Operators Manual

Circulators with
Programmable or Digital Controller

110-003, Rev 6/99

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Section 1. General Information

1.1 Warranty

Thank you for your purchase. We are confident it will serve you for a long time. Our warranty to you is as follows:

The manufacturer agrees to correct for the original user of this product, either by repair, or at the manufacturer's election, by replacement, any defect which develops after delivery of this product within the period as stated on the warranty card. In the event of replacement, the replacement unit will be warranted for 90 days or warranted for the remainder of the original unit's parts or labor warranty period, whichever is longer.

If this product should require service, contact the manufacturer/suppliers' office for instructions. When return of the product is necessary, a return authorization number will be assigned and the product should be shipped, transportation charges pre-paid, to the indicated service center. To insure prompt handling, the return authorization number should be placed on the outside of the package and a detailed explanation of the defect enclosed with the item.

This warranty shall not apply if the defect or malfunction was caused by accident, neglect, unreasonable use, improper service, or other causes not arising out of defects in material or workmanship. There are no warranties, expressed or implied, including, but not limited to, those of merchantability or fitness for a particular purpose which extends beyond the description and period set forth herein.

The manufacturer's sole obligation under this warranty is limited to the repair or replacement of a defective product and the manufacturer shall not, in any event, be liable for any incidental or consequential damages of any kind resulting from use or possession of this product.

Some states do not allow: (A) limitations on how long an implied warranty lasts or (B) the exclusion or limitation of incidental or consequential damages, so the above limitations or exclusions may not apply to you. This warranty gives you specific legal rights. You may also have other rights which vary from state to state.

1.2 Unpacking

Your circulator is shipped in a special carton. Retain the carton and all packing materials until the unit is completely assembled and working properly. Set up and run the unit immediately to confirm proper operation. Beyond one week, your unit may be warranty repaired, but not replaced. If the unit is damaged or does not operate properly, contact the transportation company, file a damage claim and contact the company where your unit was purchased.

1.3 Package Contents

— Circulator bath
— Operators Manual
— Warranty card
—Tubing, 1/2 inch I.D., insulated Buna N (-40°C to 120°C)
— A package of nylon fittings containing:

	Part #	Qty.
- 3/16 inch barbed tube fittings	300-049	2
- 1/4 inch barbed tube fittings	800-048	2
- 3/8 inch barbed tube fittings	300-047	2

— Programmable units include a 3.5 inch software disk and an RS232 communication cable.

1.4 Description of Circulating Baths

DIGITAL and PROGRAMMABLE refrigerated and heating circulating baths are designed to provide precise temperature control of fluids for circulation to external equipment or to be used as a stand alone bath. The reservoir may be used for immersing samples while the unit is connected to an external device. All wetted parts are corrosion resistant 300 series stainless steel. Models are equipped with various size reservoirs and refrigeration capacities.

1.5 Specification Chart

Controller Model	Digital	Programmable
Temperature Range (Non-Refrigerated)	Ambient +5° to 200°C	Ambient +5° to 200°C
Temperature Range (Refrigerated)	-45° to 200°C[1]	-45° to 200°C[1]
Temperature Stability[2]	±.01°C[2]	±.01°C[2]
Readout	LCD	LCD
Readout Accuracy	±.25° C	±.25° C
Pump	Simplex[3]	Duplex
Pump Flow Rate (Pressure) @ 120V, 60Hz	9 or 15 liters/min.	11 to 24 liters/min.
Pump Flow Rate (Suction)	– – –	8 to 18 liters/min.
Overtemp/Safety Cutoff	Yes (Adjustable)	Yes (Adjustable)
RS232 Interface	No	Yes
Remote Probe	No	Optional

1. Varies by model.
2. Can be effected by viscosity, specific heat of the fluid, external heat loss, and ambient temperature.
3. Digital models with high capacity refrigeration (13L and 28L reservoirs) are equipped with duplex pumps.

Section 2. Set Up

2.1 Location

Locate your circulator on a level surface free from drafts and direct sunlight. Do not place it near corrosive fumes, excessive moisture, high room temperatures, or excessively dusty areas. Refrigerated circulators must be four inches minimum away from walls or vertical surfaces so air flow is not restricted. Avoid voltage drops by using properly grounded power outlets wired with 14 gauge or larger diameter wire and close to the power distribution panel. To avoid low line voltage problems, do not use an extension cord.

2.2 Filling the Reservoir

Maximum fill level is one inch below the top of the reservoir. When in operation, add additional fluid to compensate for any additional volume needed for external circulation.

Minimum liquid depth is enough to fully cover the heater, pump, and one inch of the temperature sensor. If the proper fluid level is not maintained the heater coil may become exposed and possible damage to the heater may result.

An adjustable low liquid level/over temperature safety cutoff is an integral part of all units. See sections 3.4 Setting the Safety Thermostat (programmable models), or 5.4 Setting the Safety Thermostat (digital models).

Warning: These units are equipped with Over Temperature Protection (OTP). Failure due to low liquid level or failure to set OTP and properly immerse the heater may result in heater burnout and triac failure. While operating, do not allow the heater to contact any potentially flammable materials, such as plastic racks, as a fire hazard may result.

2.3 Reservoir Fluids

Use distilled water for temperatures from 10°C to 90°C or a mixture of laboratory grade ethylene glycol and water for temperatures -20°C to 100°C. A variety of fluids can be used depending upon your needs. The fluid must be chemically compatible with the reservoir and with 300 series stainless steel in the pump and heater. The fluid must also be able to produce the temperature range desired.

For temperature stability of ±.01°C, the viscosity should be 50 centistokes or less at the lowest operating temperature to allow good fluid circulation and to minimize heating from the pump. Most single type of fluids will be able to stabilize to ±.01°C over a 100°C range. Use fluids that will satisfy safety, health, and equipment compatibility requirements.

The chart below will help in selecting a fluid for your application. Stay within the fluid's normal range for best temperature stability, low vaporization, and safety.

You are responsible for proper selection and use of the fluids.
Extreme range operation should be avoided.

FLUID DESCRIPTION	SPECIFIC HEAT @25°C	NORMAL RANGE	EXTREME RANGE
Water	1.00	10°C — 90°C	2°C — 100°C
Ethylene Glycol 30%Water 70%	.90	0°C — 95°C	-15°C — 107°C
Ethylene Glycol 50%/Water 50%	.82	-20°C — 100°C	-30°C — 100°C
Ethylene Glycol 100%	.62	50°C — 125°C	0°C — 125°C*
Methanol 60% / Water 40%	.52	-45°C — 0°C	——
Dynalene™-HC 50	.76	-50°C — 60C°	-62°C — 60°C
DC200 5 cs Silicone Oil	.32	-35°C — 65°C	-50°C — 125°C*
DC200 10 cs Silicone Oil	.34	-20°C — 80°C	-35°C — 165°C*
DC200 20 cs Silicone Oil	.36	0°C — 100°C	-10°C — 230°C*
DC200 50 cs Silicone Oil	.39	50°C — 150°C	5°C — 270°C*
DC510 50 cs Silicone Oil	.39	50°C — 1500C	5°C — 270°C*
DC550 125 cs Silicone Oil	.42	100°C — 200°C	80°C — 232°C*
DC710 500 cs Silicone Oil	.45	150°C — 250°C	125°C — 260°C*

*WARNING - Fluid's flashpoint temperature.
DC fluids are manufactured by Dow Corning.

