FLUKE ®
Calibration

7381
Calibration Bath

User's Guide

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Introduction

The Fluke Calibration 7381 Calibration Bath (the Bath or Product) is a compact constant temperature bath used for temperature calibration and other applications that require stable temperatures. A state of the art solid-state temperature controller maintains bath temperature within extreme stability. The temperature controller uses a micro-controller to execute the many functions.

The Product provides stable calibrations from -80 °C to 110 °C.

Product features:

- User interface (LED display and buttons)
- Rapid heating and cooling
- RS-232 (standard) and IEEE-488 (optional)
- Temperature scan rate control
- Ramp and soak functions
- Compact size
- Eight set-point memory
- Adjustable readout in °C or °F
- Automatic refrigeration control

Contact Fluke Calibration

Fluke Corporation operates worldwide. For local contact information, go to our website: www.flukecal.com.

To register your product, or to view, print, or download the latest manual or manual supplement, go to our website.

+1-425-446-5500 info@flukecal.com

Safety Information

General safety Information is in the printed *7381 Safety Information* document that ships with the Product. It can also be found online at www.flukecal.com. More specific safety information is listed in this manual where applicable.

A **Warning** identifies conditions and procedures that are dangerous to the user. A **Caution** identifies conditions and procedures that can cause damage to the Product or the equipment under test.

⚠ Caution

- **The drain valve on the back of the Bath must be closed before you attempt to fill the tank with fluid.**
- **Always operate this instrument at room temperature 5 °C to 35 °C (41 °F to 95 °F). Allow sufficient air circulation by leaving at least 15 cm (6 in) of clearance around the Product.**
- **When you fill the tank, make sure the immersion coils are completely covered.**
- **Do not fill above the stir baffle, see Figure 2.**
- **Do not overfill the Bath. Overflowing fluid can damage the electrical system. Make sure to allow for thermal expansion of the fluid as the Bath temperature increases. See *Parts and Controls* for specific instructions.**
- **Do not exceed the recommended fluid viscosity of any fluid.**
- **Read *Bath Use*, before you place the Bath into service.**
- **Do not turn on the Bath without fluid in the tank and the heating coils fully immersed. See *Rear Panel and the Fluid Expansion Reservoir*.**
- **Do not change the values of the Bath calibration constants from the factory-set values. Correct setting of these parameters is important for the safety and proper Bath operation.**
- **The refrigeration can be damaged or the lifetime shortened if the set-point temperature is set >60 °C for >1 hour with the refrigeration manually on. Make sure that the refrigeration is off when the Bath is used >60 °C.**
- **The Factory Reset Sequence should be performed only by authorized personnel if no other action is successful to correct a malfunction, see Table 6. You must have a copy of the most recent Report of Test to restore the test parameters.**
- **Do not operate the Product in an excessively wet, oily, dusty, or dirty environment. Silicone oils require additional ventilation to prevent an oily, dirty environment.**
- **Most probes have handle temperature limits. Make sure that the probe handle temperature limit is not exceeded in the air above the Product.**
- **The Product and any thermometer probes used with the Product are sensitive instruments that are easily damaged. Handle these devices with care. Do not allow them to be dropped, struck, stressed, or overheated.**

COLD BATHS

Turning the Product on and off frequently adds wear to the compressor. Bath or compressor lifetime can be affected by turning the Product off and on frequently. Fluke Calibration recommends to turn the bath off if it is not going to be used for the weekend or an extended period of time.

Specifications and Environmental Conditions

Safety specifications are listed in the *Safety Information* document that ships with the Product.

Note

The Product can show some control sensitivity to moderate or severe electromagnetic fields or conducted interference of certain frequencies. In the presence of radiated EM disturbances, with frequencies of 250 MHz to 400 MHz and with amplitude >1 V/m to a maximum of 3 V/m, add 0.0025 °C to the stability specification. Stability is not guaranteed if amplitude is >3 V/m. When subject to conducted disturbances of 8 MHz to 80 MHz, and amplitude >3 V, add 0.005 °C to the stability specification.

Stability (2 sigma)	±0.006 °C at –80 °C (ethanol) ±0.005 °C at 0 °C (ethanol) ±0.005 °C at 100 °C (5012 oil)
Uniformity	±0.007 °C at –80 °C (ethanol) ±0.007 °C at 0 °C (ethanol) ±0.007 °C at 100 °C (5012 oil)
Temperature Range	5 °C to 35 °C (41 °F to 95 °F)
Mains Voltage	within ±10 % of nominal
Heating Time [1]	60 minutes, from 25 °C to 100 °C (5012 oil @ 230 V)
Cooling Time	210 minutes, from 25 °C to –80 °C (ethanol)
Stabilization Time	15 minutes to 20 minutes
Temperature Setting	Digital display with push-button entry
Set-point Resolution	0.01 °; 0.00018 ° in high resolution
Display Temperature Resolution	0.01 °
Digital Setting Accuracy	±1 °C
Digital Setting Repeatability	±0.01 °C
Wetted Parts	304 Stainless Steel

[1] Rated at listed 230 V.

Installation

The subsequent sections provide more detail on Bath installation.

Unpack the Product

Unpack the Bath carefully and inspect it for damage that may have occurred during shipment. If there is shipment damage, notify the carrier immediately. Make sure that all components are present:

- The Bath
- Access Hole Cover
- Fluid Expansion Reservoir with Cover
- Safety Information document
- RS-232 cable
- Report of Test (store in a safe place)
- Drain valve
- Tipping Prevention Bracket (with included mounting hardware for wood or concrete floor)
- 2019-DCB Kit, Liquid-in-Glass (LIG) Adapter and Carousel (optional)
- 2069 Scope, Liquid-in-Glass (LIG) with mounts (optional)

If missing any item, contact Fluke Calibration. See *Contact Fluke Calibration*.

Uncrate and Move the Bath

When you uncrate the Bath, remove all of the accessories from the foam around the Bath and remove the foam. Gently ease the Bath from the crate and use the casters to roll it. If you must lift the Bath slightly to release it from the crate, have a second person help you. Carefully slide your hands under the Bath and gently lift it only enough to clear the foam and roll the Bath from the crate. The area that contains the compressor is heavier than the rest of the Bath. Do not attempt to carry the Bath.

If you must move the Bath after installation, empty the bath fluid.

⚠⚠Warning

To prevent personal injury, do not move a bath filled with fluid. The Bath is tall and heavy and personal injury or damage can occur. Unlock the casters to roll the Bath.

Bath Environment

Locate the Bath in an appropriate environment free of dirt, drafts, extreme temperatures, and temperature changes. Place the Bath on a level surface. Allow sufficient air circulation around the Product. Leave at least 15 cm (6 in) of clearance.

Warning

To prevent personal injury, beware of accidental fluid spills. The top surface of the Bath is hot at high temperatures.

Use a fume hood or other adequate ventilation system to remove any vapors given off by hot bath fluid. Silicone oils require additional ventilation to prevent an oily, dirty environment.

Tipping Prevention Bracket Installation

To create the safest possible use conditions, the Bath comes with a Tipping Prevention Bracket. The installation of the bracket is required for compliance with the international safety standard *IEC 61010-1, Section 7.3 Stability*.

Install the bracket per *Installation On A Wood Floor* and *Installation On A Concrete Floor*. Once the bracket is installed, slide the back casters of the Bath completely into the bracket caster slots, see Figure 1. Lock the front casters. Gently push on the Bath to make sure that it is securely locked into the tipping bracket. If you have questions about the installation, contact Fluke Calibration.

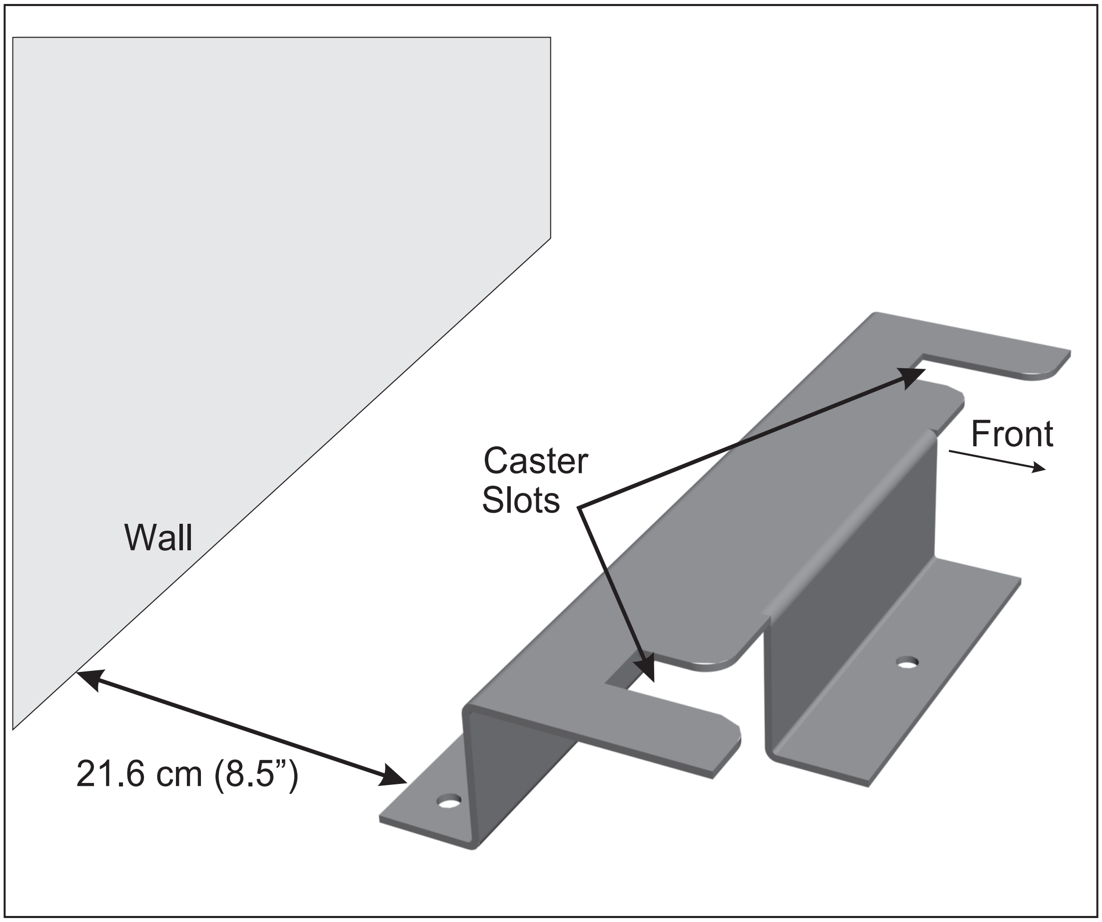
Installation On A Wood Floor

The wood floor installation kit includes lag bolts. Use the bracket to mark the hole placement and drill three 3 mm x 25.5 mm (1/8 in x 1 in) deep pilot holes. Use the lag bolts to install the bracket to the floor. Make sure to install the bracket so that the Bath has a minimum 6 in of clearance for air circulation, see Figure 1. Screw the bracket securely to the floor.

Installation On A Concrete Floor

Use a concrete drill and concrete drill bit to drill three 1/4 in x 1 3/4 in deep (approximately 6.5 mm x 32 mm) holes into the concrete floor. Use the bracket to mark the hole placement. Drop the flare anchor bolt into the hole. Tighten the screw to expand the anchor in the drilled hole to secures the bracket. Make sure to install the bracket so that the bath has a minimum of 6 inches of clearance for air circulation. Screw the bracket securely to the floor, see Figure 1.

