



Operators Manual

Circulating Bath with Digital Controller

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Section 1. General Information

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.

Remove any loose packing material which may have fallen into the reservoir during shipping. Also check that nothing remains around the heater or circulator pump. Before proceeding, be sure the Power switch is in the OFF position. Refrigerated models should have the Cooling switch in the OFF position.

1.2 Package Contents

	All	TC-101D	TC-201D	TC-501D
Circulator Bath				
Operators Manual	110-119			
$\frac{3}{16}$ in., $\frac{1}{4}$ in., and $\frac{3}{8}$ in. Nylon Barbed Tubing Adapters	510-011			
6 ft. of $\frac{1}{4}$ 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	— $3\frac{1}{2}$ inch — $4\frac{1}{4}$ 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 number VS-38*) used with type S lab stand are available from Brookfield or an authorized dealer.

1.4 Description of Circulating Bath

Digital controller refrigerated and heating circulating baths are designed to provide precise temperature control of fluids for closed loop 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.

1.5 Specification

Controller	Digital
Temperature Range (non-refrigerated)	Ambient +5° to 150°C
Temperature Range (refrigerated)	-20° to 150°C
Temperature Stability	±0.05°C
Readout Accuracy	±0.5°C
Readout	LED
Pump	Simplex
Pump Flow Rate (Pressure) @ 120V / 60 Hz	15 lpm & 9 lpm
Over temperature / Safety Cutoff	Yes (adjustable)
RS-232 Interface	Yes
Heater	1000 Watts

1.5 Specification, continued

Model	TC-101D	TC-201D	TC-501D
Dimensions (in.) (l x w x h) (cm)	14 ³ / ₄ x 8 ¹ / ₄ x 14 37.5 x 13.3 x 35.6	13 ¹ / ₄ x 14 ¹ / ₄ x 13 ¹ / ₄ 33.7 x 36.2 x 33.7	15 ³ / ₄ x 18 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)

1.6 Circulating Bath Fluid Connections To External Apparatus

On circulating baths, the pump inlet and outlet are internally 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 that are compatible with bath fluid and temperature range. If the pump inlet and outlet are not used for external circulation, for best results 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 typically restrict flow rate.

Section 2. Operation

2.1 Location

Locate your circulator on a level surface free from drafts and direct sunlight. Do not place it where there are 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 if possible, be close to the power distribution panel. The use of extension cords is not recommended, this will avoid low line voltage problems.

2.2 Filling the Reservoir

The 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 or sides of plastic tanks as a fire hazard may result.

2.3 Reservoir Fluids

Use distilled water for temperatures from 10° to 100°C or a mixture of laboratory grade ethylene glycol and water for temperatures below -20°C. 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 $\pm 0.05^\circ\text{C}$, 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 heat transfer fluids will be able to stabilize to $\pm 0.05^\circ\text{C}$ 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*
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 3 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 Circulator Pump

The two speed pressure (simplex) pump may be used for tempering of samples in the reservoir or for circulation in closed loops. It is not designed for pumping from the circulator's reservoir into and out of a second open reservoir. The HI or LO speed selection switch on the rear panel of the controller allows a choice of pump speeds.

Speed Selection	Maximum Pump Outlet Ratings	Maximum Pump Outlet Ratings
	Line Frequency = 60Hz	Line Frequency = 50Hz
HI	15 lpm / 2.6 psi	10.4 lpm / 1.8 psi
LO	7 lpm / 1.3 psi	4.8 lpm / 0.9 psi

The table uses the following criteria:

1. Maximum pump outlet flow rate is measured in liters per minute (lpm) with no restriction on the pump outlet.
2. Maximum pump outlet pressure is measured in pounds per square inch (psi) at no flow.
3. Water was used as the circulation fluid. Water has a viscosity of one centistoke. High viscosity or low density fluids will change these figures.
4. When the inlet and outlet are plugged on reservoir models, flow rate refers to internal bath circulation.

Select the HI pump speed where changes in temperature vary and there is a need for fast recovery, or when pumping to multiple external units. The LO pump speed is adequate for most applications and provides quieter pumping.

2.5 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.

