



Instruction Sheet

Variable Speed - Outdoor Reset (00-VR) "00" Cartridge Circulator

102-141

SUPERSEDES: May 1, 2010

EFFECTIVE: October 1, 2010

Plant ID# 001-3809

The Variable Speed - Outdoor Reset "00" Cartridge Circulator (00-VR) is a microprocessor-based pump designed to regulate the supply water temperature to a heating system through variable speed injection mixing. The 00-VR modulates its speed to provide outdoor reset to the heating system. A boiler sensor installed on the return line to the boiler is used to protect the boiler against flue gas condensation.

Outdoor Reset

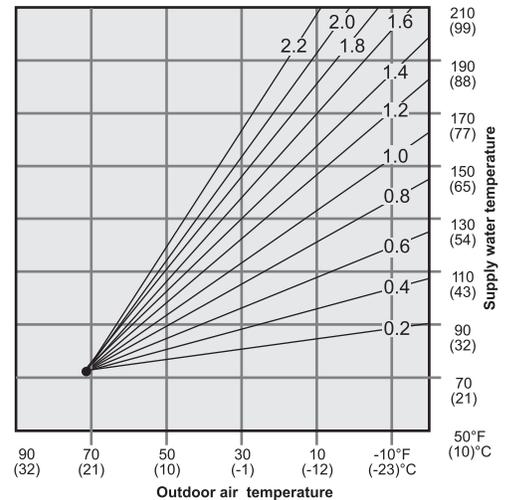
In order to properly control a hot water heating system, the heat supplied to the building must equal the heat lost by the building.

- The heat supplied to the building is directly proportional to the temperature of the water and the surface area of the heating element. The higher the temperature of the water flowing through the heating terminal, the higher the heat output.
- The heat lost from a building is dependent on the outdoor temperature. As the outdoor temperature drops, the building heat loss increases.

These two facts lead to the concept of outdoor reset which increases the supply water temperature as the outdoor temperature drops. Using this approach, the heat lost from the building is matched by the heat provided by the terminal units, therefore providing more comfort and energy savings.

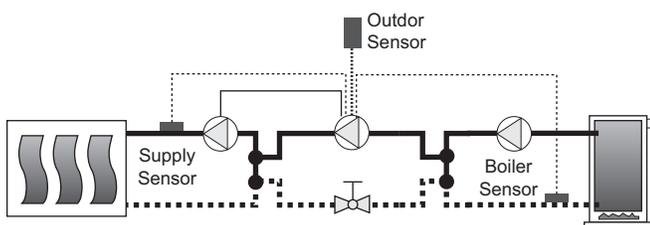
Reset Ratio

The Reset Ratio sets the relationship between outdoor temperature and supply water temperature. It determines the amount the supply water temperature is raised for every 1 degree outdoor temperature drop. For example, if a Reset Ratio of 1.2 is selected, the supply water temperature is increased by 1.2 degrees of every 1 degree of outdoor temperature drop.