Figure 1. Tipping Prevention Bracket Installation

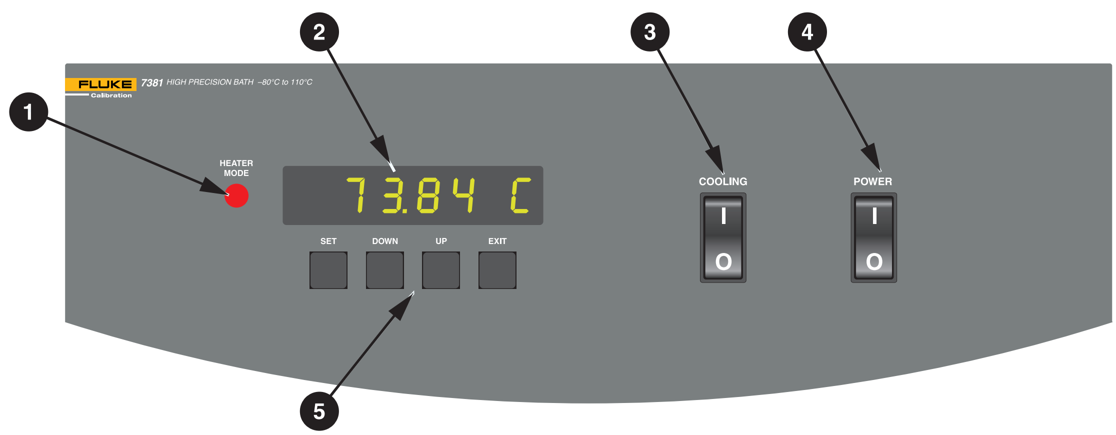


Parts and Controls

Front Panel

The front-panel controls and indicators are shown in Table 1.

Table 1. Front Panel



Number	Description
1	Control indicator light - A two-color LED that indicates the ratio of heating to cooling. • When the indicator is red, the heater is on. • When the indicator is green, the heater is off and the Bath is cooling. The indicator pulses as the Bath maintains a stable temperature.
2	Display - Used to view the set-point temperature, Bath temperature, and other functions, settings, and constants. The display shows temperatures in °C or °F units. See *Temperature Scale Units*.
3	Cooling on/off switch - Turns on the refrigeration for control <50 °C and rapid cool down. Cooling shuts off automatically >60 °C. Manually turn off the refrigeration at temperatures where it is unnecessary. See *Refrigeration*, *Cooling Mode*, and *Hot Gas Bypass Mode*.
4	Bath power switch - Used to control power to the entire Bath and includes the stirring motor.
5	Control buttons - • **SET** - Shows the next parameter in a menu and stores parameters to the shown value. • **DOWN** - Decrements the value of shown parameters. • **UP** - Increments the value of shown parameters. • **EXIT** – Escapes from a menu. When you push **EXIT**, any changes made to the shown value are ignored.

Bath Tank and Lid

The Bath tank and lid assembly includes:

- The tank
- The control probe
- The stirring motor
- The access hole
- The access-hole cover
- The stirring motor cover, covers the stirring motor, cooling fan, and control probe.
- The stainless steel Bath tank resists oxidation in the presence of most chemicals and over a wide temperature range.
- The control probe provides the temperature feedback signal to the controller that allows the controller to maintain a constant temperature. The control probe is a precision platinum resistance thermometer (PRT). Handle the delicate PRT carefully. Place the probe in the small hole in the top of the Bath inside the stir motor cover so that the probe tip is fully immersed in the bath fluid.
- The stirring motor, mounted on the Bath tank lid, drives the stirring propeller to mix the bath fluid. A proper fluid mix is important for constant temperature stability.
- On the Bath lid is a large access hole. Use this to fill and empty the Bath with fluids and to place thermometers and devices into the Bath.
- Use an access-hole cover to close the access hole in the top of the Bath. This improves bath temperature stability, prevents excess fluid evaporation or fumes, and increases safety with hot fluid. Drill or cut holes in the cover to accommodate the instruments calibrated or immersed in the Bath. Spare covers are available from Fluke Calibration.
- A stainless steel baffle inside the tank ensures proper fluid flow and protects probes and thermometers from contact with the stirrers. There are slots near the bottom of the baffle to insert the liquid-in-glass adapter.

Rear Panel and the Fluid Expansion Reservoir

Access these items from the rear panel:

- Systems fuses
- Power cord
- High/low voltage indicator
- Drain
- Serial port, IEEE-488 port (if installed)
- Fluid expansion reservoir

Attached to the Bath rear panel is the fluid expansion reservoir. The reservoir receives excess fluid that expands in the Bath when heating to higher temperatures. Any liquid expands when heated. To prevent Bath overflow, you must remove the excess fluid prior to heating or there must be a means to allow the fluid to drain out of the Bath tank.

Note

Never let the fluid level go below the heating elements.

The Bath has an overflow tube attached to the tank that extends to the rear of the Bath and drains into the fluid expansion reservoir. The reservoir has enough capacity to cover a large range of thermal expansion rates for different fluids. Do not plug the overflow tube to prevent fluid from draining. Do not fill the Bath to a level higher than the overflow tube level.

The fluid expansion reservoir is stainless steel with an aluminum heat shield to prevent touching the hot tank. A stainless steel dust cover is over the reservoir and includes an elbow on top where the drain tube is inserted. The reservoir hangs on a hook and attaches to the Bath with a thumbscrew.

⚠⚠ Warning

To prevent personal injury, know that the drain tube and dust cover can be hot. Always be sure the drain tube is fully inserted into the elbow of the dust cover.

To drain fluid from the reservoir:

1. Remove the dust cover and set aside.
2. Loosen the thumbscrew and carefully lift the reservoir with the two handles on the back.
3. Pour the fluid back into the Bath when it cools, or pour it into another approved container.

⚠⚠ Warning

To prevent personal injury, use care when you handle hot fluids, burns can result. Once you remove the excess fluid, reverse the process to replace the reservoir and dust cover. Always wipe away spilled fluid.

⚠ Caution

To prevent Product damage, know that the overflow tube is not large enough to handle large flow rates encountered from an over-filled tank. The tube is for expanding fluid rates from heating only. Fill only until the level reaches the top of the baffle, see Figure 2.

Before You Begin

⚠ Warning

The Product has a soft cutout (user-settable firmware) and a hard cutout (set at the factory). Check the flash point, boiling point, or other fluid characteristics applicable to the circumstances of Product operation. Make sure to adjust the soft cutout 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 *Heat Transfer Fluid* for specific information on bath fluids, and see *Cutout Set-point*.

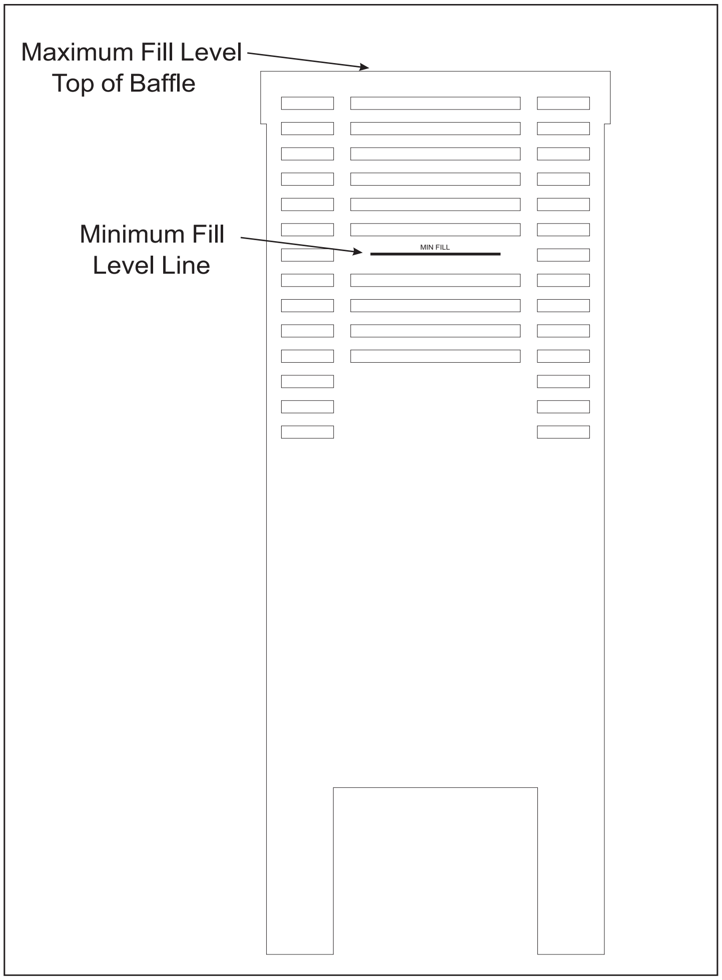
Set up requires you to fill the Bath with fluid and connect the Bath to proper power. See *Installation* for detailed instructions. Make sure to place the Bath in a safe, clean, and level location. See *Tipping Prevention Bracket Installation*.

Fill the Bath tank with an appropriate fluid. Select the correct fluid for the temperature range of the calibration. Select bath fluids that safely operate with adequate thermal properties that meet application requirements. Clean, distilled water works well for Bath operation at moderate temperatures. Carefully pour the fluid into the Bath tank through the large rectangular access hole above the tank. Do not spill any fluid.

⚠ Caution

To avoid Product damage, make sure the immersion coils are completely covered when you fill the tank. Do not fill above the stir baffle, see Figure 2.

Figure 2. Stir Baffle Fill Level



The Bath has an overflow drain for excess bath fluid due to expansion. This drains the fluid into the fluid expansion reservoir for reuse. See *Rear Panel and the Fluid Expansion Reservoir*.

Note

As Bath temperature increases, fluid level increases. See *Bath Use* and *Thermal Expansion*.

Power

Plug the power cord into a mains outlet of the proper voltage, frequency, and current capability, see *Specifications and Environmental Conditions*. Before you energize the Bath, check the rear panel label for the correct voltage and frequency. Bath power passes through a filter to prevent switching spike transmission to other equipment.

Use the front panel **POWER** to turn on (**I**) the Bath. The Bath stirring motor turns on and heats or cool to reach the previously-programmed temperature set-point. The front display indicates the actual Bath temperature. Set the cooling switch to **I** (on) for below or near-ambient temperatures.

Note

The actual temperature where cooling is required depends on the bath fluid and whether there is a cover over the access well.

When powered on, the display briefly shows a four-digit number. This number indicates the number of times power has been applied to the Bath. Data that indicates the controller hardware configuration also briefly shows. This data is used in some circumstances for diagnostic purposes.

For optimum accuracy and stability, allow the Bath adequate stabilization time after it reaches the set-point temperature.

Bath Preparation and Filling

⚠ **Caution**

To avoid Product damage, do not spill fluid on the control panel. Immediately clean up any spills. If necessary, cover the panel while you fill the Bath. Do not overfill.

The Bath does not come with bath fluid. Various fluids are available from Fluke Calibration or other sources. Depending on the desired temperature range, any of the fluids below, or others, can be used:

- Water
- Ethylene glycol/water
- Mineral oil
- Silicone oil
- Ethanol

Fluids are discussed in detail in *Heat Transfer Fluid*.

Remove any access hole cover from the Bath and check the tank for foreign matter (for example, dirt or remnant packing material).

⚠ **Caution**

To avoid Product damage, do not turn on the Bath without fluid in the tank. Make sure the heating coils are fully immersed. *Rear Panel and the Fluid Expansion Reservoir*.

Fill the Bath with clean, unpolluted fluid. Fill the Bath carefully through the large rectangular access hole to a level that allows for stirring and thermal expansion, see *Thermal Expansion*.

Make sure the fluid expansion reservoir is properly installed, clean, and free of foreign matter. Carefully monitor the bath fluid level as the Bath temperature rises to prevent excessive overflow or splashing. Carefully remove excess hot fluid when necessary.

Set the Temperature

To view or set the Bath temperature set-point:

1. Push **SET** to show the current set-point selection, for example: :

   1. 25.0 — *The set point 1, 25.0 °C*

2. Push **SET** to select this memory location and access the set-point value.
3. Push **UP** or **DOWN** to increment or decrement the shown value.

   For example, from a displayed reading of 24.68 C, push **UP** to change the value to:

   C 30.00 — *New set-point value*

4. Push **SET** to store the new set-point value and to show the vernier value. The Bath heats or cools to the new set-point:

   C 30.00 — *Newly-stored set-point value*

   0.00000 — *Current vernier value*

5. Push **EXIT** to show the Bath temperature again.

The Bath heats or cools until it reaches the new set-point temperature. Turn off the cooling to reach and control at higher temperatures.

Do not exceed the temperature limit of the bath fluid when you set the set-point. Correctly set the over-temperature cutout for added safety, see *Cutout Set-point*.

