Operators Manual

Circulating Bath

with

Programmable Controller

110-119
rev. A

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Section 1. General Information

1.1 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.

1.2 Package Contents

		All	TC-101P	TC-201P	TC-501P
Circulator Bath					
Operators Manual		110-119			
RS-232 Communication Cable		225-173			
3/16 in., 1/4 in., and 3/8 in. Nylon Barbed Tubing Adapters		510-011			
6 ft. of 1/4 in. ID Latex Tubing		300-299			
Beaker Platform(s) for Bath Reservoir	— 600 ml — 1000ml		701-402	701-402 *(qty 2)* 701-403	701-402
Deck Lid(s)	— solid — w/beaker holes		510-209 510-211	 510-209	510-209 510-211
Blue Hole Plugs ***Note: Do NOT Use Above 120°C***	— 3 1/2 inch — 4 1/4 inch		300-295	300-295 *(qty 2)* 300-296	300-295

Note: Work area "opening" is designed to measure samples directly in the bath. If additional viscometer height is required (spindle/guard clearance), either a 4 inch rod extension (*part number BLM-4E)* used with type A lab stand or an 18 inch rod replacement *(part mumber VS-38)* used with type S lab stand are available from Brookfield or an authorized dealer.

1.3 Description of Circulating Baths

The PROGRAMMABLE 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.

1.4 Specification Chart

Controller	Programmable
Temperature Range (Non-Refrigerated)	Ambient +5° to 200°C
Temperature Range (Refrigerated)	-20° to 200°C
Temperature Stability	±.01°C
Readout	LCD
Readout Accuracy	±0.25°C
Pump	Duplex
Pump Flow Rate (Pressure) @ 120V, 60Hz	11 to 24 lpm
Pump Flow Rate (Suction)	8 to 18 lpm
Overtemp/Safety Cutoff	Yes (Adjustable)
RS232 Interface	Yes
Remote Probe	Optional
Inlet / Outlet	1/4 inch NPT (female)
Heater	1000 Watts

1.4 Specification Chart, continued

Model	TC-101P	TC-201P	TC-501P
Dimensions (in.) (l x w x h) (cm)	$14\frac{3}{4}$ x $8\frac{1}{4}$ x 14 37.5 x 13.3 x 35.6	$13\frac{1}{4}$ x $14\frac{1}{4}$ x $13\frac{1}{4}$ 33.7 x 36.2 x 33.7	$15\frac{3}{4}$ x $18\frac{3}{4}$ x 17 40 x 47.6 x 43.2
Unit Weights	22 lbs (10.0 kg)	28 lbs (12.7 kg)	63 lbs (28.6 kg)
Reservoir Volumes	6 liters	10 liters	6 liters
Power Requirement	9A @ 115V / 1 / 60Hz (105V - 125V) 4.5A @ 240V / 1 / 50Hz (200V - 260V)	9A @ 115V / 1 / 60Hz (105V - 125V) 4.5A @ 240V / 1 / 50Hz (200V - 260V)	10A @ 115V / 1 / 60Hz (105V - 125V) 5A @ 240V / 1 / 50Hz (200V - 260V)

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.

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° to 90°C or a mixture of laboratory grade ethylene glycol and water for temperatures -20° 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 ±0.01°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 ±0.01°C over a 100°C range. Use fluids that will satisfy safety, health, and equipment compatibility requirements.

The following chart 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*
Dynalene-HC 50™	.76	-50°C — 60°C	-62°C — 60°C
DC510 50 cs Silicone Oil	.39	50°C — 150°C	5°C — 270°C*
DC550 125 cs Silicone Oil	.42	100°C — 200°C	80°C — 315°C*

*WARNING - Fluid's flashpoint temperature.
DC fluids are manufactured by Dow Corning. Dynalene HC is a registered TM of Advanced Fluid Technologies, Inc.

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. If buildup occurs see Section 5.1 Maintenance - Heater.

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 will adversely affect temperature stability.
2. Viscosity above 10 centistokes will adversely affect temperature uniformity.
3. High fluid viscosity and high speed pumping will generate 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. Encourage heat loss by uncovering the fluid and lowering pump speed.