DO NOT use the following fluids:

1. Automotive antifreeze with additives**
2. Hard tap water**
3. Deionized water with a specific resistance > 1 meg ohm
4. Any flammable fluids
5. Concentrations of acid or bases
6. Solutions with halides: chlorides, fluorides, bromides, iodides or sulfur
7. Bleach (Sodium Hypochlorite)
8. Solutions with chromates or chromium salts

** At temperatures above 40°C, additives or mineral deposits can adhere to the heater. If allowed to build up, the heater may overheat and fail. Higher temperatures and higher concentrations of additives will cause a faster deposit build up.

WARNING: Do not use a flammable liquid as a fire hazard may result.

APPLICATION NOTES

At fluid's low temperature extreme:

1. Presence of ice or slush adversely affects temperature stability.
2. Viscosity above 10 centistokes adversely affects temperature uniformity.
3. High fluid viscosity and high speed pumping generates heat in the fluid.

At fluid's temperature above ambient without using refrigeration:

1. Without refrigeration and within 15°C of room temperature, the viscosity should be 10 centistokes or less to avoid friction heating of the fluid. Heat loss is encouraged by uncovering the fluid and lowering pump speed.

At fluid's high temperature extreme:

1. Heat loss from vapor causes poor temperature stability.
2. A fume hood may be required to prevent the buildup of vapors inside the room.
3. Use a cover and/or floating hollow balls to help prevent heat and vapor loss.
4. Fluid lost from vapor has to be frequently replenished.

2.4 Fluid Connections

The pump inlet and outlet are threaded with female 1/4 inch NPT to allow use of barbed tubing adapters or hard plumbing. Or, you can slide 1/2 inch (13mm) ID tubing over each pipe and hold it in place with a hose clamp.

Select tubing and fittings compatible with bath fluid and temperature range. If the pump inlet and outlet are not used for external circulation, connect the inlet and outlet pipes with a short length of insulated tubing. Or, plug the pipes with male nylon plugs (supplied) or with metal plugs (not supplied) for high temperature use.

The nylon barbed tubing adapter fittings supplied are for applications from -40°C to 93°C. Brass, stainless steel or Teflon® fittings are recommended for applications above 93°C.

Quick connectors are not recommended as they typically restrict flow rate.

2.5 Pumps

A SIMPLEX (pressure) or DUPLEX (pressure & suction) pump is in each unit (see unit comparison chart 1.5).

Simplex (pressure)

The 2-speed SIMPLEX pump is found in 6L digital controller model circulators and 13L & 28L heating circulators. It may be used for direct immersion of samples, or external circulation in closed loops. Simplex HI or LO speed selection switch is on the rear panel.

Duplex (pressure/suction)

The 5-speed DUPLEX pump is found in all programmable controller circulators and selected high cooling capacity digital controller circulators. It may be used for direct immersion of samples, closed loop circulation, or circulating to an open bath. Speed selection is in the PID TUNING menu.

Note: When reducing the speed of a duplex pump, there may be a faint sound that is synchronous with the flashing of the POWER indicating LED. These sounds are the pulses coming from the motor speed controller and are normal.

PUMP SELECTION	SPEED	MAXIMUM OUTLET RATINGS PUMP TYPE 120V, 60Hz
SIMPLEX	HI	15 LPM / 2.6 PSI
	LO	9 LPM / 1.5 PSI
DUPLEX	1 = FULL	24 LPM / 5 PSI
	2 = HIGH	17.5 LPM / 2 PSI
	3 = MEDIUM	13.5 LPM / 1 PSI
	4 = LOW	12.5 LPM / 0.8 PSI
	5 = SLOW	11 LPM / 0.5 PSI

The table above uses the following criteria:

1. Maximum pump outlet flow rate is measured with no restriction on the pump outlet.
2. Maximum pump outlet pressure is measured in pounds per square inch (PSI) at no flow.
3. The figures above were measured with water as the circulation fluid. Water has a viscosity of one centistoke. High viscosity, low density fluid will reduce these figures.
4. Duplex pump suction inlet vacuum ratings are 75 percent of the outlet ratings shown.
5. When inlet and outlet are plugged, flow rate refers to internal bath circulation.
6. For 50Hz operation, derate 60Hz values by 17%.

2.6 Open Bath Circulation

The DUPLEX pump permits circulation to and from an open bath. Position both baths so that the two fluid levels are at the same elevation. If not, siphoning occurs when the unit is turned off. To prevent this, drain both hoses (pressure and suction). Use the same diameter and length of tubing and type of fittings on both the inlet and outlet connections to obtain a balanced flow. When using flexible tubing, the suction tubing must have a wall thickness that will not collapse when under vacuum, especially when going around bends. Cut the external bath end of the suction tube into a “V” shape so the end of the tube will not seal itself against the external bath tank wall and overflow the bath. The DUPLEX pump is very powerful. Firmly fasten the tubes to the external tank wall so they will not move when in use.

Prevent baths from over filling each other by introducing a small amount of air into the pump. There are two methods, internal and external bath height regulation:

Internal bath height regulation - Fill the external bath to the desired level. Set the tubes into the external bath fluid without touching the bottom of the tank. The internal bath fluid height is controlled at two inches below the level of the reservoir cover.

External bath height regulation - Fasten the inlet and outlet tubes at the desired maximum fluid level in the external bath. The flow must be regulated by use of an adjustable clamp or valve on the outlet side of the pump so that there is greater suction than pressure. Fill the internal bath to one inch below the top of the reservoir and adjust the pump outlet flow restriction so that the levels in each bath remain the same.

2.7 Closed Loop Circulation

Both DUPLEX and SIMPLEX pumps can be used in closed loop circulation. Connect the pump inlet and outlet to your application. Use care to avoid restrictions in the tubing in order to maintain adequate flow. When connecting to more than five closed loops we recommend use of a manifold made of “Y” adapters to divide the fluid into two or more banks. A booster pump may be added without damage to the circulation bath pump. After setting up multiple closed loops, check that there is adequate flow at the return manifold for each loop and recheck bath fluid level.

The control stability of a closed loop system will generally be better at the external apparatus than in the immediate vicinity of the heater, provided the apparatus control point represents a constant load and is well insulated. For example, if you circulate at 50°C through a viscometer, the temperature variation observed in the reservoir may be +0.05°C, whereas in the viscometer it may be only +0.02°C. Although temperature stability may be better at the external apparatus, the temperature accuracy at the external location may be affected by flow rate, tubing length, and insulation.

