7080/7081

Calibration Bath
User's Guide

Rev. 5B2303

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Rev. 5B2303

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1 Before You Start

1.1 Symbols Used

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

Table 1 *International Electrical Symbols*

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

Symbol	Description
	Canadian Standards Association
CAT II	OVERVOLTAGE (Installation) CATEGORY II, Pollution Degree 2 per IEC1010-1 refers to the level of Impulse Withstand Voltage protection provided. Equipment of OVERVOLTAGE CATEGORY II is energy-consuming equipment to be supplied from the fixed installation. Examples include household, office, and laboratory appliances.
	C-TIC Australian EMC Mark
	The European Waste Electrical and Electronic Equipment (WEEE) Directive (2002/96/EC) mark.

1.2 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.

1.2.1 ⚠ WARNINGS

To avoid personal injury, follow these guidelines.

GENERAL

- **DO NOT** use the instrument for any application other than calibration work. The instrument was designed for temperature calibration. Any other use of the instrument may cause unknown hazards to the user.
- **DO NOT** use the instrument in environments other than those listed in the user's guide.
- **DO NOT** overfill the bath. Overflowing extremely cold or hot fluid may be harmful to the operator. See Section 5.3, Bath Preparation and Filling, for specific instructions.
- Follow all safety guidelines listed in the user's manual.
- Calibration Equipment should only be used by Trained Personnel.
- If this equipment is used in a manner not specified by the manufacturer, the protection provided by the equipment may be impaired.
- Before initial use, or after transport, or after storage in humid or semi-humid environments, or anytime the instrument has not been energized for more than 10 days, the instrument needs to be energized for a "dry-out"

period of 2 hours before it can be assumed to meet all of the safety requirements of the IEC 1010-1. If the product is wet or has been in a wet environment, take necessary measures to remove moisture prior to applying power such as storage in a low humidity temperature chamber operating at 50°C for 4 hours or more.

- Overhead clearance is required. Do not place the instrument under a cabinet or other structure. Always leave enough clearance to allow for safe and easy insertion and removal of probes.
- The instrument is intended for indoor use only.
- The bath is a precision instrument. Although it has been designed for optimum durability and trouble free operation, it must be handled with care. Position the bath before the tank is filled with fluid by rolling it into place. **DO NOT** attempt to lift the bath. **DO NOT move a bath filled with fluid.**

BURN HAZARD

- Extremely cold temperatures may be present in this equipment. Freezer burns and frostbite may result if personnel fail to observe safety precautions.
- High temperatures may be present in this equipment. Fires and severe burns may result if personnel fail to observe safety precautions.

ELECTRICAL HAZARD

- These guidelines must be followed to ensure that the safety mechanisms in this instrument will operate properly. This instrument must be plugged into a 230V AC electric outlet of the appropriate frequency. The power cord of the instrument is equipped with a three-pronged grounding plug for your protection against electrical shock hazards. It must be plugged directly into a properly grounded three-prong receptacle. The receptacle must be installed in accordance with local codes and ordinances. Consult a qualified electrician. DO NOT use an extension cord or adapter plug.
- **DO** use a ground fault interrupt device. This instrument contains a fluid. A ground fault device is advised in case fluid is present in the electrical system and could cause an electrical shock.
- Always replace the power cord with an approved cord of the correct rating and type. If you have questions, contact a Hart Scientific Authorized Service Center (see Section 1.3).
- High voltage is used in the operation of this equipment. Severe injury or death may result if personnel fail to observe the safety precautions. Before working inside the equipment, turn off the power and disconnect the power cord.

BATH FLUIDS

- 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.
- The instrument is equipped with a soft cutout (user settable firmware) and a hard cutout (set at the factory). Check the flash point, boiling point, or other fluid characteristic applicable to the circumstances of the bath operation. Ensure that the soft cutout is adjusted to the fluid characteristics of the application. As a guideline, the soft cutout should be set 10°C to 15°C below the flash point of the bath fluid. See Section 8.1, Heat Transfer Fluid, for specific information on bath fluids and Section , Cutout.

1.2.2 ⚠ CAUTIONS

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

- Always operate this instrument at room temperature between 41°F and 122°F (5°C to 50°C). Allow sufficient air circulation by leaving at least 6 inches (15 cm) of clearance around the instrument.
- When filling the tank, ensure the immersion coils are completely covered.
- **DO NOT** overfill the bath. Overflowing fluid may damage the electrical system. See Section 5.3, Bath Preparation and Filling, for specific instructions.
- Read Section 6, Bath Use, before placing the bath into service.
- **DO NOT** turn the bath on without fluid in the tank and the heating coils fully immersed.
- **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 refrigeration may be damaged or the lifetime shortened if the set-point temperature is set above 60°C for more than one hour with the refrigeration manually on. Ensure that the refrigeration is off when the bath is used above 60°C.
- The **Factory Reset Sequence** should be performed only by authorized personnel if no other action is successful in correcting a malfunction. You must have a copy of the most recent Report of Test to restore the test parameters.
- **DO NOT** operate this instrument in an excessively wet, oily, dusty, or dirty environment.
- Most probes have handle temperature limits. Be sure that the probe handle temperature limit is not exceeded in the air above the instrument.
- The instrument and any thermometer probes used with it are sensitive instruments that can be easily damaged. Always handle these devices with care. Do not allow them to be dropped, struck, stressed, or overheated.

COLD BATHS

- Refrigerated baths require that the condensing coil be cleaned periodically. Accumulation of dust and dirt on the condenser will result in premature failure of the compressor.
- This bath has been equipped with a brownout and over voltage protection device as a safety feature to protect the system components.
- **Mode of Operation:** This bath needs to be plugged into the line voltage for at least 2 minutes before operation. This is only necessary for the first time the bath is energized or when it is moved from one location to another. Turning the bath ON or OFF does not trigger the delay.
- If a High/Low voltage condition exists for longer than 5 seconds, the bath de-energizes. An amber indicator on the back panel lights when this condition exists.
- Re-energization is automatic upon correction of the fault condition and after a delay cycle of about 2 minutes. If a fault condition exists upon application of power, the bath will not energize.
- Under and Over Voltage Protection at 230 VAC
    - Voltage Cutout: ±12.5% (203 - 257 VAC)
    - Voltage Cut In: ±7.5% (213 - 247 VAC)

1.3 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 Introduction

The Hart Scientific Model 7080/7081 is a very precise constant temperature bath. The bath is specially designed for low temperature applications. An innovative state of the art solid-state temperature controller has been incorporated which maintains the bath temperature with extreme stability. The controller uses a microprocessor to execute the many operating functions.

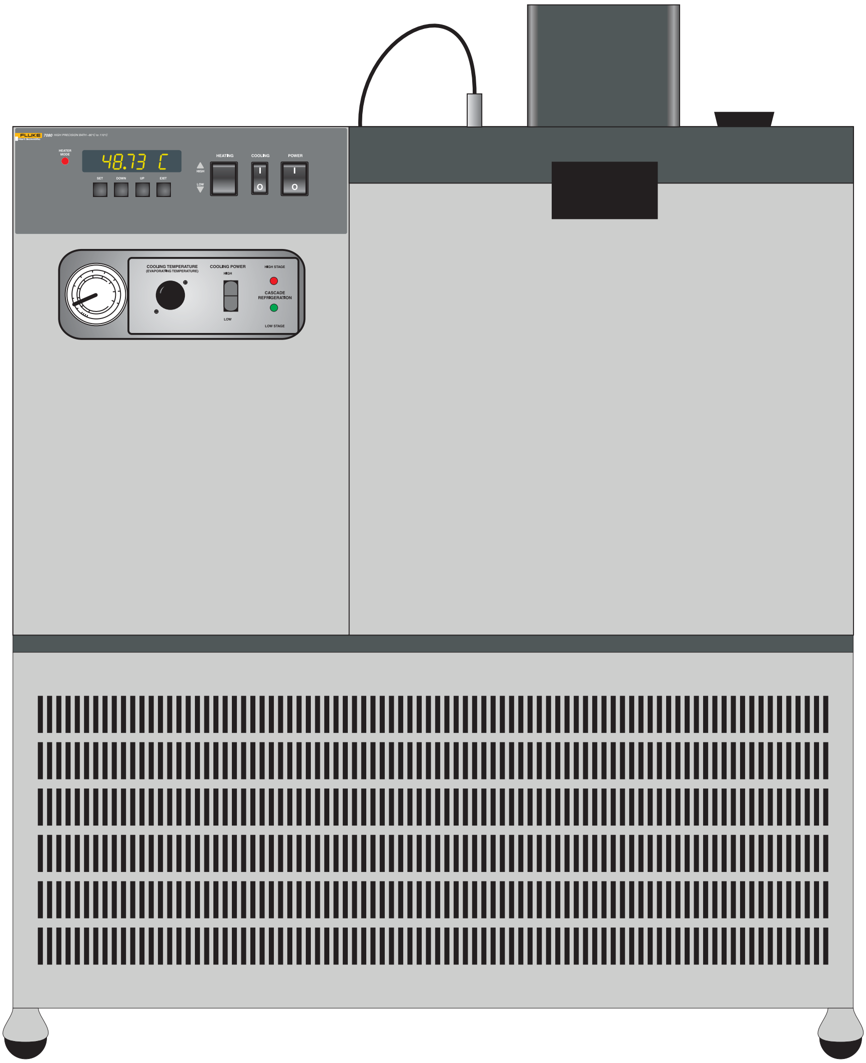


Figure 1 *Bath Assembly*

User interface is provided by the 8-digit LED display and four key-switches. Digital remote communications is optionally available with a RS-232 or IEEE-488 interface.

The tank for the 7080/7081 is stainless steel. The 7080 holds 25 liters and the 7081 holds 44 liters. There are two lids available: the standard lid with a rectangular access hole and an optional lid with a recirculation pump (see Figure 5).