At fluid's high temperature extreme:

1. Heat loss from vapor will cause 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 will have 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.

Select tubing and fittings that are 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 -20° to 93°C. Brass, stainless steel or Teflon® fittings are recommended for applications above 93°C. Quick connectors are not recommended as they restrict flow rate.

Some programmable models are not equipped with a refrigeration system. For operation of these non-refrigerated models, the included cooling coil may be used to achieve bath temperatures within 15°C above the ambient room temperature. The cooling coil also permits the bath temperature to be lowered more rapidly, after operation at an elevated temperature. The cooling coil connections are located between the circulating pump's inlet and outlet connections at the rear of the bath's controller. To use the cooling coil, slide the $^1/_4$ in. ID latex tubing from the water source over one of the coil's connections and route another length of tubing from the other coil connection to the drain.

2.5 Pump

A pressure & suction (DUPLEX) pump is built into each unit. The 5-speed DUPLEX pump is found in all programmable 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 FUNCTION TUNING menu. (See Section 3.2)

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

		MAXIMUM OUTLET RATINGS
PUMP SELECTION	SPEED	PUMP TYPE 120V, 60Hz
	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 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 will occur 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

The DUPLEX pump can also 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. Use of an extension cord is not recommended, but if necessary, use one that is properly grounded and will handle the total wattage of the unit. The extension cord must not cause more than a 10% voltage drop to the circulator.

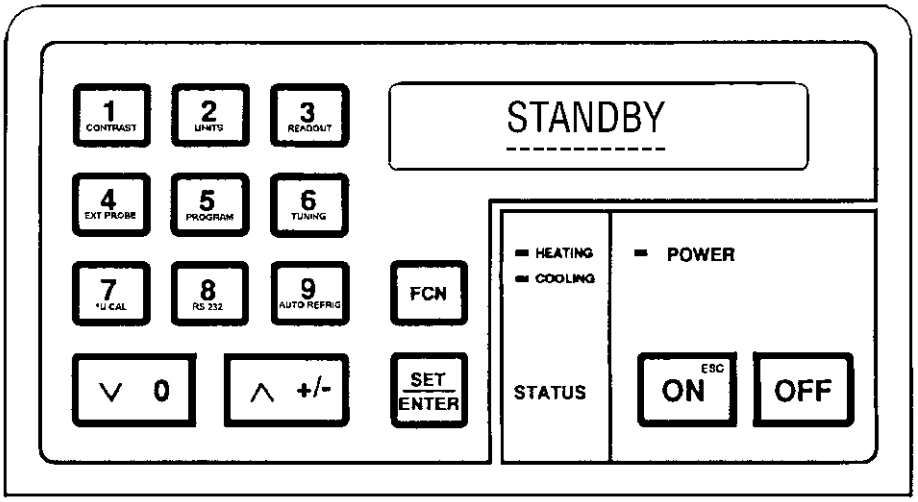
Firmware Versions

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 will be a lower case letter “v” followed by a capital letter indicating firmware version.

NOTE: This information is important when calling for service.

Section 3. Programmable Controller

Check for adequate fluid level in the bath and that aft 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, display will read . . . . . .

```
STANDBY
- - - - - - -
```

Press power ON

Unit will perform self test and read the firmware's revision level . . . . . .

```
COPYRIGHT 1995
SELF TEST VJ BB08
```

"Fluid = " is the current bath temperature

"Set = " is your temperature setting . . . . . .

```
FLUID  =  20.0
SET    =  30.0
```

Notes:

1. After 10 seconds of keypad inactivity, 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 will return 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 operating temperature. Each value is entered on the display from right to left.

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

```
FLUID  =  XX.XX°C
SET    =  000.4°C
```

Press SET ENTER then 4 then 5 then v 0

```
FLUID  =  XX.XX°C
SET    =  004.5°C
```

then SET ENTER to accept values. (Values are also accepted after 10 seconds of keypad inactivity.)

```
FLUID  =  XX.XX°C
SET    =  045.0°C
```

3.2 To Change Pump Speed . . . . . .

(also in Section 3.3, System Set Up, FCN 6 - Function Tuning)

1. Press FCN 6, The pump speed menu will appear first.
2. Select the pump speed number, then press SET ENTER
3. 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 and hold FCN and then select the desired operating parameter.

