INSTALLATION AND OPERATION MANUAL
DIGITAL DIAGNOSTIC CONTROLLER

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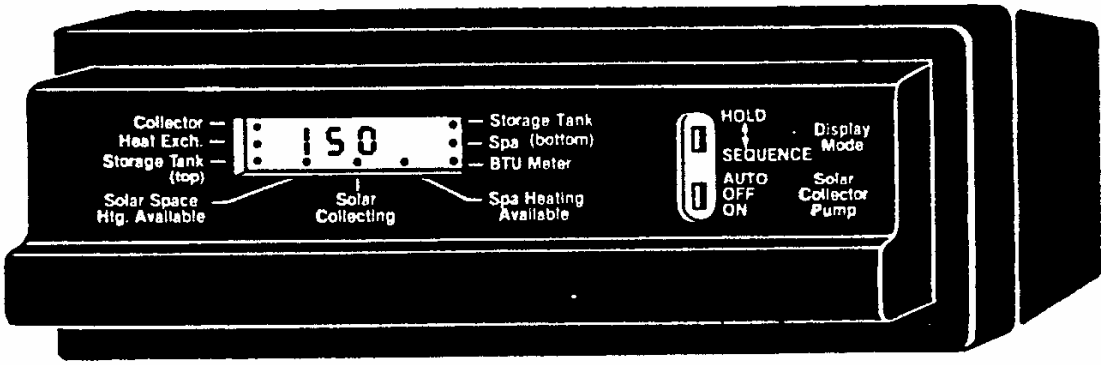
INSTALLATION AND OPERATION MANUAL

DIGITAL DIAGNOSTIC SOLAR CONTROLLER

This manual is presented in two parts: 1) Installation; and 2) Operation. Installation of the digital solar controller requires some technical knowledge of electrical wiring and how a system works. However, there should be sufficient information presented for the novice to install this controller successfully. The second section on operation describes what the controller does and how it does it. If the digital controller has already been installed, only the operation section needs to be reviewed. However, this should not preclude your reviewing the first section on installation, since it will help you to better understand the solar system and its control.

WESTERN is pleased to provide you with this product, and we hope that you are pleased with it. If you have any questions or comments please contact us.



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1. INSTALLATION

a. Mounting

The Digital Diagnostic Controller (DDC) can be mounted either next to the solar circulating pump or remotely, in another area. The first method is the most cost efficient, due to wiring costs. Mounting the DDC in another area of the house requires running all control wiring and solar pump power wiring to remote locations, often through walls. Western recommends that the DDC be located next to the solar pump for simplicity.

Two support brackets are supplied with the DDC. Mount the brackets to the DDC as shown in Figure 1. Then mount the brackets to the supporting surface.

b. Power Wiring

Pull 110-120 VAC 60 HZ single-phase power to the DDC controller, observing all national and local electrical codes. Use a dedicated power line if required by local codes. Install a 6 1/4 amp fusestat switch near the DDC as shown in Figure 2. A power switch must be installed, since the DDC does not have one. Install appropriate electrical wire strain reliefs (for example, 90 degree conduit elbows) into the power wiring cutouts. Connect line power (110-120 VAC) and circulating pump(s) as shown in Figure 3. Leave power to DDC off.

c. Temperature Sensor Placement

NOTE: The DDC must be used with 10K thermistors (temperature sensors) only. There are two types: temperature sensor in immersion well, or strap-on temperature sensor.

Install thermistors (temperature sensors) into the system, as shown in Figure 4. For solar systems which use a heat exchanger in the solar collecting loop, all DDC units have four basic thermistor inputs: 1) collector output; 2) heat exchanger output; 3) top of solar storage tank; and 4) bottom of solar storage tank. For direct solar systems using stored water as the collector heat transfer fluid without a heat exchanger in the solar collecting loop, the heat exchange output temperature sensor and bottom of storage tank temperature are the same. Connect temperature sensor wires to DDC as shown in Figure 3. INSULATE ALL SENSORS. Resistance (ohms)-temperature characteristics are shown in Figure A1 (Appendix).