3 Specifications and Environmental Conditions

3.1 Specifications

	7080	7081
Range	-80°C to 110°C	
Stability	±0.0025°C at –80°C (methanol) ±0.0015°C at 0°C (methanol) ±0.0015°C at 25°C (water) ±0.003°C at 100°C (oil)	
Uniformity	±0.007°C at –80°C (methanol) ±0.005°C at 0°C (methanol) ±0.003°C at 25°C (water) ±0.005°C at 100°C (oil)	
Temperature Setting	Digital display with push-button data entry	
Set-Point Resolution	0.01°C; high-resolution mode, 0.00007°C	
Display Resolution	0.01°C	
Digital Setting Accuracy	±1°C	
Digital Setting Repeatability	±0.01°C	
Heaters	500 and 1000 Watts	
Access Opening (call for custom sizes)	5” x 10” (127 x 254 mm)	7.25” x 12.75” (184 x 324 mm)
Depth	12” (305 mm)	13.25” (337 mm)
Wetted Parts	304 stainless steel	
Power	230 VAC (±10%), 50 or 60 Hz, 13 A, single phase, 2900 W, specify frequency	
Volume	7.2 gallons (27 liters)	11.2 gallons (42 liters)
Weight	350 lb. (159 kg)	
Size	46” H x 30.5” W x 19” D (1168 x 775 x 483 mm)	
Automation Package	Interface-it software and an RS-232 computer interface are available for setting the bath temperature via an external computer. For IEEE-488, add 2001-IEEE to the automation package.	
Safety	OVERVOLTAGE (Installation) CATEGORY II, Pollution Degree 2 per IEC1010-1	

3.2 Environmental Conditions

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

The instrument operates safely under the following conditions:

- temperature range: 5 - 50°C (41 - 122°F)
- ambient relative humidity: maximum 80% for temperature <31°C, decreasing linearly to 50% at 40°C
- pressure: 75kPa - 106kPa
- mains voltage within ± 10% of nominal
- vibrations in the calibration environment should be minimized
- altitude less than 2,000 meters

3.3 Warranty

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

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

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

To exercise this warranty, the purchaser must forward the product after calling or writing an Authorized Service Center for authorization (see Section 1.3). The Service Centers assume NO risk for in-transit damage.

THE FOREGOING WARRANTY IS PURCHASER'S SOLE AND EXCLUSIVE REMEDY AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTY OR MERCHANTABILITY, OR FITNESS FOR ANY PARTICULAR PURPOSE OR USE. HART SHALL NOT BE LIABLE FOR ANY SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OR LOSS WHETHER IN CONTRACT, TORT, OR OTHERWISE.

4 Quick Start

CAUTION: *Before placing the bath in service READ SECTION 6 ENTITLED BATH USE.*

Incorrect handling can damage the bath and void the warranty.This chapter gives a brief summary of the steps required to set up and operate the 7080 or 7081 bath. This should be used as a general overview and reference and not as a substitute for the remainder of the manual. Please read Sections5 through8 carefully before operating the bath.

4.1 Unpacking

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

Verify that all components are present:

- 7080/7081 Bath
- Access Hole Cover
- Controller Probe
- Manual
- Drain Elbow
- Report of Test
- Fill Hole Cover
- 9930 Interface-it Software and User's Guide (optional)

If you are missing any item, please contact an Authorized Service Center (see Section 1.3).

4.2 Semi-Hermetic Compressor

The semi-hermetic compressor(s), located below the bath, have had their mounting hardware tightened down to avoid damage during shipment. In addition, shipping foam has been placed between some of the refrigeration lines for the same purpose. Upon installation, please remove all pieces of the shipping foam and adjust the compressor's hardware for proper vibration absorption as illustrated below in Figure 2.

4.3 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

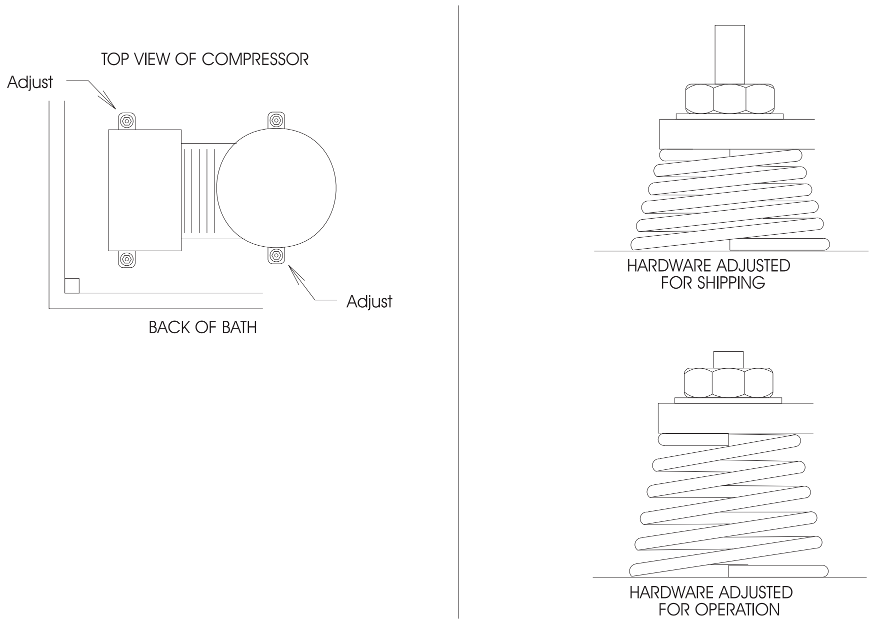


Figure 2 *Semi-hermetic Compressor*

for detailed instructions for proper installation of the bath. Be sure to 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 large rectangular access hole above the tank avoiding spilling any fluid. The fluid must not exceed a height 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. DO NOT operate the bath without the control probe properly installed.

4.4 Power

Plug the bath power cord into a mains outlet of the proper voltage, frequency, and current capability: 230 VAC (±10%), 60 Hz, 15 A. 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 setpoint. The front panel LED display will indicate the actual bath temperature.

4.5 Setting the Temperature

In the following discussion and throughout this manual a button 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 shows the set-point memory that is currently being used and its value. Eight set-point memories are available.

SET *Access set-point selection*

1. 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 heats or cools until it reaches the new set-point temperature. Set the heater switch to position "HIGH" to allow the bath to more quickly reach a higher temperature. The "HIGH" setting may be necessary to reach and control at higher 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 for added safety. See Section9.8.

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. See Section8.6.

To obtain optimum control stability adjust the proportional band as discussed in Section9.7.

5 Installation

__CAUTION__: Before placing the bath in service READ SECTION 6 ENTITLED BATH USE.

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

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 bath is not designed to be lifted. The wheels allow it to be rolled. If the unit must be lifted, contact an Authorized Service Center.

__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.

5.1 Bath Environment

The Model 7080/7081 Bath is a precision instrument which should be located in an appropriate environment. The location should be free of drafts, extreme 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.

Allow sufficient air circulation by leaving at least six inches of space between the bath and nearby objects. Provide overhead clearance to allow for safe and easy insertion and removal of probes for calibration. DO NOT place under a cabinet or other structure. Allow for overhead clearance.

5.2 “Dry-out” Period

Before initial use, after transport, and any time the instrument has not been energized for more than 10 days, the bath will need 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.

5.3 Bath Preparation and Filling

The Model 7080/7081 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
- Halocarbon 0.8
- Mineral oil
- Silicone oil

Fluids are discussed in detail in Section 8.1.

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 large square access hole to a level that will allow 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. Note that underfilling may reduce bath performance and may possibly damage the bath heater.

5.4 Probe

Inspect the bath control probe. It should not be bent or damaged in any way. Reasonable caution should be used in handling this probe as it contains a precision platinum sensor and is mechanically shock sensitive. Dropping, striking, or other physical shock may cause a shift in resistance in the probe resulting in diminished bath accuracy. If damaged, the probe can be replaced. Contact the factory for assistance.

Insert the probe into the 1/4 inch probe hole at the top left side of the bath lid. The tip of the probe must be well immersed in the fluid. The probe connector is plugged into the rear of the bath into the socket labelled “PROBE”.

5.5 Power

With the bath power off, connect the bath to an AC mains supply of the appropriate voltage to power the bath. Refer to the Specifications section for power details. Refer to and read the cautions at the front of the manual concerning the brownout and over voltage protection. Check the back panel label for the correct voltage and frequency prior to energizing the unit.

The bath power wires are located at the junction box at the back of the bath. The wires are left undressed to accommodate a variety of connection schemes. An electrician should be consulted for installation.

Use only wires and a circuit, which are capable of supplying the maximum 13 amperes of current. The wires must be fastened securely and insulated well.

Plug the stirring motor power cord into the stirrer socket at the back of the bath. Set the heater switch on the front panel to the “LOW” position. Set the cooling switch on the front panel to the “OFF” position and turn the bath on using the power switch on the front panel. The baths turns on and begins to heat or cool to reach the previously programmed temperature set-point. The front panel LED display indicates the actual bath temperature.

6 Bath Use

CAUTION: *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 will need to write their own specific procedures.

6.1 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.

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

6.2 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 (see Section 7.4). Nevertheless, probes should be inserted to the same depth in the bath liquid. Be sure that all probes are inserted deep enough to prevent stem effect. From research at Hart Scientific, we suggest a general rule-of-thumb for immersion depth to reduce the stem effect to a minimum: 15 x the diameter of the UUT + the sensor length. **Do not submerge the probe handles.** If the probe handles get too warm during calibration at high temperatures, a heat shield could be used just below the probe handle. This heat shield could be as simple as aluminum foil slid over the probe before inserting it in the bath or as complicated as a specially designed reflective metal apparatus.

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

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

In preparing to use the bath for calibration start by:

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

6.3 Calibration of Multiple Probes

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

7 Parts and Controls

7.1 Front Panel

The following controls and indicators are present on the controller front panel (see Figure 3 below): (1) the digital LED display, (2) the control buttons, (3) the bath on/off power switch, (4) the control indicator light, (5) the heater power switch, and (6) the cooling power switch.