FCN 1 — Adjust Display Contrast . . . . . .

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

Press V 0 ^ +/- 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 . . . . . .

Select desired temperature scale pressing:

°C = 1 °F = 2 °U = 3 Display will momentarily read "CONVERTING"

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

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

FCN 3 — Change Resolution - 0.1°, 0.01°, 0.001° . . . . . .

Change desired resolution value pressing:

0.1°= 4 0.01°= 5 0.001°= 6

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

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

FCN 4 — External Probe . . . . . .

Used to select temperature control via internal sensor or external remote probe (optional).

By selecting 2 = EXT, the external sensor mode, the display will read . . . . . .

1 = INTERNAL SENSOR
2 = EXT 3 = CAL EXT

MAX SETPOINT
DIFFERENTIAL = 10°C

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

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

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 internai 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.

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, Function 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 FCN 4 and select 3 = CAL EXT for calibration . . . . . .

1 = INTERNAL SENSOR
2 = EXT 3 = CAL EXT

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

select ^ +/- (YES) to CHECK BATH FLUID menu . . . . . .

CHECK BATH FLUID
UP = YES DN = NO

If you select NO, the screen will ask 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 will automatically match the probes at two temperatures that you select . . . . . .

LO SETTING 25°C
HI SETTING 65°C

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

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

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

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 values used for tuning are independent can be changed without having to change any other value.

— Pump Speed Selection . . . . . .

(also in section 3.2 To Change Pump Speed)

SELECT PUMP SPEED
HIT 1 THROUGH 5

The five selectable speeds

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

1. Press FCN 6 The pump speed menu will appear first.

2. Select the pump speed, then press SET ENTER

3. If further tuning is necessary, continue reading Function Tuning in this section.

If no further tuning is necessary, you can continue to FCN 7 -°U Cal.

Press FCN 6 If pump speed does not require adjustment,

press SET ENTER for FLUID VOLUME, Press SET ENTER again for FLOW RATE,

Press SET ENTER a third time for SPECIFIC HEAT

— Fluid Volume . . . . . FLUID VOLUME 10 LITER(S)

FCN 6 then SET ENTER once.

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

— Flow Rate . . . . . FLOW RATE 10 LITER(S) / MIN

FCN 6 then SET ENTER twice.

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 . . . . . SPECIFIC HEAT 1.00 (.25 TO 1,00)

FCN 6 then SET ENTER three times.

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, User Defined Temperature Scale** . . . . . .

°U = K1 * (°C + K2) + K3
K1 = 001.0

°U allows resetting the calibration of the display by means of the formula:

°U = K1 (°C + K2) + K3 (To change readout to **°U** refer to **FCN** **3**)

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 changes in relationship to °C if you use other scales. K2 is the variable factor, in °C, based on the change in calibration you wish to make.

Example: You work in °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 = (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.

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

Communication software may also be used in RS232 function to enter settings.

Communication Parameters:

Baud rate	: 9600
Data bits	: 8
Stop bits	: 1
Parity	: none
Flow control	: none
Terminal emulation	: VT-100

Command Set Definitions

T	-	returns current fluid temperature
S	-	returns current setpoint temperature
I	-	returns controller model identity
RA[z]	-	change operating mode (z = controller state digit) (i.e. RA1 = ON; RA2 = OFF)
RS[ssss][u]	-	change setpoint (ssss = setpoint multiplied by 10; u = unit digit (either F or C))

Controller Responses

?	-	illegal command
T[tttt][u][z]	-	tttt = current temperature (multiplied by 10)
S[ssss][u][z]	-	set point temperature displayed with temperature scale letter and unit status number *(ssss = setpoint multiplied by 10, u = unit digit (either F or C); z = controller state digit)*
I[xxxxxx]	-	TC-501 = controller ID string
RS (ssss) (u) (z)		change of setpoint temperature displayed with temperature scale letter and unit status number
RA[z]	-	controller status
RA1	-	controller on
RA2	-	controller off, in 'standby' mode
RA3	-	no probe connected to controller
RA5	-	temperature reading is above or below allowable limits
RA6	-	temperature input value outside the allowable limits

