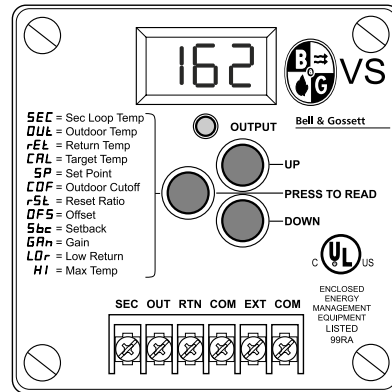




Model VS Variable Speed Pump Control

INSTALLER: PLEASE LEAVE THIS MANUAL FOR THE OWNER'S USE.



SAFETY INSTRUCTION

This safety alert symbol will be used in this manual to draw attention to safety related instructions. When used, the safety alert symbol means **ATTENTION! BECOME ALERT! YOUR SAFETY IS INVOLVED! FAILURE TO FOLLOW THESE INSTRUCTIONS MAY RESULT IN A SAFETY HAZARD.**

DESCRIPTION

The VS is a hydronic heating control. The temperature of the heating water is controlled by regulating the speed of a pump which injects water from a hot boiler loop (Primary loop) into a cooler heating loop (Secondary loop). As the speed of the pump increases, more hot water is sent into the Secondary loop, and the temperature of the heating water increases.

The VS can be used as an outdoor reset control. When the outdoor temperature falls below an adjustable start point, the heating system is activated. The temperature of the Secondary loop water is then automatically regulated based on outdoor temperature. The outdoor reset function maintains constant and comfortable ambient building temperature in all weather conditions.

The VS can also be used as a set point control. In this mode of operation, the VS will control the pump speed to hold a constant temperature (determined by the user) in the Secondary loop. The outdoor start temperature can be set to ON so the set point will be held regardless of outside temperature.

The VS is equipped with a Primary loop sensor. This sensor monitors the temperature of the boiler return water. If the boiler return water falls below an adjustable temperature, the VS can be configured to slow down the speed of the injection pump to help the boiler return water temperatures recover.

The VS can be enabled or disabled from a standard thermostat or switch, or the VS can reduce the temperature of the heating loop water when the building is not occupied or when occupants are sleeping.

OPERATIONAL LIMITS

These controls are to be used with wet rotor pumps designed to pump liquids compatible with their cast iron, bronze or stainless steel body constructions.

Electrical Rating

VS Control: 115v, 60hz, 1Ø

Injection Pump:

115v, 60hz, 1Ø

Max. Rating 1/8 HP

Permanent Split Capacitor

Secondary Loop Pump: 115v, 60hz, 1Ø or 230v, 60hz, 1Ø

Max. Rating of 8 amps

REQUIREMENTS

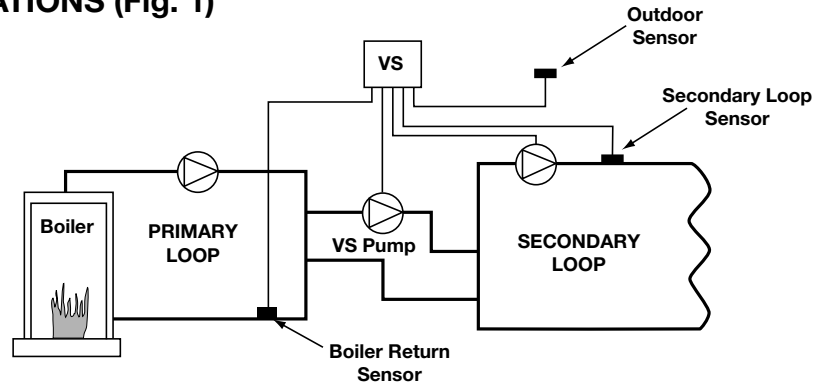
ELECTRICAL SAFETY



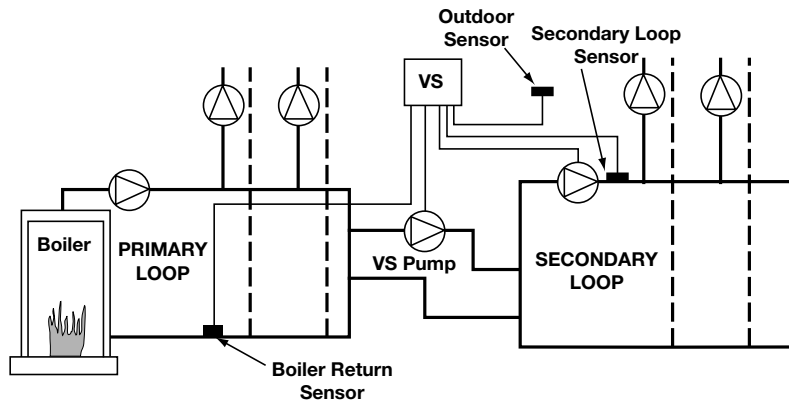
WARNING: ELECTRICAL SHOCK HAZARD

Electrical connections are to be made by a qualified electrician in accordance with all applicable codes, ordinances and good practices. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

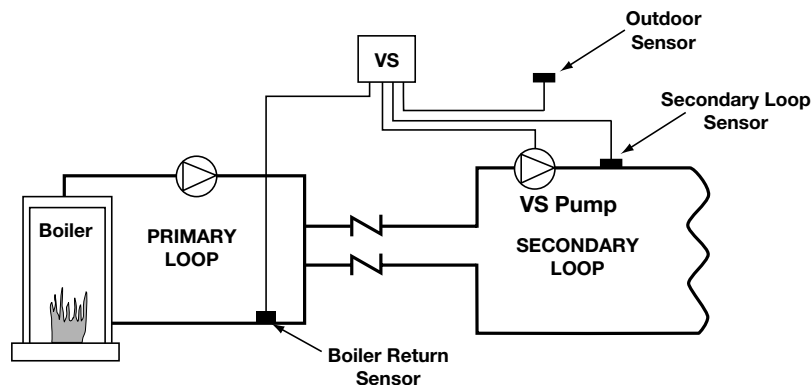
TYPICAL APPLICATIONS (Fig. 1)



Primary-Secondary Variable Speed Injection Mixing
Lower Temperature System



Primary-Secondary Variable Speed Injection Mixing
Multiple Temperature System



Primary-Secondary
Variable Load System

DESIGN SELECTION

To select the correct pump, pipe size and balance valve:

1. Determine the Primary Loop Temperature. This is the temperature the primary loop will maintain.
2. Determine the Secondary Loop Temperature. This is the design temperature of the secondary loop. If an outdoor reset function is being employed, this is the required temperature of the secondary loop under maximum load.
3. Determine the design temperature drop (ΔT or delta T) of the secondary loop. This is the design drop in temperature through the secondary loop. In most radiant heat applications, ΔT is 10. Other types of radiation such as baseboard have a higher design ΔT .