1) The digital display is an important part of the temperature controller. It displays the set-point temperature and bath temperature as well as the various other bath functions, settings, and constants. The display shows temperatures in values according to the selected scale units °C or °F.

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

A brief description of the functions of the buttons follows:

SET – Used to display the next parameter in a menu and to set parameters to the displayed value.

DOWN – Used to decrement the displayed value of settable parameters.

Figure 3 Front Panel

UP – Used to increment the displayed value.

EXIT – Used to exit from a menu. When EXIT is pressed any changes made to the displayed value will be ignored.

3) The on/off switch controls power to the entire bath including the stirring motor.
4) 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.
5) The heater power switch is used to select the appropriate heater power levels for heating and controlling temperatures.
6) The cooling switch controls power to the cooling compressors and cooling fan.

7.2 Refrigeration Controls

The front panel refrigeration control area has four features (see Figure 3 on page 21): 7) the cooling power switch, 8) the cooling temperature regulating valve, 9) the cooling temperature/pressure gauge, and 10) cascade refrigeration indicator lights.

7) The cooling power switch is used to control the cooling capacity. It is set to "LOW" power for higher bath temperatures (–40°C and above). This switch limits the capacity of the refrigeration system so that the minimum cooling power is used for the greatest temperature stability.
8) The cooling temperature regulating valve is used to adjust the temperature at which the refrigerant evaporates. Refer to the label below the gauge for approximate pressure and evaporative temperature settings. For your convenience the table from the label is reproduced below (Table 2). Do not set the pressure higher than indicated for the desired bath temperature.
9) The cooling temperature/pressure gauge is used to indicate the temperature at which the refrigerant is evaporating. The cooling temperature regulating valve is used to adjust this pressure.
10) The cascade refrigeration indicator lights show which cooling stages are operating. The "High Stage" is on when the high stage refrigeration is operating. The "Low Stage" light comes on when the refrigeration has been sufficiently cooled by the high stage compressor for the second or low stage compressor to be automatically engaged. Both High and Low stages must be on for the bath to cool.

Table 2 Temperature Chart

Second Stage Cooling h resolution, set the cut-out, adjust the proportional band, monitor the heater output power, and program the controller configuration and Temperature Chart			
Desired Bath Temperature		Set the Cooling Temperature to this Refrigerant Pressure	Cooling Power Switch
Degrees C	Degrees F	PSIG	Position
45	113	Off	N/A
40	104	90 MAX	LOW
35	95	90 MAX	LOW
30	86	90 MAX	LOW
25	77	90 MAX	LOW
20	68	90 MAX	LOW
15	59	90 MAX	LOW
10	50	90 MAX	LOW
5	41	90 MAX	LOW
0	32	90 MAX	LOW
–5	23	90 MAX	LOW
–10	14	90 MAX	LOW
–15	5	80	LOW
–20	–4	70	LOW/HIGH
–25	–13	68	LOW/HIGH
–30	–22	62	LOW/HIGH
–35	–31	56	LOW/HIGH
–40	–40	50	LOW/HIGH
–45	–49	43	HIGH
–50	–58	37	HIGH
–55	–67	30	HIGH
–60	–76	23	HIGH
–65	–85	16	HIGH
–70	–94	10	HIGH
–75	–103	5	HIGH
–80	–112	3	HIGH

7.3 Back Panel

The back panel has the following features (see Figure 4): 1) the probe connector, 2) the stirrer power outlet, 3) the terminal box for power connection, 4) the serial number label, 5) & 6) *optional* serial and IEEE interface connectors, and 7) the bath drain.

1) The probe connector on the back panel connects the control probe to the temperature controller.

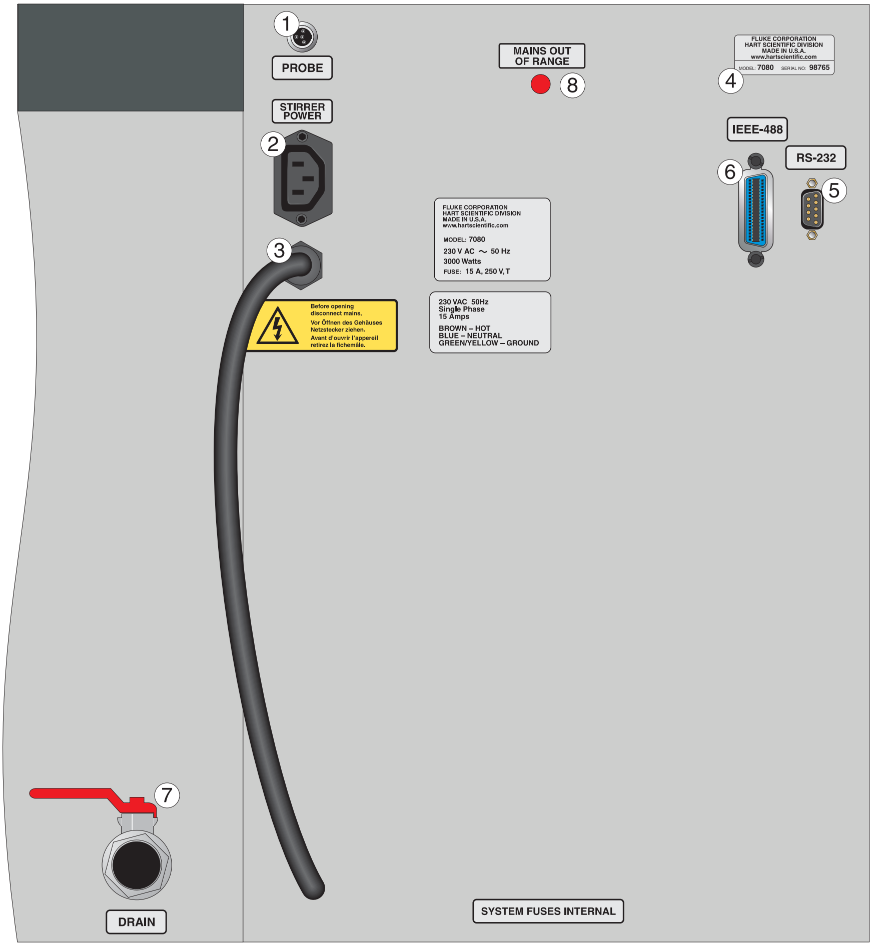


Figure 4 *Back Panel*

2) The stirrer power socket provides power for the stirring motor.

3) The terminal box holds the wires for connecting the bath to AC power. The bath requires 230 VAC (±10%), 50 or 60 Hz, 13 A.

4) The bath serial number is located at the lower right corner of the back panel. The model number is also printed here.

5) If the bath is supplied with a serial RS-232 interface, the interface cable is attached to the back of the bath at the connector labelled "SERIAL".

6) If the bath is supplied with a GPIB IEEE-488 interface, the interface cable is attached to the back of the bath at the connector labelled "IEEE".

7) A drain valve is provided for ease of removing the fluid media from the bath. It is advisable to use a container of adequate size to hold the full load of fluid. Some oils are more easily drained at higher temperatures.

8) The mains out of range indicator illuminates when a high/low voltage condition exists for 5 seconds indicating a fault condition.

7.4 Lid

There are two different types of lids (see Figure 5). The standard lid has a stirring motor with rectangular access hole and the optional lid has a recirculation pump. Their features are described with reference to figure numbers as follows:

1) There are latches at the front and back of the lid which attach the lid securely to the bath. The latches allow quick and easy removal of the lid.

2) The small round hole in the lid labelled "THERMOMETER/LIQUID LEVEL" is for filling or removing fluid, checking the liquid level, or for placing probes and devices into the bath. Normally the hole is covered with the rubber plug. Holes may be drilled in the rubber stopper for inserting probes into the bath.

3) The rectangular access hole in the standard lid may be used for filling and emptying the bath and inserting devices into the bath. This rectangular access hole provides the normal working area of the bath. The working area is defined as one inch from the access hole sides, one inch from the access hole bottom, and three inches from the top of the fluid. Normally this hole should be covered to insulate the bath. Covers may be purchased separately from Hart Scientific.

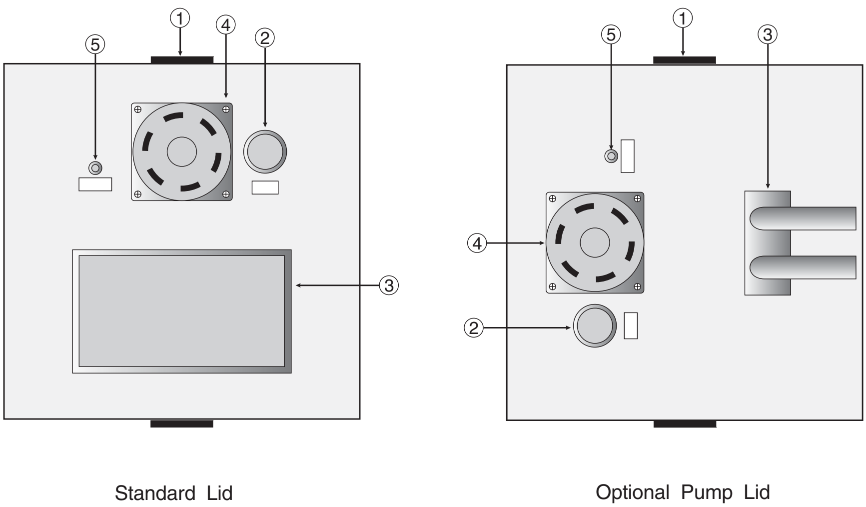


Figure 5 Lid Options

On the optional pump lid the inlet and outlet pipes replace the rectangular access hole.

4) The motor on the lid drives the stirrer on the standard lid and the pump on the optional pump lid.

5) The probe hole is for inserting the control probe into the bath.