2.8 Power Supply

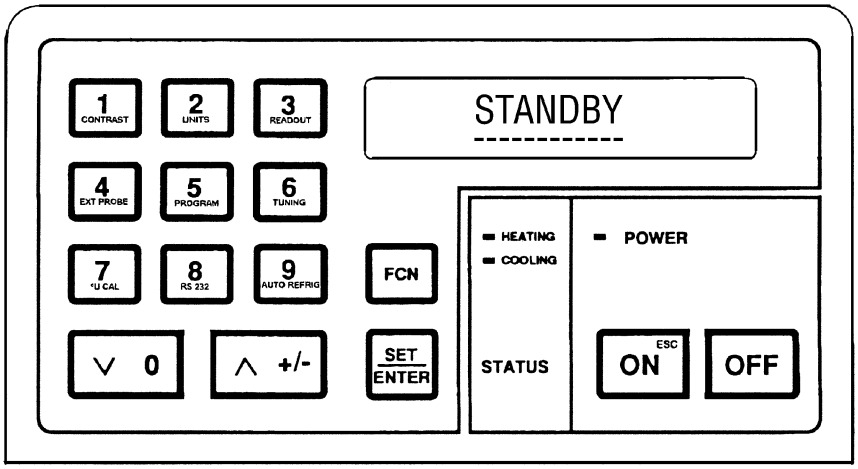
Plug the unit into a properly wired, grounded outlet with the same voltage and frequency indicated on the identification label on the back of the unit. With the power switch OFF, the display should respond by showing "STANDBY". Be sure the circuit breaker at the rear of the controller is in the ON position. Using an extension cord is not recommended, but if necessary, use one that is properly grounded and handles the total wattage of the unit. The extension cord must not cause more than a 10% voltage drop to the circulator.

Firmware Versions: Each unit contains internal programming called firmware. These programs are occasionally updated and are identified by single letters A through Z. When turning on unit, observe the display. There is a lower case letter "v" followed by a capital letter indicating firmware version.

Warning! When refrigeration is switched off, it should not be restarted for approximately 10 minutes to allow the internal pressures to equalize. System damage could result if this waiting period is not observed.

Section 3. Programmable Controller

Check for adequate fluid level in the bath and that all connections are secure.



PARAMETERS-AT-A-GLANCE

FCN 1	Contrast
FCN 2	Limits
FCN 3	Readout
FCN 4	Ext Probe
FCN 5	Program
FCN 6	Tuning
FCN 7	°U Cal
FCN 8	RS 232
FCN 9	Auto Refrig

When first plugged in, before power is turned on, the display reads . . . . . STANDBY

Press power ON

Unit performs self test and read the firmware's revision level . . . . . COPYRIGHT 1995
SELF TEST VJ BB08

"Fluid" = current bath temperature

"Set" = your temperature setting . . . . . FLUID = 20.0
SET = 30.0

Notes:

1. After 10 seconds of keypad inactivity, the display reverts back to temperature reading.
2. If an error is made in setting values, pressing [ON] (escape) allows you to backspace in order to correct the previously entered values. Repetitive backspacing returns unit to normal operating display.
3. All entered values are stored in permanent non-volatile memory.
4. To revert back to factory default settings, see section 7.7 Default Settings.
5. For negative numbers, press [∧ +/-] for the minus sign.

3.1 To Set Temperature

Press [SET ENTER]

Enter the desired operating temperature. Each value is entered from right to left.

Example: For a desired temperature of 45.0°C. . . . . .

Press [SET ENTER] then [4] then [5] then [∨ 0]

then [SET ENTER] to accept values.

(Values are also accepted after 10 seconds of keypad inactivity.)

FLUID	=	XX.XX°C
SET	=	000.4°C

FLUID	=	XX.XX°C
SET	=	004.5°C

FLUID	=	XX.XX°C
SET	=	045.0°C

3.2 To Change Pump Speed

(also in section 3.3, system setup, FCN 6 - PID Tuning)

— The Duplex Pump

1. Press [FCN] [6], The pump speed menu appears. . . . . .
2. Select the pump speed number, then press [SET ENTER]

See section 2.5 Pump for pump specifications.

SELECT PUMP SPEED
HIT 1 THROUGH 5

The five selectable speeds

FULL = [1]
HIGH = [2]
MEDIUM = [3]
LOW = [4]
SLOW = [5]

3.3 System Set Up

Each numerical keypad button permits access to all control parameters.

Press [FCN] and then select the desired operating parameter key.

[FCN] [1] — Adjust Display Contrast . . . . . .

Adjust the display's contrast to compensate for ambient light and viewing angle.

Use [∨] [∧] to adjust.

CONTRAST ADJUST
PRESS UP OR DN

[FCN] [2] — Set Limits . . . . . .

Select temperature high & low limits. If fluid temperature exceeds these limits, the unit will shut off and the alarm will activate.

Maximum high limit value that can be entered is 203°C,
Maximum low limit is -53°C (minus sign must be entered first).

HI LIMIT	=	203.00°C
LO LIMIT	=	-53.00°C

FCN **3** **— Change Readout - °C, °F, °U** . . . . . .

1 = °C 2 = °F 3 = °U
4 = 1° 5 = .01° 6 = .001°

Select desired temperature scale pressing:

°C = **1** °F = **2** °U = **3** Display momentarily reads "CONVERTING"

To set °U, user scale, refer to subsection FCN 7 -°U Cal.

FCN **3** **— Change Resolution - .1°, .01° .001°** . . . . . .

1 = °C 2 = °F 3 = °U
4 = 1° 5 = .01° 6 = .001°

Change desired resolution value pressing:

.1°= **4** .01°= **5** .001°= **6**

While readout can display three decimal places, actual resolution is only .005°C.

FCN **4** **— External Probe** . . . . . .

1 = INTERNAL SENSOR
2 = EXT 3 = CAL EXT

Used to select temperature control via internal sensor or external remote probe (optional).
By selecting 2 = EXT, the external sensor mode, the display reads . . . . . .

MAX SETPOINT
DIFFERENTIAL = 10°C

The Maximum Setpoint Differential (MSD) function provides additional protection against excessive heating of the internal reservoir.

Setting Maximum Setpoint Differential (MSD) For External Probe

Values from 1 to 30 will be accepted. Outside this range will result in default to previously entered value. Default is set to 10°C.

External Probe MSD should be set to twice the maximum difference in °C found between the internal and external probes when at the operating temperature. This must be determined by actual use.

Example A: The operating temperature of your circulator is 95°C, the exterior bath is measured to 85°C. The difference is 10°C, multiplied by 2, your (MSD) is 20. Internal temp is 95°C, add the MSD, 20°C, equals 115°C. The controller will limit the bath temperature to 115°C, as measured by the internal sensor.

Larger MSD numbers slow down the controllers settling time to reduce oscillations in temperature. As a safety, if the external probe temperature drifts more than MSD degrees from the internal probe, the internal probe takes over control.