4. Determine the Maximum Injection Heat Load. This is the maximum heat requirement of the secondary loop. The maximum injection heat load is based on the injection pump running at the highest speed. As the pump speed is reduced, less heat will be delivered to the secondary loop.

5. Use the equation below to determine the design injection flow rate.

$$\text{Design Injection Flow Rate (GPM)} = \frac{\text{Maximum Injection Heat Load (BTU/hr)}}{500 (T_{\text{primary}} - T_{\text{secondary}} + \Delta T_{\text{secondary}}) (^\circ\text{F})}$$

6. Use the table below to select the appropriate pump, pipe size and balance valve.

Design Injection Flow Rate (GPM)	Injection Pipe Size	B&G Circuit Setter® Balance Valve	B&G Circuit Setter® Valve Setting	B&G Pump
1.5	1/2"	CB-1/2 / CB-1/2S	18 / 25	NRF-22
3.5	1/2"	CB-1/2 / CB-1/2S	full open / 6	NRF-22
6	3/4"	CB-3/4 / CB-3/4S	full open / 12	NRF-22
10	1"	CB-1 / CB-1S	full open / full open	NRF-22
15	1 1/4"	CB-1 1/4 / CB-1 1/4S	5 / 5	NRF-22
24	1 1/2"	CB-1 1/2	full open	NRF-33

Based on (5) feet of pipe, (4) 90° elbows, (4) tees. Correct pipe and pump size calculation for any application should be performed by a qualified engineer or contractor.

Example:

1. Primary Loop Temp: 140°F
2. Secondary Loop Temp: 100°F
3. Design temperature drop: 10°F
4. Maximum injection heat load: 150,000 BTU/hr
5. Calculate Injection flow rate

$$\text{Design Injection Flow Rate (GPM)} = \frac{150,000 \text{ (BTU/hr)}}{500 (140 - 100 + 10) (^\circ\text{F})} = \frac{150,000}{25,000} = 6 \text{ GPM}$$

6. Injection Pipe size is 3/4", full open CB-3/4 balancing valve and NRF-22

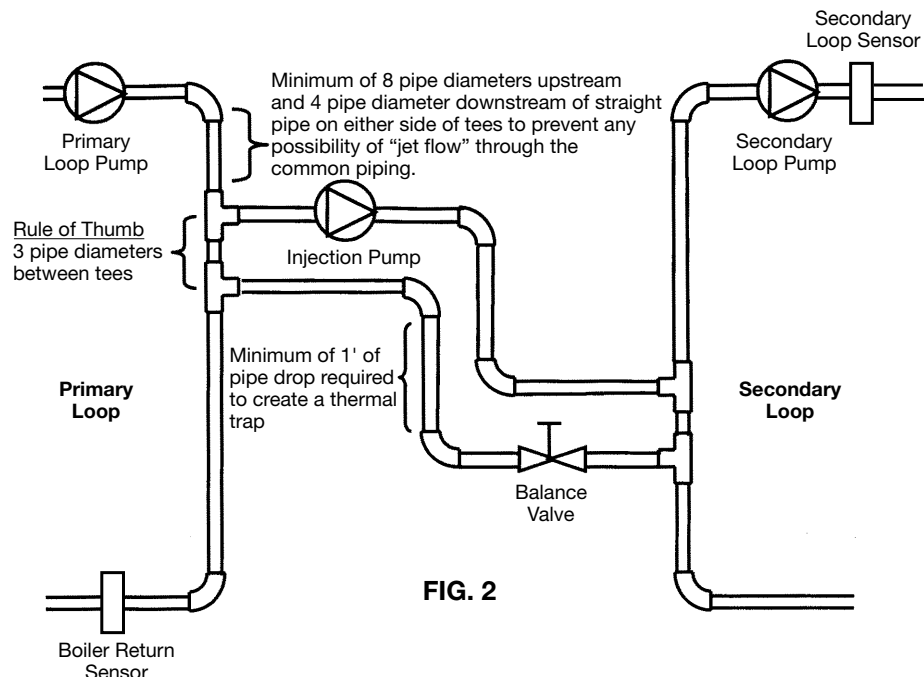


FIG. 2

PIPING

PIPING OVERVIEW

- The Primary loop may have multiple injection loops or other takeoffs. However, the piping for each injection system must meet the requirements described below.
- The Injection piping can be installed in either a horizontal or a vertical configuration.
- The pipe diameters of the Primary and Secondary loops may differ.
- The Injection Piping diameter must be at least one pipe size smaller than the smaller of the Primary and Secondary loop piping. For example, if the Primary loop diameter is 1 1/4" and the Secondary loop diameter is 1", then the diameter of the Injection piping must be 3/4" or smaller.



CAUTION: The Injection pump and pipe sizing should be performed by a qualified engineer or contractor.

- The Injection pump motor must be a fractional B&G NRF, NBF or SSF permanent split capacitor type pump. (Refer to operational limits on Page 2 for pump information.) The Injection pump will control the amount of water pumped from the Primary loop into the Secondary loop.

- A balancing valve should be installed on the injection return piping. This helps to balance the system.
- The distance between the injection tees should be as short as possible. The rule of thumb distance between the tees is 3 times the pipe diameter. For instance, if the pipe diameter is 1" then the length of straight pipe between the two injection tees should be 3".