8 General Operation

8.1 Bath Fluid

Many fluids work with 7080/7081 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 conductivity, fluid lifetime, safety, and cost.

8.1.1 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 used. 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.

8.1.2 Viscosity

Viscosity is a measure of the thickness of a fluid, how easily it can be poured and mixed. Viscosity affects the temperature uniformity and stability of the bath. With lower viscosity, fluid mixing is better therefore creating 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 practical upper limit of allowable viscosity. Viscosities greater than this cause very poor control stability because of poor stirring 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.

8.1.3 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. It also affects the heating and cooling rates. Generally, a lower specific heat means quicker heating and cooling. Different specific heats may require an adjustment to the proportional band to compensate for the change in the sensitivity of the bath temperature to heat input.

8.1.4 Thermal Conductivity

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

8.1.5 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 increases may cause overflow. Excessive thermal expansion may also be undesirable in applications where constant liquid level is important. Oils typically have significant thermal expansion.

8.1.6 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 electrical resistivity.

8.1.7 Fluid Lifetime

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

8.1.8 Safety

When choosing a fluid always consider the safety issues associated. Obviously where there are conditions of extreme hot or cold there can be danger to people 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.

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 available inside the tank.

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

8.1.9 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.

8.1.10 Commonly Used Fluids

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

8.1.10.1 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 lower 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 deionized to prevent mineral deposits. Consider using an algicide chemical in the water to prevent contamination.

8.1.10.2 Ethylene Glycol

The temperature range of water may be extended by using a solution of 50% water and 50% ethylene glycol (antifreeze). The characteristics of the ethylene glycol-water solution are similar to water but with higher viscosity. Use caution with ethylene glycol since the fluid is very toxic. Ethylene glycol must be disposed of properly.

8.1.10.3 Methanol

Methanol is a relatively inexpensive fluid with a low temperature range. Pure methanol has a temperature range from its freezing point of about -96 °C to near its flash point at 54 °C. Vaporization is significant above 25 °C so its use above this temperature is not recommended. Methanol at low temperatures tends to condense and absorb water from the air. This is generally an advantage, however, since small amounts of water (less than 11%) mixed with methanol decreases the freezing point. The resulting low temperature capability can be well below -100 °C but the viscosity can become excessive at such low temperatures. The viscosity is quite acceptable from -80 °C up. A mixture of 50/50 methanol and water provides a non-flammable solution capable of attaining -40 °C. Because methanol has an infinite capability to absorb water, there is no ice formation below 0 °C. This is convenient for long term use. The mixture has poor electrical resistivity and so may not be suitable for some applications.

The primary disadvantage with methanol is its toxicity. It is also quite flammable. Some labs may not permit its use. Refer to the MSDS sheets for more information. Use methanol only in a well ventilated area and use a hood that draws the vapors away from the user at temperatures above 0 °C.

8.1.10.4 Halocarbon 0.8

Halocarbon 0.8 is a low temperature fluid with a wide temperature range. It may be used as low as -90 to -100 °C before viscosity becomes too great. It may be used as high as 70°C before evaporation becomes excessive. Halocarbon 0.8 does not absorb water and forms ice at temperatures below 0 °C. Ice crystals turn the fluid into a slush which effectively increases the viscosity and reduces temperature stability. Pumping systems may be rendered ineffective due to ice blockage. The ice (water) can be removed occasionally by heating the fluid up to 100 °C for brief periods of time. Use halocarbon 0.8 under a fume hood at higher temperatures to remove vapors. Toxicity is low but caution is always recommended. Halocarbon 0.8 has excellent electrical resistivity. This fluid is fairly expensive.

8.1.10.5 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 use of a fume hood is highly recommended. As with most oils, mineral oil expands 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 are poorer than water so temperature stability is not as good. Mineral oil has very high electrical resistivity. Use caution with mineral oil since it is flammable and may also cause serious injury if inhaled or ingested.

8.1.10.6 Silicone oil

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. Silicone oils are fairly safe and non-toxic. These oils are relatively expensive.

8.1.11 Fluid Characteristics Charts

Table 3 and Figure 6 on pages 32 and 33 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 useable fluids may not have been shown in this listing.

8.1.11.1 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 performance. Sources of information sometimes vary for particular properties. Your company's safety policies as well as personal judgement regarding flash points, toxicity, etc. must also be considered. You are responsible for reading the MSDS sheets and making a judgement 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.

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 apply to your bath.

8.1.11.2 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: This is 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: Point at which ignition may occur. See flash point discussion in Section. The point shown may be either the open or closed cup flash point. See Figure 6 on page 33.

Table 3 *Table of Bath Fluids*

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	–100°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)	10°C (fl,cc)	12°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	–30°C (fr)	90°C (b)	NONE	7 @ 0°C 2 @ 50°C 0.7 @ 100°C	1.05	0.8 @ 0°C	0.001		
Mineral Oil No.7 #5011	10°C (v)	166°C (fl)	168°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
Silicone Oil Type 200.05 #5010	–40°C (v)**	130°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
Silicone Oil Type 200.10 #5012	–30°C (v)**	209°C (fl, cc)	211°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
Silicone Oil Type 200.20 #5013	10°C (v)	230°C (fl, cc)	232°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
Silicone Oil Type 200.50 #5014	30°C (v)	278°C (fl, cc)	280°C	50 @ 25°C	0.96 @ 25°C	0.4	0.00037 @ 25°C	0.00104	1000 @ 25°C 50 @ 150°C
Silicone Oil Type 550 #5016	70°C (v)	230°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
Silicone Oil Type 710 #5017	80°C (v)	300°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
Silicone Oil Type 210-H	66°C (v)	313°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	180°C (fr)	550°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.

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 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.

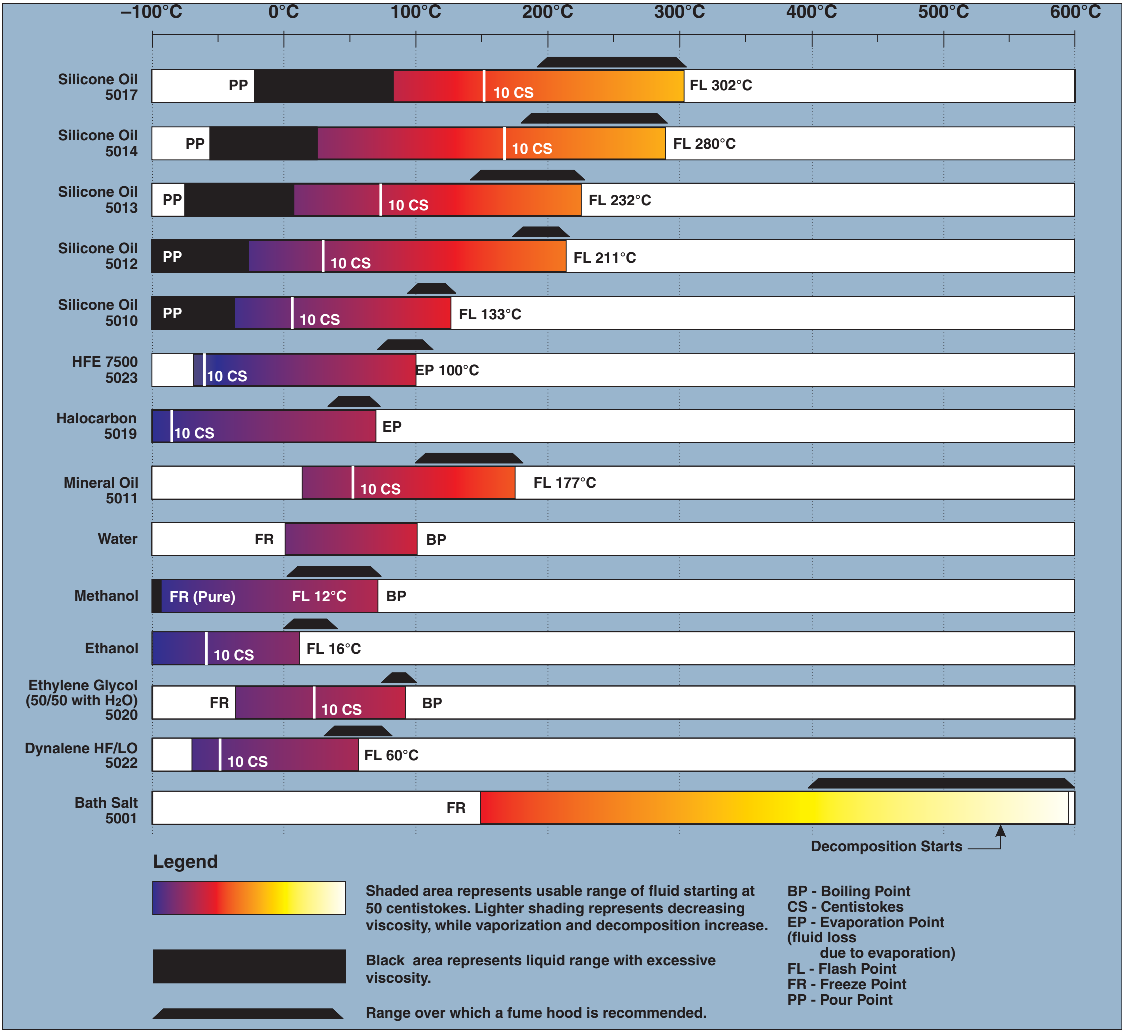


Figure 6 *Chart of Various Bath Fluids*

8.2 Stirring

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

8.3 Pump

The bath may have the optional pump lid for recirculating bath fluid through equipment outside the bath. Be sure the hoses are fastened securely to the pump inlet and outlet tubes before operating the bath with the pump lid. Always use tubing with material properties consistent with the application considering chemical and temperature compatibility. The centrifugal pump may develop 5 psi. of pressure. To maximize the flow rate use hoses with 1/2 in. or greater ID. Maximum flow rate may be approximately 8 gal/min.