FIGURE 1: DIGITAL DIAGNOSTIC CONTROLLER - MOUNTING

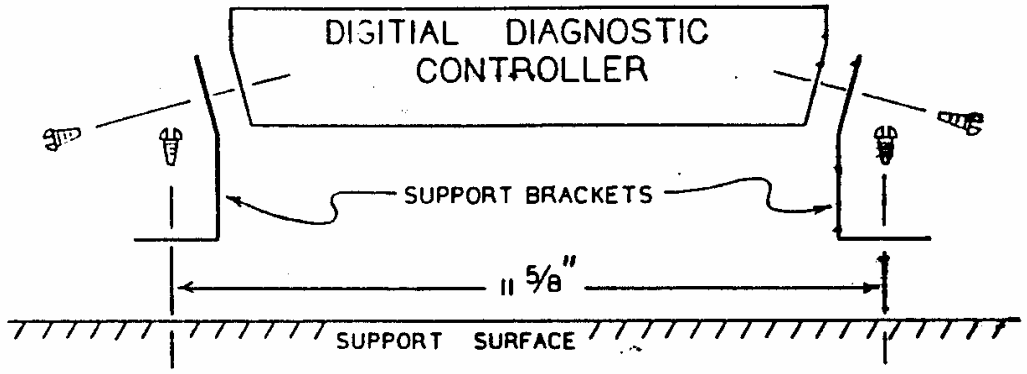


FIGURE 2: GENERAL POWER WIRING

Low Voltage Wiring
(28 VAC max)

High Voltage Wiring
(110-120 VAC)

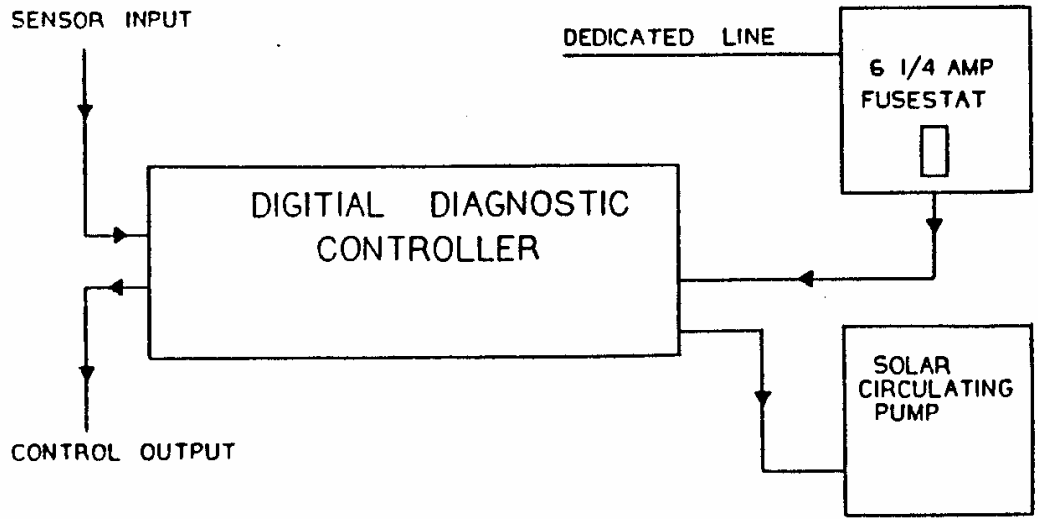
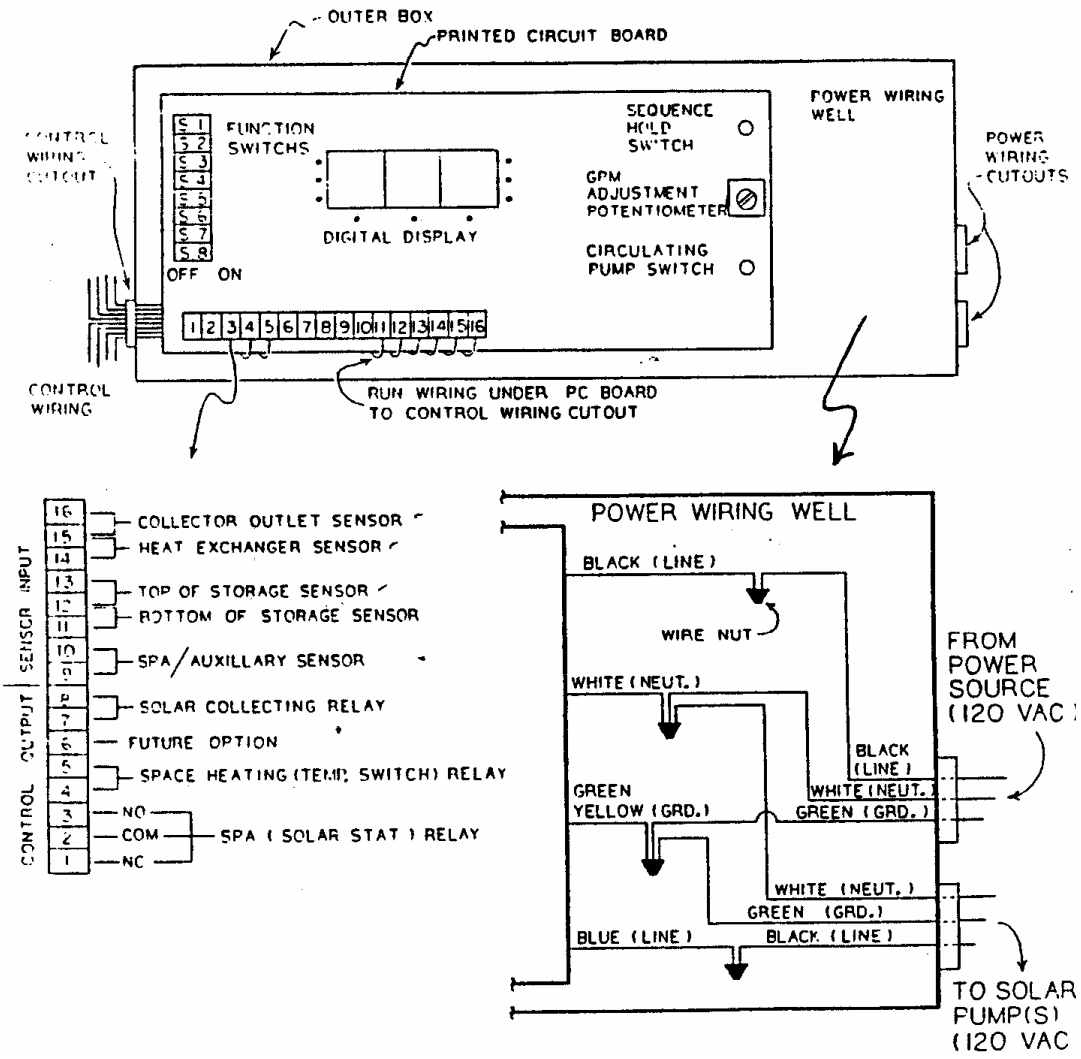