To control stability, adjust the proportional band, see *Proportional Band*.

Bath Use

General

Make sure to select the correct fluid for the temperature range of the calibration. Select bath fluids that operate safely with adequate thermal properties that meet application requirements. Fluids expand when heated and can overflow if not observed, see *Rear Panel and the Fluid Expansion Reservoir*. See *General Operation* for information specific to fluid selection and refer to the MSDS sheet specific to the fluid selected.

Warning

To prevent personal injury, prepare a place for extracted probes. Probes can be extremely hot when removed from the Bath. The Bath generates extreme temperatures.

Carefully place probes on a heat/cold resistant surface or rack until they are at room temperature. Wipe the probe with a clean soft cloth or paper towel before you insert the probe into another bath. This prevents the mixing of fluids from one bath to another. If the probe was calibrated in liquid salt, carefully wash the probe in warm water and dry completely before you transfer it to another fluid. Make sure that the probe is completely dry before you insert it into hot fluid.

Comparison Calibration

Comparison calibration tests a probe to be calibrated (device under test, DUT) against a reference probe. After you insert the DUT into the Bath, allow sufficient time for the probes to settle and the Bath temperature to stabilize.

A significant benefit of bath use, instead of a dry-well, to calibrate multiple probes is that the probes do not need to be identically constructed. The bath fluid lets you calibrate different probe types simultaneously. However, stem effect from different probe types is not totally eliminated. Even though all baths have horizontal and vertical gradients, these gradients are minimized inside the Bath work area. Nevertheless, insert the probes to the same depth in the bath fluid. Make sure to insert all probes deep enough to prevent stem effect. Fluke Calibration recommends a general rule for immersion depth to reduce the stem effect to a minimum: 20 x the diameter of the DUT + the sensor length. **Do not submerge the probe handles.** If the probe handles get too warm during calibration at high temperatures, use a heat shield just below the probe handle. This heat shield can be as simple as aluminum foil slid over the probe before you insert it into the Bath. It can be as complicated as a specially-designed reflective metal apparatus.

For best results, when you calibrate over a wide temperature range, start at the highest temperature and progress down to the lowest temperature.

To hold the probes in place in the Bath, use probe clamps or drill holes in the access cover. Design other fixtures to hold the probes when necessary. Keep the reference probe and the DUT probe(s) as closely grouped as possible in the Bath work area. Bath stability is maximized when the Bath work area is kept covered.

To prepare for calibration:

- Place the reference probe in the Bath work area.
- Place the DUT in the Bath work area as close as possible to the reference probe. Do not touch the probe to the Bath tank surface areas.

Calibrate Multiple Probes

Fully loading the Bath with probes increases the temperature stabilization time after you insert the probes. Use the reference probe as the guide and make sure that the temperature is stable before you start calibration.

General Operation

The information in this section is for general information only. Do not use this section as the basis for calibration laboratory procedures. Each laboratory must write their specific procedures.

Heat Transfer Fluid

Many fluids work with the Bath. When you choose a fluid, consider the characteristics of the fluid.

Temperature Range

One of the most important characteristic considerations is the fluid temperature range. Few fluids work well throughout the entire bath temperature range. Bath temperature must be within the safe and useful temperature range of the fluid. The lower temperature range of the fluid is determined by the fluid freeze point or by the temperature at which the viscosity is too great. The upper temperature is usually limited by vaporization, flammability, or chemical breakdown of the fluid. Fluid vaporization at higher temperatures can adversely affect temperature stability because of cool condensed fluid that drips into the Bath from the lid.

To limit Bath temperature, set the safety cutout so that the temperature cannot exceed the safe operating temperature limit of the fluid, see *Cutout Set-point*.

Viscosity

Viscosity is a measure of the fluid thickness or how easily the fluid can be poured and mixed. Viscosity affects the temperature uniformity and Bath stability. With lower-viscosity fluid, mixing is better and creates a more uniform Bath temperature. This improves bath response time so the Bath maintains a more constant temperature. For good control, the viscosity should be <10 centistokes. 50 centistokes is about the practical upper limit of allowable viscosity. Viscosity greater than this causes poor control stability because of poor stirring and can overheat or damage the stirring motor.

Viscosity can vary greatly with temperature, especially with oils. Viscosity increases as temperature decreases. When fluid viscosity increases, stability performance of the Bath can decrease.

Make sure stirring occurs at all temperatures. When you use higher-viscosity fluids, the controller proportional band (see *Proportional Band*) may need to be increased to compensate for the reduced response time. Otherwise, the temperature can oscillate.

Specific Heat

Specific heat is the measure of the heat storage ability of the fluid. Specific heat, to a small degree, affects the control stability and heating/cooling rates. Generally, a lower specific heat means quicker heating and cooling. The proportional band can require adjustment depending on the specific heat of the fluid.

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 quicker, more evenly, and improves Bath performance.

Thermal Expansion

Thermal expansion describes how much the fluid volume changes with temperature. You must consider fluid thermal expansion since the increase in fluid volume, as the Bath temperature increases, can cause overflow into the fluid expansion reservoir, *Rear Panel and the Fluid Expansion Reservoir*. The expansion can also cause loss of valuable bath fluid. Excessive thermal expansion can be undesirable in applications where constant fluid level is important.

Thermal expansion coefficients of several fluids are shown in Table 2. Fluid manufacturers can also provide this information. Thermal expansion coefficients are shown in units of cm/cm/°C. However, the values are the same for any unit of length. Divide the value by 1.8 for °F coefficients.

Use this equation to find the desired depth:

$$D_E=D_S\,[K(T_E-T_S)+1]$$

Or

$$D_S=D_E/\,[K(T_E-T_S)+1] \text{ where } D_E \leq \text{The Maximum Fill Depth}$$

Where:

K=Expansion coefficient

T_E=Ending temperature

T_S=Starting temperature

D_E=Ending depth

D_S=Starting depth

The maximum-fill depth is typically 1.3 cm to 2.0 cm (0.5 in to 0.8 in) below the level of the gasket at the top of the Bath tank top (not the top of the Bath lid). Use caution with different stirring arrangements to prevent splashes on the Bath lid gasket.

Example:

The final depth of Dow Corning 710 silicone oil in the Bath tank is to be 23 cm (9.06 in) when heated from 25 °C to 300 °C. What should the starting depth be?

Expansion coefficient for 710 oil on Table 2, $K = 0.00077$ cm/cm/°C

Ending temperature, $T_E = 300$ °C

Starting temperature, $T_S = 25$ °C

Ending depth, $D_E = 9.2$ in (23 cm)

D_S = 9.2 / [0.00077 (300-25) + 1] = 7.59 inches (18.98 cm)

Electrical Resistivity

Electrical resistivity is how well the fluid insulates against electric current flow. In some applications, such as when you measure the resistance of bare temperature sensors, it can be important that little or no electrical leakage occur through the fluid. In such conditions, choose a fluid with high-electrical resistivity.

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, which substantially reduces fluid lifetime.

Safety

With bath fluids, always consider the safety issues. Where there are extreme temperatures, there can be danger to personnel and equipment. Fluids can be hazardous for other reasons. Some fluids are toxic. Contact with eyes, skin, or inhalation of vapors, can cause injury. If hazardous or bothersome vapors are produced, you must use a proper fume hood or adequate ventilation system.

⚠ **Warning**

To prevent personal injury, know that fluids at high temperatures pose danger from burns, fire, or toxic fumes. Use appropriate caution and safety equipment.

Some fluids are flammable and require special fire-safety equipment and procedures. Consider the fluid flash point. The flash point is the temperature where there is sufficient vapor given off that when adequate oxygen is present, and an ignition source is applied, the vapor ignites. This does not necessarily mean that fire is sustained at the flash point.

The flash point can be either of the open cup or closed cup type. Either condition can occur in a bath environment. The open cup flash point is measured under the condition of vapors that escape the tank. The closed cup flash point is measured with the vapors contained within the tank. Since oxygen and an ignition source are less available inside the tank, the closed cup flash point is lower than the open cup flash point.

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

Cost

Cost of bath fluids can vary greatly, from low cost for water to expensive for synthetic oils. Cost is important when you choose a fluid.

Commonly Used Fluids

Commonly used fluids and their characteristics are discussed in the subsequent sections.

Water

Water is often used because of its low cost, availability, and its excellent temperature control characteristics. Water has low viscosity, good thermal conductivity, and heat capacity which makes it among the best fluids for stability at lower temperatures. Temperature stability is reduced 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 prevents its use in some applications. Water has a limited temperature range, from a few degrees >0 °C to a few degrees <100 °C. At higher temperatures, evaporation becomes significant. Use only distilled or deionized water in the Bath to prevent mineral deposits. To prevent contamination, consider an algicide chemical added to the water.

Note

Water at temperatures >75 °C (167 °F) may be unstable.

Ethylene Glycol

⚠ **Warning**

To prevent personal injury, know that ethylene glycol is extremely toxic.

Extend the temperature range of water with a solution of 1 part water and 1 part ethylene glycol (antifreeze). The characteristics of the ethylene glycol-water solution are similar to water but with higher viscosity. Properly dispose of Ethylene glycol.

Mineral Oil

⚠ **Warning**

To prevent personal injury, use caution with mineral oil since it is flammable and can cause serious injury if inhaled or ingested.

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 can be dangerous and Fluke Calibration highly recommends the use of a fume hood or adequate ventilation. As with most oils, mineral oil expands as temperature increases, see *Rear Panel and the Fluid Expansion Reservoir*. The viscosity and thermal characteristics of mineral oil is poorer than water and temperature stability is not as good. Mineral oil has low electrical conductivity.

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 occurs. These oils have high electrical resistivity. Silicone oils are fairly safe and non-toxic but can be expensive. Silicone oils can degrade and eventually breakdown when used at higher portions of their temperature range for long periods. This limits their usable lifetime depending on the duration spent at high temperature.

Fluid Characteristics Charts

⚠ Caution

Due to the unique properties of silicone oils and their ability to migrate and creep through seals, adequate ventilation must be used to prevent oil vapors from creating an oily, dirty environment. Oily, dirty environments reduce the lifetime of the electrical components of the Product.

Table 2 and Figure 3 provide help to select a heat exchange fluid media for your constant temperature bath. These charts provide a visual and numerical representation of most of the physical qualities important to make a selection. The list is not all inclusive. There may be other useful fluids not shown. The charts include information on a variety of fluids which are often used as heat transfer fluid in baths. Because of the temperature range, some fluids may not be useful with your bath.

Limitations and Disclaimer

The fluid information given in this manual is intended only as a general guide to choose a fluid. Though every effort has been made to provide correct information, Fluke Calibration cannot guarantee accuracy of data or assure suitability of a fluid for a particular application. Specifications may change and sources sometimes offer differing information. Fluke Calibration cannot be liable for any personal injury or damage to equipment, product, or facilities that result from the use of these fluids. The Bath user is responsible for collecting correct information, exercising proper judgment, and ensuring safe operation. Operation near the limits of certain properties such as the flash point or viscosity can compromise safety or performance. You must consider your company safety policies with regard to flash points, toxicity, and other safety issues. It is your responsibility to read the MSDS (material safety data sheets) and act accordingly.

Table 2. Table of Bath Fluids

Fluid	Lower Temp. Limit*	Upper Temp. 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	
Ethanol	–97 °C (fr)	16 °C (fl,cc)	16 °C	1@20 °C	0.809 @ 20 °C	0.61	0.00047	-	-
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 200.05 #5012	–30 °C (v)**	209 °C (fl, cc)	211 °C	10 @ 25 °C 3 @ 135 °C	0.934@25 °C	0.43 @ 40 °C 045 @ 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 #5017 710	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
Silicon 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/cm³

*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.

About the Chart

Figure 3 illustrates some of the important qualities of the fluids shown.

Temperature Range: The temperature scale is in degrees Celsius. The shaded bands indicate the general range of application of the fluid. Qualities that include pour point, freeze point, important viscosity points, flash point, boiling point, and others may be shown.

Freezing Point: The freezing point of a fluid limits stirring. As the freezing point approaches, high viscosity can also limit performance.

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

Viscosity: Points shown are at 50 centistokes and 10 centistokes viscosity. When viscosity is >50 centistokes, stirring is poor and the fluid is unsatisfactory for bath applications. Optimum stirring generally occurs at ≤10 centistokes.