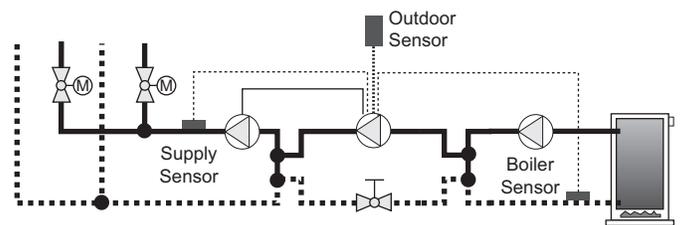


Variable Speed Injection Mixing

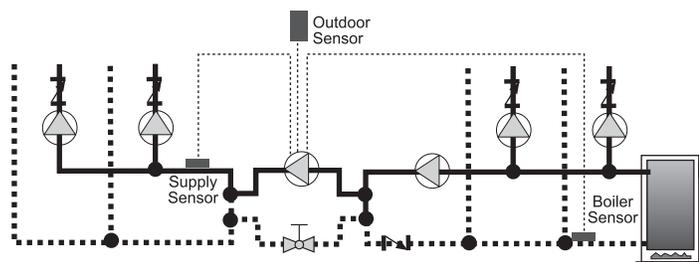
Variable Speed Injection Mixing uses a pump as a mixing device instead of a 2-way, 3-way or 4-way valve. The 00-VR operates a pump in order to inject hot water from the boiler loop into the cooler system loop. The speed of the pump is modulated in order to inject different rates of hot water into the cooler system return water. This allows for virtually any water temperature to be supplied to the heating system. Most boilers cannot operate at low temperatures, therefore the 00-VR injection pump can be modulated back in order to prevent the boiler from operating at cold temperatures.



Variable Speed Injection Mixing



Variable Speed Injection with Low Temperature Zones



Variable Speed Injection Mixing with Low and High Temperature Zones



A Taco resource – saving product

In order to properly accomplish this mixing method, the following piping details should be considered.

When the injection pump is turned off, there must be no heat transfer from the boiler loop to the system loop. In order to avoid this unwanted heat transfer, primary/secondary piping techniques are used as shown in figure 1.

This piping arrangement requires that the injection piping be at least one pipe diameter smaller than the piping of the boiler and system loops (Note 1), in order to prevent ghost flow when the injection pump is off and the system or boiler pump is on. Also, there must be at least 6 pipe diameters of straight pipe on either side of the tees (Note 2), in order to prevent the momentum of water from the boiler and system loops from pushing flow through the injection loop. Finally, there should be a minimum of 1 foot drop in the injection loop in order to create a thermal trap (Note 3) in order to prevent convective heat transfer through the injection loop.

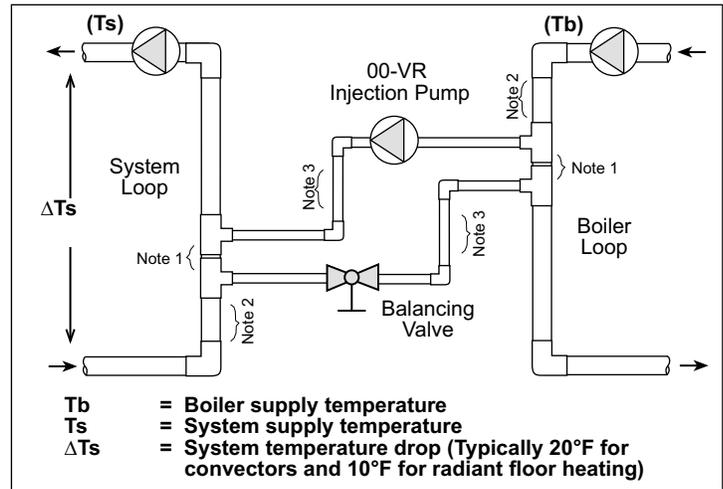


Fig. 1

Design Procedure

In order to properly size the pump, follow the design procedure below:

- 1) Determine the design operating temperatures of the system loop and boiler. (Ts and Tb from figure 1)
- 2) Determine the flow rate and design temperature drop (ΔT - Delta T) in the system loop. If one of these variables is unknown use Equation 1 or 2 to calculate the other variable.
- 3) Compute Tb - Ts. Look up the ratios in figure 2.
- 4) The design injection flow rate for direct injection is calculated from Equation 3. If the injection flow rate is greater than 40 US GPM, a 3-way or 4-way valve may be required.
- 5) Decide whether or not to include a balancing valve in the injection piping. A balancing valve allows adjustment when the injection pump is larger than needed. A balancing valve also provides the possibility of manual operation of the system by turning the injection pump fully on and adjusting the balancing valve to obtain the desired supply water temperature.
- 6) The injection piping size and model of Taco 00 pump to install can now be looked up in figure 3. Do not oversize the injection system. If the injection system is not able to provide enough heat, the boiler's aquastat may be increased.