MSD should be set greater than 5°C if:

1. External heat requirement is greater than 100 Watts.
2. External bath fluid is viscous or stirring is very slow.
3. Heat exchanger in the application is inefficient.
4. External probe is not inserted directly into the fluid.
5. External fluid lines are greater than 10 feet long.

MSD could be higher than 5°C if any of the above is true. Maximum limit is 30°C.

MAXIMUM SETPOINT
DIFFERENTIAL (MSD)

Internal bath temp
— External bath temp
= Temp difference

Temp difference x 2 = MSD

MSD
+ Internal bath temp
Heat limit to internal bath

Example A:
95°C Internal bath temp
— 85°C External bath temp
= 10°C Temp difference

10°C x 2 = 20°C MSD

20°C MSD
+ 95°C Internal bath temp
= 115°C limit to internal bath

Optimizing of Maximum Setpoint Differential

CONTROL SYMPTOM	EXTERNAL PROBE MSD
Response time too slow	Lower the MSD number
Temp won't stay at set temp	Raise the MSD number
Temp won't reach setpoint	Usually raise the MSD number (Occasionally, it may be necessary to lower MSD)

When Using an External Probe in Jacketed or Air Filled Vessel

To attain temperature uniformity, stir the external fluid with pumps or mix air with fans. Also improve the efficiency of the heat exchanger. Enter the entire fluid volume (see steps under FCN 6, Tuning) of your complete set up and the flow rate of the slowest circulation point in your system.

Expect only ± 1.0°C stability with air or any medium that does not conduct heat well. Insulate and cover entire set up to remove temperature gradients. The controller cannot compensate for external chamber or component temperature gradients.

External Probe Hookup

The optional stainless steel external probe is 5/16 inch diameter, seven inches long, and is available in cable lengths of 10, 25 or 50 feet with connector. If you have a special application requiring a different probe shape, you can use an industry standard probe from any RTD sensor manufacturer and wire it to the controller.

RTD specifications

–Platinum RTD, four wire hookup
–100 ohms at 0°C
–DIN standard 00385 temperature coefficient

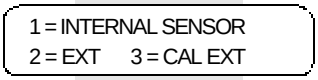
Hookup Specifications

Use a DB9 Male 9-pin connector with a housing to connecting cable to controller. Connect four wires to pins 6, 7, 8, 9. Shielded wire should be used. Connect the shield to ground on pin 1.

Automatic External Probe Calibration

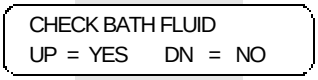
To automatically match the external probe's calibration to the internal probe, fill the units' reservoir with cold fluid, place the external probe into the reservoir near the internal probe,

press  and select 3 = CAL EXT for calibration . . . . . .



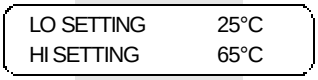
If there is proper fluid in the bath and the external probe is placed properly,

select  (YES) to CHECK BATH FLUID menu . . . . . .



If you select NO, the screen asks for Max Setpoint Differential. Refer to FCN 4, under steps for "Setting Maximum Setpoint Differential For External Probe."

Enter two calibration temperatures close to the range where you will be working. The unit automatically matches the probes at two temperatures that you select . . . . . .



While no two RTDs have exactly the same curves the two RTD probes are now closely matched at those two points without factory calibration.

FCN 6 — PID Tuning (Pump Speed and Controller Optimization)

— Pump Speed Selection

(also in section 3.2 To Change Pump Speed)

1. Press FCN 6 The pump speed menu appears.
2. Select the pump speed, then press SET ENTER
3. If further tuning is necessary, continue reading PID Tuning in this section. If no further tuning is necessary, you can continue to FCN 7 -°U Cal.

SELECT PUMP SPEED
HIT 1 THROUGH 5

The five selectable speeds

FULL = 1
HIGH = 2
MEDIUM = 3
LOW = 4
SLOW = 5

— Controller Optimization (PID - Proportional Integral Derivative)

If the factory settings for temperature stability is satisfactory, there is no need to change the controller tuning. If needed, there are provisions to optimize the controller for special applications.

Control performance greater than 5°C from the setpoint temperature is not affected by tuning. To achieve close control, tuning may be necessary if you use: a closed loop system of large volume; a fluid other than water; or a viscous fluid.

The tuning parameters below are simplified and are figures that can be easily measured and entered. The settings are not critical, estimates are acceptable. Each of the three tuning values are independent and can be changed without changing any of the other values.

Press FCN 6

If pump speed does not require adjustment, press SET ENTER for FLUID VOLUME,

press SET ENTER a second time for FLOW RATE, press SET ENTER a third time for SPECIFIC HEAT

— Fluid Volume

FCN 6 then SET ENTER once.

FLUID VOLUME
10 LITER(S)

Enter the total internal and external fluid volume in liters. Default setting is 10 liters.

— Flow Rate

FCN 6 then SET ENTER twice.

FLOW RATE
10 LITER(S) / MIN

Enter an estimate of the fluid's flow rate. (Not pump speed) See chart in section 2.5 for flow rates. If using a viscous fluid, enter half the rated flow rate.

Note: This setting does not change the speed of the pump motor.

If you are using the external inlet outlet connections, you can measure or estimate the flow through the external pipes and enter this in liters per minute. Default setting is 10 liters per minute.

— Specific Heat

FCN 6 then SET ENTER three times.

SPECIFIC HEAT
1.00 (.25 TO 1,00)

Enter the specific heat capacity of the bath fluid used. See section 2.3. for fluid specific heats. Density of a fluid usually does not vary as much as the specific heat. In cases where the density in grams per cubic centimeter is significantly more or less than one, multiply the density by the specific heat to obtain a closer figure.

If Control Is Too Slow Or Unstable

Unusually low pump flow rates with viscous fluids, small fluid volumes, or low specific heat, can cause temperature control instability. The tuning parameters adjust the PID tuning constants to permit control to ±0.01°C even under unusual conditions. Settings are not critical, estimates are acceptable.

Applications using large, poorly insulated external chambers may experience poor temperature stability due to excessive temperature gradients.

If external circulation is not required, the circulation and temperature uniformity in the internal bath may be improved by attaching tubing from the inlet connection to the outlet connection of the circulator.

Application Notes In Tuning

CONTROL SYMPTOM	PUMP SPEED SETTING	FLUID VOLUME SETTING	FLOW RATE SETTING	SPECIFIC HEAT SETTING	EXTERNAL PROBE MSD*
Too Slow	Raise	Raise	Raise	Raise	Lower
Unstable	Raise	Lower	Lower	Lower	Raise
Won't Reach Setpoint	Raise	Raise	Raise	Raise	Raise or Lower

* Only needed when using the external probe. See section 3.2, FCN 4 for setting the Maximum Setpoint Differential.