FIGURE 3: DIGITAL DIAGNOSTIC CONTROLLER (face plate removed)

Power, Control and Temperature Sensor Wiring



Run all control and sensor wiring through the control wiring cutout, under the PC board to the 16 position terminal strip.

Connect spa/auxiliary temperature sensor wires (optional) to DDC, as shown in Figure 3. If the DDC has the spa option, then install a thermistor (temperature) sensor in the spa water circulating system, taking care to place the sensor before the water goes through heaters or heat exchangers. Connect the thermistor wiring to the DDC as shown in Figure 3. If the DDC does not have the spa option, a thermistor can be placed wherever desired and have its temperature displayed on the DDC, utilizing the auxillary input connection (see Figure 3). If the spa/auxiliary temperature input is not used, it must be deactivated by placing one of the function switches (S2) to the "off" position (see Figure 9).

d. Control Wiring

Install space heating control wiring (optional). If the DDC has the space heating option, connect space heating control wires (28 VAC, 3 amps maximum) to the appropriate connections in the space heating controller and to DDC control wiring terminal strip as shown in Figure 3. The space heating control wires are connected to a relay in the DDC which is closed when minimum space heating temperatures are reached in the solar storage tank and open when storage temperatures are below that point.

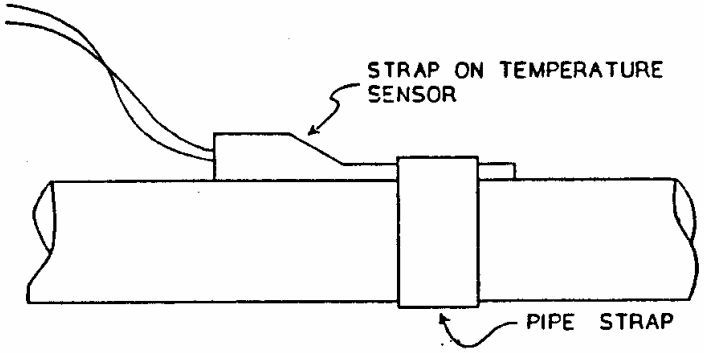
Install spa heating control wiring (optional). If the DDC has the spa heating option, connect spa heating control wires (28 VAC, 3 amps Maximum) to the appropriate connections in the spa heating interface controller and to the DDC control wiring terminal strip, as shown in Figure 3. The spa heating control wires are connected to a double-throw relay in the DDC, which switches when the top of solar storage tank temperature rises to 25 F greater than the spa temperature. The switch reverses when the solar storage tank falls to within 15 F of the spa temperature.

e. Solar Collection Indicator Relay (optional)