$$\text{Eq. 1: System Flow Rate (US GPM)} = \frac{\text{Design Heating Load (BTU/hr)}}{500 \times \Delta T_s (\text{°F})} \quad \text{Eq. 2: } \Delta T (\text{°F}) = \frac{\text{Design Heating Load (BTU/hr)}}{500 \times \text{System Flow Rate (US GPM)}}$$

$$\text{Eq. 3: Design Injection Flow Rate (US GPM)} = \text{System Flow Rate (US GPM)} \times \text{Flow Ratio}$$

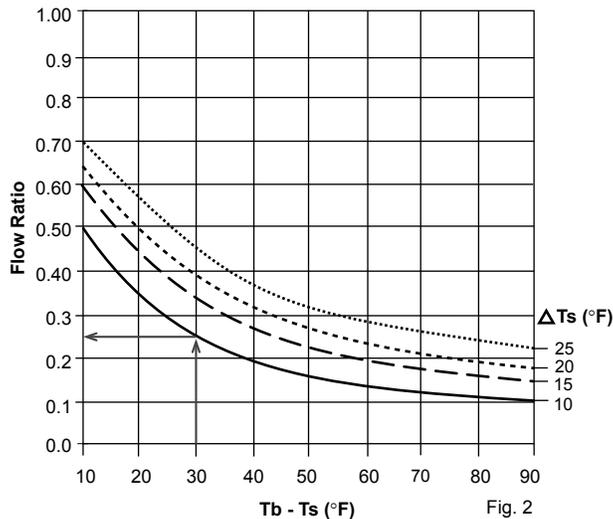


Fig. 2

Design Injection Flow Rate (US GPM)	Balancing Valve Position (% open)	Balancing Valve Cv	Nominal Pipe Diameter (inches)	TACO Pump
1.5	30	2.4	0.5	003
2	40	4.5	0.5	003
3	40	4.5	0.5	006
4	100	15	0.5	006
7	40	6.9	0.75	007
8	50	10.4	0.75	007
9	30	5.76	1	007
12	40	10.8	1	007
14	40	10.8	1	0010
16	100	36	1	0010
20	50	19.8	1.25	0010
25	50	28.8	1.5	0010
30	30	18.2	2	0012
40	40	34.2	2	0012

This table assumes there are 5 feet of pipe, 4 elbows, and 4 branch tees of the listed diameter. Balancing valve is assumed to be a ball valve. The approximate Cv value is provided in order to allow for proper balancing device. Valve characteristics may vary for the same size and type of ball valve from manufacturer to manufacturer.

Fig. 3

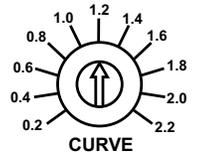
Sequence of Operation

Power Up and Heat Request

Whenever the control is powered up, the green PWR LED turns on. The 00-VR starts operating once a heat request signal is present at the Heat Request (Ht Req) terminals. A heat request signal may be provided by external end switches from zone valves or ZVC/SR Zone Controls, applying a dry contact closure or a powered 24 V (ac) signal across the Ht Req terminals. If end switches or switching relays are not available, a jumper must be installed to provide a heat request. Once a heat request is present, the HEAT REQ LED turns on.

Reset Ratio

Once a heat request is present, the control turns on the system pump (PMP) contact and operates the injection pump to provide outdoor reset at the supply sensor location. The percent output (% OUT) LED flashes at different rates based on the speed of the pump. As the % OUT LED flashes faster it indicates a faster speed of the pump. A fully on LED indicates the pump is at 100% capacity. The control targets a supply temperature based on the outdoor temperature measured and the reset ratio (Curve) dial setting. The reset ratio is set using the following formula:

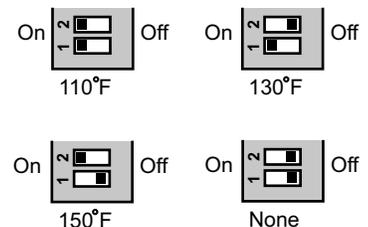


$$\text{Reset Ratio} = \frac{\text{Design Supply Temperature} - 72^{\circ}\text{F}}{72^{\circ}\text{F} - \text{Design Outdoor Temperature}}$$

Maximum System Supply Temperature (DIP switch 1 & 2)

The 00-VR has a maximum supply function used to set a maximum supply water target temperature. The maximum temperature is selected using DIP switches 1 & 2. Select the desired Maximum System Supply temperature based on the DIP switch settings shown.