Choose different physical characteristics of fluid, bath sizes, tubing sizes and insulation, or covering schemes as below:

CONTROL SYMPTOM	MODIFY EXTERNAL FLOW RESTRICTION	MODIFY ACTUAL FLUID VOLUME	MODIFY INSULATION COVERING OF BATH	MODIFY SPECIFIC HEAT OF FLUID
Too Slow	Increase Diameter	Decrease	Improve	Raise
Unstable	Increase Diameter	Decrease	Improve	Raise

FCN 7 °U CAL **— °U Cal** .....

°U = K1 * (°C + K2) + K3
K1 = 001.0

°U (user scale) allows resetting the calibration of the display by means of the formula:

°U = K1 (°C + K2) + K3

(to select readout to °U, refer to section FCN 3 READOUT)

At times there are slight differences between the displayed temperature and actual temperature as determined by a certified temperature measuring device. Or, you may wish to make the display match a particular value so you have standardization between different laboratory instruments.

The default values for the K factors are:

Degrees	K1	K2	K3
Kelvin	1.0	0.0	273.0
Fahrenheit	1.8	0.0	32.0
Celsius	1.0	0.0	0.0

Use the K1 and K3 factors if you are using any of the three scales shown in the above default value chart. K1 and K3 will change in relationship to °C if you use other scales. Factor K2 is the variable factor, in °C, based on the change in calibration you wish to make.

Example: You work in °F (32°-212°). The actual bath temperature and display temperature do not match. The bath temperature reads 10.25°C as measured with a certified temperature measuring device. The display reads 50°F (10°C). The K2 factor is the difference between these two values (certified temperature of the bath minus display temperature).

K2 is determined by the formula:

K2 = (the certified bath temperature minus the display temperature)
K2 = (10.25°C - 10°C)
K2 = 0.25°C.

The final calculation becomes:

°U = K1 (°C + K2) + K3.
°U = 1.8 (°C from the display + K2) + 32
°U = 1.8 (10°C + 0.25°C) + 32
°U = 18.45 + 32
°U = 50.45°F

To set °U:

Press FCN 7 . . . . . °U = K1 * (°C + K2) + K3 K1 = 001.0

Enter K1 from the keypad and press SET ENTER . . . . . °U = K1 * (°C + K2) + K3 K2 = 001.0

Enter K2 from the keypad the press SET ENTER . . . . . °U = K1 * (°C + K2) + K3 K3 = 001.0

Enter K3 from the keypad and press SET ENTER to get to normal operating display

FCN 8 **— RS232** . . . . . SELECT BAUD RATE 1 = 1200 2 = 9600

Allows selection of 1200 BAUD or 9600 BAUD (default setting). An IBM 9-pin D-subminiature straight wire serial RS232 communication cable is supplied. Older XT computers only have a 25-pin connectors. If you purchase a 25-pin connector to 9-pin cable or adapter, it must be a “NULL MODEM” type. If not, pins 2 and 3 of the 9-pin side of the connection must be reversed, or there will be no response from the RS232. See section 4.4 for additional information.

DOS Programming Disk

Software is provided as an aid for time/temperature programming via PC. See section 4.4, Programming With A Computer, for information about this software and optional PolyTemp® Windows® based software.

Direct Manual Control of Circulator Via a Modem Program on a PC

Communication software may also be used in RS232 function to enter settings. We recommend and support the use of Procomm®.

Procomm communication parameters:

LINE SETTINGS: (ALT P), 9600, N, 8, 1

TERMINAL SETUP: (CONTROL S)

1) Terminal emulation VT-100

2) Duplex . . . . . Full

3) Flow control . . . . . NONE

4) CR translation (in) . . . . . CR/LF shows commands, NONE for long lists

10) Break Length (ms) 0

Procomm® is a registered trademark of Datastorm Technologies Inc.

All RS232 commands below require RETURN or ENTER
On a PC type:

A 1 . . . . . - to confirm link. Controller signals “OK” on computer display.
? . . . . . - gives quick help and list 3 other levels of help.

Command Set Definitions:

S ?	- displays current setpoint of controller
S 30.1	- sets controller temperature at 30.1
F ?	- displays current fluid temperature
U ?	- displays readout in °C, °E or °U
UC or UF or UU	- changes controller to °C, °F, or °U
& L H nn	- sets high limit
& L L nn	- sets low limit set
& L H ?	- displays current high limit
& L L ?	- displays current low limit
& P O or 1 or 2 or 3	- changes # of decimal places
& R nn	- sets auto temperature setpoint
& X 0 or 1	- changes 0 internal, 1 external
& Dn	- number between 1 and 30 for maximum differential
OFF	- turns the controller off
ON	- turns unit on and turns on RS232 communication
$Z	- Resets all parameters to original factory default values

Note: All letters may be upper or lower case. Note: n denotes a number.

Automatic Data Acquisition:

Connect serial cable to PC serial port. To enable data acquisition logging mode use command El. The command E0 will disable logging mode. Enable and disable commands are stored in permanent non-volatile memory.

When running in logger mode, the unit will send set and actual fluid temperature readings to the RS232 port in an ASCII format. Use download feature in communications software and specify ASCII file format. Once saved, data file can be imported to any software that accepts an ASCII file.

FCN 9 **— Auto Refrig . . . . . .**

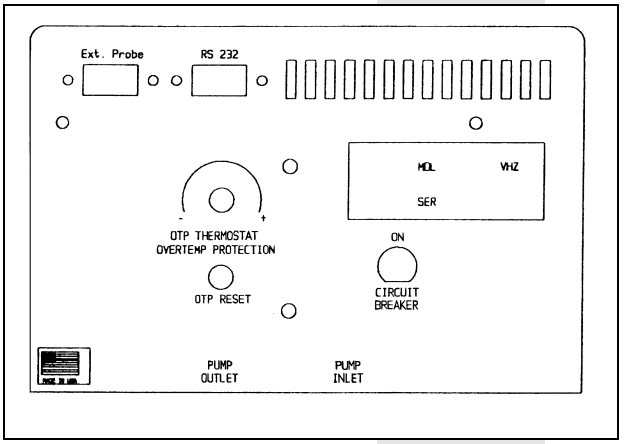
AUTOSWITCH TO 20 TO 055
REFRIG ON < 045°C

Selects the temperature below which refrigeration is activated.

For most applications, we recommend setting Auto Refrig at 15°C above room temperature. For energy savings you may select a lower value. This may effect the rate of cooling down from a higher temperature. For fast cool downs from high temperature, select the highest allowable value. Low temperature models with Cool Command™ refrigeration technology can be set to start cooling at 200°C.

3.4 Setting the Safety Thermostat

The Over Temperature Protection (OTP) thermostat safety feature prevents your unit from over heating, in case of primary controller failure or a low liquid condition, by switching off power to the heater. This feature is independent of the high limit setting and has a range of 60°C to 220°C.
The high limit must still be set (refer to FCN 2, Setting The High Limit.)



Rear View

For Temperatures Less Than 60°C:

1. Turn the OTP thermostat (at the rear of the controller) fully counterclockwise (–). 240 Volt models have a recessed slot that is to be set with a standard screwdriver.

