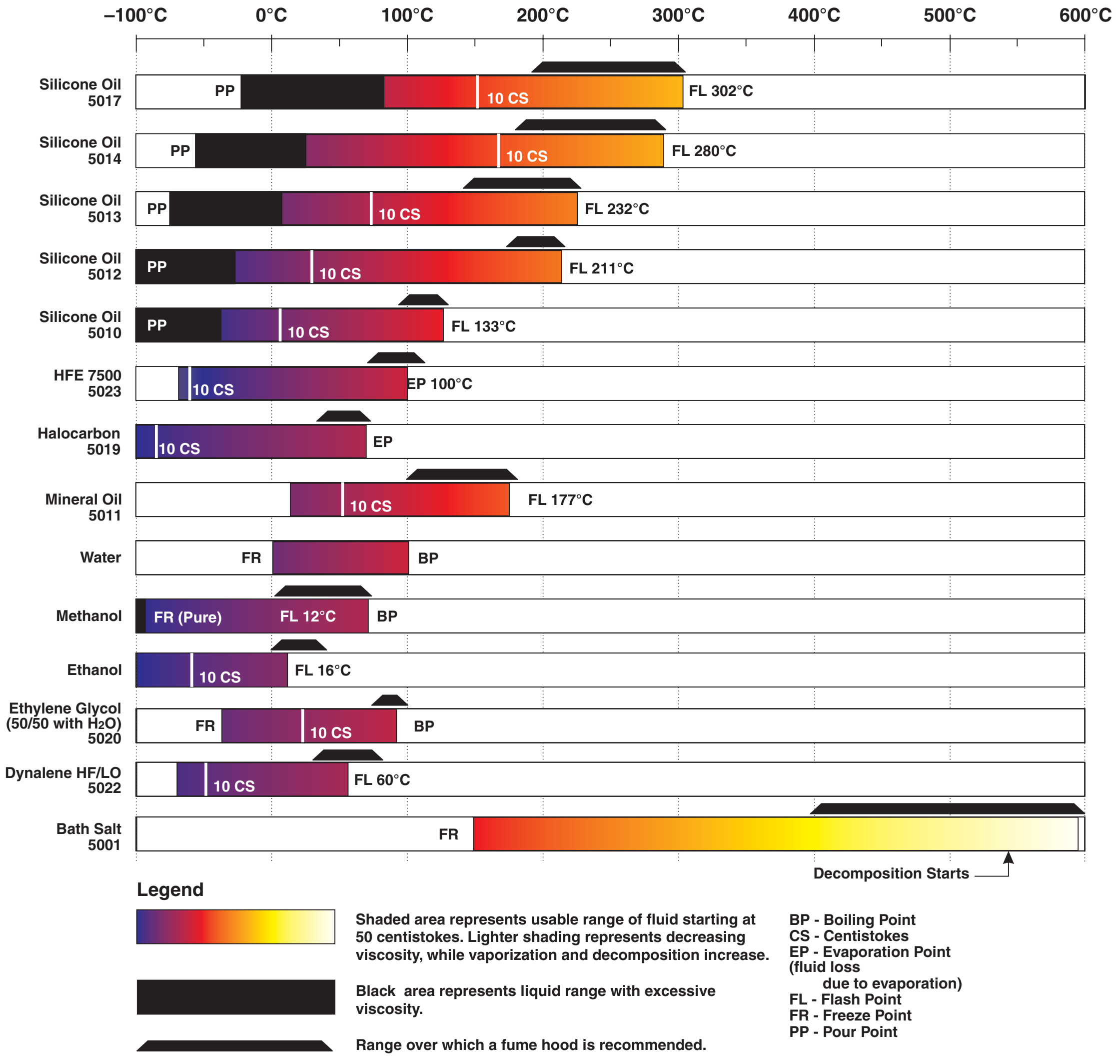

Figure 6 *Fluid Characteristics Chart*

The charts include information on a variety of fluids which are often used as heat transfer fluid in baths. Because of the temperature range some fluids may not be useful with your bath.

7.3.11.2 About the Graph

The fluid graph visually illustrates some of the important qualities of the fluids shown.