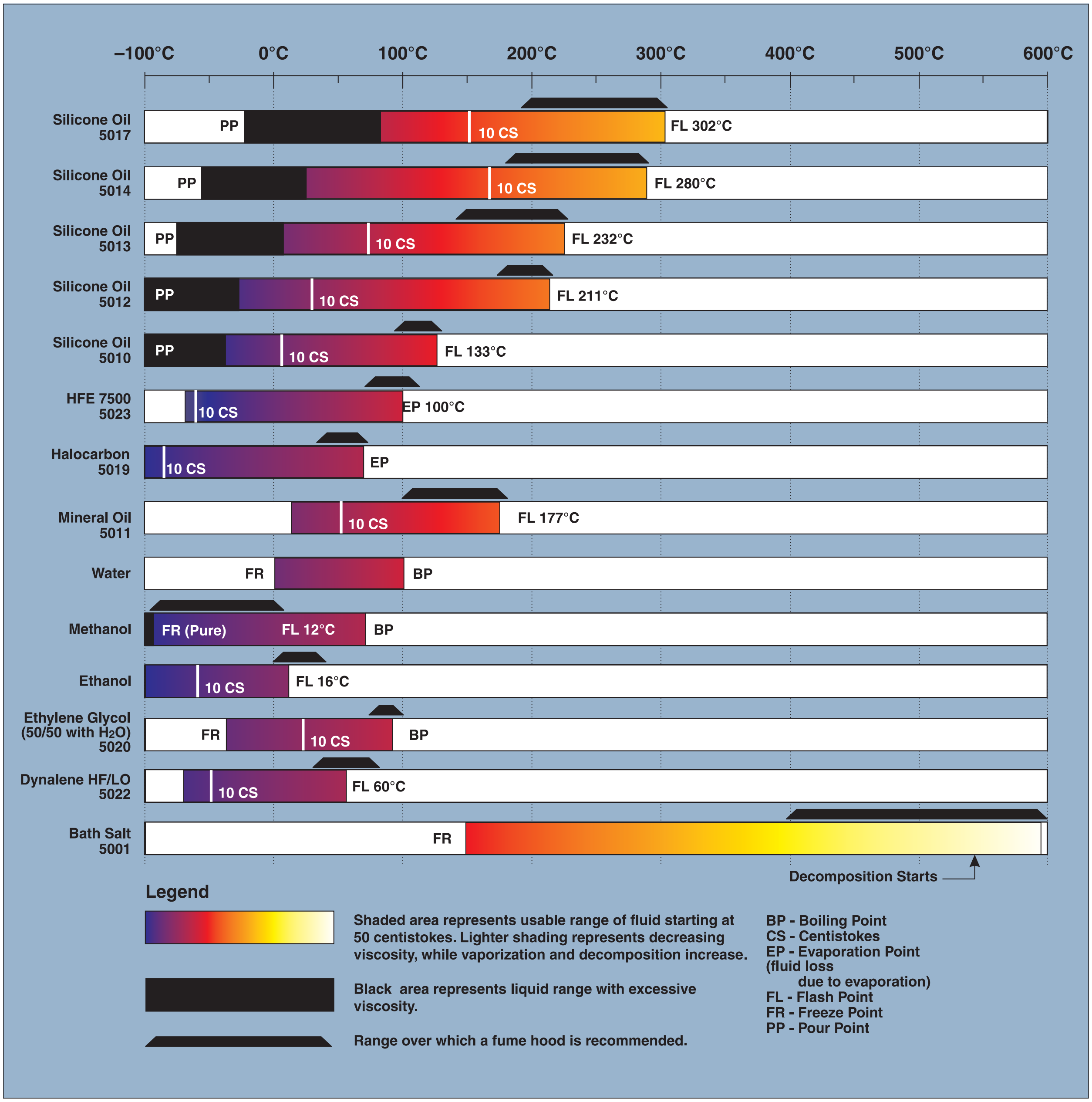
Fume Point: Fume point is the point at which you must use a fume hood or ventilation system to prevent health hazards posed by fume vapors. In the graph, it is assumed that the bath access hole is covered at this point. This is subject to you company policy. Fluke Calibration recommends the use of a ventilation system as soon as the fluid produces vapors. Keep the access hole covered to reduce evaporation.

Flash Point: The point at which ignition may occur. The point shown can be either the open or closed cup flash point. Refer to the flash point discussion in *Safety*.

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

Decomposition: The temperature can reach a point at which decomposition of the fluid begins. To further increase the temperature can accelerate decomposition to the point of danger or impracticality. Silicone oils can oxidize, which causes the fluid to thicken. Replace at the first sign of viscosity increase.

Figure 3. Chart Showing Usable Range of Various Fluids



Stirring

Stirring of the bath fluid is 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.

Heater

The temperature controller precisely controls the Bath heater to maintain a constant bath temperature. To control the power, the Bath periodically switches on a solid-state relay that turns the heater on for a certain interval.

The front-panel red/green control indicator shows the state of the heater, see Table 1.

Temperature Controller

A unique hybrid digital/analog temperature controller controls the Bath temperature. The controller offers the tight control stability of an analog temperature controller and the flexibility and programmability of a digital controller.

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

The Bath operates within the temperature range given in the specifications. To protect against solid-state relay failure or other circuit failure, the microcontroller automatically turns off the heater with a second mechanical relay if the Bath temperature exceeds a certain amount above the set-point temperature. As a second protection device, the controller has a separate thermocouple temperature monitoring circuit that shuts off the heater if the temperature exceeds the cutout set-point.

Use the controller to set the Bath temperature with high resolution, set the cutout temperature, adjust the proportional band, monitor the heater output power, and program the controller configuration and calibration parameters.

When you set the controller to a new set-point, the Bath heats or cools to the new temperature. Once the Bath reaches the new temperature, allow 15 minutes to 20 minutes for the temperature to stabilize. There may be a small overshoot or undershoot of about 0.5 °C.

Cutout

For protection against software or hardware fault, shorted heater triac, or user error, the Bath has an adjustable heater cutout 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 heating beyond the safe operating temperature. This protection prevents hazardous vaporization, breakdown, or ignition of the liquid. From the front panel. Set the cutout temperature below the upper temperature limit of the fluid and no more than 10 degrees above the upper temperature limit of the Bath, see *Cutout Set-point*.

If the cutout is activated because of excessive bath temperature, power to the heater shuts off, the bath cools, and the display flashes Cut-out. The display flashes between the actual temperature and Cut-out until the temperature falls below the reset temperature and the cutout is reset.

Cooling Control

The Bath has a fully-automated refrigeration control system when the cooling power switch on the front panel is activated (**I**). Under normal conditions, the refrigeration is on at any temperature below approximately 60 °C, see *Refrigeration*. When the Bath controls at temperatures between –61 °C and 60 °C, the refrigeration is in the Hot Gas Bypass or Reduced Cooling mode. < –61 °C, the refrigeration is in the High Cooling mode and the Hot Gas Bypass automatically turns off. When the Bath cools from one temperature to another <60 °C, cooling is at maximum until the temperature is within 0.5 °C of the set-point. These conditions are the default conditions but can be altered in these ways:

- The cooling (refrigeration) can be set to operate in the auto, on, or off modes. See *Cooling Mode*.
- The Hot Gas Bypass or reduced-cooling mode can also be set to on (manual), off, or auto.

These controls are available from the front panel as described *Operating Parameters*, or through the digital interface as described in *Interface Commands* and *Cooling Control*. Set the cooling mode control to automatic, on, or off. With these selections, the refrigeration is in automatic as described above, always on, or always off. The hot gas bypass modes are similarly selectable between automatic, on, or off. This system is in automatic as described above, always on (low-cooling capacity, adjustable) or always off (high-cooling capacity).

The auto modes allows the Bath to operate automatically in the manner described above. The cooling on function eliminates this auto feature and the refrigeration is on at all times unless the front-panel switch is turned off (**O**) or until you make another menu selection. The Hot Gas Bypass mode selection works the same way. The auto function is the default and active until off or on is selected. On means it is always on with manual selection, and off is always off (or cooling always on maximum). For different reasons, you might want to eliminate the automatic functioning. If that is the case, make the appropriate selections with the front panel or the digital communications interface.

Refrigeration

A compact cascade-refrigeration system that uses the ozone-safe R-507 and R-508bHFC refrigerants provides cooling. Depending on the fluid used, and if you use the access cover, refrigeration is often unnecessary when the Bath is >45 °C to 60 °C. The automated system automatically turns the system off when >60 °C. The refrigeration system automatically changes modes depending on Bath temperature and operation needs as described below. The refrigeration system activates once the switch on the front panel is on.

If the Bath is below the 60 °C cutoff point and is set to a temperature >60 °C, refrigeration shuts off to protect the Bath from overheating and creating excessive internal pressures. If the Bath is >60 °C and is set to a new temperature below the cutoff temperature, refrigeration turns on again at 59 °C.

As the Bath controls at temperatures between 60 °C and –61 °C, the Bath operates in a low-cooling capacity mode with the Hot Gas Bypass valve on (HGb on). See *Hot Gas Bypass Mode*.

When the Bath is cooled and the new set-point is at least 2 °C below the current bath temperature, the cooling turns to maximum capacity (HGb off) until the Bath is within about 0.5 °C of the new set-point. This provides the fastest cooling possible to achieve the new set-point temperature.

When you heat the Bath and the new set-point is at least 5 °C above the current bath temperature, the refrigeration turns off until the bath is about 1.5 °C below the new set-point. This permits the maximum heating rate to reach the higher temperatures as quickly as possible. (When the scan rate is active this function is modified, see *Scan*. The cooling remains off at temperatures >60 °C.

The automatic cooling mode might not be ideal for all circumstances. The automatic mode can be turned off to permit manual control.

These situations benefit from cooling mode changes:

- When you select the scan mode and the desired cooling scan requires maximum cooling capacity in a range where the hot gas bypass would normally be on.
- The application requires maximum cooling capacity when the hot gas bypass would normally be on.
- When you use the bath at temperatures <–61 °C in an ambient temperature <23 °C, a small stability benefit might be realized if you use the hot gas bypass.
- The refrigeration can be beneficially used for short times (<1 hr) >60 °C but <100 °C.

This list is not complete, but suggests some situations when automatic modes might not be best. Fluke Calibration recommends use of the automatic functions as they are adequate.

Controller Operation

This section discusses Bath temperature controller operation with the front control panel.

Use the front panel to:

- 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 cutout set-point
- program the probe calibration parameters
- operating parameters
- serial and IEEE-488 interface configuration
- controller calibration parameters

Figure 4 summarizes operation of the primary functions.

Bath Temperature

The display normally shows the actual Bath temperature. The temperature units are on the right. For example,

25.00 C *Bath temperature in degrees Celsius*

Push **EXIT** to access the temperature display function from any function.

Reset Cutout

If the over-temperature cutout triggers, the display flashes Cut-out. The message flashes between the actual temperature and Cut-out until the temperature reduces and the cutout is reset. See *Cutout*.