Temperature control stability can be expected to be less with the recirculation pump. Insulating the fluid hoses may be required at low bath temperatures to reduce warming of the fluid and to prevent condensation or icing around the hoses. The refrigeration may require adjustment to optimize performance. If heat flux to the recirculated fluid is excessive the bath may not be able to achieve the lowest temperatures.

8.4 Power

Power to the bath is provided by an AC mains supply of the appropriate voltage to power the bath. Refer to the Specifications section for power details. Refer to and read the cautions at the front of the manual concerning the brownout and over voltage protection. Check the back panel label for the correct voltage and frequency prior to energizing the unit. Power to the bath passes through a filter to prevent switching spikes from being transmitted to other equipment.

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

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

8.5 Heater

The power to the bath heater is precisely controlled by the temperature controller to maintain a constant bath temperature. Power is controlled by periodically switching the heater on for a certain amount of time using a solid-state relay.

The front panel red/green control indicator shows the state of the heater. The control indicator glows red when the heater is on and glows green when the heater is off. The indicator pulses constantly when the bath is maintaining a stable temperature.

The heater has two power level settings. The "HIGH" heater power setting is used to quickly heat the bath fluid up to the desired operating temperature. The "HIGH" heater power setting may also be required for control at high temperatures. The "LOW" setting is used for control at lower temperatures and for scanning at slower rates. When controlling at the "HIGH" heater power setting instead of "LOW" the proportional band may need to be increased (typically by a factor of four) to compensate for the increase in power gain. Otherwise the temperature may oscillate.

The heater current is regulated by two 10 A fuses. These protect against excess current due to short or failure. The fuses are internal. Contact an Authorized Service Center for assistance.

8.6 Cooling

The Model 7080/7081 refrigeration system is a 2-stage cascade system. This means there are two individual refrigeration systems or stages. The first stage cools down or provides cooling for the second stage. The second stage cools the bath. This type of system is required to attain very low temperatures.

The first stage is an air-cooled unit using R-507 refrigerant. The fins of the air-cooled condenser must be kept clean. Dirty condensers cause inefficiency and limit the life of the system.

The second stage is cooled by the first via the heat exchange of the cascade condenser. The refrigerant is ethylene (cp grade) and propane (cp grade). The system is statically charged. Contact the factory if recharging is required.

The refrigeration controls are part of the second stage system. Depending on the temperature at which the bath is operated the cooling capacity may require adjustment. The cooling capacity is controlled using the COOLING-ON/OFF switch, the COOLING POWER-HIGH/LOW switch, and the COOLING TEMPERATURE adjustment valve. For typical settings refer to the chart Table 2 on page 23.

At higher temperatures, typically about 45°C and above, the refrigeration is not required as there is sufficient cooling to the room. For controlling in this temperature range switch the COOLING switch to “OFF”. The cooling may be switched on to more quickly lower the bath temperature from a high temperature.

For maximum cooling, and for slewing to and controlling at lower temperatures, the cooling power should be switched to “HIGH” and the cooling pressure should be set to 5 to 10 psig. Readjust higher or lower as required after the set-point temperature is reached.

8.7 Temperature Controller

The bath temperature is controlled by Hart Scientific’s unique hybrid digital/analog temperature controller. The controller offers the tight control stability of an analog temperature controller as well as the flexibility and programmability of a digital controller.

The bath temperature is monitored with a platinum resistance sensor in the control probe. The signal is electronically compared with the programmable reference signal, amplified, and then fed to a pulse-width modulator circuit which controls the amount of power applied to the bath heater.

The bath is operable within the temperature range given in the specifications. For protection against solid-state relay failure or other circuit failure, the microcontroller automatically turns off the heater with a second mechanical relay anytime the bath temperature is more than a certain amount above the set-point temperature. As a second protection device, the controller is also equipped with a separate thermocouple temperature monitoring circuit which will shut off the heater if the temperature exceeds the cut-out set-point.

The controller allows the operator to set the bath temperature with higcalibration parameters. The controller may be operated in temperature units of degrees Celsius or Fahrenheit. The controller is operated and programmed from the front control panel using the four key switches and digital LED display. The controller may also be optionally equipped with an RS-232 serial or IEEE-488 GPIB digital interface for remote operation. Operation of the controller using the front control panel is discussed following in Section9. Operation using the digital interfaces is discussed in Section10.

When the controller is set to a new set-point the bath will heat or cool to the new temperature. Once the new temperature is reached the bath usually takes 10-15 minutes for the temperature to settle and stabilize. There may be a small overshoot or undershoot of about 0.5°C.

9 Controller Operation

This section discusses in detail how to operate the bath temperature controller using the front control panel. Using the front panel key switches and LED display the user may monitor the bath temperature, set the temperature set-point in degrees C or F, monitor the heater output power, adjust the controller proportional band, set the cut-out set-point, and program the probe calibration parameters, operating parameters, serial and IEEE-488 interface configuration, and controller calibration parameters. Operation is summarized in Figure 7.

9.1 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.

9.2 Reset Cut-out

If the over-temperature cut-out has been triggered, the temperature display alternately flashes,

cut-out	*Indicates cut-out condition*

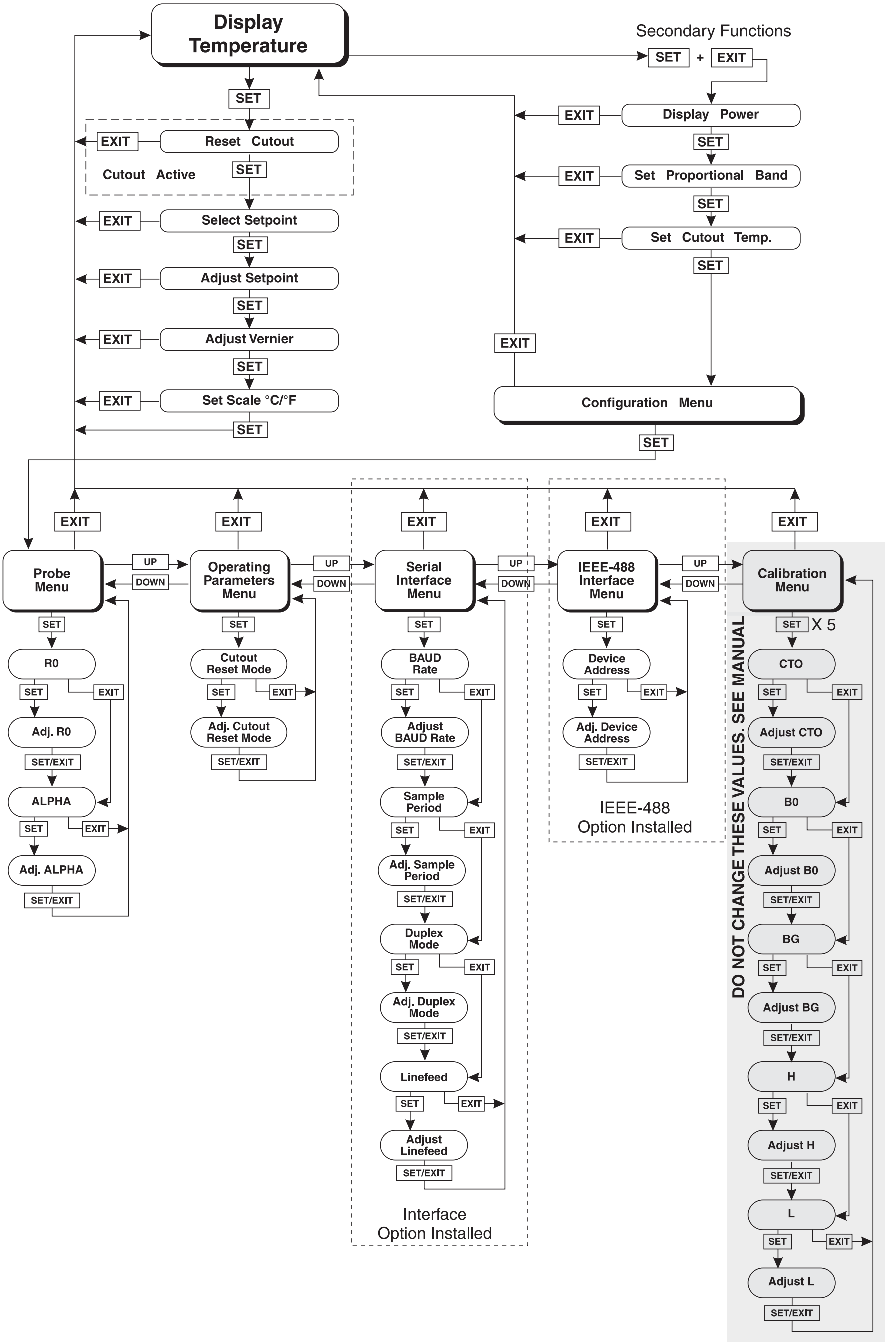
The message continues to flash until the temperature is reduced and the cut-out is reset.

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”), 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 indicates the reset function.



Display Temperature
Secondary Functions
SET + EXIT
SET
EXIT
Reset Cutout
Cutout Active
Select Setpoint
Adjust Setpoint
Adjust Vernier
Set Scale °C/°F
Display Power
Set Proportional Band
Set Cutout Temp.
Configuration Menu
Probe Menu
Operating Parameters Menu
Serial Interface Menu
IEEE-488 Interface Menu
Calibration Menu
UP
DOWN
R0
Adj. R0
ALPHA
Adj. ALPHA
SET/EXIT
Cutout Reset Mode
Adj. Cutout Reset Mode
BAUD Rate
Adjust BAUD Rate
Sample Period
Adj. Sample Period
Duplex Mode
Adj. Duplex Mode
Linefeed
Adjust Linefeed
Interface Option Installed
Device Address
Adj. Device Address
IEEE-488 Option Installed
SET X 5
CTO
Adjust CTO
B0
Adjust B0
BG
Adjust BG
H
Adjust H
L
Adjust L
DO NOT CHANGE THESE VALUES. SEE MANUAL

`rESEt ?` *Cut-out reset function*

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

[SET] *Reset cut-out*

This action also switches the display to the set temperature function. To return to displaying the temperature press the “EXIT” button. If the cut-out is still in the over-temperature fault condition the display continues to flash “cut-out”. The bath temperature must drop a few degrees below the cut-out set-point before the cut-out can be reset.