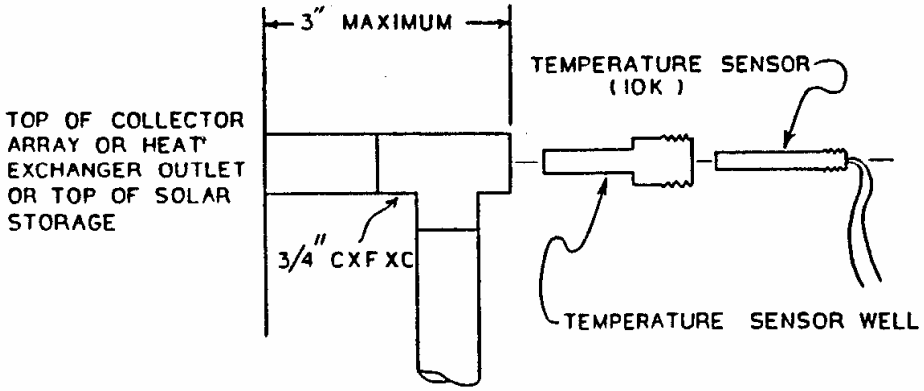
The "pump on" relay is a set of mechanical relay contacts which are open when the solar collecting pump(s) are off, and closed when the pump(s) are on. It is used to provide the pump status to other control systems or a remote light to indicate collecting status. Connect wiring to terminals labeled "solar collecting relay". Do not exceed 28 VAC, 3 amps maximum.

FIGURE 4: TEMPERATURE (Thermistor) SENSOR PLACEMENT

STRAP ON MOUNTING (Standard)



IMMERSION WELL MOUNTING (Optional)

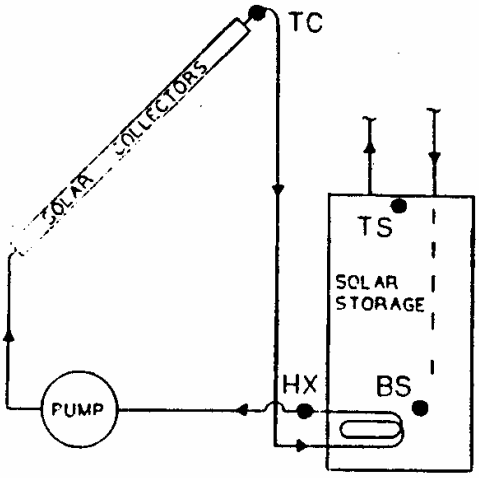


NOTE: STRAP ON MOUNTING TEMPERATURE SENSORS COME STANDARD WITH THE DDC. IMMERSION WELL TEMPERATURE SENSORS ARE AVAILABLE.

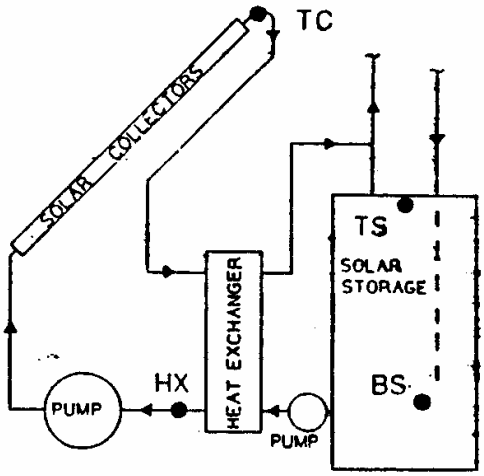
(Figure 4. Continued on next page)

Figure 4 (Continued): TEMPERATURE SENSOR (THERMISTOR) PLACEMENT

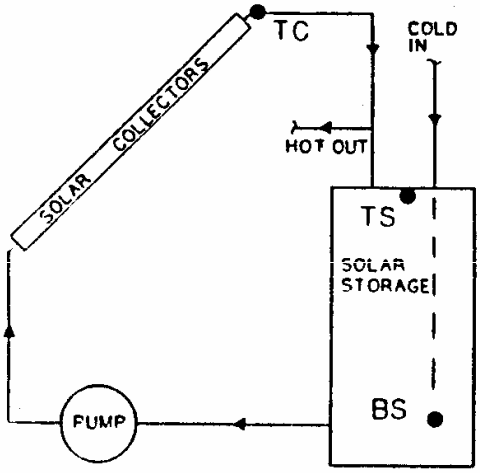
INTERNAL HEAT EXCHANGER SYSTEM



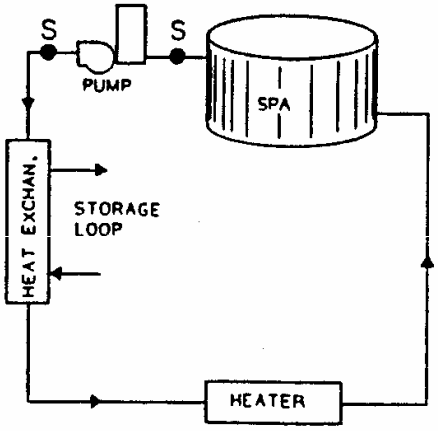
EXTERNAL HEAT EXCHANGE SYSTEM



DIRECT FLUID SYSTEM (No heat exchanger)



SPA SYSTEM



Temperature Sensors	Location
TC	Top of collectors
TS	Top of storage (place under insulation on top of storage tank)
BS	Bottom of storage
HX	Heat exchanger
S	Spa (Two possible locations)

f. Setting DDC Functions (Figures 3 and 9)

Set internal function switches S1, S2, S3 and S4 to positions described in Figure 9 for desired options. If the DDC does not have the spa option, S2 will activate or deactivate the "auxiliary" temperature sensor input.