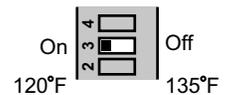
If the actual supply water temperature approaches the maximum system supply, the control reduces the speed of the injection pump and the reduced output (RED. OUT) LED is turned on. This function may be disabled by setting the DIP switches 1 & 2 to off.



Minimum Boiler Return Temperature (DIP switch 3)

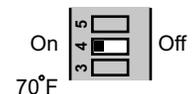
The 00-VR includes a boiler protection function which minimizes low temperatures back to the boiler. Whenever the boiler sensor is installed and a heat request is present, the 00-VR monitors the boiler return temperature and backs off the pump speed when the return temperature is near the minimum setting. The minimum setting is selected via the DIP switch 3. When the switch is turned on, the minimum temperature is set to 120°F and when the DIP is turned off the minimum is 135°F.

When using low temperature boilers such as condensing or electric, the boiler minimum temperature may be disabled by powering up the control without a boiler return sensor connected.



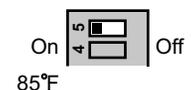
Warm Weather Shut Down (WWSD) (DIP switch 4)

When the outdoor temperature is warmer than 70°F, the 00-VR and system pump turns off and ignores any heat request. The WWSD LED turns on during warm weather shut down. This function may be turned on by setting the DIP switch 4 to the on position.



Minimum System Supply Temperature (DIP switch 5)

A minimum system supply temperature may be set on the 00-VR. This function is selectable by turning on DIP switch 5. Even though the reset ratio strategy requires a lower temperature during mild outdoor temperatures, the 00-VR will target a minimum of 85°F. This function is useful for applications such as floor warming.



System Pump

The 00-VR is capable of controlling a system pump. Whenever a heat request is present and the control is not in WWSD, the system pump contact (PMP) is turned on. The pump relay is rated for a maximum of 5 amps.

Exercising

During long periods of no operation, the 00-VR is designed to exercise itself and the system pump for 10 seconds every 3 days of no operation in order to prevent precipitate build-up in the pump. The % OUT LED turns on during the exercising function. The 00-VR and system pump outputs are exercised sequentially in order to prevent uncontrolled heat transfer to the heating system.

Pump Purge

Whenever the heat request signal is removed or the 00-VR enters WWSD, the 00-VR continues to operate for 20 seconds at the last speed used. This function increases efficiency by injecting the stand by heat from the boiler loop into the system loop.

Wiring and Sensor Installation

WARNING: Wiring connections must be made in accordance with all applicable electrical codes.

CAUTION: To prevent electrical shock, disconnect electric power to system at main fuse or circuit breaker box until installation is complete. When a service switch is installed, more than one disconnect switch may be required to deenergize this device for servicing.

Powering the Control

Insert the line voltage wires through the knockout of the enclosure and connect the live wire to the H terminal and the neutral wire to the N terminal on the PC board. Ensure that no power is present during this process.

System Pump

The 00-VR includes a 5 amp relay in order to operate the system pump. Connect one of the wires of the system pump to the PMP terminal on the control. The other wire on the system pump must be connected to the neutral (N) side of the 120 V (ac).

Heat Request

The heat request signal may be provided by jumpering the heat request (Ht Req) terminals or by applying 24 V (ac) to the Ht Req terminals. This signal may come from zone valve end switches, Taco ZVC/SR zone controls, or thermostats.

Sensors

Do not apply power to these terminals as this will damage the control. The wiring terminals for the sensors may be removed for ease of installation.

Do not run the wires parallel to telephone or power cables. If the sensor wires are located in an area with strong sources of electromagnetic interference (EMI), shielded cable or twisted pair should be used or the wires can be run in a grounded metal conduit. If using shielded cable, the shield wire should be connected to the Com terminal on the PC board and not to earth ground.