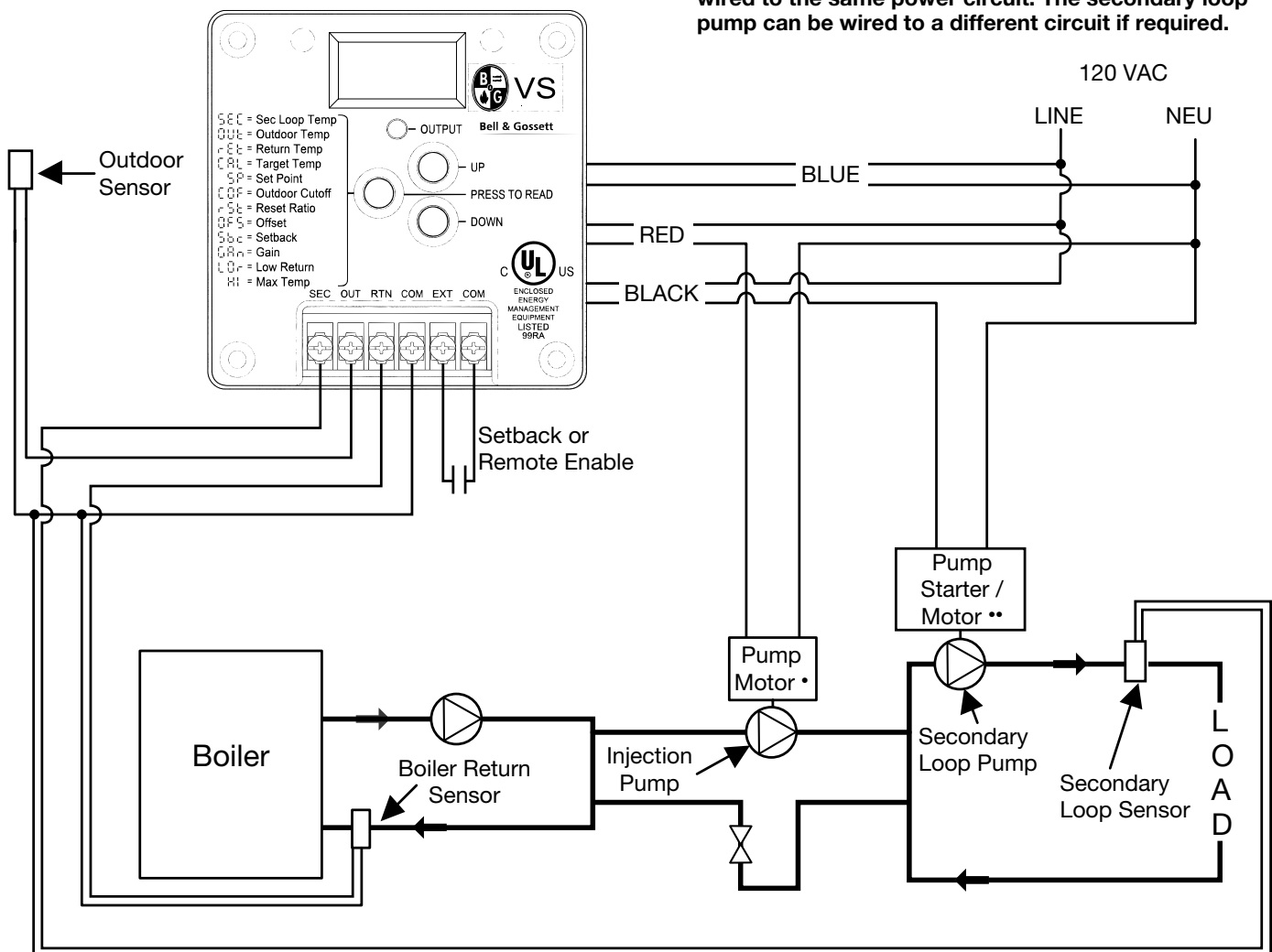
HORIZONTAL PIPING CONFIGURATION

- The Injection piping can be installed horizontally as shown in Fig. 2.
- The Injection supply piping should run horizontally from the Primary to the Secondary loop.
- On the Injection piping it is necessary to install a heat trap to prevent heat from the Primary loop entering the Secondary loop when the Injection pump is not running.
- The injection piping must drop down vertically at least 18" and then rise back up vertically at least 18".

VERTICAL PIPING CONFIGURATION

- The Injection piping can be installed vertically.
- The Primary loop must be at least 18" vertically above the Secondary loop.

VS WIRING DIAGRAM (Fig. 3)



NOTE: Injection Pump and the VS Control MUST be wired to the same power circuit. The secondary loop pump can be wired to a different circuit if required.

- Injection pump must be connected directly to 120VAC motor N.O. pump starter.
- Secondary pump starter/motor can be 115V or 230V.

CONTROL INSTALLATION



WARNING: ELECTRICAL SHOCK HAZARD

Disconnect and lock out power before making electrical connections. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

MOUNTING THE CONTROL

- The VS is designed to mount on a standard 4"x4" electrical box.
- Locate the VS in a convenient location near the variable speed pump. The VS can not be mounted more than 500' from any sensor location.
- Mount the VS away from excessive heat or cold. Ambient operating temperature is from 20° to 120°F.
- After completing all the wiring connections (see Figure 3) use the two corner screws provided to mount the VS to the electrical box.

INSTALLING THE SENSORS

- The sensor wires can be extended up to 500' from the controller. If the sensor wires are located near strong sources of electro-magnetic 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 control and not to earth ground. Do not run wires in conduit with line voltage.
- The Outdoor sensor should be mounted in the shade on the north side of the building (never in direct sunlight). Keep the sensor approximately 10' above ground level and away from doors, windows, exhaust fans, or other heat sources. Do not insulate.
- In a primary/secondary application, the secondary loop sensor should be mounted downstream of the inlet loop and before any major heating units. That will provide the control a more accurate reading (refer to Figures 1 and 2).
- If used, the boiler return water sensor should be mounted downstream of all the return loop piping and before the boiler on the primary loop. (Refer to Figures 1 and 2.)

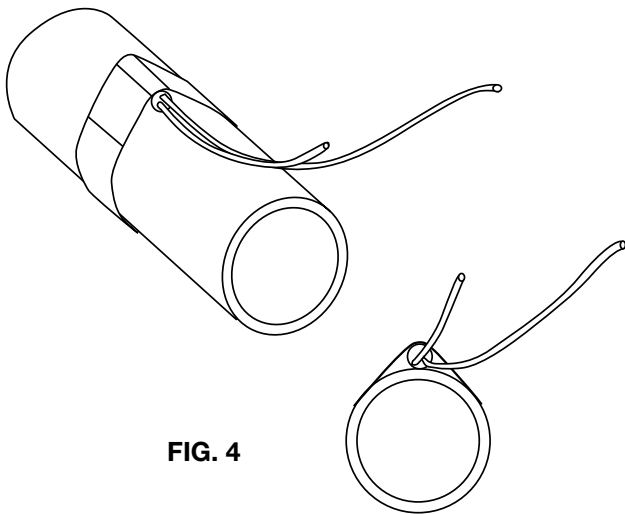


FIG. 4

- Strap the boiler return and secondary loop sensors to the pipe as shown in Figure 4.
- Wrap the pipe and sensor assembly with insulating tape to insure adequate heat transfer to the sensor.

WIRING THE SENSORS

- The sensor wires have no polarity. Either wire from a sensor can be connected to the appropriately marked VS screw terminal (see Figure 5) or the sensor common marked *COM*.
- Either or both screw terminals marked *COM* can be used as the sensor common. They are interchangeable.
- If the sensor wires have been extended, connect the shield to a *COM* terminal. Do not connect the shield at the sensor end.
- The two wires from the Secondary loop sensor must be connected to the VS front screws marked *SEC* and *COM*.
- The two wires from the Outdoor sensor must be connected to the VS front screws marked *OUT* and *COM*.
- The two wires from the Boiler return water sensor, if used, must be connected to the VS front screws marked *RTN* and *COM*. (If not using this sensor, see the NOTE in Low Return pg. 11.)