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 080
REFRIG ON < 045°C

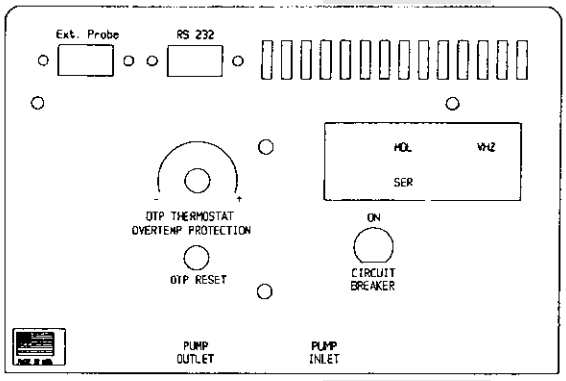
Selects the temperature below which refrigeration is activated.

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. (Models vary in allowable temperatures.)

Some programmable models are not equipped with a refrigeration system. For operation of these non-refrigerated models, the included cooling coil may be used to achieve bath temperatures within 15°C above the ambient room temperature. The cooling coil also permits the bath temperature to be lowered more rapidly, after operation at an elevated temperature. The cooling coil connections are located between the circulating pump's inlet and outlet connections at the rear of the bath's controller. To use the cooling coil, slide the $^1/_4$ in. ID latex tubing from the water source over one of the coil's connections and route another length of tubing from the other coil connection to the drain.

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 your applications highest set temperature.
3. Turn the OTP slowly counterclockwise (-) until you hear a click. The unit will STOP and the display reads . . . . . .

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 will accept 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 temps 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

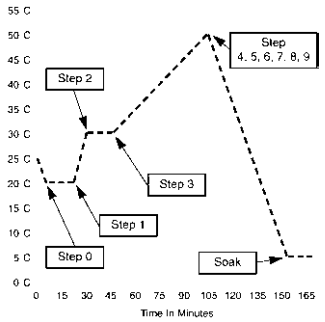
Circulating baths are primarily designed to hold temperatures steady rather than change temperature rapidly. It is easy to underestimate the amount of time needed for the circulator to reach the fluid temperature. If you do not allow enough time to reach a temperature, the circulator will continue to 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, copy the last temperature into each of the remaining steps with zero for the time. This cancels the action of the remaining steps.

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.

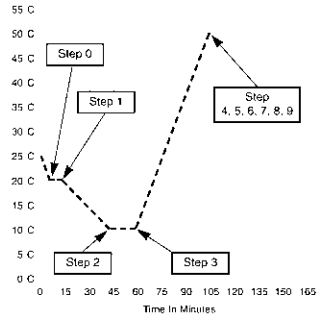


STEP	0	1	2	3	4	5	6	7	8	9	cycles	soak
TEMP	20°C	20°C	30°C	30°C	50°C	50°C	50°C	50°C	50°C	50°C	1	5°C
TIME	0.15	0.0	0.15	1.0	0.0	0.0	0.0	0.0	0.0	0.0	—	—

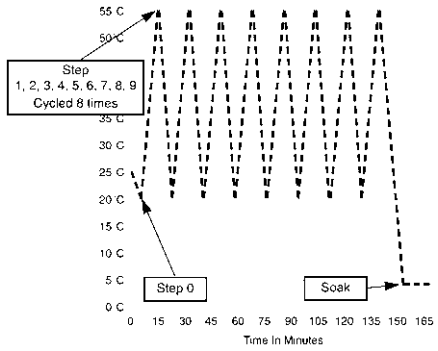
Example B

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. Once 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	0.05	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 will see the word TRANSFERRING, then the display will read . . . . . 1 = DISPLAY AND EDIT
2 = RUN 3 = ESCAPE

Select 1 = DISPLAY AND EDIT, and enter all Temp and Time points of your program (as described in 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 will reach . . . . . # CYCLES

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 = <u>*XXX.X*</u>°C

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

Your unit will hold 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 will see the word TRANSFERRING, then it will read . . . . . 1 = DISPLAY AND EDIT
2 = RUN 3 = ESCAPE

Select 2 = RUN. The program will begin running.