Place "SEQUENCE/HOLD" switch to "SEQUENCE" and the "SOLAR PUMP" switch to "OFF".

Turn on power to DDC. The display should start sequencing through its different outputs. Make sure all temperature sensors are free from errors and are reading correct temperatures. Figure A1 (Appendix) provides a resistance-temperature conversion chart for 10K ohm thermistors.

If the solar loop has been plumbed and the circulating pump flooded with heat transfer fluid, the circulating pump can be activated by turning the solar pump switch to the "AUTO" or "ON" position. CAUTION: NEVER RUN THE SOLAR CIRCULATING PUMP WITHOUT FLUID IN THE PUMP!

g. Space Heat and Boil Protect Limit Calibration (Figures 3 and 9)

The high-temperature limit is the highest temperature that the storage tank is designed to reach. When the bottom of storage reaches the temperature limit selected, the solar collecting pump will be turned off regardless of whether or not solar energy is available at the collector. The most often selected shut off temperature for a DHW system is 180 degrees F.

The space available limit is the lowest temperature at which solar space heating will take place. When the top of storage temperature is below this selected temperature limit, the space heating relay contacts will open, signalling to the space heating control system that solar energy is not available for use. Typical forced-air systems use a shut off temperature of 80 or 90 degrees F, while hydronic heating systems generally shut off at 100 degrees F.

h. Flow-Rate Calibration

One-time flow-rate calibration is needed for the correct heat transfer reading to be displayed. The unit will run properly without calibration, but BTU/hr. readings may be incorrect. The DDC expects a "corrected" flow-rate input. The corrected flow-rate means that the actual flow-rate of the system has to be adjusted to a standardized temperature, (140 F). There are two techniques for determining solar loop flow-rate: 1) empirical calculation ; and 2) direct flow meter reading. The direct method is more accurate. Once the "corrected" flow-rate has been determined, go to the calibration section to set the flow-rate.

EMPIRICAL CALCULATION OF FLOW METER READING.

Use this technique on a bright sunny day, around 12 noon and with the solar storage tank between 50-150 F.

- Turn off potable water flow through solar storage tank.
- Turn on solar collecting loop, making sure it stays on during this calibration procedure.
- If taking measurements on a Western fiberglass tank, turn the heat distribution pump on, but do not allow space heating auxillary system to turn on. This is to allow the tank to mix during measurement.
- Allow solar system to run for 15 min.
- Read and record collector output temperature, heat exchanger (HX) output temperature and top of solar storage tank temperature. (START TIMING).
- Allow system to run for 30 - 40 more minutes without interruption (calibration time).
- Read and record calibration time in minutes, output temperature, heat exchanger (HX) output temperature and top of storage tank temperature. (STOP TIMING).
- Use the following formulas to determine the DDC "corrected" flow meter reading. Calculate BTU, FACTOR A, FACTOR B, FACTOR C and FACTOR D then use the last formula to determine "corrected" flow rate in gpm.

1) BTU = (STOP top tank temp. - START top tank temp.) x 8.3 x No. gal. tank storage x 60/Calibration Time (Min)

2) FACTOR A = (Coll. START Temp + Coll. END Temp)/2

3) FACTOR B = (HX START Temp + HX END Temp)/2

		Collector Fluid
4) FACTOR C	= 225	Brayco 888
	= 425	Glycol/Water
	= 175	Silicone Oil
	= 500	Water Only

		Collector Fluid
5) FACTOR D	= .0025 * FACTOR A + 0.65	Brayco 888
	= .0018 * FACTOR A + 0.75	Glycol/Water
	= .0070 * FACTOR A + 0.02	Silicone Oil
	= .0012 * FACTOR A + 0.83	Water Only

$$6)\ \text{Corrected GPM} = \frac{\text{BTU}}{(\text{Factor A} - \text{Factor B}) * \text{Factor C} * \text{FACTOR D}}$$

NOTE: If this technique is being used on pressurized, stone lined tanks, reduce corrected GPM by 25% due to tank stratification.

DIRECT FLOW METER READING TECHNIQUE.