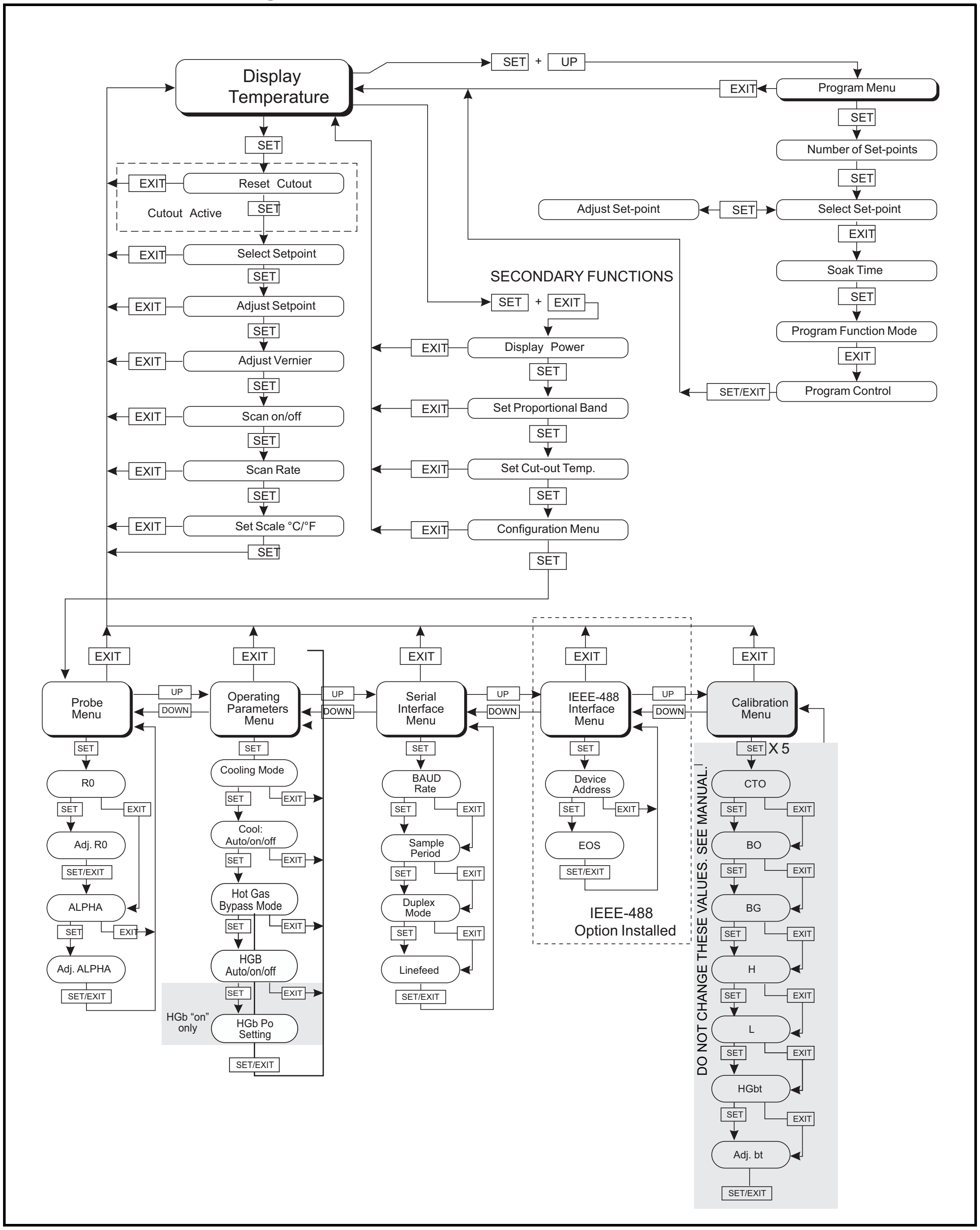
When the cutout is active and cutout mode is set to manual (reset), the display flashes Cut-out until you reset the cutout.

To access the reset cutout function, push **SET**.

1. Push **SET**, the display prompts rESEt ?.
2. Push **SET** again to reset the cutout.

The display changes to the set temperature function. To return the display to temperature, push **EXIT**. If the cutout 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 cutout set-point before the cutout can be reset.

Figure 4. Controller Operation Flowchart



Temperature Set-point

The Bath temperature can be set to any value within the range as given in the specifications with a high degree of resolution. The temperature range of the particular bath fluid must be known by the operator and the Bath should only be operated well below the upper temperature limit of the fluid. Additionally, the cutout temperature should be set below the upper limit of the fluid.

To set the Bath temperature:

1. Select the set-point memory
2. Adjust the set-point value
3. Adjust the vernier, if desired

Programmable Set-points

The controller stores eight set-point temperatures in memory. Quickly recall the set-points to conveniently set the bath to a previously-programmed temperature set-point.

To set the Bath temperature, push **SET** to first select the set-point memory. The number of the set-point memory currently used shows at the left of the display followed by the current set point value. For example:

25.00 C *Bath temperature in degrees Celsius*

To set a programmable set-point:

1. Push **SET** to access set-point memory

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

2. Push **UP** or **DOWN** to change the set-point memory.

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

3. Push **SET** to accept the new selection and access the set-point value.

Set-point Value

After you select the set-point memory and push **SET**, adjust the set-point value in increments of 0.01 ° (C or F). The set-point value shows the temperature units at the left, for example:

C 40.00 *Set-point 4 value in °C*

If you do not need to change set-point value, push **EXIT** to show the bath temperature. To change the set-point value:

1. Push **UP** or **DOWN** to adjust the set-point value.
2. When you reach the desired set-point value, push **SET** to accept the new value and access the set-point vernier. Or push **EXIT** to ignore changes made to the set-point.

Set-point Vernier

Use the set-point vernier to adjust the temperature below or above the set-point by a small amount with high resolution. Each of the eight stored set-points has an associated vernier setting. The set-point vernier can be set in increments of 0.00018 °C.

To access the vernier from the set-point:

1. Push **SET**. The six-digit vernier setting shows with five digits after the decimal point. This is a temperature offset in degrees of the selected temperature units, for example:

   0.00000 *Current vernier value in °C*

2. Push **UP** or **DOWN** to adjust as necessary.

   Unlike most functions, the vernier setting takes immediate effect as you adjust the vernier. There is no need to push **SET**. This allows the displayed Bath temperature to be continually adjusted.

3. Push **EXIT** to return to the temperature display or push **SET** to access the temperature scale units selection.

Scan

The scan rate can be set and enabled so that when you change the set-point the Bath heats or cools at a specified rate (degrees per minute) until it reaches the new set-point. With the scan disabled, the Bath heats or cools at the maximum possible rate.

Scan Control

Control the scan with the scan on/off function that shows in the main menu after the set-point function. For example:

ScAn=OFF *Scan function off*

1. Push **UP** or **DOWN** to toggle the scan on or off.
2. Push **SET** to accept the setting and continue.
3. Push **EXIT** until the bath temperature shows.

Always leave the controller in the main temperature display menu while in the scan mode. To view other menus causes the controller to halt scanning while in the menu. Normal scanning resumes once you exit the menu to the temperature display.

Scan Rate

The scan rate can be set from 0.001 °C to 5.0 °C/min. The maximum scan rate, however, is limited by the natural heating or cooling rate of the Product. This is typically <1 °C/min, especially when cooling. The scan rate function shows in the main menu after the scan control function. For example:

Sr=0.010 *Scan rate in °C/min*

1. Push **UP** or **DOWN** to change the scan rate.
2. Push **SET** to accept the new scan rate and continue.

Temperature Scale Units

Set the temperature scale units to degrees Celsius (°C) or Fahrenheit (°F). The Bath shows these units for:

- bath temperature
- set-point
- vernier
- proportional band
- cutout set-point

Access the temperature units after the vernier adjustment function.

1. Push **SET**.
2. From the Temperature Display function, push **SET** four times to access the units (Un) selection.
3. Push **UP** or **DOWN** to change the units (C or F).
4. Push **SET** to store the new selection.

Program Menu

Use the Ramp and Soak Program feature to program a number of set-points and have the Product automatically cycle between the temperatures, holding at each for a length of time. Select one of four different cycle functions.

To show the program parameter (ProG) menu:

1. Push **SET** and then **UP**.
2. Push **SET** to enter the program menu.

Number of Program Set-points

The first parameter in the Program menu is the number of set-points to cycle through. Set a maximum of eight set-points for a ramp and soak program (Pn=1 through Pn=8). These set-points are independent from the programmable set-points described in *Programmable Set-points*.

To program a set-point:

1. Push the **UP** or **DOWN** buttons to change the number from 2 to 8.
2. Push **SET** to store the new value and continue, or push **EXIT** to ignore changes made and continue.

Set-points

The next parameters are the program set-points. For example:

1 50.0 *First set-point*

1. Use the **UP** or **DOWN** buttons to select any of the set-points. For example, set-point 3:

   3 30.0 *Third set-point*

2. Push **SET** to be able to change the set-point.
3. Use **UP** or **DOWN** to change the set-point value.
4. Push **SET** to save the new set-point value.

Set the other set-points in the same manner. Once you program the set-points, push **EXIT** to continue to the next function.

Program Soak Time

The next menu parameter is soak time. Soak time is defined as the minutes that each program set-point is maintained after settling before proceeding to the next set-point. At the point the temperature reaches its set-point, the duration is counted. For example:

Pt= 15 *Soak time in minutes*

1. Push **UP** or **DOWN** to change the time.
2. Push **SET** to continue.

Program Function Mode

The next parameter in the menu is the program function or cycle mode. There are four possible modes that determine whether the program scans up only (from set-point 1 to n) or both up and down (from set-point n to 1), also whether the program stops after one cycle or repeats the cycle indefinitely. Table 3 below shows the action of each of the four program mode settings.

Table 3. Program Setting Mode Actions

Function	Action
1	up-stop
2	up-down-stop
3	up-repeat
4	up-down-repeat

To select the program mode (PF):

PF= 1 *Program mode*

1. Use the **UP** or **DOWN** buttons to change the mode.
2. PF=4 *New program mode*
3. Push **SET** to continue.

Program Control

The final menu item is the control parameter. These options are available to control the ramp and soak program:

- Start the program from the beginning (GO)
- Continue the program from where it was when it was stopped (Cont)
- Stop the program (OFF)

Pr=OFF *Program presently off*

1. Push **UP** or **DOWN** to change the status.

   Pr=Cont *Start cycle from beginning*

2. Push **SET** to activate the new program control command and return to the temperature display.

Secondary Menu

Use the secondary menu to access less-used functions. To get to the secondary menu, push **SET** and **EXIT** simultaneously, then release. The first function in the secondary menu is the heater power display.

Heater Power

The temperature controller pulses the heater on and off to control Bath temperature. The total power applied to the heater is determined by the duty cycle or ratio of heater on time to the pulse cycle time. Watch the red/green control indicator light or read from the display to estimate this value. The heating amount, once known, can tell the user if the Bath heats up to the set-point, cools down, or controls at a constant temperature. Monitor the percent heater power to determine Bath temperature stability. With control stability, the percentage of heating power should not fluctuate more than ±1 % within 1 minute.

Access the heater power display from the secondary menu. The heater power shows as a percentage of full power, for example:

12 Pct *Heater power in percent*

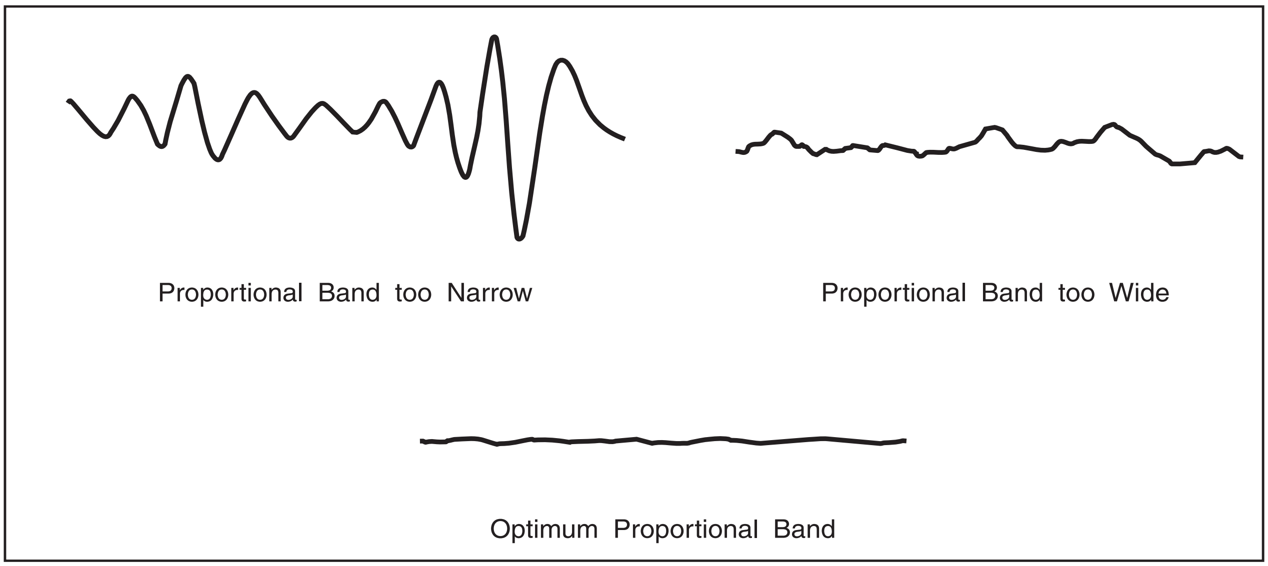
To escape from of the secondary menu, push **EXIT**. To continue to the proportional band setting function, push **SET**.