Note: You may stop the program by pressing ON, 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 will be suspended until selection is made.
Select 1 to continue the program, select 2 to exit or abort the program entirely.

Section 5. Maintenance

5.1 Heater

The heater should be kept clean. If deposits build up on the heater they may be removed by scouring with a non-metallic scour pad, or a plastic pad with fiberglass beads embedded to provide roughness. Do not use copper or steel wool, it will cause stainless steel to rust.

5.2 Pump Motor

The top and bottom bearings are permanently lubricated with a high temperature silicone grease. They should not require lubrication. The pump motor bearings are not available separately. If the bearings become noisy, we recommend to replace the entire motor to save cost in labor and retain reliability. A pump motor replacement kit is available. See Replacement Parts, Section 7.

5.3 Condenser and Air Vents (Refrigeration Units)

The condenser and the right and left air vents should be kept free of dust and dirt. Dirt thermally insulates the condenser and reduces the cooling capacity of the refrigeration system. Clean the fins of the condenser periodically with compressed air or strong vacuum.

5.4 Cleaning

To clean the circulators exterior, use only mild soap and water or a mild general-purpose spray cleaner. Be careful to prevent cleaning liquids from entering the inside of the controller.

5.5 Maintaining Clear Bath Water

Optimum temperature and moisture conditions for algae growth exist when using water as the bath fluid. To prevent algae contamination and to minimize frequency of draining the reservoir, an algicide should be used. Do NOT use chlorine bleach.

Section 6. Troubleshooting

6.1 Unit Disabled, Service Required

System error in microprocessor memory. Try unplugging the unit and plugging in again to fully reset the system. If unit continues to display incorrect message, then seek service.

6.2 No Pumping or Insufficient Pumping

Check that the pump impeller turns freely. Check fluid level of bath. Check for low line voltage, especially when the heater is on.

6.3 No Cooling or Insufficient Cooling

Check if cooling is selected, cooling light should be on. Check for low or high line voltage. Check for blocked airflow through ventilation screens. Refrigeration unit should not be operated above 32°C room ambient temperature, such conditions may cause refrigeration compressor to temporarily shut down. Check if heat is being added to the fluid in excess of the refrigeration system's capacity.

6.4 No Heating or Insufficient Heating

Check if unit is pumping properly. If heat light is not on, check the setting of the setpoint temperature and bath temperature. Check fluid level of the bath. Check for proper line voltage. Check for excessive external cooling lead on unit. At higher temperatures, it could be due to heat loss from tanks, hoses or vapor from a tank. Variance of heat load on the system from experiments may exceed the power handling of the unit. Changes in heat load or setpoint requires time to settle to a stable temperature.

6.5 Triac Failure

Heater triac has failed or line supply voltage has a source of extreme interference from other equipment. Try unit on another power source. If it still displays triac failure, a triac or triac driver needs replacement.

6.6 Default Settings

You may easily reset all parameters to factory default settings.

With unit in standby mode press the 

then 

then 

then select default EEPROM

Section 7. After-sale Support

All instruments requiring warranty repair must be returned to Brookfield Engineering Laboratories, Inc. or the Brookfield dealer from whom it was purchased. Transportation is at the purchaser's expense.

For repair or service in the United States, return to:

Brookfield Engineering Labs., Inc.
11 Commerce Boulevard
Middleboro, MA 02346 USA

Telephone: 508-946-6200
Fax: 508-946-6262
service@brookfieldengineering.com

For repair or service outside the United States, consult Brookfield Engineering Laboratories, Inc. or the dealer from whom you purchased the instrument.

For repair or service in the United Kingdom, return to :

Brookfield Viscometers Limited
1 Whitehall Estate
Flex Meadow
Pinnacles West
Harlow, Essex CM19 5TJ, United Kingdom

Telephone (44) 27/945-1774
Fax: (44) 27/945-1775
service@Brookfield.co.uk

For repair or service in Germany, return to:

Brookfield Engineering Labs. Vertriebs GmbH
Barbarossastrasse 3
D-73547 Lorch, Germany

Telephone: 7172/927100
Fax: 7172/927105
info@brookfield-gmbh.de

Section 8. 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.