For Temperatures Over 60°C:

1. Turn the OTP thermostat (at the rear of the controller) fully clockwise (+) until it stops. 240 Volt models use a screwdriver.
2. Stabilize the bath at the maximum desired control temperature.
3. Turn the OTP slowly counterclockwise (–) until you hear a click.
   The unit will STOP and the display will read . . . . . RESET OTP THERMOSTAT THEN PRESS ON SWITCH
4. Turn the OTP clockwise (+) slightly above the position where the unit tripped then reset the OTP thermostat breaker by pressing the OTP reset. OTP is now set to trip a few degrees over the stabilized fluid temperature.
5. Press ON to restart.

Section 4. Programming

4.1 Writing A Program

Each program accepts up to 10 different temperature points (number 0 to 9) over adjustable time periods. In each step, setting the temperature point is first, then it is followed by a time. To hold a steady temperature, two different temperature points must be the same. To ramp a temperature, the next temperature point must be different than the last temperature point.

To prepare a program, draw a simple graph of times and temperatures you desire. Label each step from 0 to 9. The time period of each point is entered at each step. The time to go from one temperature to another is specified in hours or minutes in the programming step which starts the ramping.

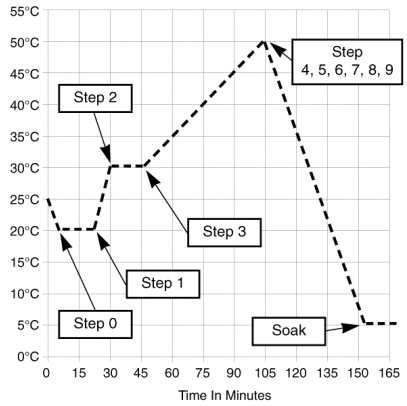
Allowing Proper Time In Programs

Circulating baths are primarily designed to hold temperatures steady rather than change temperature rapidly. It is easy to underestimate the amount of time needed for the circulator to reach the fluid temperature. If you do not allow enough time to reach a temperature, the circulator continues to try to reach within ± 0.1°C of the desired temperature before going to the next program step.

! **To complete a program, all 10 steps must be entered, whether or not they are needed.**
To finish, repeat the last temperature into each of the remaining steps with zero for the time. This cancels the action of the remaining steps.

Examples of Programming

Example A

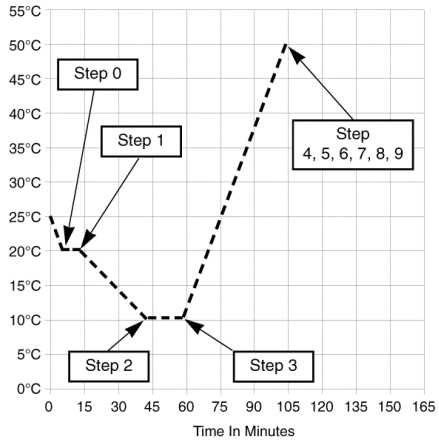


Initial temperature is at 25°C.

1. Go quickly to 20°C and hold temperature for 15 minutes.
2. Go quickly to 30°C and hold temperature for 15 minutes.
3. Ramp slowly up to 50°C over a period of 1 hour.
4. Go down to 5°C and hold temperature indefinitely.

STEP	0	1	2	3	4	5	6	7	8	9	CYCLES	SOAK
TEMP	20°C	20°C	30°C	30°C	50°C	50°C	50°C	50°C	50°C	50°C	1	5°C
TIME	0.15	0.0	0.15	1.0	0.0	0.0	0.0	0.0	0.0	0.0	—	—

Example B

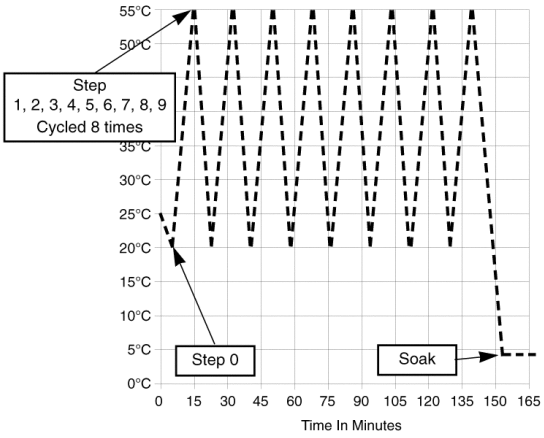


Initial temperature is at 25°C.

1. Stabilize at 20°C for 5 minutes.
2. Ramp slowly from 20°C down to 10°C over 30 minutes.
3. Stay at 10°C for 15 minutes.
4. Ramp slowly up to 50°C over a period of 1 hour.
5. After reaching 50°C, shut off circulator.

STEP	0	1	2	3	4	5	6	7	8	9	CYCLES	OFF
TEMP	20°C	20°C	10°C	10°C	50°C	50°C	50°C	50°C	50°C	50°C	1	—
TIME	0.5	0.30	0.15	1.0	0.0	0.0	0.0	0.0	0.0	0.0	—	—

Example C



Initial temperature is at 25°C

1. Go quickly to 20°C
2. Go quickly to 55°C
3. Repeat 7 times (8 cycles)

STEP	0	1	2	3	4	5	6	7	8	9	CYCLES	SOAK
TEMP	20°C	55°C	55°C	55°C	55°C	55°C	55°C	55°C	55°C	55°C	8	4°C
TIME	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	—	—

4.2 Entering A Program Into Memory

To begin entering a program, press FCN 5 . . . . . SELECT PROGRAM 1 OR 2
3 = ESCAPE

The controller can store two individual programs. Select either program 1 or 2. You see the word TRANSFERRING, the display reads . . . . . 1 = DISPLAY AND EDIT
2 = RUN 3 = ESCAPE

Select 1 = DISPLAY AND EDIT, and enter all Temp and Time points of your program (refer to section 4.1, Writing a Program) Press SET ENTER after each item . . . . . TEMP 0 = *XXX.X* °C
TIME 0 = *XXX* HR *XX* MIN

Note: All 10 temperature/time steps must be entered into the program.

After passing all 10 steps, you reach . . . . . CYCLE = *XXX.X* °C

Enter the number of cycles (repetitions) your program is to go through, up to 999 times. Then press SET ENTER

At the end of the program you may choose . . . . . 1 = SOAK
2 = PWR OFF WHEN DONE

Selecting 1 = SOAK tells the controller to stay at one temperature indefinitely at the end of the program. You must enter a final temperature . . . . . SOAK = *XXX.X* °C

If you select 2 = POWER OFF WHEN DONE, the unit turns off when the controller reaches the end of the program.

Your unit holds two separate programs in it's memory.