Temperature Range: The temperature scale is shown in degrees Celsius. A sense of the fluid's general range of application is indicated. Qualities including pour point, freeze point, important viscosity points, flash point, boiling point and others may be shown.

Freezing Point: The freezing point of a fluid is an obvious limitation to stirring. As the freezing point is approached high viscosity may also limit good stirring.

Pour Point: This represents a handling limit for the fluid.

Viscosity: Points shown are at 50 and 10 centistokes. Greater than 50 centistokes stirring is very poor and unsatisfactory for bath applications. At 10 centistokes and below optimum stirring can occur. These are rules of thumb which have been useful for most applications.

Fume Point: The point at which a fume hood should be used. This point is very subjective in nature and is impacted by individual tolerance to different fumes and smells, how well the bath is covered, the surface area of the fluid in the bath, the size and ventilation of the facility where the bath is located and others. We assume the bath is well covered at this point. This is also subject to company policy.

Flash Point: The point at which ignition may occur. See flash point discussion in Section 7.3.8. The point shown may be either the open or closed cup flash point.

Boiling Point: At the boiling point of the fluid the temperature stability is difficult to maintain. Fuming is excessive. Excessive amounts of heater power may be required because of the heat of vaporization.

Decomposition: All high temperature fluids may be reach a temperature point at which decomposition of some form will begin. While it always begins slowly at some lower temperature, the rate can increase to the point of danger or impracticality at a higher temperature.

8 Controller Operation

This chapter 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, serial and IEEE-488 interface configuration, and controller calibration parameters. Operation is summarized in Figure 7.

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,

25.00 C	*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 alternately flashes,

cut-out	*Indicates cut-out condition*

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

The cut-out has two modes — automatic reset and manual reset. The mode determines how the cut-out is reset which allows the 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.

SET	*Access cut-out reset function*

The display will indicate the reset function.