Outdoor Sensor (S1)

Remove the screw and pull the front cover off the outdoor sensor enclosure.

The sensor can either be mounted directly onto a wall or in a 2" x 4" electrical box. When the sensor is wall mounted, the wiring should enter through the back or bottom of the enclosure. Do not mount the sensor with the conduit knockout facing upwards as rain could enter the enclosure and damage the sensor.

In order to prevent heat transmitted through the wall from affecting the sensor reading, it may be necessary to install an insulating barrier behind the enclosure.

The sensor should be mounted on a wall which best represents the heat load on the building (a northern wall for most buildings and a southern facing wall for buildings with large south facing glass areas). The outdoor sensor should not be exposed to heat sources such as ventilation or window openings.

Connect 18 AWG or similar wire from the outdoor sensor directly into the Com and S1 terminals on the PC board.

Replace the front cover of the sensor enclosure.

Supply and Boiler Return Sensors

The sensors can be strapped directly to the pipe using a cable tie. Insulation should be placed around the sensor to reduce the effect of air currents on the sensor measurement.

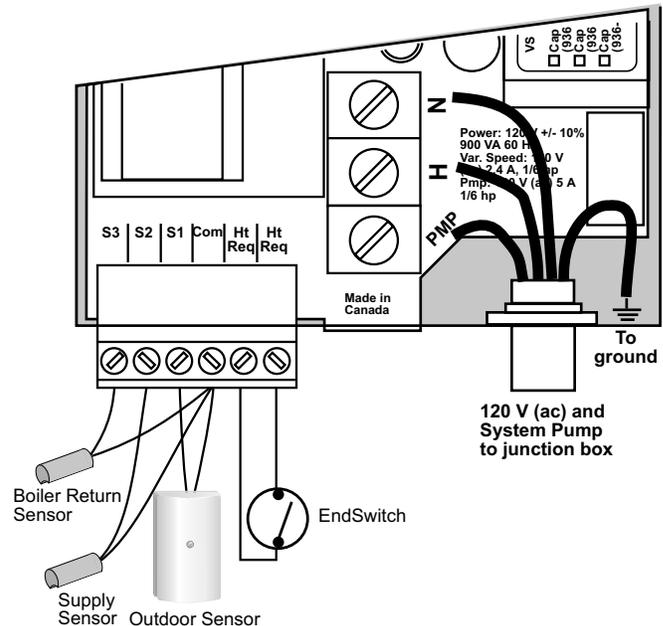
The sensors should be placed downstream of a pump or after an elbow or similar fitting. This is especially important if large diameter pipes are used because the thermal stratification within the pipe can result in erroneous sensor readings. Proper sensor location requires that the fluid is thoroughly mixed within the pipe before it reaches the sensor.

System Supply Sensor (S2)

Connect the two wires from the supply sensor directly into the Com and S2 terminals on the PC board.

Boiler Return Sensor (S3)

Connect the two wires from the boiler return sensor directly into the Com and S3 terminals on the PC board.



Troubleshooting

As in any troubleshooting procedure, it is important to isolate a problem as much as possible before proceeding. The error messages greatly simplify troubleshooting of the 00-VR. When the 00-VR flashes an error message, identify the fault and follow standard testing procedures to confirm the problem. If you suspect a wiring fault, return to the wiring section on this brochure and carefully check all external wiring and wiring connections.

For your safety and protection of permanent damage to the microprocessor, the 00-VR includes a 2.5 A 250 V (ac) field replaceable fuse.

Multi-Status LED

LED	LED Status	00-VR Status
PWR	Solid	Power On
HEAT REQ	Solid	Heat Request
WWSD	Solid	Warm Weather Shut Down
RED OUT	Solid	Reduced Output (Boiler Protection Activated)
% OUT	Flash (Solid)	Variable Speed Output (100% Speed)
HEAT REQ	Flash	Outdoor Sensor fault. The 00-VR assumes an outdoor temperature of 32°F.
WWSD	Flash	Supply Sensor Fault. If a system maximum is set (DIP 1 & 2), the 00-VR turns off, otherwise it operates at 10%.
HEAT REQ & WWSD	Flash	Boiler Sensor Fault. Boiler protection is ignored.