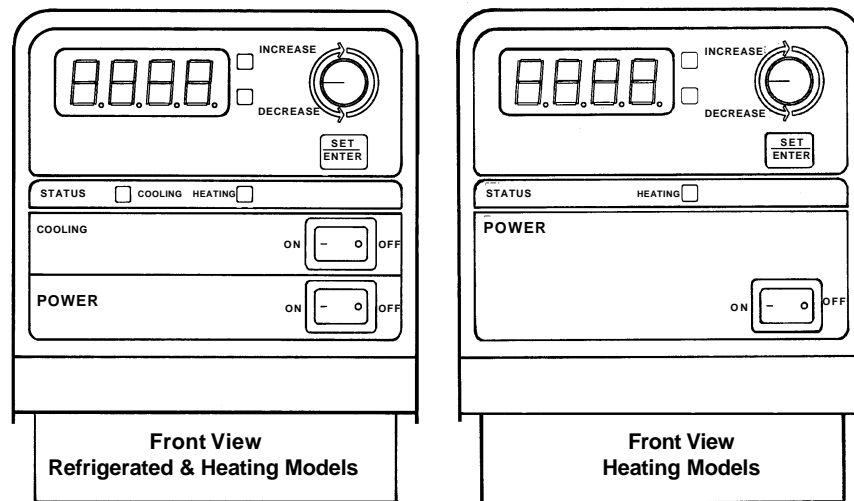
The control stability of a closed loop system will generally be better at the external apparatus than in the immediate vicinity of the heater, provided the apparatus control point represents a constant load and is well insulated. For example, if you circulate at 50°C through a viscometer, the temperature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

Although stability is better at the external apparatus control point, depending on the insulation and length of tubing used, the accuracy of temperature may be slightly different than the temperature indicated in the reservoir.

2.6 Power

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 indicates standby mode (...). If there is no response, check if the circuit breaker is in the ON position.

Use of 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.



2.7 Setting the Temperature

After filling the reservoir with fluid, set the temperature:

1. Set the Safety Thermostat (OTP) knob on the rear panel to full clockwise position, then press the Power switch ON. The pump starts to operate. The LED display indicates the power up self-test (8888). You are now ready to set the front panel controls to the desired temperature setting.
2. Press the SET/ENTER button. The degree light flashes indicating the temperature can be changed.
3. Turn the INCREASE/DECREASE knob to the desired setting. This setting is accepted after pressing the SET/ENTER button or automatically accepted after a few seconds. The degree light stops flashing and the display indicates the actual bath temperature.

The set temperature may be checked at any time by pressing the SET/ENTER button. Allow sufficient time for the bath to stabilize at the desired temperature.

If you are unable to raise the set temperature, it is possible that the High Limit is set lower than the set temperature you have selected. If this happens, set the High Limit to be 1°C or more higher than your desired temperature.

2.8 Setting the High Limit

This feature provides additional set point security by allowing a selectable upper limit set point. If the fluid reaches the high limit, the unit will shut down and display "HI-L" until the fluid temperature is reduced or the "HI-L" value is raised. The "HI-L" should be at least 1°C higher than the selected control temperature to avoid unwanted shut down during regular operation.

TO SET THE HIGH LIMIT TEMPERATURE:

1. Press and hold the SET/ENTER button until the display reads "UNIT".
2. Turn the INCREASE/DECREASE knob until the display reads "HI-L".
3. Press the SET/ENTER button and enter the desired value using the INCREASE/DECREASE knob.
4. Press SET/ENTER or the setting will be accepted after a few seconds.

2.9 Setting the Safety Thermostat

The Over Temperature Protection (OTP) thermostat safety feature prevents your unit from burnout 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 as indicated in Section 2.3 (above) must still be set.

For temperatures less than 60°C:

1. Turn the OTP knob located at the rear of the controller fully counterclockwise (minimum setting)
Note: 240V models have a recessed slot that is to be set with a standard screwdriver.

For temperatures over 60°C:

1. Turn the adjustable thermostat, OTP knob, (on controller's back) fully clockwise (maximum+) 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 stops and the display will read "E-oP" (Over temperature).
4. Turn the OTP knob clockwise slightly above the position where the unit tripped then reset the OTP breaker by pressing the red OTP reset button (below the knob). OTP is now set to trip a few degrees over the stabilized fluid temperature.

2.10 Operation of Refrigerated Models

For operation at temperatures below 40°C, refrigeration is normally required. To start the refrigeration system, press the cooling switch to the ON position. The refrigeration automatically shuts down if the bath fluid is above 80°C, even if the refrigeration switch is on.

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 you do not observe this waiting period.

2.11 Operation of Heat-Only Models

For operation of 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 inch 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.

2.12 Selection of Celsius or Fahrenheit Readout

To change the readout to display in °F or °C:

1. Press and hold the SET/ENTER button until the display reads "UNIT".
2. Press SET/ENTER again then turn the INCREASE/DECREASE knob and select °C or °F.
3. Press SET/ENTER or the setting is accepted after a few seconds.

2.13 Optimization of Controller

There is provision to optimize the the controller for special applications. If the temperature stability using factory settings is satisfactory, there is no need to change the controller tuning.

Control performance equal to or greater than $\pm 5^{\circ}\text{C}$ 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.

Tuning of Proportional Integral Derivative (PID) controllers requires extensive knowledge of PID technology or time lost in pure guesswork. The tuning parameters below are simplified and are figures that can be easily measured and entered. Settings are not critical, estimates are acceptable.