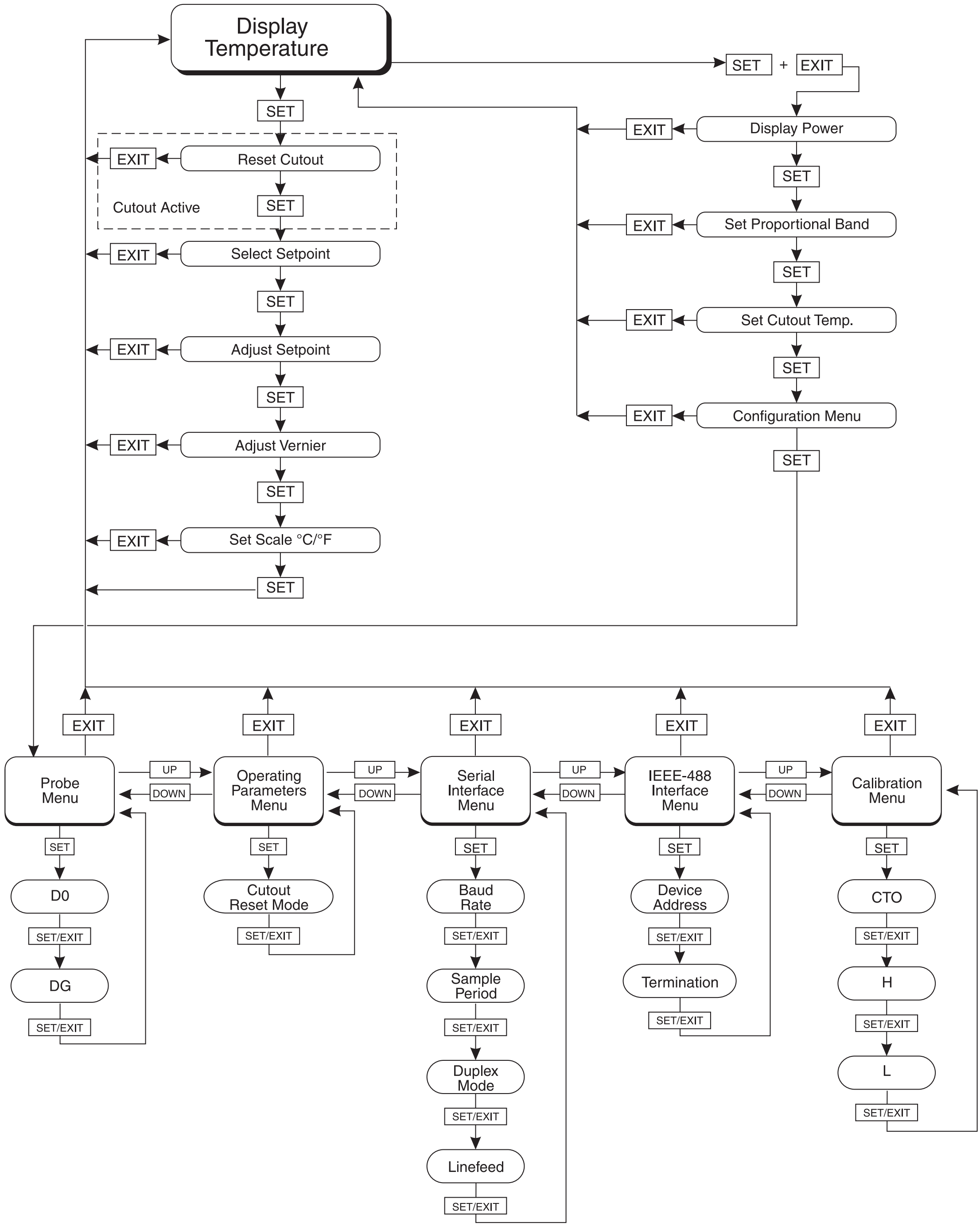

Figure 7 *Controller Operation Flowchart*

`rESEt ?` *Cut-out reset function*

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

[SET] *Reset cut-out*

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 and with resolution as given in the specifications. 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 set-point.

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*

[SET] *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”.

`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. Press "UP" or "DOWN" to adjust the set-point value.

`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 only be set with a resolution of 0.01°C. The user may want to adjust the set-point slightly to achieve a 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.

`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 are 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.

25.00 C	*Bath temperature*
SET	*Access set-point memory*
1. 25.0	*Set-point memory*
SET	*Access set-point value*
C 40.00	*Set-point value*
SET	*Access vernier*
0.00000	*Vernier setting*
SET	*Access scale units selection*
Un= C	*Scale units currently selected*

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

Un= F	*New units selected*

Press "SET" to accept the new 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.

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 to the bath 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 Pct *Heater power in percent*

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

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 8. If the band is too wide the bath temperature deviates excessively from the set-point due to varying external conditions. This is because the power output changes very little with temperature and the controller cannot respond very well to changing conditions or noise in the system. If the proportional band is too narrow the 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.

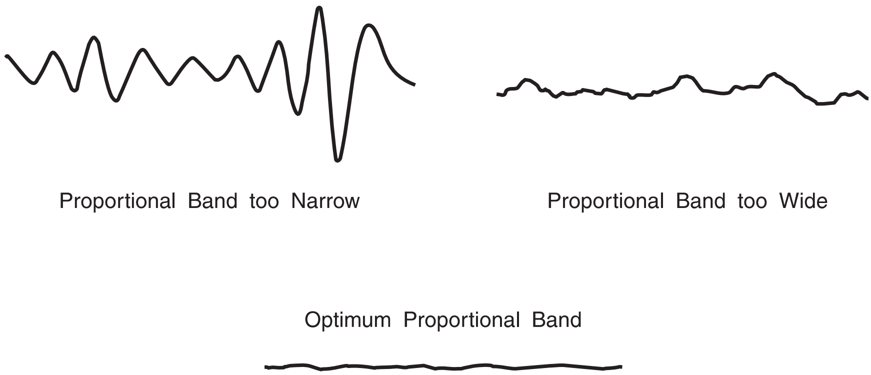

Figure 8 *Bath temperature fluctuations at various proportional band settings*

The optimum proportional band width depends on several factors among which are fluid volume, fluid characteristics (viscosity, specific heat, thermal conductivity), heater power setting, 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 heater power setting and fluid viscosity. The proportional band should be wider when the higher power setting is used so that the change in output power per change in temperature remains the same. The proportional band should also be wider when the fluid viscosity is higher because of the increased response time.