Proportional Band

In a proportional controller like this, heater output power is proportional to the Bath temperature over a limited range of temperatures around the set-point. This temperature range is the proportional band. At the bottom of the proportional band, heater output is 100 %. At the top of the proportional band, heater output is 0 %. As the Bath temperature rises, the heater power reduces, which usually lowers the temperature. These actions maintain a fairly-constant temperature.

Temperature stability of the Bath depends on the width of the proportional band, see Table 5. If the band is too wide, the Bath temperature deviates excessively from the set-point due to varying external conditions. This is because the power output changes a minor amount with temperature, and the controller does not respond well to changing conditions or noise in the system. If the proportional band is too narrow, Bath temperature can oscillate because the controller overreacts to temperature variations.

Figure 5. Bath Temperature Fluctuations at Various Proportional Band Settings



Optimum proportional band width depends on factors that include:

- fluid volume
- fluid characteristics (viscosity, specific heat, thermal conductivity)
- heater power setting
- operating temperature
- stirring

The proportional band width can require adjustment for best Bath stability when any of these conditions change. Of these conditions, the most significant factors that affect the optimum proportional band width are heater power setting and fluid viscosity. The proportional band should be wider when you use the higher power setting so that the change in output power per change in temperature remains the same.

The proportional band should also be wider when fluid viscosity is higher because of the increased response time.

Easily adjust the proportional band width from the front panel. You can set the width to discrete values in the selected temperature units. Monitor the stability with a high-resolution thermometer or with the controller percent output power display to determine the optimum proportional band width setting. Narrow the proportional band width to the point at which the 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	Proportional Band	Stability
Water	30.0 °C	0.31 °C	±0.003 °C
Water	60.0 °C	0.31 °C	±0.003 °C
Eth-Gly 50 %	35.0 °C	0.31 °C	±0.005 °C
Eth-Gly 50 %	60.0 °C	0.31 °C	±0.005 °C
Eth-Gly 50 %	100.0 °C	0.4 °C	±0.010 °C
Oil 200.10	35.0 °C	0.6 °C	±0.004 °C
Oil 200.10	60.0 °C	0.6 °C	±0.004 °C
Oil 200.10	100 °C	0.6 °C	±0.004 °C
Oil 710	200 °C	0.4 °C	±0.008 °C

Access the proportional band adjustment from the secondary menu. Once in the secondary menu and you see heater power, push **SET** to access the proportional band:

Pb=0.101C *Proportional band setting*

1. Push **UP** or **DOWN** to change the proportional band, for example:

   DOWN *Decrement display*

   Pb=0.060C *New proportional band setting*

2. Push **SET** to accept the new setting and access the cutout set-point. Push **EXIT** to escape the secondary menu and ignore any changes made to the proportional band value.

Cutout Set-point

Access the cutout set-point from secondary menu. Once in the secondary menu and you see heater power, push **SET** twice to access the cutout set-point. The cutout set-point shows, for example:

CO= 110C	*Cutout set-point*

1. Push **UP** or **DOWN** to change the cutout set-point.

DOWN	*Decrement display*
CO= 75C	*New cutout set-point*

2. Push **SET** to accept the new cutout set-point.

The next function is the configuration menu. Push **EXIT** to show the Bath temperature.

Controller Configuration

Configuration and operating options and calibration parameters follow the cutout set-point function in the secondary menu. Enter the secondary menu and push **SET** until the display shows COnF IG. Push **SET** again to enter the configuration menu. The configuration menu has five sets of configuration parameters:

- probe parameters
- operating parameters
- serial interface parameters
- IEEE-488 interface parameters
- controller calibration parameters

Push **UP** or **DOWN** to highlight the desired parameter, and push **SET**.

Probe Parameters

Push **SET** to enter the menu. The probe parameters menu (PrObE) contains the parameters, R0 and ALPHA, which characterize the resistance-temperature relationship of the platinum control probe. Adjust these parameters if necessary to improve Bath accuracy, see *Cooling Control*.

1. Push **SET** to access the probe parameters.
2. Push **UP** or **DOWN** to change the value of the parameter.
3. After you reach the desired value, push **SET** to store the parameter as the new value. Push **EXIT** to escape the parameter and ignore any changes made.

R_0

This probe parameter, normally set for 100.000 Ω, refers to the resistance of the control probe at 0 °C.

ALPHA

This probe parameter, normally set for 0.00385°C^{-1}, refers to the average probe sensitivity between 0 °C and 100 °C.

Operating Parameters

When in the probe menu, push **UP** to indicate the operating parameters menu (PAr).

Push **SET** to enter the menu. The operating parameters menu contains:

- cooling mode
- hot gas bypass mode

Cooling Mode

The cooling mode (CooL) determines whether refrigeration is in Auto mode, On, or Off. Normally, the cooling mode is set to Auto mode. In Auto mode, refrigeration is On below approximately 60 °C.

Note

If the fluid is cooling from >60 °C, the refrigeration turns on at approximately 59 °C. If the fluid is heating from <60 °C, the refrigeration shuts off at 60 °C. If the set-point is over 5 °C higher than the current Bath temperature, the refrigeration automatically shuts off until needed to maintain the temperature selected.

Sometimes, Auto mode is undesirable. In that case, set the refrigeration to On or Off. When the refrigeration is set to On or Off, the refrigeration is on or off for all temperatures.

⚠Caution

To avoid Product damage, know that the refrigeration can be damaged, or the lifetime shortened, if used >60 °C for over 1 hour.

To change cooling modes:

1. Push **SET** to access the parameter setting.

   Auto — *Cooling mode set for automatic*

2. To change to On or Off mode, push **DOWN** until the desired mode appears.

   On — *Cooling mode set to on*

   OFF — *Cooling mode set to off*

3. Push **SET**. Push **EXIT** to skip individual steps.

Hot Gas Bypass Mode

The hot gas bypass (HGb) system reduces cooling or refrigeration capacity. Reduce cooling capacity to improve temperature stability in the Bath and reduce energy consumption for specific bath conditions.

The HGb (HGb) modes are:

- Auto (normally-set mode)
- On (manual)
- Off

If for a special application, the automatic mode is undesirable, set the HGb to On or Off.

Automatic Mode: This mode is best for most applications. When you scan down in temperature (for set points >2 °C below the current temperature) the system switches to maximum cooling capacity. The system automatically switches back to HGb mode just before it reaches the new set-point, but only if the new set-point is >-61 °C. When in this mode, the HGb setting adjusts automatically to ensure the percent of heater power is approximately 30 %. For temperatures <-61 °C, the capacity remains in the maximum-cooling condition. Maximum cooling is generally required at these low temperatures.

On Mode: This mode allows for the manual selection of thehot gas capacity control setting for all temperatures and conditions where the refrigeration is on. The HGb capacity control setting has a range of 40 to 448 (with 40 being the setting with no capacity reduction, and 448 being the setting with maximum capacity reduction). An increase of the HGb setting decreases the cooling power and, correspondingly, reduces the percent of heater power applied to maintain the temperature.

Off Mode: This mode does not permit capacity reduction and the cooling is at maximum throughout the temperature range used by the refrigeration.

Note

The cooling capacity of the system can exceed the capacity of the heater at higher temperatures.

To change the HGb parameter:

1. Push **SET** to access the parameter setting.

   Auto *HGb mode is set for automatic operation*

2. Push **DOWN** to select On or OFF modes.
3. Push **SET** to store the change or push **EXIT** to ignore any changes made and escape to the menu.

After you set the mode selection, the display shows the HGb setting (St) unless the HGb is set to Off mode. The temperature controller automatically selects the HGb setting for Auto mode and this cannot be manually adjusted. The user must select the HGB setting in On mode.

4. Push **UP** or **DOWN** to change the value.

   HGb Po *HGB setting parameter indicator*

5. Push **SET** to access the parameter setting

   St=170 *Current HGb setting value*

6. Push **UP** or **DOWN** to change the value (if in On mode).
7. Push **SET** to store the value or push **EXIT** to discard the changes and escape to the menu.

Serial Interface Parameters

Push **UP** to access the Serial Interface Parameters menu from the Operation Parameters menu. SErIAL indicates the serial RS-232 interface parameters menu.

The serial interface parameters menu contains parameters that determine serial interface operation:

- BAUD rate
- sample period
- duplex mode
- linefeed

BAUD Rate

BAUD rate (bAUd) is the first parameter in the menu. The BAUD rate setting determines the serial communications transmission rate. Program the Bath BAUD rate serial communications to 300, 600, 1200, or 2400 BAUD.

1. Push **SET** to choose to set the baud rate. The current BAUD rate value shows.

   1200 b *Current BAUD rate*

2. Push **UP** or **DOWN** to change the BAUD rate value.
3. Push **SET** to store the new baud rate value, or **EXIT** to abort the operation and go to the next menu parameter.

Sample Period

Sample period is the next parameter in the Serial Interface Parameter menu. The sample period is the time, in seconds, between temperature measurements transmitted from the serial interface. If you set the sample rate (SAnPLE) to 5, the Bath transmits the current measurement over the serial interface approximately every 5 seconds. A sample period of 0 disables the automatic sampling.

1. Push **SET** to choose to set the sample period. The current sample period shows.

   SA= 1 *Current sample period (seconds)*

2. Push **UP** or **DOWN** to adjust the value.
3. Push **SET** to store the sample rate.

Duplex Mode

Duplex mode (dUPL) is the next parameter in the Serial Interface Parameter menu. Set the duplex mode to full duplex or half duplex. With full duplex, any commands received by the Bath from the serial interface are immediately echoed or transmitted back to the device of origin and the command executes. With half duplex, the commands are executed but not echoed.

To change duplex mode:

1. Push **SET** to access the mode setting.

   dUP=FULL *Current duplex mode setting*

2. Push **UP** or **DOWN** to change the mode (HALF or FULL).
3. Push **SET**.

Linefeed

Linefeed mode is the final parameter in the Serial Interface Parameter. Linefeed mode (LF) enables (On) or disables (OFF) linefeed character (LF, ASCII 10) transmission after transmission of any carriage-return. Push **SET** to access the linefeed parameter.

To change linefeed mode:

1. Push **SET** to access the mode setting.
2. Push **UP** or **DOWN** to change the mode.
3. Push **SET**.

IEEE-488 Setup (Optional)

Baths can be fitted with an IEEE-488 GPIB interface option. To use the IEEE-488 interface, connect an IEEE-488 standard cable to the back of the Bath, set the device address, and set the transmission termination character.

Use the option to set the interface address and the transmission-termination character within the IEEE-488 Parameter menu (IEEE). The GPIB type communication bus allows many instrument connections and simultaneous control of those instruments. Use a shielded GPIB cable to eliminate noise.

IEEE-488 Parameters

This menu appears in the Serial Interface Parameter menu only on Baths fitted with the interface. To enter the IEEE-488 parameter programming menu:

1. Push **UP** repeatedly until the IEEE-488 interface menu (IEEE) shows.
2. Push **SET** to enter menu.

IEEE-488 Address

You must configure the IEEE-488 interface to use the same address as the external communication device.

To change the address (AddrESS):

1. Push **SET** to access the address setting.

   Add= 22 *Current IEEE-488 interface address*

2. Push **UP** or **DOWN** to adjust the address.
3. Push **SET** to store the address.

Commands can now be sent with 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). See *Interface Commands*.

Transmission Termination

The transmission termination character can be set to carriage return only, linefeed only, or carriage return (Cr) and linefeed (LF). Regardless of the option selected, the Product interprets either a carriage return or a linefeed as a command termination (EOS) during reception.