9.3 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.

9.3.1 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”.

[UP] *Increment memory*

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

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

SET — *Accept selected set-point memory*

9.3.2 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 needs to be changed, press "UP" or "DOWN" to adjust the set-point value.

UP — *Increment display*

`C   42.50` — *New set-point value*

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

SET — *Accept new set-point value*

9.3.3 Set-point Vernier

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

`0.00000` — *Current vernier value in °C*

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

UP — *Increment display*

`0.00090` *New vernier setting*

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

[SET] *Access scale units*

9.4 Temperature Scale Units

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

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

`25.00 C` *Bath temperature*

[SET] *Access set-point memory*

`1. 25.0` *Set-point memory*

[SET] *Access set-point value*

`C 25.00` *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.

[UP] *Change 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*

9.5 Secondary Menu

Functions which are used less often are accessed within the secondary menu. The secondary menu is accessed by pressing "SET" and "EXIT" simultaneously and then releasing. The first function in the secondary menu is the heater power display. (See Figure 7 on page 38.)

9.6 Heater Power

The temperature controller controls the temperature of the bath by pulsing the heater on and off. The total power being applied to the heater is determined by the duty cycle or the ratio of heater on time to the pulse cycle time. This value may be estimated by watching the red/green control indicator light or read directly from the digital display. By knowing the amount of heating the user can tell if the bath is heating up to the set-point, cooling down, or controlling at a constant temperature. Monitoring the percent heater power will let 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".

[EXIT] *Return to temperature display*

9.7 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 setpoint. 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 on page 43. If the band is too wide the bath temperature will deviate excessively from the set-point due to varying external conditions. This is because the power output changes very little with temperature and the controller cannot respond very well to changing conditions or noise in the system. If the 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.

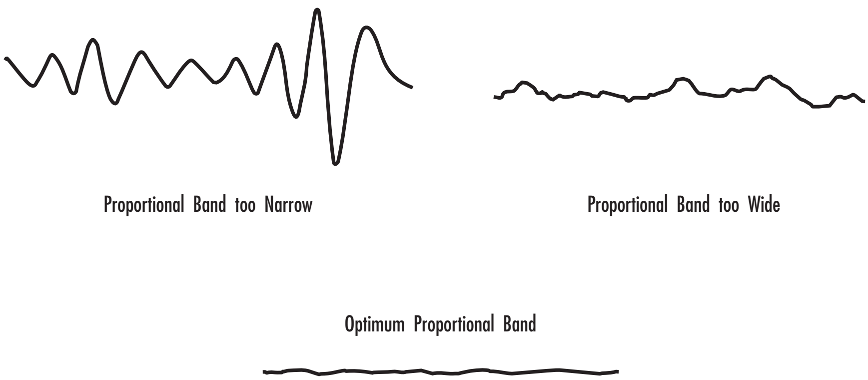


Figure 8 *Bath Temperature Fluctuation at Various Proportional Band Settings*

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

Table 4 *Proportional Band — Fluid Table*

Fluid	Temperature	Heater Setting	Proportional Band	Stability
Methanol	–80°C	Low	0.04°C	±0.001°C
Methanol	–40°C	Low	0.04°C	±0.0008°C
Water	0.0°C	Low	0.04°C	±0.0008°C
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

The proportional band adjustment may be accessed within the secondary menu. Press "SET" and "EXIT" to enter the secondary menu and show the heater power. Then press "SET" to access the proportional band.

SET + EXIT *Access heater power in secondary menu*

12 Pct *Heater power in percent*

SET *Access proportional band*

Pb=0.101C *Proportional band setting*

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

DOWN *Decrement display*

Pb=0.060C *New proportional band setting*

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

SET *Accept the new proportional band setting*

9.8 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 shuts 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, power to the heater is shut off and 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, 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= 210C *Cut-out set-point*

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

DOWN *Decrement display*

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

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

SET *Accept cut-out set-point*

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

9.9 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".

9.10 Probe Parameters Menu

The probe parameter menu is indicated by,

PrObE *Probe parameters menu*

Press "SET" to enter the menu. The probe parameters menu contains the parameters, R0 and ALPHA, which characterize the resistance-temperature relationship of the platinum control probe. These parameters may be adjusted to improve the accuracy of the bath. This procedure is explained in detail in Section11.

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" causes the parameter to be skipped ignoring any changes that may have been made.

9.10.1 R0

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

9.10.2 ALPHA

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

9.11 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 parameter.

9.11.1 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 manual mode.

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

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

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

9.12 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.

9.12.1 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.

9.12.2 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, 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 is 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*

9.12.3 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*

9.12.4 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*

9.13 IEEE-488 Parameters Menu

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.

9.13.1 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*

9.14 Calibration Parameters

The operator of the bath controller has access to a number of the bath calibration constants namely CTO, B0, BG, H, and L. These values are set at the factory and must not be altered. The correct values are important to the accuracy and proper and safe operation of the bath. Access to these parameters is available to the user only so that in the event that the controller's memory fails the user may restore these values to the factory settings. The user should have a list of these constants and their settings with the manual.

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

The calibration parameters menu is indicated by,

`CAL` *Calibration parameters menu*

Press "SET" five times to enter the menu.

9.14.1 CTO

Parameter CTO sets the limit of the over-temperature cut-out. This is not adjustable by software but is adjusted with an internal potentiometer. For the 7080/7081 baths this parameter should read between 110 and 130.

9.14.2 BO and BG

These parameters calibrate the accuracy of the bath set-point. These are programmed at the factory when the bath is calibrated. Do not alter the value of these parameters. If the user desires to calibrate the bath for improved accuracy then calibrate R0 and ALPHA according to the procedure given in Section11.

9.14.3 H and L

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

10 Digital Communication Interface

If supplied with the option, the 7080/7081 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 switch must be set to “OFF” and the COOLING POWER switch set to “HIGH” to enable remote control. Adjust the cooling temperature to the lowest temperature desired.

Digital Interface Setup (front panel controls):

HEATER switch - LOW

COOLING switch - OFF

COOLING POWER switch - HIGH

COOLING TEMPERATURE - 5 psi.

10.1 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 Section9 with the exception of the BAUD rate setting.

10.1.1 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 DB-9 connector and the shield.

10.1.2 Setup

Before operation the serial interface of the bath must first be set up by programming the BAUD rate and other configuration parameters. These parameters are programmed within the serial interface menu. The serial interface parameters menu is outlined in Figure 7 on page 38.

To enter the serial parameter programming mode first press “EXIT” while pressing “SET” and release to enter the secondary menu. Press “SET” repeatedly until the display reads “ProbE”. This is the menu selection. Press “UP”

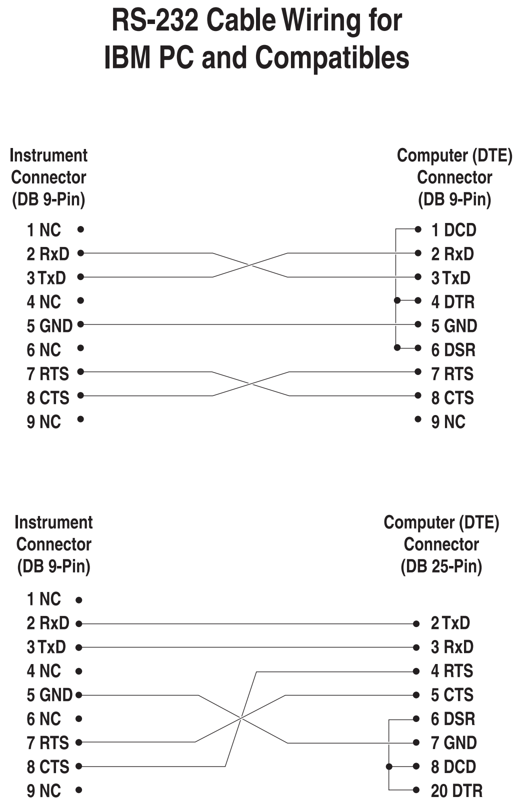


Figure 9 *Serial Cable Wiring*

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.

10.1.2.1 BAUD Rate

The BAUD rate is the first parameter in the menu. The display prompts with the BAUD rate parameter by showing "BAUd". Press "SET" to choose to set the BAUD rate. The current BAUD rate value is displayed. The BAUD rate of the bath's 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.

10.1.2.2 Sample Period

The sample period is the next parameter in the menu and prompted with "SAM-PLE". 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 bath transmits the current measurement over the serial interface approximately every five seconds. The automatic sampling is disabled with a sample period of 0. Press "SET" to choose to set the sample period. Adjust the period with "UP" or "DOWN" and then use "SET" to set the sample rate to the displayed value.

10.1.2.3 Duplex Mode

The next parameter is the duplex mode indicated with "dUPL". The duplex mode may be set to half duplex ("HALF") or full duplex ("FULL"). With full duplex any commands received by the bath via the serial interface 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".

10.1.2.4 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".

10.1.3 Serial Operation

Once the cable has been attached and the interface set up properly the controller immediately begins 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.

10.2 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.

10.2.1 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. The IEEE-488 interface parameters menu is outlined in Figure 7.

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.

10.2.1.1 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".

10.2.2 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.

10.3 Interface Commands

The various commands for accessing the bath controller functions via the digital interfaces are listed in this section (see Table 5). These commands are used with both the RS-232 serial interface and the IEEE-488 GPIB interface. In either case the commands are terminated with a carriage-return character. The interface makes no distinction between upper and lower case letters, hence either may be used. Commands may be abbreviated to the minimum number of letters which determines a unique command. A command may be used to either set a parameter or display a parameter depending on whether or not a value is sent with the command following a "=" character. For example, "s"<CR> returns the current set-point and "s=50.00"<CR> sets the set-point to 50.00 degrees.