WIRING THE VS POWER

- Attach 120VAC line voltage to the two Blue wires extending from the back of the VS.
- Use wire nuts, or wrap the connections with electrical tape.
- Class 1 voltage must enter the 4" conduit box through a different opening from any Class 2 wiring.

WIRING THE INJECTION PUMP

- The injection pump MUST be wired to the same power circuit as the VS control.
- The Red wires provide a solid state switching output to the Injection pump.
- The Injection pump motor must be a fractional horsepower permanent split capacitor type motor.
- The Red wires must be directly in series with the pump power (see Figure 3). The signal can not be wired through any pilot duty relays or pump starters.
- If used, safety limit switches or HOA switches must be wired in series with the pump power.
- Use wire nuts, or wrap the connections with electrical tape.
- Class 1 voltages must enter the electrical box through a different opening from any Class 2 wiring.

WIRING THE SECONDARY LOOP PUMP

- The Black wires provide a Normally Open (N.O.) relay output for the Secondary loop pump.
- The Black wires are a dry contact output only. They do not source any power.
- Use wire nuts, or wrap the connections with electrical tape.
- Class 1 voltages must enter the electrical box through a different opening from any Class 2 wiring.
- Wire the N.O. dry contacts to the pump starter.



WARNING: This Bell & Gossett control is strictly an operating control; it should never be used as a primary limit or safety control. All equipment must have its own certified limit and safety controls required by local codes. The installer must verify proper operation and correct any safety problems prior to the installation of this Bell & Gossett control. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

WIRING THE EXT INPUT

- The *EXT* and *COM* terminals can only accept a dry contact input.



CAUTION: If power is applied across the *COM* and *EXT* terminals, the VS may be damaged.

- The control is factory supplied with a metal jumper between the *EXT* and *COM* terminals. If the control is not using a Setback or Thermostat, the jumper must be left in place and the control should be left in the default Thermostat mode. If no wiring is connected to the *EXT* and *COM* terminals, the jumper must be in place for the control to operate.
- The *EXT* Input can be configured to provide one of the following two functions:

Setback Mode

- The *EXT* Input can be used to accept an input from an external clock with a normally open switching action to lower the temperature of the Secondary loop when the building is not occupied, or when the occupants are sleeping. Remove the jumper between the *EXT* to *COM* terminals. Connect external clock to the *EXT* and *COM* terminals.
- When the *EXT* to *COM* terminals are open, the VS will run normally.
- When the *EXT* to *COM* terminals are shorted/closed the temperature of the Secondary loop will be reduced by the number of degrees of *Setback* (see pg. 11).

Thermostat Mode

- The *EXT* Input can be used to accept an input from a thermostat to activate the heating system. Remove the jumper between the *EXT* to *COM* terminals. Connect the thermostat to the *EXT* and *COM* terminals.
- When the *EXT* to *COM* terminals are open, the VS will not be active. Both pump outputs will be disabled.
- When the *EXT* to *COM* terminals are shorted/closed the VS will activate the heating system if there is a call for heat.

SETTING THE OPERATING MODES

- Whenever the VS is powered up, it will display the software version number and then the current operating modes. Each display will remain on the screen approximately 5 seconds. If the modes are correct, there is no need to make any adjustments.
- Once the modes have been set for a particular application, they will be retained in memory and will not need to be reset.
- Note that if you do change an operating mode, you will need to reset all other settings.
- An operating mode can only be changed when it is being displayed in the start-up sequence. To restart the sequence it is necessary to remove power to the VS and then power it again.

- To change a mode, hold down the center button while pushing either the UP or DOWN button to toggle between the settings. (Refer to Figure 5.)
- When the correct mode is selected, release the buttons and wait approximately 5 seconds to go the next mode.
- Set the operating modes as described in sequence below:

°F or °C – Fahrenheit or Celsius Temperature Operation

- If the display shows °F then the VS will operate in Fahrenheit degrees.
- If the display shows °C then the VS will operate in Celsius degrees.

r or S – Reset or Set Point Operation

- If the display shows *r* then the VS will run with as an outdoor reset control (see pg. 10). As it gets colder outside, the VS will automatically increase the temperature of the Secondary loop.
- If the display shows *S* then the VS will hold the selected set point temperature in the Secondary loop. To select the *Set Point*, see chart on pg. 8).

Sb or tt – Setback or Thermostat Mode

- If the display shows *Sb* then the VS will use the *EXT* Input for an external clock or switch to lower temperature of the Secondary loop. In such a case, the VS will lower secondary loop water temperature by the amount of the Setback (*Sbc*) on a short/closure between *EXT* and the *COM* terminals. When switched to an open status, the VS will go into Boost mode (increase secondary loop temperature by the Setback (*Sbc*)) for one hour.
- If the display shows *tt* then the VS will use the *EXT* Input for a thermostat. When the thermostat input is open, both pump outputs will be disabled.

no or YES – Pump Exercise every 3 idle days

- If the display shows *YES* then the VS will activate both the Secondary Loop pump and the Injection pump for 10 seconds every 3 idle days.
- If the display shows *no* then the VS will only run the pumps when the system requires it. This setting will prevent hot water from being pumped into the Secondary loop when there is no call for heat.

nrS or rS – Return Sensor

- If the display shows *nrS* (*No Return Sensor*), then the VS will not monitor the boiler return temperature.
- If the display shows *rS* (*Return Sensor*), then the VS will monitor the boiler return temperature. If the Return Temperature falls below the Low Return Temperature *LOR*, the VS will reduce the injection pump to half the current speed until the Return Temperature rises above the Minimum Return again.