Connect a flow meter to the solar collector fluid loop. Turn the solar circulating pump to "ON". Take a reading. Make sure the flow meter is calibrated to the heat transfer fluid being used. The proper calibration of the DDC BTU meter is done with the collector fluid temperature corrected to 140 degrees F. If the flow-rate is taken at another temperature, the flow-rate must be corrected. Multiply the flow-rate measured by the correction factor from Figures 5, 6, 7 or 8. For example, if the collector temperature was 100 degrees F when a flow rate of 3.2 gpm was measured a glycol/water heat transfer fluid, then the corrected flow rate would be 3.5 gpm (3.2 * 1.09).

FIGURE 5: BRAYCO 888

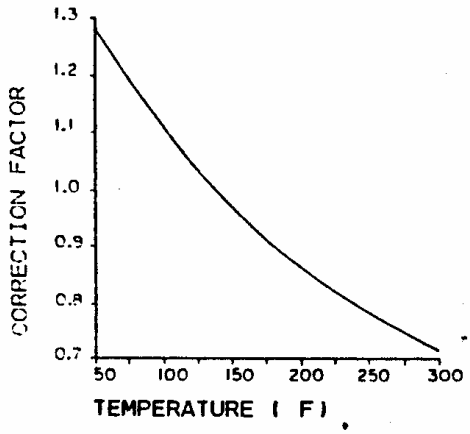


FIGURE 6: GLYCOL/WATER

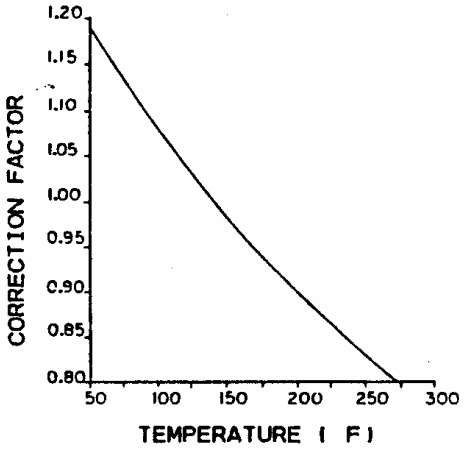


FIGURE 7: WATER ONLY

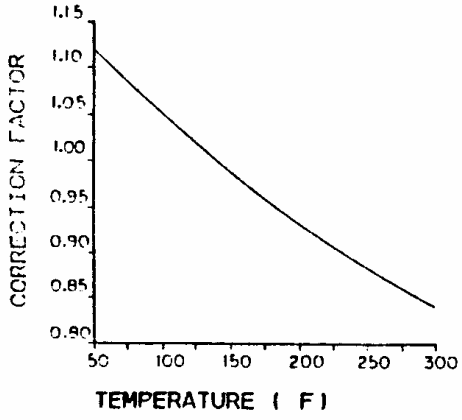
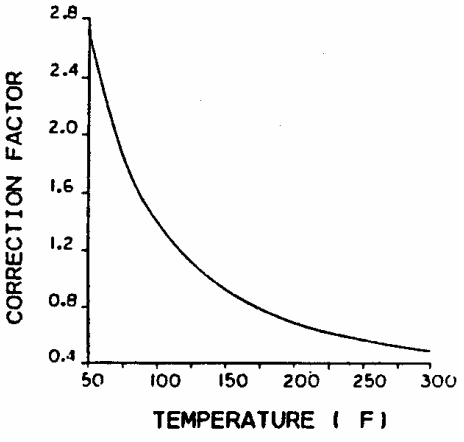


FIGURE 8: SILICONE



CALIBRATION (DDC flow rate in corrected gpm).

Place internal function control switch S1 to right (on) position. This will cause GPM to be displayed. Using the corrected flow-meter reading (direct or empirically calculated), adjust DDC display to the same reading by adjusting gpm potentiometer (between "SEQUENCE/HOLD and "SOLAR PUMP" switches, Figure 3).

Place internal function control switch S1 to left (off) position. Place solar pump switch to "AUTO" and replace DDC cover. This completes Installation and Calibration.

NOTE:
If during the calibration of flow rate, setting the space available limit or storage high temperature limit, the DDC displays an E5, E6, or E7 error code instead of the value desired, turn power to DDC off, wait 15-20 seconds, then turn power back on. The DDC should reset itself. If the error codes continue to occur, the controller has an internal problem and must be returned to the factory for replacement or repair.