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. Table 3 lists typical proportional band settings for optimum performance with a variety of fluids at selected temperatures.

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.

Table 3 *Proportional Band — Fluid Table*

Fluid	Temperature	Heater Setting	Proportional Band	Stability
Water	30.0°C	Low	0.04°C	±0.0004°C
Water	60.0°C	Low	0.04°C	±0.001°C
Eth-Gly 50%	35.0°C	Low	0.05°C	±0.0005°C
Eth-Gly 50%	60.0°C	Low	0.05°C	±0.001°C
Eth-Gly 50%	100.0°C	High	0.4°C	±0.007°C
Oil	35.0°C	Low	0.1°C	±0.003°C
Oil	60.0°C	Low	0.2°C	±0.002°C
Oil	100°C	Low	0.2°C	±0.003°C

SET + EXIT *Access heater power in secondary menu*

12 Pct *Heater power in percent*

SET *Access proportional band*

Pb=0.101C *Proportional band setting*

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

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 shuts off and the bath cools. The bath cools 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 selectable modes — automatic reset or manual reset. If the mode is set to automatic, then the cut-out automatically resets 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 remains 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= 110C` *Cut-out set-point*

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

`CO= 75C` *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." 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".

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, DO and DG, which characterize the transfer function of the linearized thermistor control probe. These parameters may be adjusted to improve the accuracy of the bath. This procedure is explained in detail in Section10.

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 DO

This probe parameter refers to the temperature at which the control probe output would be 0. Normally this is set for -25.229.

8.10.2 DG

This probe parameter refers to the temperature span of the probe between 0 and 100% output. Normally this is set for 186.974.

8.11 Operating Parameters

The operating parameters menu is indicated by,

PAr	*Operating parameters menu*

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

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,

CtorSt	*Cut-out reset mode parameter*

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

Cto=Auto	*Cut-out set for automatic reset*

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

Cto=rSt	*Cut-out set for manual reset*

8.12 Serial Interface Parameters

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

SErIAL	*Serial RS-232 interface parameters menu*

The Serial interface parameters menu contains parameters which determine the operation of the serial interface. These controls only apply to 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, then 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,

`SAMPLE` *Serial sample period parameter*

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

`SA= 1` *Current sample period (seconds)*

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

`SA= 60` *New sample period*

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

`dUPL` *Serial duplex mode parameter*

Press "SET" to access the mode setting.

`dUP=FULL` *Current duplex mode setting*

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

`dUP=HALF` *New duplex mode setting*

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,

`LF` *Serial linefeed parameter*

Press “SET” to access the linefeed parameter.

`LF= On` *Current linefeed setting*

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

`LF= OFF` *New linefeed setting*

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` *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,

`AddrESS` *IEEE-488 interface address*

Press “SET” to access the address setting.

`Add= 22` *Current IEEE-488 interface address*

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

`Add= 15` *New IEEE-488 interface address*

8.13.2 Termination

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

EOS	*IEEE-488 termination*

Press "SET" to access the termination setting.

EOS=Cr	*Present IEEE-488 termination*

Use "UP" or "DOWN" to change the selection.

EOS=LF	*New termination selection*

Use "SET" to save the new selection.

8.14 Calibration Parameters

The operator of the bath controller has access to a number of the bath calibration constants namely CTO, H, and L. These values are set at the factory and must not be altered. The correct values are important to the 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 7007 bath this parameter should read between 110 and 130.

8.14.2 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 exceeding its temperature range causing damage or fire.

9 Digital Communication Interface

If supplied with the option, the 7007 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.

With a digital interface the bath may be connected to a computer or other equipment. This allows the user to set the bath temperature, monitor the temperature, and access any of the other controller functions, all using remote communications equipment. In addition the heater power setting and cooling capacity may be controlled using the interface. To enable the heater to be switched to high using the interface the “HEATER” switch must be set to the “LOW” position. The cooling power switch must be set to OFF to enable remote control.

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 Section 8 with the exception of the BAUD rate setting.