SETTING THE OPERATING MODE (IN SEQUENCE)

SEQ. NO.	DISPLAY	INITIAL FACTORY SETTING (DEFAULT)	MODE DESCRIPTION
1.	1	N/A	Software Version (no changes required)
2.	°F or °C	°F	Temperature in °F or °C that the VS will operate (°F is the initial default setting)
3.	<i>r</i> or <i>s</i>	<i>r</i>	Reset or Set Point Operation. <i>r</i> will run the VS as an outdoor reset control. As outdoor temperature gets colder, the temperature in the secondary loop will automatically increase (see page 10). <i>s</i> will run the VS so that the selected set point temperature is maintained in the secondary loop. See chart on page 8 for instructions on setting the set point temperature.
4.	<i>Sb</i> or <i>tt</i>	<i>tt</i>	Setback or Thermostat. <i>tt</i> setting can be used with a thermostat, when thermostat has a call for heat (input is closed) the injection and secondary pump are allowed to operate. When thermostat is satisfied (input is open), the pumps will not operate (turn off). <i>ss</i> is used with an external NO timer or clock. When input is closed, the temperature of the secondary loop will decrease by the amount of the setback (<i>Sbc</i>). When input is open, the VS will go into Boost mode for 60 minutes. After 60 minutes, the VS will return the secondary loop to the set point temperature.
5.	<i>na</i> or <i>YES</i>	<i>YES</i>	Pump Exercise. <i>YES</i> will activate both pumps for 10 seconds every 3 idle days <i>na</i> , the pumps will only run when the system requires them to operate.
6.	<i>nrS</i> or <i>rS</i>	<i>nrS</i>	Boiler Return Sensor for Boiler Protection. <i>nrS</i> setting will not monitor the return water temperature to the boiler. <i>rS</i> setting will monitor the boiler return water temperature. If the return water drops below the Low Return Temperature (<i>LDr</i>) setting, the speed of the injection pump will be reduced by half the current speed until the Return Temperature rises above the Minimum Return Temperature.

INITIAL SETTINGS FOR A RESET CONTROL

(see *r* on pg. 6)

- After setting the operating mode, the VS will display the temperature of the Secondary loop. This is the default display.
- To see and/or adjust the other parameters, press then release the center button marked *PRESS TO READ*. The VS will display a code to indicate which parameter will be displayed next. After two seconds, the value of the parameter will be shown.
- For those parameters where the values can be set (shown on chart pg. 8), press the *UP* or *DOWN* button to change the value while it is being displayed. Holding the *UP* or *DOWN* button will cause the value to change more quickly.
- The *Outdoor Cutoff (COF)*, also known as warm weather shut down, temperature setting is the outdoor temperature above which the VS will not give heat. The factory default setting is 60°F.
- The *Reset Ratio (rSt)* determines how quickly the water temperature in the Secondary loop will increase as the outdoor temperature decreases (see Figure 6). Lower numbered curves result in lower water temperatures. The factory default curve is 7 or (1:1). This means for every degree the outdoor temperature falls (below the *System Start* temperature) the Secondary loop temperature will be increased by one degree. For baseboard heat, start with 7. For most radiant tubing applications, start with 4 and an offset of -10 (see page 10).
- The *Offset (DFS)* value is added or subtracted to the calculated water temperature for the Secondary loop. It effectively moves the starting point of the reset curves up and down by the number of degrees selected (see pg. 10). Start with the factory default setting of 0.
- The *Low Return (LDr)* comes factory set to *OFF*. This is the correct setting if you are not using the Boiler return water sensor. If you do use the Boiler return sensor for boiler protection, then the setting must be set to the boiler manufacturer's specification.
- The *High Supply (HI)* value must be adjusted to the maximum temperature value specified for the Secondary loop components.

- The *Setback (Sbc)* value determines how many degrees the Secondary loop temperature will be decreased when the *EXT* Input in the Setback mode (see pg. 11) is shorted. Start with the factory default setting of 10°F. In order to adjust the setback value, *Sb* has to be selected in the initial operating mode sequence. If *tt* is selected, the setback *Sbc* will be *OFF*.

INITIAL SETTINGS FOR A SET POINT CONTROL

(see *S* on pg. 6)

- After setting the operating mode, the VS will display the temperature of the Secondary loop. This is the default value for the VS display.
- To see and/or adjust the other parameters, press then release the center button marked *PRESS TO READ*. The VS will display a code to indicate which parameter will be displayed next. After two seconds, the value of the parameter will be shown.
- For those parameters where the values can be set (shown on chart pg. 8), press the *UP* or *DOWN* button to change the value while it is being displayed. Holding the *UP* or *DOWN* button will cause the value to change more quickly.
- The *Outdoor Cutoff (COF)*, also known as warm weather shut down, temperature setting is the outdoor temperature above which the VS will not give heat. Set to *ON* if the system set point should be held regardless of outside temperature. The factory default setting is 60°F.
- The *Low Return (LDr)* comes factory set to *OFF*. This is the correct setting if you are not using the Boiler return water sensor. If you do use the Boiler return sensor for boiler protection, then the setting must be set to the boiler manufacturer's specification.
- The *Set Point (SP)* should be set to the desired temperature for the Secondary loop.
- The *Setback (Sbc)* value determines how many degrees the Secondary loop temperature will be decreased when the *EXT* Input in the Setback mode (see pg. 11) is shorted. Start with the factory default setting of 10°F. In order to adjust the setback value, *Sb* has to be selected in the initial operating mode sequence. If *tt* is selected, the setback *Sbc* will be *OFF*.

DISPLAY VALUES and ADJUSTMENTS

Press SELECT Button	DISPLAY	Press and hold either the UP or DOWN button to adjust
Once	<i>OUT</i> Outdoor Temp ♦	This is the temperature of the outdoor sensor. If it does not read correctly, check the Troubleshooting guide.
Twice ♦♦♦	<i>ret</i> Return Temp ♦	This is the temperature of the water returning to the boiler. If this sensor is not installed it will display <i>OPn</i> . If the sensor is installed and does not read correctly, check the Troubleshooting guide. Available only when the Return Sensor (<i>r5</i>) is selected from the Startup menu.
3 Times	<i>SP</i> Set Point	This is the Set Point the Secondary Loop is to maintain. Available only when the Set Point (<i>S</i>) is selected from the Startup menu. It is adjustable from 100°F to 180°F with a default value of 120°F.
3 Times ♦♦	<i>CAL</i> Calculated Temp ♦	This is the Set Point temperature calculated using the Outdoor Reset logic. Available only when Reset (<i>r</i>) is selected from the Startup menu.
4 Times	<i>COF</i> Outdoor Cutoff (warm weather) shut down)	This is the outdoor temperature below which the VS will activate the Secondary loop pump and control the variable speed pump. If the ON setting is selected, the VS will activate or control both pumps regardless of outdoor temperature. If the OFF setting is selected, the VS will never activate either pump. It is adjustable from 40° to 100°F with a default value of 60°F.
5 Times ♦♦	<i>rSt</i> Reset Ratio	The higher the curve number selected, the faster the temperature of the Secondary loop will be increased as outdoor temperature decreases. Available only when Reset (<i>r</i>) is selected from the Startup menu. (For Reset Curves see Figure 6.) It is adjustable from 1 to 12 with a default value of 7.
6 Times ♦♦	<i>OFFS</i> Offset	The Offset will adjust the calculated Secondary loop temperature (determined by the outdoor temperature, Reset Ratio and Setback) by the amount displayed. Available only when Reset (<i>r</i>) is selected from the Startup menu. Adjustable ±40°F.
7 Times	<i>Sbc</i> Setback	This is the number of degrees the Secondary loop water temperature will be lowered if the VC is put into Setback. In addition, this amount will be added to the Secondary loop water temperature when control is in Boost (switching from Setback to normal operation) for a full hour. It is adjustable from 0 to 30 with a default value of 10.
8 Times	<i>GRn</i> Gain	The Gain controls how aggressively the VS will change the pump speed when the Secondary loop temperature is away from the Calculated Temp or the Set Point. It is adjustable from -10 to +10 with a default value of 0.
9 Times ♦♦♦	<i>LOR</i> Low/Min Return	With Return Water Sensor: Set to the boiler manufacturer's specification for minimum boiler return temperature. It is adjustable from 70° to 170°F with a default value of 70°F.
10 Times ♦♦	<i>HI</i> Hi Supply Temp	This is the highest Secondary loop water temperature the VS will maintain. Available only when Reset (<i>r</i>) is selected from the Startup menu. It is adjustable from 100°F to 200°F with a default value of 160°F. IMPORTANT: The VS is not a safety control. All appropriate safety controls must be installed.
11 Times Default ♦♦	<i>SEC</i> 2nd Loop Temp ♦	This is the temperature reading of the Secondary loop sensor. If it does not read correctly, check the Troubleshooting guide.