Adjustment of Settings

- If the outdoor temperature is cold and the building is cold, increase the Reset Ratio (Curve dial) setting by one notch per day.
- If the outdoor temperature is near the WWSD temperature and the building is cold, turn DIP switch 5 on.

Testing the Sensors

A good quality test meter capable of measuring up to 5000 k Ω (1 k Ω = 1000 Ω) is required to measure the sensor resistance. In addition to this, the actual temperature must be measured with a good quality digital thermometer.

First measure the temperature using the thermometer and then measure the resistance of the sensor at the 00-VR. The wires from the sensor must not be connected to the PC board while the test is performed. The wiring terminals are easily removed by pulling them from the PC board. Using the chart below, estimate the temperature measured by the sensor. The sensor and thermometer readings should be close. If the test meter reads a very high resistance, there may be a broken wire, a poor wiring connection or a defective sensor. If the resistance is very low, the wiring may be shorted, there may be moisture in the sensor or the sensor may be defective. To test for a defective sensor, measure the resistance directly at the sensor location.

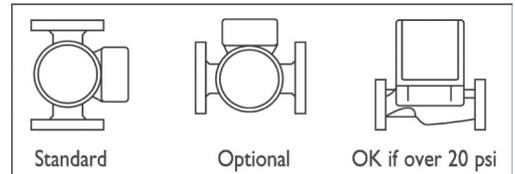
Temperature		Resistance	Temperature		Resistance	Temperature		Resistance	Temperature		Resistance
°F	°C	Ω	°F	°C	Ω	°F	°C	Ω	°F	°C	Ω
-30	-34	234,196	30	-1	34,558	90	32	7,334	150	66	2,045
-20	-29	165,180	40	4	26,099	100	38	5,828	160	71	1,689
-10	-23	118,018	50	10	19,900	110	43	4,665	170	77	1,403
0	-18	85,362	60	16	15,311	120	49	3,760	180	82	1,172
10	-12	62,465	70	21	11,883	130	54	3,050	190	88	983
20	-7	46,218	80	27	9,299	140	60	2,490	200	93	829

APPLICATION

1. Maximum operating pressure: 125 psi (862 kPa) on all "00" Series Circulators, 200 psi (1379 kPa) on all Load Match® Circulators.
2. Maximum water temperature not to exceed nameplate rating.
3. Cast iron circulators are to be used for closed loop systems. Bronze circulators are to be used for open loop, fresh water, or potable water systems.
4. Taco Cartridge circulator pumps are for indoor use only – employer uniquement a l'interieur.

INSTALLATION

1. Mounting position – Circulator must be mounted with the motor in a horizontal position. It may be mounted vertically with the motor up, provided that the system pressure is at least 20 psi (138 kPa).
2. Rotating body – Body has an arrow on the front that indicates direction of flow. To rotate body, remove the four body bolts, rotate body and replace bolts. Make sure that the junction box is NOT located underneath the circulator. (The junction box must NOT be located in the 6 o'clock position, as viewed from the motor end.)
3. Electrical connections – Observe all applicable codes when connecting to power supply. The motor is impedance protected, and does not require overload protection. The pump cannot run backwards.



- WARNING:** Do not use in swimming pool or spa areas; pump has not been investigated for this application.
- WARNING:** In the event the retaining screws have been pulled out of the housing, DO NOT replace them. Use of any other screw may short out the stator windings, creating a risk of electrical shock.
- CAUTION:** When installing electrical connections, do not apply mechanical loads to the capacitor box; otherwise, retaining screws may be pulled out of the housing, making circulator unusable.

4. Fill system with tap water – The system must be filled before operating the circulator. The bearings are water lubricated and should not be allowed to operate dry. Filling the system will result in immediate lubrication of the bearings. It is always good practice to flush a new system of foreign matter before starting the circulator.
5. Circulator operation – Operate the circulator for 5 minutes immediately after filling system to purge remaining air from the bearing chamber. This is especially important when installing the circulator during the off-season.