9.1.1 Wiring

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

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.

RS-232 Cable Wiring for IBM PC and Compatibles

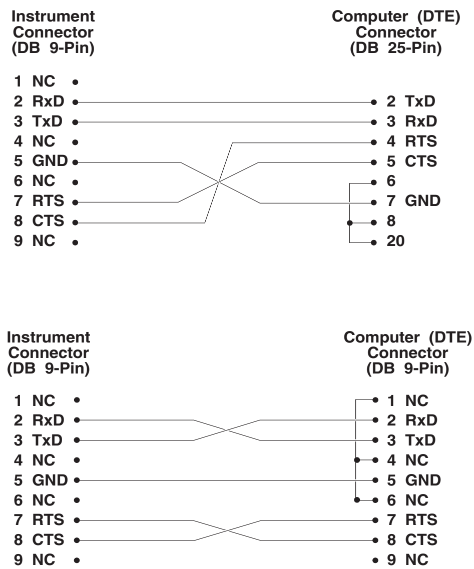

Figure 9 *Serial Cable Wiring Diagram*

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

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 7007 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, the 7007 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 thermometer via the serial interface are immediately echoed or transmitted back to the device of origin. With half duplex the commands are executed but not echoed. The default setting is full duplex. The mode may be changed using "UP" or "DOWN" and pressing "SET".

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 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 interface 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

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.

9.2.1.1 IEEE-488 Interface Address

The IEEE-488 address is prompted with “AddrESS”. Press “SET” to program the address. The default address is 22. Change the device address of the 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 4). 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

Table 4 *Serial Interface Commands*

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Display Temperature					
Read current set-point	s[etpoint]	s	set: 9999.99 {C or F}	set: 150.00 C	
Set current set-point to n	s[etpoint]=n	s=450			Instrument Range
Read 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 cutout setting	c[utout]	c	c: 9999 {x},{xxx}	c: 620 C, in	
Set cutout setting:	**c[utout]=n/r[eset]**				
Set cutout to *n* degrees	c[utout]=n	c=500			Temperature Range
Reset cutout now	c[utout]=r[eset]	c=r			
Read heater power (duty cycle)	po[wer]	po	po: 9999	po: 1	
Configuration Menu					
Probe Menu					
Read D0 calibration parameter	*d0	*d0	d0: 999.9999	d0: -25.2290	
Set D0 calibration parameter to *n*	*d0=n	*d0=-25.2290			-999.9999 to 999.9999
Read DG calibration parameter	*dg	*dg	dg: 999.9999	dg:186.9740	
Set DG calibration parameter to *n*	*dg=n	*dg=186.9740			-999.9999 to 999.9999
Operating Parameters Menu					
Read cutout mode	cm[ode]	cm	cm: {xxxx}	cm: AUTO	
Set cutout mode:	**cm[ode]=r[eset]/a[uto]**				RESET or AUTO
Set cutout to be reset manually-	cm[ode]=r[eset]	cm=r			
Set cutout to be reset automatically	cm[ode]=a[uto]	cm=a			
Serial Interface Menu					
Read serial sample setting	sa[mple]	sa	sa: 9	sa: 1	

Table 5 *Serial Interface Commands continued*

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
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 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 *n* (where *n* is 1 to 5)	f*n*	f*n*	f*n*:9	f*n*:1	
Set Heater *n*	**f*n*=1/0**				**0 or 1**
Set heater to low	f*n*=*n*	f*n*=0			
Set heater to high	f*n*=*n*	f*n*=1			
Read Refrigeration	f6	f6	f6:9	f6:0	
Set Refrigeration	**f6=1/0**				**0 or 1**
Set Refrigeration to on	f6=*n*	f6=1			
Set Refrigeration to off	f6=*n*	f6=0			
Read Cooling Temperature	f7	f7	f7:9	f7:1	
Set Cooling Temperature	f7=1/0				**0 or 1**
Set Cooling Temperature to on	f7=*n*	f7=1			
Set Cooling Temperature to off	f7=*n*	f7=0			
Read Back Pressure	f8	f8	f8:9	f8:1	
Set Back Pressure	f8=1/0				**0 or 1**
Set Back Pressure on	f8=*n*	f8=1			
Set Back Pressure off	f8=*n*	f8=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.				