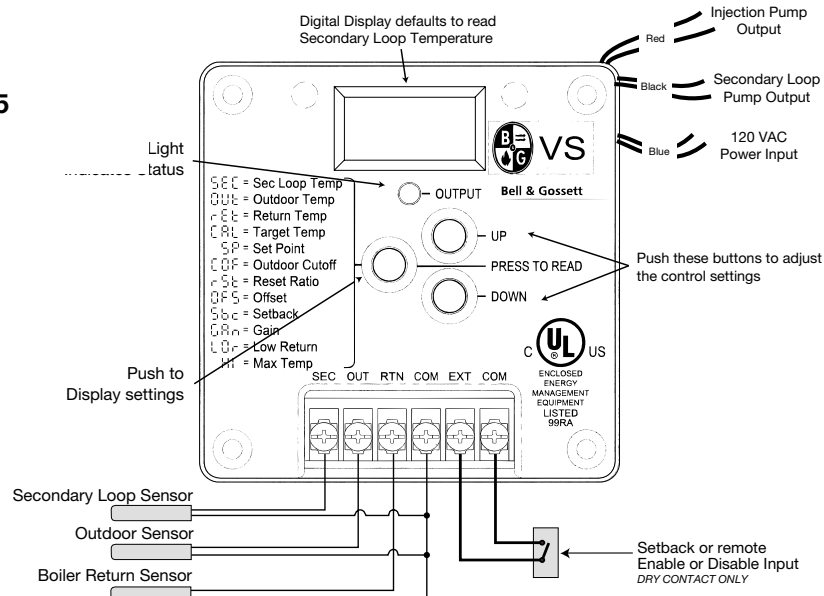
♦ These are sensor readings. They can not be adjusted.

♦♦ The display of each setting will remain active for approximately 20 seconds after the last adjustment. Then the display will revert to the default reading.

♦♦♦ These options are available with Reset Mode only. Select *r* from Startup menu.

♦♦♦♦ These options are available with Return Sensor Mode only. Select *r5* from Startup menu.

FIG. 5



OPERATION

OUTPUT LIGHT

The output light has the following three indications:

Light Off

- The heating system is not active. Neither the Secondary loop pump nor the Injection pump output are active.

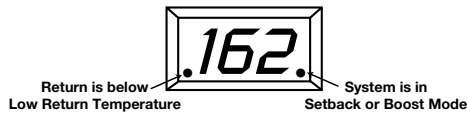
Light On

- The heating source output is active. The Secondary loop pump relay is energized, and the speed of the Injection pump is being controlled.

Flashing

- The Secondary loop pump relay is energized to circulate the water through the loop. The Injection pump output is not active. This would occur when there is a call for heat, but the temperature of the Secondary loop is satisfied so none of the hot water from the Primary loop is needed in the Secondary loop.

DEFAULT DISPLAY INDICATORS



The Display when not used will display the temperature of the secondary loop. The display has the following indications:

Right Decimal Point Light

- Decimal point indicator located on the right hand side of the right most digit of the LED display in the default display mode will light to indicate the system is in the Setback/Boost mode.

Left Decimal Point Light

- Decimal point indicator located on the left hand side of the left most digit of the LED display in the default display mode will light to indicate the Return is below the Low Return Temperature.

OUTDOOR CUTOFF (Warm Weather Shut Down)

The Outdoor Cutoff (*CDF*) is the outdoor temperature below which the Secondary loop pump will be activated to circulate water through the loop and the Injection pump speed will be regulated to control the temperature of the Secondary loop water. When the outdoor temperature rises above this point, the Secondary Pump relay (BLACK wires) and the Injection pump output (RED wires) will be off. The Outdoor Cutoff (*CDF*) is adjustable from 40°F to 100°F with a default of 60°F. The Outdoor Cutoff (*CDF*) also has two special modes:

OFF

- When the Outdoor Cutoff (*CDF*) is set to OFF, neither the Secondary loop pump nor the Injection pump will run. This can be used for testing or to disable heat to the particular loop. Do not use this feature to turn off pumps for maintenance. For this, use the safety disconnect.

ON

- When the Outdoor Cutoff (*CDF*) is set to ON, the Secondary loop pump will run regardless of outdoor temperature. The Injection pump speed will be regulated to control the temperature of the Secondary loop water temperature. Follow the chart on pg. 8 to adjust the Outdoor Cutoff (*CDF*).

RESET OPERATION

Reset Ratio (rSt)

- The Reset Ratio (rSt) determines how the Secondary loop water temperature will vary with outside temperature. With any ratio, the colder it is outside, the hotter the temperature of the Secondary loop. At a 1:1 reset ratio (Curve 7) a 1 degree drop in outdoor temperature will increase the Secondary loop temperature by 1 degree; at the 3:1 ratio (Curve 3) an outdoor temperature drop of 3 degrees will increase the Secondary loop temperature by 1 degree.
- The ratios are adjustable from 8:1 (Curve 1) for the least amount of heat to a 1:4 (Curve 12) for the most amount of heat (see side chart). With most baseboard heating applications, a 1:1 (Curve 7) setting is a good place to start. Radiant heat applications usually require a lower curve.
- Adjust the *Reset Ratio* (rSt) in cold weather. If the ambient space temperatures are too cold in cold weather, increase the curve number by one. If the space temperatures are too warm, decrease the curve number by one. After making a change to the ratio, wait 24 hours to evaluate the impact of the change. See chart on pg. 8 to adjust the *Reset Ratio* (rSt).