- CAUTION:** 1. The addition of petroleum based fluids or certain chemical additives to systems utilizing TACO equipment voids the warranty.
2. Use supply wires suitable for 90°C – ATTENTION: Employer des fils d'alimentation adequats pour 90°C.
- WARNING:** To avoid electrical shock, disconnect the power supply to the circulator and the main electrical unit.

- CAUTION:** Installations at higher elevations over 5000 feet must have higher fill pressure of 20 psi to prevent pump cavitation and flashing. Premature failure may result. Adjust expansion tank pressure to equal fill pressure. A larger size expansion tank may be required.

REPLACING CARTRIDGE ASSEMBLY

1. Disconnect the electrical supply.
2. Reduce system pressure to 0 psi and allow system to return to room temperature. Isolate the circulator by closing the service valves or draining the system.
3. Remove the body bolts and swing motor assembly away from the body.
4. Pull cartridge out of the motor housing.
5. Install replacement cartridge, making sure that the cover plate is between the cartridge flange and motor.
6. Make sure the replacement cartridge corresponds to the full circulator product number. A complete parts list is available from your local plumbing supply wholesaler.
7. Reassemble the circulator using the new gasket and bolts supplied.
8. Follow the "Installation" procedure to start up the circulator.

REPLACING INTEGRAL FLOW CHECK (IFC) ASSEMBLY (if applicable)

1. Disconnect the electrical supply.
2. Reduce system pressure to 0 psi and allow system to return to room temperature. Isolate the circulator by closing the service valves or draining the system.
3. Remove the body bolts and swing motor assembly away from the body.
4. Remove IFC, using needle nose pliers.
5. Install replacement IFC by pressing valve into casing until it is firmly seated.
6. Reassemble the circulator using the new gasket and bolts supplied.
7. Follow the "Installation" procedure to start up the circulator.

REPLACING CIRCUIT BOARD

1. Disconnect the electrical supply and all field wiring to the circuit board.
2. Unplug the 3-pin plastic connector that connects the motor to the circuit board.
3. Bend the lip of the capacitor base to ease the removal of the circuit board. Pull the circuit board up and out.
4. Reverse directions to install the new circuit board.

NOTES

LIMITED WARRANTY STATEMENT

Taco, Inc. will repair or replace without charge (at the company's option) any Taco 00 Series circulator or circulator part which is proven defective under normal use within three (3) years from the date of manufacture.

In order to obtain service under this warranty, it is the responsibility of the purchaser to promptly notify the local Taco stocking distributor or Taco in writing and promptly deliver the subject product or part, delivery prepaid, to the stocking distributor. For assistance on warranty returns, the purchaser may either contact the local Taco stocking distributor or Taco. If the subject product or part contains no defect as covered in this warranty, the purchaser will be billed for parts and labor charges in effect at time of factory examination and repair.

Any Taco product or part not installed or operated in conformity with Taco instructions or which has been subject to misuse, misapplication, the

addition of petroleum-based fluids or certain chemical additives to the systems, or other abuse, will not be covered by this warranty.

If in doubt as to whether a particular substance is suitable for use with a Taco product or part, or for any application restrictions, consult the applicable Taco instruction sheets or contact Taco at (401-942-8000).

Taco reserves the right to provide replacement products and parts which are substantially similar in design and functionally equivalent to the defective product or part. Taco reserves the right to make changes in details of design, construction, or arrangement of materials of its products without notification.

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TACO WILL NOT BE LIABLE FOR ANY SPECIAL, INCIDENTAL, INDIRECT OR CONSEQUENTIAL DAMAGES RESULTING FROM THE USE OF ITS PRODUCTS OR ANY INCIDENTAL COSTS OF REMOVING OR REPLACING DEFECTIVE PRODUCTS.

This warranty gives the purchaser specific rights, and the purchaser may have other rights which vary from state to state. Some states do not allow limitations on how long an implied warranty lasts or on the exclusion of incidental or consequential damages, so these limitations or exclusions may not apply to you.

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