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 to 50.00 degrees.

In the following list of commands, characters or data within brackets, "[" and "]", are optional for the command. A slash, "/", denotes alternate characters or data. Numeric data, denoted by "n", may be entered in decimal or exponential notation. 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 Heater and Refrigeration Control 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. The 7007 bath has eight control functions with the digital interface.

The first five functions control the heating. These are controls for heaters 1, 2, 3, 4, and boost heater. 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. To allow the interface to control the heating, the front panel controls are disabled by switching the heater control and boost heater switch to "OFF". Otherwise, the interface would not be able to switch these functions off.

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. A command with 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 7 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 7 *Heater Commands*

Heater	F1	F2	F3	F4	F5
OFF	0	0	0	0	0
0-–300 W	1	0	0	0	0
0–600 W	1	1	0	0	0
600–950 W	1	1	1	0	0
950–1300 W	1	1	1	1	0
2000 W	1	1	1	1	1

The last three control functions operate the bath cooling (see Table 6). These

Table 6 *Refrigeration Commands*

Temperature in °C	Refigeration F6	Cooling Temperature Range F7	Back Pressure F8
–5 to 20	1	0	1
20 to 45	1	1	1
45 to 110	0	X	X

are controls for switching the refrigeration on and off and setting the refrigeration control valves. The front panel cooling switch must be set to “OFF”. The cooling valves must also be adjusted for the desired range. The valves are adjusted as outlined in Section 6.4. The following example can be used to achieve the full range of the 7007 bath. Set the LOW range cooling valve for 10°C lower than the lowest desired control point. To achieve the -10°C, set the valve to about 9-10 psig. Set the HIGH range valve to about 60-65 psig to divide the range. Other values may be selected for narrower bath temperature ranges. Use the LOW range control for non automated applications.

Serial command “F6" turns the refrigeration on and off. For example “F6=1”<RETURN> turns on the refrigeration. ”F7" and “F8" set the COOLING TEMPERATURE and BACK PRESSURE controls by operating solenoid valves. ”F7" selects the Cooling Temperature range. “F7=1" sets the cooling temperature to the HIGH range. ”F7=0" sets the cooling temperature to the LOW range. Manually adjust the low and high range cooling temperatures as previously described. The lowest temperature (pressure) of the two must be adjusted on the low range valve. Pressures are adjusted with the compressor running and the appropriate range selected via computer. “F8" controls the back pressure. ”F8=1" by-passes the back pressure valve for normal or full cooling capacity and “F8=0" selects the valve for reduced cooling. The cooling capacity is adjusted manually with this back pressure valve to achieve the desired results.

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 DO and DG 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 0.1°C over a range of 50 degrees.

10.1 Calibration Points

In calibrating the bath DO and DG 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 farther 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 20°C and 80°C are chosen as the calibration temperatures then the bath may achieve an accuracy of say ±0.2°C over the range 20 to 80°C. Choosing 30°C and 70°C may allow the bath to have a better accuracy of maybe ±0.05°C over the range 30 to 70°C but outside that range the accuracy may be only ±0.5°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 tL. 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 errL which is the actual bath temperature minus the set-point temperature. If for example the bath is set for a lower set-point of tL=20°C and the bath reaches a measured temperature of 19.7°C then the error is -0.3°C.

Next, set the bath for the upper set-point tH and after stabilizing measure the bath temperature and compute the error errH. For our example we will suppose the bath was set for 80°C and the thermometer measured 80.1°C giving an error of +0.1°C.