To change the parameter:

1. Push **SET** to access the termination parameter.

   E=Cr *Current IEEE-488 termination*

2. Push **UP** or **DOWN** to change the selection.
3. Push **SET** to store the new selection.

Calibration Parameters

The Bath controller gives access to these Bath calibration constants:

- CTO
- B0
- BG
- H
- L
- HGbt

These values are factory-set. Only adjust these parameters if the controller memory fails. Restore these values to the factory settings. A list of these constants and their values are in the Report of Test with the manual.

⚠ Caution

Do not change the values of the Bath calibration constants from the factory-set values. The correct parameter settings are important to the safety and proper operation of the Bath.

Push **SET** five times to enter the Calibration Parameters menu (CAL).

CTO

The factory-set parameter, CTO, sets the calibration of the over-temperature cutout. Adjust CTO with an internal potentiometer. It is not adjustable by software.

BO and BG

The-set parameters, BO and BG, calibrate the accuracy of the Bath set-point. Do not alter these parameters. For improved accuracy, calibrate R_0 and ALPHA with the procedure in *Cooling Control*.

H and L

The factory-set parameters, H and L (H,L), set the upper and lower set-point limits of the Bath.

Note

Fluke Calibration recommends a high limit setting below the flash-point of the fluid in the Bath.

HGbt

⚠ Caution

To ensure best performance without damage to the Bath compressor, do not alter this parameter value.

The factory-set parameter, HGbt (HGbt), sets the temperature where the hot gas bypass activates.

Digital Communication Interface

The Bath can communicate with and be controlled by other equipment through the digital interface. An RS-232 serial interface which is standard and an IEEE-488 GPIB interface is optional. See *Serial Interface Parameters* and *IEEE-488 Setup (Optional)*.

With a digital interface, the Bath can connect to a computer or other equipment. Use the remote communication equipment to:

- set the Bath temperature
- monitor the temperature
- access all controller functions
- control cooling

The cooling power switch must be on (**I**) to control the cooling with the interface.

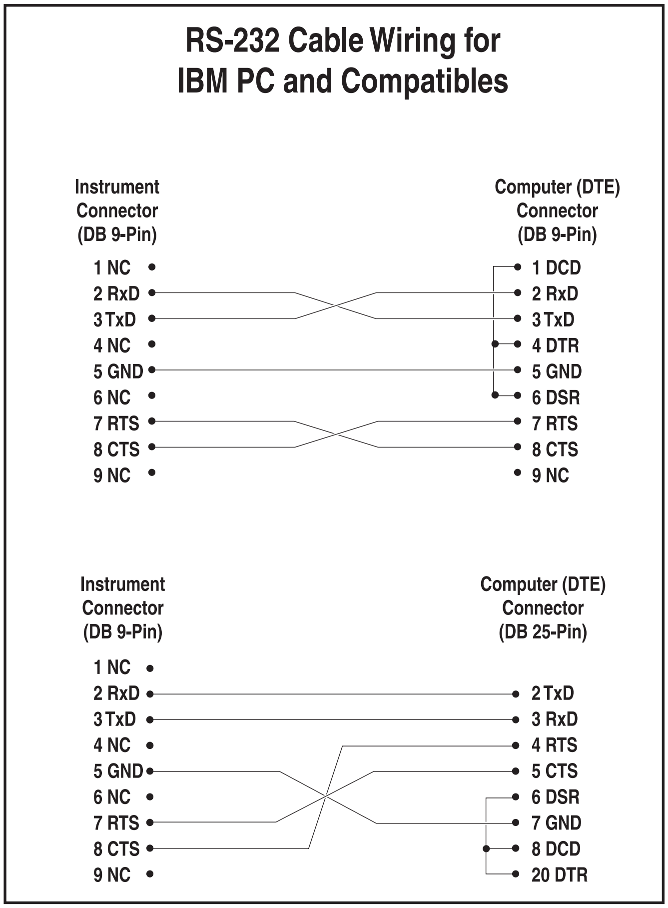
Serial Communications

The RS-232 serial interface allows serial digital communications over fairly-long distances (15.24 m). The serial interface can access any of the controller functions, parameters, and settings discussed in *Controller Operation*, with the exception of the BAUD Rate parameter. The serial interface operates with 8 data bits, 1 stop bit, and no parity.

Wiring

The serial communications cable attaches to the Bath through the DB-9 connector on the rear panel. Figure 6 shows the connector pin-out and suggested cable wiring. To eliminate noise, the serial cable should be shielded with low resistance between the connector (DB-9) and the shield.

Figure 6. Serial Communication Cable Wiring



Interface Commands

The various commands to access the Bath controller functions from the digital interfaces are in Table 5. Use the commands with the RS-232 serial interface and the IEEE-488 GPIB interface. Commands are terminated with a carriage-return character (Cr, ASCII 13). The interface makes no distinction between upper and lower case letters, use either. Abbreviate commands to the minimum number of letters that determine a unique command. Use a command to set a parameter or show 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 (set-point 1) to 50.00 degrees.

In the list of commands, characters or data within brackets, **[** and **]**, are optional for the command. A slash, **/**, denotes alternate characters or data. Numeric data, **n**, can be entered in decimal or exponential notation. Characters are shown in lower case although upper case can be used. Spaces can be added within command strings and are ignored. Use backspace (BS, ASCII 8) to erase the previous character. A terminating CR is implied with all commands.

Table 5. Interface Command Summary

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Display Temperature					
Read current set-point	s[etpoint]	s	set: 9999.99 {C or F}	set: 150.00 C	
Set current set-point to n	s[etpoint]=n t[emperature]=n	s=150 t=150			Instrument Range -40 °C to 150 °C
Read vernier	v[ernier]	v	v: 9.99999	v: 0.00000	
Set vernier to *n*	v[ernier]=n	v=.00018			Depends on Configuration
Read scan function	sc[an]	sc	scan: {ON or OFF}	scan: ON	
Set scan function:	**sc[an]=on/of[f]**				ON or OFF
Turn scan function on	sc[an]=on	sc=on			
Turn scan function off	sc[an]=of[f]	sc=of			
Read scan rate	sr[ate]	sr	srat: 9.999 {C or F}/min	srat: 0.010 C/min	
Set scan rate to *n* degrees per minute	sr[ate]=n	sr=5			0.001 to 5.000°C/min 0.002 to 9.000°F/min
Read temperature	t[emperature]	t	t: 9999.99 {C or F}	t: 55.69 C	
Read temperature units	u[nits]	u	u: x	u: C	
Set temperature units:	**u[nits]=c/f**				C or F
Set temperature units to Celsius	u[nits]=c	u=c			
Set temperature units to Fahrenheit	u[nits]=f	u=f			
Ramp and Soak Menu					
Read number of programmable set-points	pn	pn	pn: 9	pn: 2	
Set number of programmable set-points to *n*	pn=n	pn=4			2 to 8
Read programmable set-point number *n*	psn	ps3	psn: 9999.99 {C or F}	ps1: 50.00 C	
Set programmable set-point number n to n	psn=n	ps3=50			1 to 8, Instrument Range –40 °C to 150 °C
Read program set-point soak time	pt	pt	ti: 999	ti: 5	
Set program set-point soak time to *n* minutes	pt=n	pt=5			0 to 500
Read program control mode	pc	pc	prog: {OFF or ON}	prog: OFF	
Set program control mode:	**pc=g[o]/s[top]/c[ont]**				GO or STOP or CONT
Start program	pc=g[o]	pc=g			
Stop program	pc=s[top]	pc=s			
Continue program	pc=c[ont]	pc=c			
Read program function	pf	pf	pf: 9	pf: 3	
Set program function	pf=n	pf=2			1 to 4

Table 5. Interface Command Summary (cont.)

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Secondary Menu					
Read proportional band setting	pr[op-band]	pr	pb: 9.999	pb: 0.315	
Set proportional band to *n*	pr[op-band]=n	pr=0.326			Depends on Configuration
Read cutout setting	c[utout]	c	cu: 999 {x},{xxx}	cu: 120 C, in	
Set cutout setting:	**c[utout]=n/r[eset]**				
Set cutout to n degrees	c[utout]=n	c=120			Temperature Range
Reset cutout now	c[utout]=r[eset]	c=r			
Read heater power (duty cycle)	po[wer]	po	po: 9999	po: 1	
Configuration Menu					
Probe Menu					
Read R0 calibration parameter	r[0]	r	r0: 999.999	r0: 100.578	
Set R0 calibration parameter to *n*	r[0]=n	r=100.324			98.0 to 104.999
Read ALPHA calibration parameter	al[pha]	al	al: 9.9999999	al: 0.0038573	
Set ALPHA calibration parameter to *n*	al[pha]=n	al=0.0038433			.00370 to .0039999
Serial Interface Menu					
Read serial sample setting	sa[mple]	sa	sa: 9999	sa: 1	
Set serial sampling setting to *n* seconds	sa[mple]=n	sa=0			0 to 4000
Set serial duplex mode:	**du[plex]=f[ull]/h[alf]**				FULL or HALF
Set serial duplex mode to full	du[plex]=f[ull]	du=f			
Set serial duplex mode to half	du[plex]=h[alf]	du=h			
Set serial linefeed mode:	**lf[eed]=on/of[f]**				ON or OFF
Set serial linefeed mode to on	lf[eed]=on	lf=on			
Set serial linefeed mode to off	lf[eed]=of[f]	lf=of			

Table 5. Interface Command Summary (cont.)

Command Description	Command Format	Command Example	Returned	Returned Example	Acceptable Values
Calibration Menu					
Read C0 calibration parameter	*b0	*b0	b0: 9.9999	b0: 0.0002	
Set C0 calibration parameter to ***n***	*b0=n	*b0=0			Unlimited
Read CG calibration parameter	*bg	*bg	bg: 999.99	bg: 406.25	
Set CG calibration parameter to n	*bg=n	*bg=406.25			Unlimited
Read Cool Mode:	co[ol]	co	co:xxx	co:auto	
Set Cool mode	**co[ol]=of[f]/on/au[to]**				On, Off, Auto
Set Cool mode to Off	co[ol]=of[f]	cp=of			
Set Cool mode to On	co[ol]=on	cp=on			
Set Cool mode to Auto	co[ol]=au[uto]	cp=au			
Read HGb mode	hg[b]	hg	hgb:xxx	hdb:auto	
Set HGb mode:	**hg[b]=of[f]/on/au[to]**				On, Off, Auto
Set HGb mode to Off	hg[b]=of[f]	hg=of			
Set HGb mode to On	hg[b]=on	hg=on			
Set HGb mode to Auto	hg[b]=au[to]	hg=au			
Read HGB Setting	*p	*p	step:999	step=170	
Set HGB Setting	*p=n	*p=170			40 to 448
Read low set-point limit value	*tl[ow]	*tl	tl: 999	tl:-40	
Set low set-point limit to *n*	*tl[ow]=n	*tl=40			-60 to 20
Read high set-point limit value	*th[igh]	*th	th: 999	th: 150	
Set high set-point limit to *n*	*th[igh]=n	*th=150			-150 to 30
Miscellaneous (Not on Menus)					
Read all parameters	all	all	list of operating parameters		
Read firmware version number	*ver[sion]	*ver	ver.9999,9.99	ver.7381,1.00	
Read all extended parameters	*all	*all	list of extended parameters		
Read structure of all commands	h[elp]	h	list of commands		
Legend:	[] Optional Command data {} Returns either information n Numeric data supplied by user 9 Numeric data returned to user x Character data returned to user				
Note:	When DUPLEX is set to FULL and a command is sent to READ, the command is returned followed by a carriage return and linefeed. Then the value is returned as indicated in the RETURNED column.				

Calibration Procedure

Note

Consider this procedure a general guideline. Each laboratory should write their own procedure based on their equipment and their quality program. Each procedure should have an uncertainty analysis based on the laboratory equipment and environment.

In some instances, you may want to calibrate the Bath to improve the temperature set-point accuracy. To calibrate, adjust the controller probe calibration constants R_0 and ALPHA so that the temperature of the Bath (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. Use a good thermometer and carefully follow procedures to calibrate the Bath to an accuracy of better than 0.02 °C over a range of 100 degrees.

Calibration Points

When you calibrate the Bath, adjust R_0 and ALPHA to minimize the set-point error at each of two different bath temperatures. Use any two reasonably-separated bath temperatures for the calibration. However, best results are obtained when you use bath temperatures that are just within the most useful operating range of the Bath.