Select 1 or 2 to store your new program . . . . . STORE AS 1 OR 2

4.3 Running A Program

To run the program, press FCN 5 . . . . . SELECT PROGRAM 1 OR 2
3 = ESCAPE

Select program 1 or 2, you see the word TRANSFERRING, the display reads . . . . . 1 = DISPLAY AND EDIT
2 = RUN 3 = ESCAPE

Select 2 = RUN. The program begins running.

Note: You may stop the program by pressing ON/ESC At this point the program is suspended and display shows . . . . . 1 = CONTINUE
2 = ABORT

While the program is suspended, alterations to a test may be made without starting the program over again.

Program is suspended until selection is made.

Select 1 to continue the program, select 2 to exit or abort the program entirely.

4.4 Programming With A Computer

DOS Programming Software is provided for complex time/temperature programming and data storage. Follow the installation instructions on the floppy disk and reference the HELP menu for further information.

The system requirements for the DOS based PC software are: AT, XT, IBM compatible with at least one floppy, a hard drive, and 640K RAM. The DOS based PC software runs at 9600 BAUD. Reference the README and *.BAS files for direct user communication information and examples.

See section 3.3 System Set Up, FCN 8 - RS232 for information about acquiring data and controlling the circulator via computer and communications software.

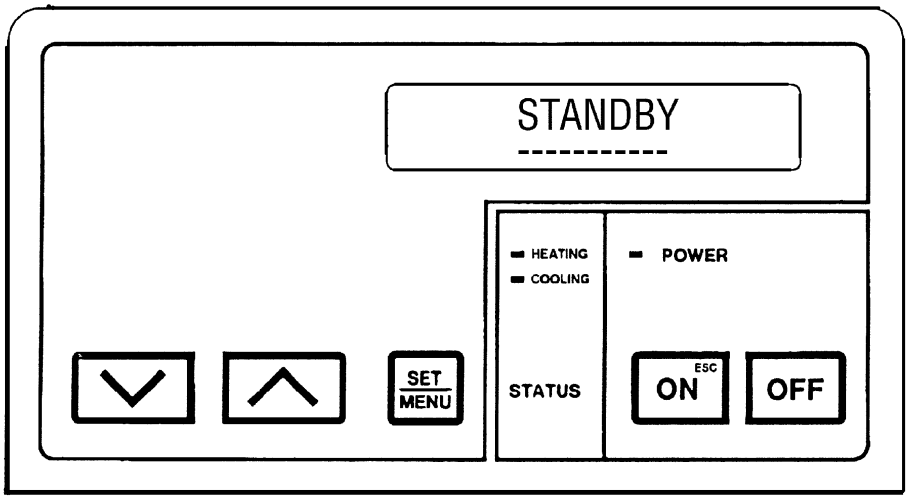
Optional PolyTemp® Software

PolyTemp® software is for use with Windows®, Windows 95®, & Windows 98®. An easy-to-use circulator programming and data-retrieval package, it creates multi-step temperature programs. The charting functions compare the set parameters vs. actual conditions. PolyTemp® automatically graphs up to 10,000 real time data points with setable or automatic sample rate. Data records can be saved through PolyView, a separate program within PolyTemp®.

For further information about PolyTemp®, including system requirements, or to order, ask for Catalog Number 060471.

Section 5. Digital Controller

Check for adequate fluid level in the bath and that all connections are secure.



To access menus
use SET MENU

To change setting
use ⌄ ⌃

To accept each setting
use SET MENU
Display flashes specific digit indicating which value you are entering.

When first plugged in, before power is turned on, display reads . . . . . .

STANDBY
– – – – –

Press power ON Unit performs self test and display shows unit's revision level . . . . . .

COPYRIGHT 1995
SELF TEST VJ BB08

"Fluid" = current bath temperature.

"Set" = current temperature setting . . . . . .

FLUID = 20.0°C
SET = 20.0°C

Notes:

1. After 10 seconds of keypad inactivity, display reverts back to temperature readout.
2. If an error is made in setting values, press ON (escape) to backspace to get to the previously entered values. Repetitive backspacing returns unit to normal operating display.
3. All entered values are stored in permanent non-volatile memory.
4. To revert back to factory default settings, see section 7.7 Default Settings.
5. For negative numbers, pressing ⌄ reaches negative values.

5.1 To Set Temperature

Press SET MENU Enter the desired set temperature. Use ⌄ ⌃ to change the specific digit the display is flashing

Press SET MENU to accept that value and move to the next digit.

Example: for a desired temperature of -45.0°C

Press SET MENU ⌄ until you reach –4, press SET MENU to accept value . . . . . .

FLUID	=	XX.X°C
SET	=	–40.0°C

Press ⌄ ⌃ until you reach 5, press SET MENU to accept value . . . . . .

FLUID	=	XX.X°C
SET	=	–45.0°C

Press ⌄ ⌃ until you reach 0, press SET MENU to accept value . . . . . .

FLUID	=	XX.X°C
SET	=	–45.0°C

For Refrigerated Models

1. When a temperature is set, the display indicates status of refrigeration mode. . . . . .

REFRIGERATION ON
PRESS DN TO SWITCH

2. Press ⌄ to switch refrigeration on or off, then SET ENTER

5.2 To Change Pump Speed

(For Duplex Pump Models, also see section 5.3 System Set Up, under subsection PID Tuning)

— For The Duplex Pump Models

CONTRAST ADJUST
PRESS UP OR DOWN

1. Hold SET MENU until display reads. . . . . .

PRESS THE DN KEY TO
CHANGE SETUP

2. Press SET MENU 7 times, passing through all System Menus until display reads . . . . . .

SELECT PUMP SPEED		
PUMP	=	FULL

3. Press ⌄ the display reads (The first subsection under PID Tuning.) . . . . . .

use ⌄ ⌃ to adjust the speed

The five selectable speeds are: FULL, HIGH, MEDIUM, LOW, SLOW

— For The Simplex Pump Models

The Pump Speed Selector is on the rear of the controller. Select HI or LO.

5.3 System Set Up

System menu consists of:

- — DISPLAY CONTRAST
- — READOUT (°C, °F, °U)
- — LIMITS (HI & LO TEMPERATURE LIMITS)
- — RESOLUTION (.1 °, .01°)
- — PID TUNING (DUPLEX MODELS INCLUDE PUMP SPEED SELECTION)
- — U° (USER) CALIBRATIONS

Press and hold SET MENU until display reads CONTRAST . . . . . .

CONTRAST ADJUST
PRESS UP OR DOWN

By repetitiously pressing SET MENU, each of these individual system menus appear on the display to be set.

(Flashing Fluid/Set values indicate temperature set mode & cannot activate system menus.)

— Adjust Display Contrast . . . . . .

CONTRAST ADJUST
PRESS UP OR DOWN

Adjusts the display's contrast to compensate for ambient light and viewing angle.

Use ⌄ ⌃ to adjust, then SET MENU to accept setting,

— Changing Readout . . . . . .

READOUT
°C

After accepting your CONTRAST setting, the READOUT menu appears.

Press ⌄ ⌃ to select scale: °C, °F, °U user scale (see subsection - U° Cal)

press SET MENU to accept selection.