10.3 Computing DO and DG

Before computing the new values for DO and DG 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 DO′ and DG′ are computed by entering the old values for DO and DG, the calibration temperature set-points tL and tH, and the temperature errors errL and errH into the following equations,

$$DO' = \frac{err_H\,(t_L - DO) - err_L\,(t_H - DO)}{t_H - t_L} + DO$$

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

If for example DO and DG were previously set for -25.229 and 186.9740 respectively and the data for tL, tH, errL, and errH were as given above then the new values DO′ and DG′ would be computed as -24.627 and 185.728 respectively. Program the new values DO and DG into the controller. The new constants will be used the next time the bath temperature is set. Check the calibration by setting the temperature to tL and tH 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 25 and 75°C and it is desired to calibrate the bath as accurately as possible for operation within this range. The current values for DO and DG are -25.229 and 186.974 respectively. The calibration points are chosen to be 25.00 and 75.00°C. The measured bath temperatures are 24.869 and 74.901°C respectively. Refer to Figure 10 for applying equations to the example data and computing the new probe constants.

D0 = -25.229

DG = 0.0028530

t_L = 25.00°C

measured t = 24.869°C

t_H = 75.00°C

measured t = 74.901°C

Compute errors,

err_L = 24.869 - 25.00°C = -0.131°C

err_H = 74.901 - 75.00°C = -0.099°C

Compute C_0,

$$D_0{}' = \frac{(-0.131)(75.0-(-25.229)) - (-0.099)(25.0-(-25.229))}{75.0 - 25.0} + (-25.229) = -25.392$$

Compute C_G,

$$D_G{}' = \left[\frac{(-0.099) - (-0.131)}{75.0 - 25.0} + 1\right] 0.0028530 = 0.0028548$$

Figure 10 *Calibration Example*

11 Charging Instructions

11.1 Preparation

Remove the refrigeration cover by removing the screws that hold it on. This provides access to the compressor. The refrigeration system must be leak checked and then evacuated to 50 microns. After the unit is evacuated, it is ready to be charged.

11.2 Charging

After the system is evacuated, pressurize it with R-134a. Next, turn on the main unit power and the refrigeration power. Check to make sure that the back pressure valve is completely open (CCW) and that there is room temperature (approx. 25°C) fluid in the bath. Using the cooling power valve located on the side of the unit, adjust the pressure reading to 10 psi. Add R-134a slowly through the low pressure side until the sight glass located at the back of the unit is full. This sight glass should begin to show gas between 15 and 20 psi, but should be full below that pressure.

12 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.

- If the outside of the bath becomes soiled, it may be wiped clean with a damp cloth and mild detergent. Do not use harsh chemicals on the surface. These chemicals may damage the paint.
- 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.
- Heat transfer medium lifetime is dependent upon the type of medium and the environment. The fluid should be checked at least every month for the first year and regularly thereafter. This fluid check provides a baseline for knowledge of bath operation with clean, usable fluid. Once some fluids have become compromised, the break down can occur rapidly. Particular attention should be paid to the viscosity of the fluid. A significant change in the viscosity can indicate that the fluid is contaminated, being used outside of its temperature limits, contains ice particles, or is close to a chemical breakdown. Once data has been gathered, a specific maintenance schedule can be outline for the instrument. Refer to the General Operation section (Section 7) for more information about the different types of fluids used in calibration baths.
- Depending on the cleanliness of the environment, the internal parts (parts behind the front cover only) of the cold bath should be cleaned and/or checked at least every month for dust and dirt. Particular attention should be paid to the condensing coil fins. The fins should be vacuumed or brushed free of dust and dirt on a regular basis. Dust and dirt inhibit the operation of the condensing coil and thus compromise the performance and life-time of the cooling system.
- 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, call 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 would 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 8.8) 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.*

13 Troubleshooting

13.1 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 Hart Scientific Customer Service for assistance. A wiring diagram is also included. Opening the unit without contacting an Authorized Service Center may void the warranty.

13.1.1 The heater indicator LED stays red but the temperature does not increase

The display does not show “cut-out” nor displays an incorrect bath temperature, but the controller otherwise appears to operate normally. The problem may be either insufficient heating or no heating at all or too much cooling. 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. Try reducing cooling capacity by increasing the cooling temperature, switching the cooling power switch to “LOW”, or switching off the cooling altogether.

One or more burned out heaters or blown heater fuses may also cause this problem. If the heaters seem to be burned out, contact an Authorized Service Center for assistance.