Offset (DFS)

- The Offset (DFS) allows you to adjust the starting points of the *Reset Ratio* (rSt) curves (see side charts). When the Offset (DFS) is changed, that change is always directly added or subtracted to the calculated water temperature. For instance, if the calculated Secondary loop water temperature were 130°F and the Offset (DFS) were changed from 0° to 10° (an increase of 10°), then the calculated water temperature would immediately change to 140°F.
- Adjust the Offset (DFS) in mild weather. If the ambient space temperatures are warm in mild weather, decrease the Offset (DFS). If the space temperatures are cold in the mild weather, increase the Offset (DFS). The rule of thumb for baseboard radiation is to change the Offset (DFS) by 1° or 2° for every degree you wish to change the space temperature. See chart on pg. 8 to adjust the Offset (DFS).

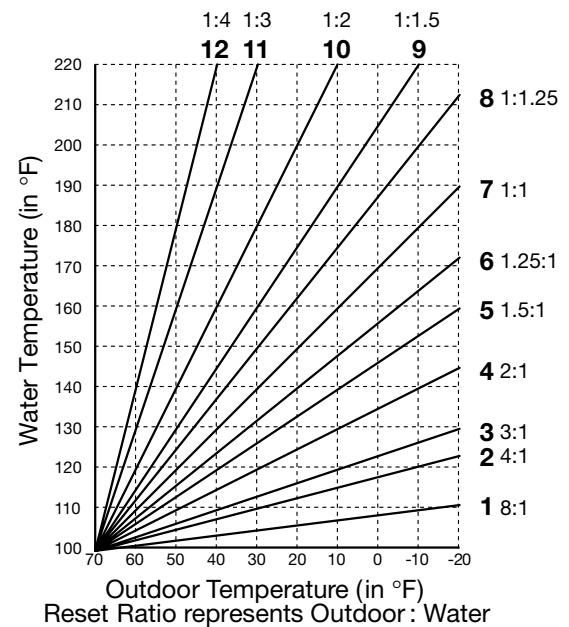
Hi Supply Temperature (HI)

- The Hi Supply (HI) setting is the maximum Secondary loop temperature the VS will maintain. In some applications, it may be necessary to limit the temperature of the water going out to the Secondary loop. This may be done for comfort or because the Secondary loop components or flooring may be damaged by high temperatures.
- The Hi Supply (HI) should never be set higher than the maximum value specified by either the Secondary loop component or the flooring manufacturer. Adjust the Hi Supply (HI) as shown in the chart on pg. 8.

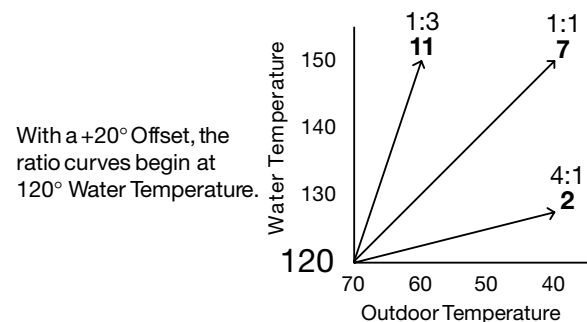
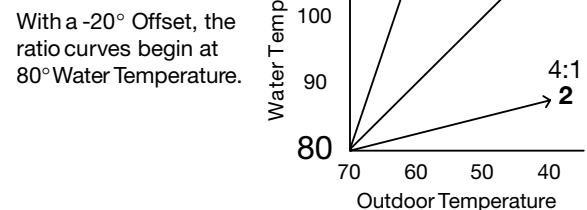
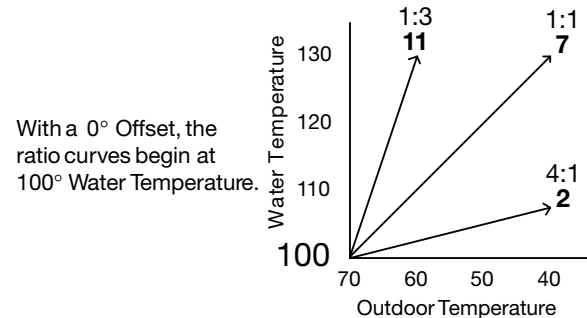
SET POINT OPERATION

Set Point (SP)

- The Set Point (SP) setting is the Secondary loop temperature the VS will maintain whenever there is a call for heat.
- The Set Point (SP) should never be set higher than the maximum value specified by either the Secondary loop component or the flooring manufacturer. Adjust the Set Point (SP) as shown in the chart on pg. 8.



Reset Ratio Curves (Fig. 6)



Setback and Boost (*Sbc*)

- The Setback (*Sbc*) setting has no effect if the VS is in Thermostat mode (see pg. 6).
- When the VS is initialized to run in the Setback mode, the *EXT* Input can be connected to an external clock or switch (see Fig. 5). When the *EXT* to *CDM* terminals are shorted/closed, the VS will switch to Setback mode and reduce the temperature of the Secondary loop by the number of degrees selected. The VS switches from Setback mode back to Boost mode when the *EXT* to *CDM* terminals are opened. In the Boost mode, the VS will increase the secondary loop temperature by the number of degrees selected in the setback for a period of one hour to allow faster heat recovery to the zone.

Example: If the calculated Secondary water temperature is 130°F and the Setback (*Sbc*) is set to 10°F, when the *EXT* Input is shorted/closed, the calculated water temperature would immediately change to 120°F. When the *EXT* input is opened, the VS will go into boost mode and the calculated water temperature would immediately change to 140°F for a period of one hour. After the one hour of operation, the calculated water temperature will return to the standard operating mode of 130°F.

- The rule of thumb for adjusting the Setback (*Sbc*) with baseboard radiation is to decrease the water temperature 4° for each degree you wish to lower the ambient space temperatures. Therefore, if you wish the space temperatures to be 5° colder at night or when the building is not occupied, adjust the Setback (*Sbc*) to 20°. With radiant heat, adjust the Setback (*Sbc*) only 1 or 2 degrees for each degree you wish to lower the space temperature.

OPERATION SETTINGS

Gain (*GAn*)

- The Gain (*GAn*) controls how aggressive the VS will change the injection pump's speed.
- A higher Gain (*GAn*) setting will generate larger changes. A lower Gain (*GAn*) setting will generate smaller changes.
- If the system tends to stay below the set point, increase the gain. If the system overshoots and undershoots the set point rapidly, decrease the gain.