In Table 5, 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 are simply ignored. Backspace (BS, ASCII 8) may be used to erase the previous character. A terminating CR is implied with all commands.

10.4 Power Control Functions

The digital interface is capable of controlling the heating and cooling functions so that the bath can be remotely operated at any temperature within the range of the bath. To allow the interface to control the heating and the cooling, the front panel controls are disabled by 1) switching the heater switch to "LOW", 2) switching the cooling switch to "OFF", switching the cooling power switch to

Table 5 *Interface Command Summary*

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Display Temperature					
Read current set-point	s[etpoint]		set: 9999.99 {C or F}		
Set current set-point to n	s[etpoint]=n				Instrument Range
Read vernier	v[ernier]				
Set vernier to n	v[ernier]=n				Depends on Configuration
Read temperature	t[emperature]		t: 9999.99 {C or F}	N	
Read temperature units			f		:
Set temperature units:	**u[nits]=c/f**				
Set temperature units to Celsius					
Set temperature units to Fahrenheit					f
Secondary Menu					
Read proportional band setting	f	f			
Set proportional band to *n*					Depends on Configuration
Read cutout setting	c[utout]		c: 9999 {x},{xxx}		
Set cutout setting:	**c[utout]=n/r[eset]**				
Set cutout to *n* degrees	c[utout]=n				Temperature Range
Reset cutout now	c[utout]=r[eset]				
Read heater power (duty cycle)	po[wer]				
Configuration Menu					
Probe Menu					
Read R0 calibration parameter					
Set R0 calibration parameter to *n*	e				
Read ALPHA calibration parameter	al[pha]				
Set ALPHA calibration parameter to *n*	al[pha]=n				.00370 to .00399
Operating Parameters Menu					
Read cutout mode			cm: {xxxx}		
Set cutout mode:	**cm[ode]=r[eset]/a[uto]**	N			RESET or AUTO
Set cutout to be reset manually-	cm[ode]=r[eset]		f		:
Set cutout to be reset automatically	cm[ode]=a[uto]				
Serial Interface Menu					
Read serial sample setting	sa[mple]	sa	sa: 9	sa: 1	
Set serial sampling setting to *n* seconds	sa[mple]=n	sa=0			
Set serial duplex mode:	**du[plex]=f[ull]/h[alf]**				
Set serial duplex mode to full	du[plex]=f[ull]		f	f	f
Set serial duplex mode to half	du[plex]=h[alf]				
Set serial linefeed mode:	**lf[eed]=on/of[f]**				
Set serial linefeed mode to on	lf[eed]=on				
Set serial linefeed mode to off	lf[eed]=of[f]				
Calibration Menu					

Interface Command Summary Continued

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Read B0 calibration parameter			N		
Set B0 calibration parameter to *n*					
Read BG calibration parameter					
Set BG calibration parameter to *n*					
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		f	f
Read high set-point limit value	*th[igh]	f			
Set high set-point limit to *n*	*th[igh]=n			b	
Miscellaneous (not on menus)					
Read firmware version number	*ver[sion]				
Read structure of all commands	h[elp]		list of commands		
	f1	f1	f1:9	f1:1	
Set Heater	**f1=1/0**				**0 or 1**
Set heater to low	f1=*n*	f1=0			
Set heater to high	f1=*n*	f1=1			
Read Refrigeration	f2	f2	f2:9	f2:0	
Set Refrigeration	**f2=1/0**	:	v		**0 or 1**
Set Refrigeration to on	f2=*n*	f2=1			
Set Refrigeration to off	f2=*n*	f2=0			
Read Expansion Valve 1	f3	f3	f3:9	f3:1	
Set Expansion Valve 1	f3=1/0				**0 or 1**
Set Expansion Valve 1 to on	f3=*n*	f3=1			
Set Expansion Valve 1 to off	f3=*n*	f3=0			
Read Cooling Power		N			
Set Cooling Power	f4=1/0				**0 or 1**
Set Cooling Power to on	f4=*n*				
Set Cooling Power to off	f4=*n*				
Read Expansion Valve 2	f5	f5	f5:9	f5:1	
Set Expansion Valve 2	f5=1/0				**0 or 1**
Set Expansion Valve 2 to on	f5=*n*	f5=1		f	f
Set Expansion Valve 2 to off	f5=*n*	f5=0	f		
Legend:	[] Optional Command data				

"HIGH", and adjusting the cooling temperature pressure to 5 psi. Otherwise, the interface would not be able to switch these functions off. The 7080/7081 bath has five control functions with the digital interface. These are 1) heater power high/low, 2) cooling on/off, 3) expansion valve 1 open/closed, 4) cooling power high/low, and 5) expansion valve 2 open/closed.

10.4.1 Heater Control

To control the heater with the digital interface the front panel heater switch must be set to LOW (500 W). The heater function is controlled with the “F1" command. Setting the “F1" parameter to 0 sets the heater to LOW (500 W) and setting it to 1 sets the heater to HIGH (1000 W). Sending “F1" with no value causes the controller to return the heater setting value. When the heater setting is changed, a pop is heard as the heater relay opens or closes.

10.4.2 Cooling Control

To control the refrigeration power with the serial interface the front panel cooling switch must be off. The refrigeration power function is controlled with serial “F2” command. Setting the “F2” value to 0 turns the refrigeration off and setting it to 1 turns it on. “F2” alone returns 0 or 1 showing the state of the refrigeration power control.

The “F3” and “F5” commands control the cooling temperature or expansion valves. These valves adjust the cooling temperature which sets the cooling capacity. Setting “F3” to 0 turns off valve 1 and 1 turns the valve on. Setting “F5” to 0 turns off valve 2 and 1 turns the valve on. A command with no value returns the current value.

To control the cooling power the COOLING POWER switch must be in the HIGH position. Command “F4” controls the cooling power. Setting the “F4” parameter to 0 switches cooling to high power and 1 switches to low power.

Table 6 summarizes the serial control functions for heating and cooling. Table 7 shows the recommended control settings for each operating temperature range. The ranges may need to be adjusted depending on the bath and its particular use.

Table 6 *Serial Power Control Functions*

Function	Command	0	1
Heater	F1	low	high
Refrigeration	F2	off	on
Exp. Valve 1	F3	off	on
Cooling Power	F4	high	low
Exp. Valve 2	F5	off	on

Table 7 *Temperature Range Control Functions*

Bath Temperature Range (°C)	Heating	Cooling	Cooling Power	Expansion Valve 1	Expansion Valve 2	Pressure Setting (Front Panel)
-80 to -40	low	on	high	off	off	3 psi (Front Panel†)
-40 to -15	low	on	low	on	off	50 psi (Valve 1, Internal)
-20 to 40	low	on	low	off	on	80 psi (Valve 2, Internal)
40 to 110	low	off	N/A	N/A	N/A	N/A

†Readjust to minimum desired temperature for manual operation

11 Calibration Procedure

In some instances the user may want to calibrate the bath to improve the temperature set-point accuracy. Calibration is done by adjusting the controller probe calibration constants R0 and ALPHA so that the temperature of the bath as measured with a standard thermometer agrees more closely with the bath set-point. The thermometer used must be able to measure the bath fluid temperature with higher accuracy than the desired accuracy of the bath. By using a good thermometer and carefully following procedure the bath can be calibrated to an accuracy of better than 0.02°C over a range of 100 degrees.

11.1 Calibration Points

In calibrating the bath R0 and ALPHA are adjusted to minimize the set-point error at each of two different bath temperatures. Any two reasonably separated bath temperatures may be used for the calibration. However, best results are obtained when using bath temperatures which are just within the most useful operating range of the bath. The further apart the calibration temperatures, the larger the calibrated temperature range, but the calibration error is also greater over the range. For instance, if 0°C and 100°C are chosen as the calibration temperatures, the bath may achieve an accuracy of maybe ±0.03°C over the range –10 to 110°C. Choosing 30°C and 70°C may allow the bath to have a better accuracy of maybe ±0.01°C over the range 25 to 75°C but outside that range the accuracy may be only ±0.05°C.

11.2 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 setpoint, t_L. Wait for the bath to reach the set-point and allow 15 minutes to stabilize at that temperature. Check the bath stability with the thermometer. When both the bath and the thermometer have stabilized, measure the bath temperature with the thermometer and compute the temperature error, err_L, which is the actual bath temperature minus the set-point temperature. For example, if the bath is set for a lower set-point of t_L=0°C and the bath reaches a measured temperature of –0.3°C then the error is -0.3°C.

Next, set the bath for the upper set-point, t_H, and after stabilizing measure the bath temperature and compute the error, err_H. For example, suppose the bath was set for 100°C and the thermometer measured 100.1°C giving an error of +0.1°C.

11.3 Computing R0 and ALPHA

Before computing the new values for R_0 and ALPHA the current values must be known. The values may be found by either accessing the probe calibration menu from the controller panel or by inquiring through the digital interface.

The user should keep a record of these values in case they may need to be restored in the future. The new values, R_0' and ALPHA′, are computed by entering the old values for R_0 and ALPHA, the calibration temperature set-points t_L and t_H, and the temperature errors err_L and err_H into the following equations.

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

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

For example R_0 and ALPHA were previously set for 100.000 and 0.0038500 respectively and the data for t_L, t_H, err_L, and err_H were as given above, then the new values R0′ and ALPHA′ would be computed as 99.885 and 0.0038302 respectively. Program the new values R_0 and ALPHA into the controller. Check the calibration by setting the temperature to t_L and t_H and measuring the errors again. If desired the calibration procedure may be repeated again to further improve the accuracy.