Each of the three values used for tuning can be changed without having to change any other value. Each value is independent.

TO CHANGE THE TUNING:

Press and hold the SET/ENTER button until the display reads "UNIT".

Turn the INCREASE/DECREASE knob until the display reads "CAP" - Capacity.

1. Press SET/ENTER.
2. Enter the estimated total system volume in liters using the INCREASE/DECREASE knob.
3. Press SET/ENTER or setting is accepted after a few seconds.

Turn the INCREASE/DECREASE knob until the display reads "FLO" - Flow Rate.

1. Press SET/ENTER.
2. Enter the estimated actual flow rate in liters per minute using the INCREASE/DECREASE knob.
3. Press SET/ENTER or setting is accepted after a few seconds.

Turn the INCREASE/DECREASE knob until the display reads "SHC"- Specific Heat Capacity.

1. Press SET/ENTER.
2. Enter the specific heat capacity of the fluid being used by using the INCREASE/DECREASE knob.
3. Press SET/ENTER or setting is accepted after a few seconds.

Refer to Section 2.3 Reservoir Fluids for specific heat values of various liquids and Section 4.8 Controller Default Settings for returning to factory default controller settings.

2.14 Controller Display Messages

	Display	Message
Normal Screens		
	Standby mode. Unit plugged in. Power switch OFF.
	8888	Power up self-test. Power switch ON.
Menu Screens		
	FLO	Flow rate selection for controller tuning
	CAP	Capacity (volume) for controller tuning
	SHC	Specific heat value for controller tuning
	Unit	Change to °F or °C
Error Screens		
	AL-M	High temperature alarm
	E-oP	Over temperature fault
	E-5F	Sensor failure
	E-tF	Triac (alternistor) failure

Section 3. Maintenance

3.1 Heater

The heater should be kept clean. If deposits build up on the heater they may be removed by scouring with a non-metallic (plastic) abrasive pad. Do NOT use steel wool, it causes stainless steel to rust.

3.2 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 replacement of the entire motor to save cost in labor and retain reliability. A replacement pump and motor mounting kit is available.

3.3 Condenser and Air Vents (Refrigerated Models)

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. Set up a periodic schedule to clean the fins of the condenser with compressed air.

3.4 Cleaning

Use only mild detergent and water or an approved cleaner on the painted and stainless steel surfaces. Do not allow cleaning liquids or sprays to enter the controller head vents.

3.5 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 4. Troubleshooting

4.1 Unit Disabled - Service Required

- Check the power to the unit.
- Be sure circuit breaker is on.
- Try unplugging the unit and plugging in again to fully reset the system.
- If the unit continues to display an error message or no message, request service.

4.2 No Pumping

- If the pump motor does not spin, check the Hi-Lo pump speed switch is all the way up or down. If it is in the middle, the pump will not receive power.
- Check the pump impeller turns freely.
- Check fluid level of the bath to be sure the pump head is covered with fluid.

4.3 Insufficient Pumping

- Check for low line voltage, especially when the heater is on.
- Hose diameter may be too small.
- Fluid viscosity may be high.

4.4 No Cooling or Insufficient Cooling

- Check the Cooling switch is ON, the cooling light should also 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 ambient temperature, such a condition may cause the refrigeration compressor to temporarily shut down.
- Check if heat is being added to the fluid in excess of the refrigeration system's capacity.

4.5 No Heating

- Check if the unit is pumping properly.
- If the heat light is not on, check the setting of the setpoint temperature and bath temperature.
- Be sure HI limit setting is higher than the setpoint.
- Check fluid level of the bath to be sure the heater is covered.

4.6 Insufficient Heating

- Check if the unit is pumping properly.
- Check for proper line voltage.
- Check for excessive external cooling load on unit. At higher temperatures, problem could be due to heat loss from tanks, hoses or vapor from the tank. Variance of heat load on the system from experiments may exceed the power handling of the unit. Changes in heat load or setpoint will require some time to settle to a stable temperature.

4.7 Triac Failure

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

4.8 Controller Default Settings

Should the need arise, use the following steps to return all settings to the factory default values.

1. Turn the Power switch ON, then unplug the power cord.
2. With the Power switch still ON, press and hold the SET/ENTER button while plugging the power cord in.
3. The controller will display "DEF" and go to the standby mode.
4. Control point and high limit settings will have to be reset. Any special tuning settings will also have to be reset. OTP is not affected by default resetting, but should be checked again.

Section 5. Service and Technical Support

If you have followed the troubleshooting steps and your circulator fails to operate properly, contact the distributor or manufacturer from whom the unit was purchased. Have the following information available for the customer service person:

- Model and Serial Number
- Voltage (from back panel label)
- Date of purchase and your purchase order number
- Suppliers' order number or invoice number
- A summary of your problem

Section 6. 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
URL: www.brookfield.com
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 7. 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.