Note

The farther apart the calibration temperatures, the greater the calibrated temperature range, and the calibration error.

If, for example, 0 °C and 100 °C are chosen as the calibration temperatures, the Bath can achieve an accuracy of ±0.3 °C over the range –10 °C to 110 °C. Choosing 30 °C and 70 °C allows the Bath to possibly have a better accuracy of ±0.1 °C over the range 25 °C to 75 °C, but outside of that range, the accuracy may be only ±0.5°C.

Measure the Set-point Error

The first step in the calibration procedure is to measure the temperature errors (including sign) at the two chosen calibration temperatures.

1. Set the Bath to the lower set-point, t_L.
2. Wait for the Bath to reach the set-point and allow 15 minutes to stabilize at that temperature.
3. Check the Bath stability with the thermometer.
4. When both the Bath and the thermometer have stabilized, measure the Bath temperature with the thermometer and compute the temperature error (the actual Bath temperature minus the set-point temperature, err_L). For example, set the Bath to 0 °C. The bath reaches a measured temperature of –0.3 °C giving an error of –0.3 °C.
5. Set the Bath for the upper set-point, t_H, and after the Bath stabilizes, measure the Bath temperature and compute the error, err_H. For example set the Bath to 100 °C. If the thermometer measured 100.1 °C, this would mean an error of +0.1 °C.

Compute R_0 and ALPHA

Before you can compute the new R_0 and ALPHA values, you must know the current values. Access the Probe Calibration menu from the controller panel or inquire through the digital interface to find these values. Keep a record of these values in case they need to be restored in the future. To compute the new R_0' and ALPHA′ values, enter 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 these equations,

$$R_0' = \left[\frac{err_H \; t_L - err_L \; t_H}{t_H - t_L} \, ALPHA + 1 \right] R_0$$

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

For example, if 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 R_0' and ALPHA′ are computed as 100.193 and 0.0038272, respectively. Add the new values for 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 can be repeated again to further improve the accuracy.

Calibration Example

The Bath is to be used between 25 °C and 75 °C and it is desired to calibrate the Bath as accurately as possible for operation within this range. The current values for R_0 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 °C and 79.914 °C respectively. Refer to Figure 7 to apply equations to the example data and to compute the new probe constants.

Figure 7. Calibration Example

$R_0 = 100.000$

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 R0′,

$$R_0' = \left[\frac{(-0.086) \times 30.0 - (-0.157) \times 80.0}{80.0 - 30.0} 0.00385 + 1 \right] 100.000 = 100.077$$

Compute ALPHA′,

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

Maintenance

The Product uses a battery maintain operation parameters. Regularly make sure that all operation and calibration parameters are accurate to ensure proper operation of the Bath. See *Troubleshooting*.

⚠⚠Warning

To prevent possible electrical shock, fire, or personal injury, disconnect the mains power cord before Product service.

- **If the mains supply cord becomes damaged, replace it with a cord of the appropriate gauge wire for the current of the Bath. If there are any questions, contact a Fluke Calibration service center, see *Contact Fluke Calibration*.**
- **Do not use the Product for anything other than its intended purpose. Bath operation can be impaired or safety hazards can arise.**

⚠Caution

To avoid Product damage:

- **Do not operate the Product in dirty or dusty environments.**
- **Wipe the Bath clean with a damp cloth and mild detergent. Do not use harsh chemicals on the surface which can damage the paint. Before you use another cleaning or decontamination method, except those recommended, check with a Fluke Calibration service center to make sure that the proposed method does not damage the equipment, see *Contact Fluke Calibration*.**
- **Keep the Bath fluid level full. A drop in the fluid level affects Bath stability. Changes in fluid level are dependent upon several factors specific to the conditions in which the equipment is used. A schedule cannot be outlined to meet each set of conditions. Therefore, check the Bath weekly and make adjustments as required.**

- **Check the fluid 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 are compromised, fluid break down can occur rapidly. Pay particular attention 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. Heat transfer medium lifetime depends upon the type of medium and the conditions used. Once you gather this data, outline a specific maintenance schedule for the Product. See *General Operation* for more information about the different types of fluids used in calibration baths.**
- **Keep MSDS sheets applicable to all fluids used in the baths near the Product. For bath fluid spills inside or on the Product, take the appropriate decontamination steps as outlined by the national safety council.**
- **Check the over-temperature cutout every 6 months to see that it works properly. To check and set the user-selected cutout, follow the directions in *Reset Cutout*. Set the Bath temperature higher than the cutout. Check to see if the display flashes** Cut-out **and that the temperature is decreases.**

⚠ Warning

To prevent possible personal injury, or Product damage:

- **When you check the over-temperature cutout, do not exceed bath fluid temperature limits. Exceeding the temperature limits of the bath fluid could cause harm to the operator, lab, and instrument.**
- **With silicone oil, the Bath requires periodic maintenance. Silicon oil condenses on the Bath in normal operation due to the outgasing of the oil. How often and how long the Bath operates at higher temperatures determines how often to do maintenance. Wipe down the oily areas of the Bath with a mild degreaser. Do not spray the degreaser directly on the Bath. Spray the degreaser on a cloth and wipe the Bath down with the cloth. Repeat the process as necessary to keep the oil from collecting on the Bath. If oil collects on the Bath, it may run into the Bath and collect on the interior causing internal damage that might affect the lifetime of the Product.**

⚠ Warning

To prevent personal injury or damage to the Product or lab, do not exceed bath fluid temperature limits when you check the over-temperature cutout.

Troubleshooting

Table 6 contains information to troubleshoot the Product. This information pertains to a number of bath models and certain specifics may not pertain to your model.

If the Product 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, read this section carefully and attempt to understand and solve the problem. If the probe seems faulty or the problem cannot otherwise be solved, contact Fluke Calibration for assistance. Make sure to have the model number and serial number of your Product available.

Table 6. Troubleshooting

Problem	Causes and Solutions
The heater indicator LED stays red but the temperature does not increase.	The display does not show Cut-out or show an incorrect bath temperature, but the controller otherwise appears to operate normally. The problem can be either insufficient heating, no heating at all, or too much cooling. • One or more burned out heaters or blown heater fuses can also cause this problem. If the heaters seem to be burned out, contact Fluke Calibration for assistance.
The display flashes Cut-out and the heater does not operate	The display flashes Cut-out alternately with the process temperature. • If the process shown temperature seems grossly in error, consult the problem: *The display flashes Cut-out and an incorrect process temperature*. • Normally, the cutout disconnects power to the heater when the bath temperature exceeds the cutout set-point causing the temperature to drop back down to a safe value. The heater only comes on again when the temperature is reduced and the cutout is manually reset by the operator, see *Cutout Set-point*. Check that the cutout set-point is adjusted to 10 °C or 20 °C above the maximum bath operating temperature. • If the cutout activates when the bath temperature is well below the cutout set-point or the cutout does not reset when the bath temperature drops and it is manually reset, then the cutout circuitry or the cutout thermocouple sensor may be faulty or disconnected. Contact Fluke Calibration.

Table 6. Troubleshooting (cont.)

Problem	Causes and Solutions
The display flashes Cut-out and an incorrect process temperature	The problem may be that the Product voltmeter circuit is not functioning properly. • A problem could exist with the memory back-up battery. If the battery voltage is insufficient to maintain the memory, data can become scrambled and cause problems. A nearby large static discharge may also affect data in memory. Make sure that the parameters on the Report of Test are accurate. Cycle the power off, disconnect the bath from ac, and then restart the Bath. • If the problem reoccurs, replace the battery. Contact Fluke Calibration for assistance. • If initializing the memory does not remedy the problem, there may be a failed electronic component. Contact Fluke Calibration. • The controller may need to be reset. Perform the following Factory Reset Sequence: Hold **SET** and **EXIT** buttons simultaneously while you power up the Product. The display shows -init-, the model number and firmware version. You must reprogram each of the controller parameters and calibration constants. The values can be found on the Report of Test that ships with the Product.

Table 6. Troubleshooting (cont.)

Problem	Causes and Solutions
The displayed process temperature is in error and the controller remains in the cooling or the heating state at any set-point value	Possible causes may be either a faulty control probe or erroneous data in memory. • The probe might be disconnected, burned out, or shorted. The Probe is insided the stirrer motor cover. • Make sure that the probe is connected properly. Check the probe 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 Ω to 2.0 Ω between pins 1 and 2 on the probe connector and 0.2 Ω to 2.0 Ω between pins 3 and 4. The resistance should read from 100 Ω to 300 Ω between pins 1 and 4 depending on the temperature. If the probe is defective, contact Fluke Calibration. • If the problem is not the probe, erroneous data in memory can be the cause. Re-initialize the memory as discussed in the problem *The display flashes* Cut-out *and an incorrect process temperature*. If the problem remains, the cause may be a defective electronic component, contact Fluke Calibration.

Table 6. Troubleshooting (cont.)

Problem	Causes and Solutions
The controller controls or attempts to control at an inaccurate temperature	The controller operates normally except when controlling at a specified set-point. At this set-point, the temperature shown does not agree with the temperature measured by a reference thermometer to within the specified accuracy. This problem can be caused by an actual difference in temperature between the points where the control probe and thermometer probe measure temperature, by erroneous bath calibration parameters, or by a damaged control probe. • Make sure the vernier setting for the set-point. • Make sure that the Bath has an adequate amount of fluid in the tank and that the stirrer operates properly. • Make sure the resistance between the pins and the sheath of the probe. They should be open. • Make sure that the thermometer probe and control probe are both fully inserted into the bath to minimize temperature gradient errors. • Make sure that the calibration parameters are all correct according to the Report of Test. If not, re-program the constants. The memory backup battery may be weak and causing errors in data as described in the problem: *The display flashes* Cut-out *and an incorrect process temperature*. • Make sure that the control probe has not been struck, bent, or damaged. If the cause of the problem remains unknown, contact Fluke Calibration.

Table 6. Troubleshooting (cont.)

Problem	Causes and Solutions
The controller does not maintain controller parameters or parameters are reset each time the power to the unit is removed	*Note* *Before you perform the memory check, you must record the controller calibration parameters (found in the CAL menu) and any user-adjusted parameters that you have changed (such as the programmable set-points and proportional band).* **Memory Check** The easiest way to verify the ability of the battery to maintain controller parameters, is to do a memory check. 1. Power off the Product. 2. Disconnect the instrument from ac power for 10 seconds. 3. Reconnect the ac power and power on the Product. 4. If the display shows InIt and/or the cycle count shows a low number, such as 0002, the battery is spent and needs replacement. Contact Fluke Calibration. 5. After the battery is replaced, you must reprogram the calibration and user-adjustable parameters into the controller.
The controller shows that the output power is steady but the process temperature is unstable	Possible causes are an improper proportional band setting or the fluid under use. • If the bath temperature does not achieve the expected degree of stability when measured with a thermometer, try to adjust the proportional band to a narrower width as discussed in *Proportional Band*. • Make sure the fluid has not deteriorated or is not too thick.
The controller alternately heats for a while then cools	The Bath is unstable and the duty cycle is not constant. The proportional band being too narrow typically causes this oscillation. Increase the width of the proportional band until the temperature stabilizes as discussed in *Proportional Band*.

Table 6. Troubleshooting (cont.)

Problem	Causes and Solutions
The controller erratically heats then cools, control is unstable	If both the Bath temperature and output power do not vary periodically but in a very erratic manner, the problem can be excess noise in the system. Noise due to the control sensor should be <0.001 °C. However, if the probe is damaged or has developed an intermittent short, erratic behavior can exist. The probe is located inside the stirrer motor cover. • Make sure for a damaged probe or poor connection between the probe and Bath. • Make sure the resistance between the probe pins and the sheath is open. • Intermittent shorts in the heater or controller electronic circuitry can also be a possible cause. Contact Fluke Calibration.
The Bath does not achieve low temperatures	Too much heating or not enough cooling can cause this problem. Check that the control indicator glows green which shows that the controller is attempting to cool. The heaters can be disabled as a test by temporarily removing the heater fuses. Insufficient cooling can be caused by lack of refrigerant in the system. Contact Fluke Calibration.