— Set Limits . . . . . .

HI LIMIT = *XX.XX*°
LO LIMIT = *XX.XX*°

After accepting your READOUT setting, the LIMITS menu appears.

Use ⌄ ⌃ to select temperature high & low limits.

Press SET MENU after each digit to accept that value and continue to the next digit.

If fluid temperature exceeds these limits, the unit shust off and the alarm activates.

— Resolution . . . . . .

READOUT
.1°

After accepting your LIMITS settings, the READOUT menu appears.

Press ⌄ ⌃ to select .1 or .01 resolution, press SET MENU to accept selection.

— PID Tuning . . . . . .

PRESS THE DN KEY
TO CHANGE SETUP

after accepting your READOUT setting, press SET MENU again.

The Duplex Pump : To optimize temperature control regarding:

(1) PUMP SPEED SELECTION, (2) FLUID VOLUME, (3) FLOW RATE,
(4) SPECIFIC HEAT OF FLUID, (5) U° CALCULATIONS

The Simplex Pump : To optimize temperature control regarding:

(1) FLUID VOLUME, (2) FLOW RATE, (3) SPECIFIC HEAT OF FLUID,
(4) U° CALCULATIONS

If the temperature stability is satisfactory, there is no need to change the controller tuning. If needed, there are provisions to optimize the controller for special applications.

Control performance equal to or greater than + 0.5°C from the setpoint temperature is not affected by tuning. To achieve close control, tuning may be necessary if you use: a closed loop system of large volume; or a fluid other than water; or a viscous fluid.

The tuning parameters are simplified and can be easily measured and entered. Settings are not critical, estimates are acceptable. Each of the values used for tuning are independent of each other, and can be changed without changing any of the other values.

Display flashes SELECT PUMP SPEED . . . . . .

SELECT PUMP SPEED
PUMP = FULL

(This Submenu is in Duplex Models only, see section 5.2 To Change the Pump Speed)

Use  to adjust the speed, then  to accept value

Display flashes FLUID VOLUME . . . . . .

FLUID VOLUME
10 LITER(S)

Use  to set. Enter actual volume of fluid in bath. Range of fluid volume is 01 liters to 99 liters, then  to accept value

Display flashes FLOW RATE . . . . . .

FLOW RATE
10 LITERS(S) / MIN

Use  to enter the actual flow rate in liters/min then  to accept value

Display flashes SPECIFIC HEAT . . . . . .

SPECIFIC HEAT
1.00 (.25 TO 1.00)

Use  to enter the specific heat of the fluid in bath, range .25 to 1.00, then  to accept value

If further information about controller optimization in needed, please refer to section 3.2 System Setup, under subsection FCN 6 - PID Tuning. 'If Control Is Too Slow Or Unstable' & 'Application Notes In Tuning'.

— U° Cal . . . . . .

°U = K1 * (°C + K2) + K3
K1 = 001.0

°U (user scale) allows resetting the calibration of the display by means of the formula:

°U = K1 (°C + K2) + K3

At times there are slight differences between the displayed temperature and actual temperature as determined by a certified temperature measuring device. Or, you may wish to make the display match a particular value so you have standardization between different laboratory instruments. The default values for the K factors are:

Degrees	K1	K2	K3
Kelvin	1.0	0.0	273.0
Fahrenheit	1.8	0.0	32.0
Celsius	1.0	0.0	0.0

Use the K1 and K3 factors if you are using any of the three scales shown in the default value chart. K1 and K3 will change in relationship to °C if you use other scales.

Factor K2 is the variable factor, in °C, based on the change in calibration you wish to make.

Example: You work in °F (32°- 212°F). The actual bath temperature and display temperature do not match. The bath temperature reads 10.25°C as measured with a certified temperature measuring device. The display reads 50°F (10°C). The K2 factor is the difference between these two values (certified temperature of the bath minus display temperature).

K2 is determined by the formula:

K2 = (certified bath temperature – display temperature)

K2 = (10.25°C – 10°C) K2 = 0.25°C.

The final calculation becomes: °U = K1 (°C + K2) + K3.

°U = 1.8 (°C from the display + K2) + 32

°U = 1.8 (10°C + 0.25°C) + 32

°U = 18.45 + 32

°U = 50.45°F

To set °U:

Press SET MENU 6 times

Enter K1 using ▼ ▲ press SET MENU to accept settings . . . . . °U = K1 * (°C + K2) + K3 K1 = 001.0

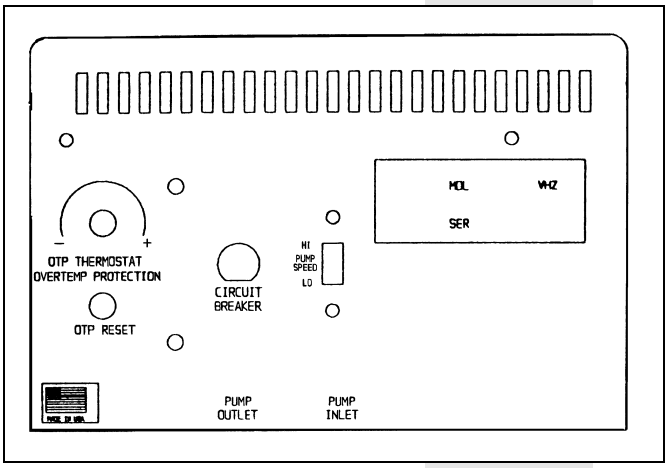
Enter K2 using ▼ ▲ press SET MENU to accept settings . . . . . °U = K1 * (°C + K2) + K3 K2 = 001.0

Enter K3 using ▼ ▲ press SET MENU to accept settings . . . . . °U = K1 * (°C + K2) + K3 K3 = 001.0

Press SET MENU to return to normal operating display.

5.4 Setting the Safety Thermostat

The Over Temperature Protection (OTP) thermostat shuts power off and prevents your unit from over heating in case of primary controller failure or a low liquid condition. This feature is independent of the high limit setting and has a range of 60°C to 220°C. The high limit must still be set. (see section 5.3 System Setup, under subsection Set Limits)



Rear View

For Temperatures Less Than 60°C:

1. Wait for bath to stabilize at Set Temperature.
2. Turn the OTP knob located at the rear of the controller fully counterclockwise (–)

For Temperatures Over 60°C:

1. Turn the adjustable thermostat (OTP knob) located at the rear of the controller fully clockwise (+) until it stops.
2. Stabilize the bath at the maximum desired control temperature.
3. Turn the OTP knob slowly counter-clockwise until you hear a click. The unit halts and the display reads . . . . . RESET OTP THERMOSTAT THEN PRESS ON SWITCH
4. Turn the OTP knob clockwise slightly above the position where the unit tripped then reset/press the OTP thermostat breaker, located next to the OTP knob. OTP is now set to trip a few degrees over the stabilized fluid temperature.
5. Press SET MENU to restart.