11.4 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 R0 and ALPHA are 100.000 and 0.0038500 respectively. The calibration points are chosen to be 30.00 and 80.00°C. The measured bath temperatures are 29.843 and 79.914°C respectively. Refer to Figure 10 for applying equations to the example data and computing the new probe constants.

R0 = 100.000

ALPHA = 0.0038500

t_L = 30.00°C

measured t = 29.843°C

t_H = 80.00°C

measured t = 79.914°C

Compute errors,

err_L = 29.843 - 30.00°C = -0.157°C

err_H = 79.914 - 80.00°C = -0.086°C

Compute R_0,

$$R0' = \left[\frac{(-0.086) \times 30.0 - (-0.157) \times 80.0}{80.0 - 30.0} 0.00385 + 1 \right] 100.000 = 100.077$$

Compute ALPHA,

$$ALPHA' = \left[\frac{(1 + 0.00385 \times 80.0)(-0.157) - (1 + 0.00385 \times 30.0)(-0.086)}{80.0 - 30.0} + 1 \right] 0.00385 = 0.0038416$$

Figure 10 *Sample Calibration Computations*

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.

- A battery is used to maintain operating parameters in the unit. All operating parameters, including calibration parameters should be checked on a regular basis to insure accuracy and proper operation of the instrument. See the troubleshooting section for the procedure on checking the status of the battery.
- 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 which 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 8) 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 ap-

plicable 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 will not damage the equipment.
- If the instrument is used in a manner not in accordance with the equipment design, the operation of the bath may be impaired or safety hazards may arise.
- The over-temperature cut-out should be checked every 6 months to see that it is working properly. In order to check the user selected cut-out, follow the controller directions (Section 9.8) 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.

CAUTION: *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.*

12.1 Draining the Bath

The drain is located on the back of the bath. See Figure 4, Back Panel. Locate the drain plug on the end of the drain tube. This drain plug is to be fluid tight until the bath is drained.

The following information is helpful when draining the bath.

1. Always use a container capable of holding the entire load of fluid. Use safety equipment as appropriate.
2. Drain water and low viscosity fluids at room temperature. Normal care must be taken for fluids that may have corrosive or damaging effects on the surrounding facility or equipment.
3. High viscosity oils should be sufficiently low in viscosity to drain effectively. Some oils, such as 710 silicone oil, may need to be heated to 80°C to drain well. The viscosity affects how rapidly it drains as well as how well it flows off of the walls. Appropriate temperature resistant containers and appropriate safety equipment such as face shields, gloves, and body covering should be used.

13 Troubleshooting

In the event the bath appears to function abnormally this section may help to find and solve the problem. Several possible problem conditions are described along with likely causes and solutions. If a problem arises please read this section carefully and attempt to understand and solve the problem. If the bath seems faulty or the problem cannot otherwise be solved, then contact an Authorized Service Center for assistance.

13.1 Troubleshooting

Problem	Causes and Solutions
The bath does not turn on and the display remains blank	If a fault condition exists upon application of power, the bath will not energize. The bath needs to be plugged in to the line voltage for at least 10 minutes before turning power on. This is only necessary for the first time that the bath is energized or when it is moved from one location to another. If a high or low voltage condition exists for longer than 5 seconds, the compressor is de-energized and the "Mains Out of Range" light on the back panel illuminates indicating a fault condition. Re-energization is automatic upon correction of the fault condition and after a delay cycle of about 10 minutes. High and low voltage protection limits at 230 VAC: Voltage Cut-out: ±12.5% (203 – 257 VAC) Voltage Cut-in: ±7.5% (213 – 247 VAC) See the Caution in the front of this manual for additional information.
The heater indicator LED stays red but the temperature does not increase	If the display does not show "cut-out" and shows the correct bath temperature, consider the following possibilities: **Insufficient heating.** Insufficient heating may be caused by the heater power setting being too low, especially at higher operating temperatures. Switching to the higher heater power switch setting, if available, may solve the problem. **No heating.** This is caused by blown heater fuses and/or burned out heaters. Check the heater fuses to make sure that they are still good. Access the heater fuses by removing the L-shaped panel covering the display electronics. If they are blown, and continue to blow when replaced, the heaters may be shorted. If you suspect that the heaters are shorted or burned out, contact an Authorized Service Center for assistance. **Too much cooling.** Try reducing the cooling capacity by increasing the cooling pressure, switching the cooling power switch to "LOW", or switching off the cooling altogether.

Problem	Causes and Solutions
The controller display flashes "CUT-OUT" and the heater does not operate	If the display flashes "CUT-OUT" alternately with the correct process temperature, check the following: **Wrong cut-out setting.** The cut-out disconnects power to the heaters when the bath temperature exceeds the cut-out set-point. This causes the bath 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. (Refer to section 9.8.) Check that the cut-out set-point is adjusted to 10 or 20°C above the desired maximum bath operating temperature and that the cut-out mode is set as desired. **Bad cut-out.** 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, the cut-out circuitry may be faulty. Try performing the Factory Reset Sequence explained below. **Factory Reset Sequence -** Hold the "SET" and "EXIT" keys down at the same time while powering up the unit. The display shows "-init", the model number, and the firmware version. Each of the controller parameters and calibration constants must be re-programmed. The values can be found on the Report of Calibration that was shipped with the instrument.
The display flashes "CUT-OUT" alternately with an incorrect process temperature	**Low battery.** A problem could exist with the memory back-up battery. If the battery voltage is insufficient to maintain the memory, data may become scrambled causing problems. A nearby large static discharge may also affect data in memory. Access the battery by removing the L-shaped panel covering the display electronics. **Corrupt controller memory.** If the problem reoccurs after the battery is replaced, initialize the memory by performing a Factory Reset Sequence (described in a previous solution).
The controller displays the wrong temperature and the bath continually heats or cools regardless of the set-point value	**Bad control probe.** The bath control probe may be disconnected, burned out, or shorted. Check first that the probe is connected properly to the socket in the rear of the bath labeled "PROBE". The probe may be checked with an ohmmeter to see if it is open or shorted. The probe is a platinum 4-wire Din 43760 type. The resistance should read 0.2 to 2.0 ohms between pins 1 and 2 on the probe connector and 0.2 to 2.0 ohms between pins 3 and 4. The resistance should read from 100 to 300 ohms between pins 1 and 4 depending on its current temperature. **Corrupt controller memory.** Initialize the memory by performing a Factory Reset Sequence (described in a previous solution).

Problem	Causes and Solutions
The controller controls or attempts to control at an inaccurate temperature	If the controller appears to operate normally except that the bath's temperature does not agree with the temperature measured by the user's reference thermometer to within the specified accuracy, consider the following: **Erroneous parameters.** Check that the calibration parameters are all correct according to the Report of Calibration. If not, reprogram the constants. If the controller does not keep the correct parameters, the memory backup battery may be weak causing errors in data. See "Low Battery" in a previous solution. **Poor uniformity.** There may be an actual difference between the bath's control probe and the reference thermometer due to excess gradients in the bath. Check that the bath has an adequate amount of fluid in the tank and that the stirrer is operating properly. Also check that the reference thermometer and control probe are both fully inserted into the bath to minimize temperature gradient errors. **Bad control probe.** Check that the control probe has not been struck, bent, or damaged. Refer to the previous solution for how to check the probe's resistance.
The controller shows that it is controlling at the proper temperature, but the bath temperature is unstable	If the bath does not achieve the expected degree of temperature stability when measured using a thermometer, consider the following: **Wrong proportional band setting.** If the proportional band is set too narrow, the bath will oscillate causing poor stability. In this case, increase the width of the proportional band. If the proportional band setting is too wide, the long-term stability of the bath is affected. In this case decrease the width of the band. (Refer to section 9.7.) **Bath fluid is too thick.** Make sure that the bath fluid used is less than 50 centi-Stokes (10 is ideal) at the temperature at which the bath is controlling. Check the fluid manufacturer's specifications. You should also change the bath fluid regularly and if it changes colors or becomes too thick. **Bad control probe.** Check that the control probe has not been struck, bent, or damaged. Refer to the previous solution for how to check the probe's resistance.
The controller alternately heats for a while then cools	**Wrong proportional band setting.** If the proportional band is set too narrow, the bath will oscillate between too much heating and too much cooling causing instability. Increase the width of the proportional band until the temperature stabilizes. (Refer to section 9.7.)

Problem	Causes and Solutions
The bath does not achieve low temperatures	**Too much heating.** 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. Check the refrigeration system by switching the heater to low, switching the cooling on, setting the cooling power to high, setting the cooling pressure to approximately 7 PSI, and setting the cooling temperature to 10-15°C below the bath set point. The bath should then cool as quickly as possible to the new set point. **Insufficient cooling.** This may be caused by lack of refrigerant because of a leak in the system.
Power Up	The unit is equipped with external operator accessible fuses. If a fuse blows, it may be due to a power surge or failure of a component. Replace the fuse once. DO NOT replace the fuse with one of a higher current rating. Always replace the fuse with one of the same rating, voltage, and type. If the fuse blows a second time, it is likely caused by failure of a component part. Contact an Authorized Service Center (Section 1.3) for assistance.
The controller does not maintain controller parameters or parameters are reset each time the power to the unit is removed	**Note:** Before performing the memory check,you need to record the controller calibration parameters (found in the CAL menu of the instrument) and any user-adjusted parameters that you have changed (such as the programmable set points and proportional band). **Memory Check** Doing a memory check is the easiest way to verify the ability of the battery to maintain controller parameters. 1. Power off the instrument. 2. Disconnect the instrument from AC power for 10 seconds. 3. Reconnect the AC power and power on the instrument. 4. If the display shows InIT and/or the cycle count shows a low number such as 0002, the battery is spent and should be replaced. Contact an Authorized Service Center for assistance. 5. After replacing the battery, you must reprogram the calibration and user-adjustable parameters into the controller.

13.2 Comments

13.2.1 EMC Directive

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

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

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

13.2.1.1 Emission Testing

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

13.2.2 Low Voltage Directive (Safety)

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