FIGURE 9: DIGITAL DIAGNOSTIC CONTROLLER

Function Control (switch position) Chart
(see Figure 3 for switch location)

Function	Switch Position S1	S2	S3	S4
Normal - DHW	OFF	OFF	OFF	OFF
Normal - DHW + Auxiliary Sensor	OFF	ON	OFF	OFF
Normal - DHW + Space	OFF	OFF	ON	OFF
Normal - DHW + Space + Auxiliary	OFF	ON	ON	OFF
Normal - DHW + Spa	OFF	ON	OFF	OFF
Normal - DHW + Space + Spa	OFF	ON	ON	OFF
Service - Calibrate GPM	ON	*	*	OFF

ON - Right OFF - Left * - either OFF or ON

Limit	Temperature (F) Off	On	Switch Position S5	S6	S7	S8
Bottom-Sensor High Temperature	* 170	160	-	-	ON	ON
	180	170	-	-	OFF	ON
	190	180	-	-	Off	OFF
Top-Sensor Space Available	* 80	90	ON	ON	-	-
	90	100	OFF	ON	-	-
	100	110	OFF	OFF	-	-

ON - Right OFF - Left

NOTE 1: Boil Protect Limit/Space Available Limit check

To check boil protect limit and space available limit, turn on the DDC, place switches SW4 and SW1 in the ON position. The position of the other switches is not important. The display will alternate between the two values. For example, 180 and 90 would indicate a 180 F boil protect limit and a 90 F space available limit. To resume normal operation return SW4 and SW1 to the appropriate position.

NOTE 2: DDC Circuitry Self Check

This mode checks all the display lights and relays by activating them in sequence. To check, turn off the DDC, place SW1 & SW4 in the ON position, then turn power back on. This will activate the self check. To resume normal operation, turn off the power to the DDC and place SW1 & SW4 in the off position. Restore power to the DDC.

OPERATING INSTRUCTIONS (Figure 10)

The WSP Digital Diagnostic Controller (DDC) is a microprocessor-based unit which provides control of the solar circulating pump. Digital display of important temperatures in the solar collection and storage units is offered along with instantaneous system heat collection amounts and provisions for complete diagnostic testing of the system and its temperature sensors. Optional features include space-heating and spa-heating availability relays, and a solar collection pump indicator relay as needed. See Figure 11 for model numbers and descriptions.

Once the DDC has been correctly installed and calibrated, operation is simple and dependable.

a. Turning DDC on/off

The DDC unit is connected to line power through a local fuse disconnect (example: 6 1/4 amp fusestat with switch) or service breaker. Simply turn the service disconnect on or off to activate or deactivate the DDC. Normally the DDC stays on all the time unless servicing requires that the power be turned off.

b. Sequence/Hold Display

An external two-position toggle switch in the upper right corner of the DDC allows two display options.

In the SEQUENCE position, the display sequences through a series of temperature readings and a BTU/hour collection value. As the display is sequencing, an LED (Light Emitting Diode) lights up, indicating which output is being displayed and will vary depending on the applicable options. Figure 10 shows outputs for collector (output) temperature, heat exchanger (output) temperature, top of solar storage tank temperature, bottom of solar storage tank temperature, spa/auxillary probe temperature, and instataneous system BTU gain. "Space heating available" relay status, "solar circulating pump" status and "spa heating available" relay status along the bottom of the display are NOT controlled by the sequence/hold display switch.

The HOLD position will stop the display from sequencing and hold the display in the current position. The display is for information purposes only and thus will not affect normal controller operations.

FIGURE 10: DIGITAL DIAGNOSTIC CONTROLLER (front panel)

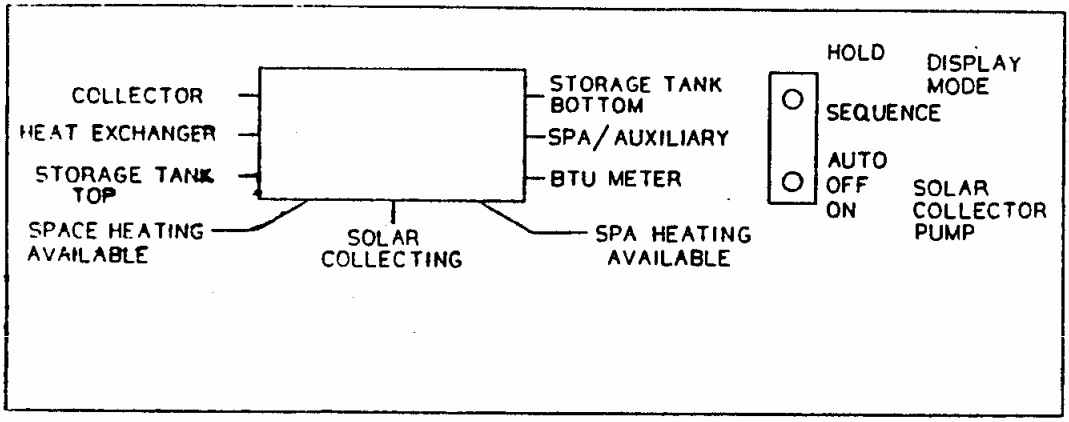


FIGURE 11: DIGITAL DIAGNOSTIC CONTROLLER MODEL NUMBERS

Type of Controller	WESTERN Model #
Domestic hot water	WD000-*
-- with optional "pump on" relay	WD00R-*
Domestic hot water and spa	WD0S0-*
-- with optional "pump on" relay	WD0SR-*
Domestic hot water and space heating	WDH00-*
-- with optional "pump on" relay	WDH0R-*
Domestic hot water, space heating and spa	WDHS0-*
-- with optional "pump on" relay	WDHSR-*