13.1.2 The controller display flashes “CUT-OUT” and the heater does not operate

The display will flash “CUT-OUT” alternately with the process temperature. If the process temperature displayed seems grossly in error, consult Section13.1.3. Normally, the cut-out disconnects power to the heater when the bath temperature exceeds the cut-out set-point causing the temperature to drop back down to a safe value. If the cut-out 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 cut-out is manually reset by the operator. See Section8.8. Check that the cut-out set-point is adjusted to 10 or 20°C above the maximum bath operating temperature and that the cut-out mode is set as desired.

If the cut-out activates when the bath temperature is well below the cut-out set-point or the cut-out does not reset when the bath temperature drops and it is manually reset, then the cut-out circuitry may be faulty or the cut-out thermocouple sensor may be faulty or disconnected. Contact an Authorized Service Center for assistance.

13.1.3 The display flashes "CUT-OUT" and an incorrect process temperature

The problem may be that the controller's voltmeter circuit is not functioning properly. 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. The memory may be reset by holding the "SET" and "EXIT" keys down while power to the controller is switched on. The display shows "—init—" indicating the memory is being initialized. At this point, each of the controller parameters and calibration constants must be reprogrammed into memory. You can obtain the calibration constants from the test results sheet of the calibration report. If the problem reoccurs then the battery should be replaced. Contact an Authorized Service Center for assistance. If initializing the memory does not remedy the problem, there may be a failed electronic component. Contact an Authorized Service Centerf or assistance.

13.1.4 The displayed process temperature is in error and the controller remains in the cooling or the heating state at any set-point value

Possible causes may be either a faulty control probe or erroneous data in memory. The probe may be disconnected, burned out, or shorted. Check that the probe is connected properly. 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, therefore, 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 the temperature. If the probe is defective, contact an Authorized Service Center for assistance.

If the problem is not the probe, erroneous data in memory may be the cause. Re-initialize the memory as discussed in Section 13.1.3 above. If the problem remains, the cause may be a defective electronic component. Contact an Authorized Service Center for assistance.

13.1.5 The controller controls or attempts to control at an inaccurate temperature

The controller operates normally except when controlling at a specified set-point. At this set-point, the temperature does not agree with that measured by the user's reference thermometer to within the specified accuracy. This problem may be caused by an actual difference in temperature between the points where the control probe and thermometer probe measure temperature, by erroneous bath calibration parameters, or by a damaged control probe.

- Check that the bath has an adequate amount of fluid in the tank and that the stirrer is operating properly.
- Check that the thermometer probe and control probe are both fully inserted into the bath to minimize temperature gradient errors.

- Check that the calibration parameters are all correct according to the certification sheet. If not then reprogram the constants. The memory backup battery may be weak causing errors in data as described in Section13.1.3.
- Check that the control probe has not been struck, bent, or damaged. If the cause of the problem remains unknown, contact an Authorized Service Center for assistance.

13.1.6 The controller shows that the output power is steady but the process temperature is unstable

If the bath temperature does not achieve the expected degree of stability when measured using a thermometer, try adjusting the proportional band to a narrower width as discussed in Section 8.7.

13.1.7 The controller alternately heats for a while then cools

This oscillation is typically caused by the proportional band being too narrow. Increase the width of the proportional band until the temperature stabilizes as discussed in Section 8.7.

13.1.8 The controller erratically heats then cools, control is unstable

If both the bath temperature and output power do not vary periodically but in a very erratic manner, the problem may be excess noise in the system. Noise due to the control sensor should be less than 0.001°C. However, if the probe has been damaged or has developed an intermittent short, erratic behavior may exist. Check for a damaged probe or poor connection between the probe and bath.

Intermittent shorts in the heater or controller electronic circuitry may also be a possible cause. Contact an Authorized Service Center for assistance.

13.1.9 The bath does not achieve low temperatures

This problem can be caused by too much heating or not enough cooling. Check that the control indicator glows green showing that the controller is attempting to cool. The heaters may be disabled as a test by temporarily removing the heater fuses.

Maximize cooling by switching the cooling on, setting the cooling power to high, if applicable, and setting the cooling temperature to 10–15°C below the bath set-point (see the chart on the bath).

Insufficient cooling may be caused by lack of refrigerant because of a leak in the system. Refer to Section 11, Charging Instruction