Low Return (*LDr*) Available with Return Sensor Mode only (Startup menu *r* option)

- The Low Return (*LDr*) setting is designed to help speed recovery in the event of low boiler return water temperatures. The boiler manufacturer may require a minimum return water temperature to protect the boiler. Check with the boiler manufacturer for the specified temperature.
- If the VS registers that the temperature of the water returning to the boiler is below the Low Return (*LDr*), the VS will immediately reduce the Injection pump speed by half and not allow the speed to increase again until the return temperature rises to the Low Return (*LDr*) setting. This means that the VS will decrease the load on the Primary loop, but will still provide some heat to the Secondary loop.

NOTE: If a minimum return water temperature is not specified by the boiler manufacturer, or if the Secondary loop size is such that it will have little impact on the Primary loop temperature, the Boiler Return sensor (see Figure 2) may not be installed. If the return sensor is not connected, the control will ignore the *LDr* setting and no error will be displayed.



WARNING: This Bell & Gossett control is strictly an operating control; it should never be used as a primary limit or safety control. All equipment must have its own certified limit and safety controls required by local codes. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

TROUBLESHOOTING

No Display:

Check the 120VAC power into the Blue input wires. If power is present, turn the power to the VS off and then back on.

Display shows or flashes *OPn* or *SHt*:

Follow the procedure for Sensors on next page.

OUTPUT light is OFF when heat is required:

Check the Outdoor Cutoff (*COF*) setting (see pg. 9). If the outdoor temperature sensor reading is above the setting, the VS will not give heat. Also check if the VS is in the Thermostat (*tt*) mode (see pg. 6). In the Thermostat (*tt*) mode, the VS will never give heat if terminals *EXT* and *CDM* are not shorted together.

OUTPUT light is FLASHING when heat is required:

The Output light flashes when the Secondary loop pump is on but the Injection pump is off. This will occur when the VS is satisfied with the temperature of the Secondary loop. See Insufficient Heat conditions below.

OUTPUT light is FLASHING or ON but Secondary loop pump is not running:

Turn off the power to the Secondary loop pump. The VS power must remain connected. Then disconnect all wires attached to the VS Black wires. Test for continuity across the Black wires. If the wires are continuous, the VS is working properly. Check the Secondary loop pump and its power.

OUTPUT light is ON but Injection pump is not running:

If the Output light is on, the Injection pump should be running. However, if it is running at a very low speed, it may be hard to detect. It is possible to test the Injection pump output with a



WARNING: This test can only be performed with the Injection Pump power connected. This test should only be performed by a qualified electrician or electrical contractor. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

voltmeter which can read at least 120VAC.

Place the leads of the voltmeter across the power inputs of the Injection pump. At the highest speed, the AC Volt reading will be approximately 120VAC. As the speed is decreased, the reading will decrease. At the lower speeds, the reading may fluctuate by several Volts. This is considered to be normal.

OUTPUT light is OFF or FLASHING but Injection pump is running:

When the Output light is off or flashing, the Injection pump should not be running. Check the wiring to see if any other control, a HOA switch, or other switch input is causing the pump to run. Turn the power off to the VS. If the Injection pump continues to run, the VS is not the cause of the pump running.

Insufficient Heat when the OUTPUT light is ON

(Reset Operation):

Check all the settings. If the Boiler Return (*rtn*) sensor reading is below the Low Return (*LDr*) setting the VS will halve the speed of the Injection pump until the boiler return temperatures recover. The temperature of the Secondary loop will never exceed the High Supply (*HI*) setting for any prolonged period of time. Check that the High Supply (*HI*) is not set too low. Check if the VS is in Setback and therefore running lower water temperatures. If none of these conditions are causing insufficient heat, then adjust the Reset Ratio (*rSt*) or Offset (*DFS*) (see pg. 10).

Insufficient Heat when the OUTPUT light is ON

(Set Point Operation):

Check all settings. If the Boiler Return (*rtn*) sensor reading is below the Low Return (*LDr*) setting (see above) the VS will halve the speed of the Injection pump until the boiler return temperatures recover. Check if the VS is in Setback and therefore running lower water temperatures. If neither of these conditions are causing insufficient heat, then increase the Gain (*GA*) (see pg. 11).

SENSORS

Each of the three VS sensors are interchangeable and can be tested in the same way. If the Secondary loop sensor is open or shorted, the main display will show *OPn* or *SHt*. If either the Outdoor or the Boiler Return sensor is open or shorted, the display will first flash the code for the sensor (either *SEC* or *rtn*) and then flash *OPn* or *SHt*. To test the sensor, remove the pair of sensor wires connected to the VS terminals. Take a resistance reading across the detached wires going to the sensor. If the reading shows:

OPEN *OPn* or a resistance greater than 100,000Ω: Check the wires going to the sensor. They may have been broken or become disconnected. If the wires are fine, check the resistance at the sensor itself. If the value is still open, the sensor has been damaged and needs to be replaced.

SHORT *SHt* or a resistance less than 100Ω: Check the wires going to the sensor. They may have become shorted together in the run of the wire. If not, check the resistance at the sensor itself. If there still is no resistance, the sensor has been damaged and needs to be replaced.

Resistances from 200Ω to 100,000Ω: Find the temperature that corresponds to the resistance value on the chart. If the sensor appears to be outputting correctly, check that the wires were properly connected to the VS. If they were, the VS may have been damaged. If the sensor is not outputting correctly, take another reading at the sensor itself. If this is correct, the problem is in the wiring between the sensor and the VS. Otherwise, the sensor has been damaged, and should be replaced.



WARNING: The VS is an operating control only. The boiler must have all safety and limit controls required by code. It is the responsibility of the installer to verify that all the safety and limits are working properly before and after the VS is installed. Failure to follow these instructions could result in serious personal injury, death and/or property damage.

PERIODIC INSPECTION

Bell & Gossett products are designed to provide years of trouble free service. It is recommended that periodic inspections be made to check for potential problems with the pump and control. If any leakage or evidence of leakage is present, repair or replace the unit.

TEMPERATURE SENSOR CHART

TEMPERATURE (in Degrees °F)	Value (in Ohms)
-30	117720
-20	82823
-10	59076
0	42683
10	31215
20	23089
25	19939
30	17264
35	14985
40	13040
45	11374
50	9944
55	8714
60	7653
70	5941
80	4649
90	3667
100	2914
110	2332
120	1879
130	1524
140	1243
150	1021
160	842
170	699
180	583
190	489
200	412
210	349
220	297
230	253
240	217
250	187

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