Type of Heat Transfer Fluid	suffix (*)
Glycol/Water	G
Brayco 888	H
Water Only (No heat exchanger in solar loop)	W1
Water Only (Heat exchanger used in solar loop)	W2
Silicone Oil	S

c. DDC Display Output Description (normal operational mode)

DISPLAY DESCRIPTION	COMMENTS
Collector Temperature (F) - Heat transfer fluid temperature at the collector output port.	Standard
Heat Exchanger Temperature (F) - Heat transfer fluid temperature at the heat exchanger output port.	Standard (If used)
Top of Solar Storage Tank Temperature (F)	Standard
Bottom of Solar Storage Tank Temperature (F)	Standard
Spa or Auxiliary Temperature (F) - Temperature of spa circulating water or, if no spa option, this display can indicate the temperature of an auxiliary thermistor sensor.	Optional
BTU/hour (BTU's x 1000) - This output displays the approximate number of kilo-BTU's per hour being collected and stored by the solar system at any given point in time.	Standard

d. System Operational Displays

Three system operation LED display lights are also provided to indicate the state of the controller's output relays. These are:

- SOLAR COLLECTING (Standard) - When lit, the circulating pump in the solar loop is on.

- SPACE HEATING AVAILABLE (Optional) - When lit, indicates that the temperature at the top of the solar storage tank is sufficiently hot to provide solar space heating needs. This is typically set at 90 F for forced air heating systems and 100 F for hydronic heating systems. Values of 80, 90 and 100 degrees F are field-selectable.

- SPA HEATING AVAILABLE (Optional) - When lit, indicates that the temperature at the top of the solar storage tank is sufficiently hot to provide spa heating needs. If the top of the tank is 25 F warmer than the spa temperature, the relay will switch and the light will turn on. If the top of solar storage tank is 15 F or colder than the spa, the light will turn off and the relay will again switch.

e. Solar Pump Switch

A 3-position toggle switch in the lower right corner of the DDC allows control over the solar circulating pump.

The "AUTO" position is the normal operating position. When in this position, the circulating pump is under control of the DDC operating system. The DDC will turn on the pump when the temperature of the solar collectors becomes 20 F (or warmer) than the bottom of the solar storage tank. It will turn the solar pump off when these temperatures are within 3 F of each other. The DDC will also turn the pump off if the tank temperature exceeds a preset temperature limit. High temperature limits of 170, 180 and 190 F are field-selectable.

The "ON" or "OFF" position will manually activate or deactivate the pump for servicing. If the switch is turned to the "ON" or "OFF" position, be sure to return the switch to "AUTO" (up) position to resume normal operation of the system.

3. ERROR CODES

In addition to the operational displays, error message codes can also appear. These codes generally apply to a specific sensor. For example: an "E2" is displayed when the collector temperature sequence comes up, indicating either the sensor has failed, or a wire to the sensor has been cut or disconnected. If an error is occurring, the indicator LED for that sensor will also blink, calling attention to the error.

Code	Description
E1	Sensor or wiring shorted
E2	Sensor or wiring open
E3	Low or no flow through solar collecting loop
*** or E4,E5,E6	Nondescript error codes. There has been some type of DDC malfunction. Turn power to DDC off, wait 15-20 seconds, then turn the power back on. The DDC should reset itself. If the nondescript error codes continue to occur, contact your local dealer or the factory.

NOTE: In some cases a display of [- - -] may occur on the BTU meter. This simply indicates that the solar collection rate exceeds the display of 99.9 BTU/hr. This is not an error and does not indicate a problem with the DDC.

If the DDC will not turn on, there are three major possibilities:

FUSE BLOWN -
Power is not getting to the DDC because of a blown fuse. Check fuses and make sure power (110-120 VAC) is reaching the DDC. If electricity is reaching the DDC, there is a power supply fuse on the back circuit board of the DDC. If blown, replace with a 0.38 amp normal blow fuse. If fuses continue to blow, the unit must be sent back to the factory for repair or replacement.

LOW VOLTAGE -
The DDC display will fade as voltage drops below 110 VAC. If voltage drops below 90 VAC, the DDC will stop operating. If the DDC will not work and the fuses are functional check the line voltage. The DDC will reset itself when voltage returns to 110-120 VAC.

INTERNAL PROBLEM -
Internal circuits to the DDC have been damaged. The unit must be returned to the factory for repair or replacement.

APPENDIX

FIGURE A1: 10K ohm Temperature sensor (Thermistor) characteristics.