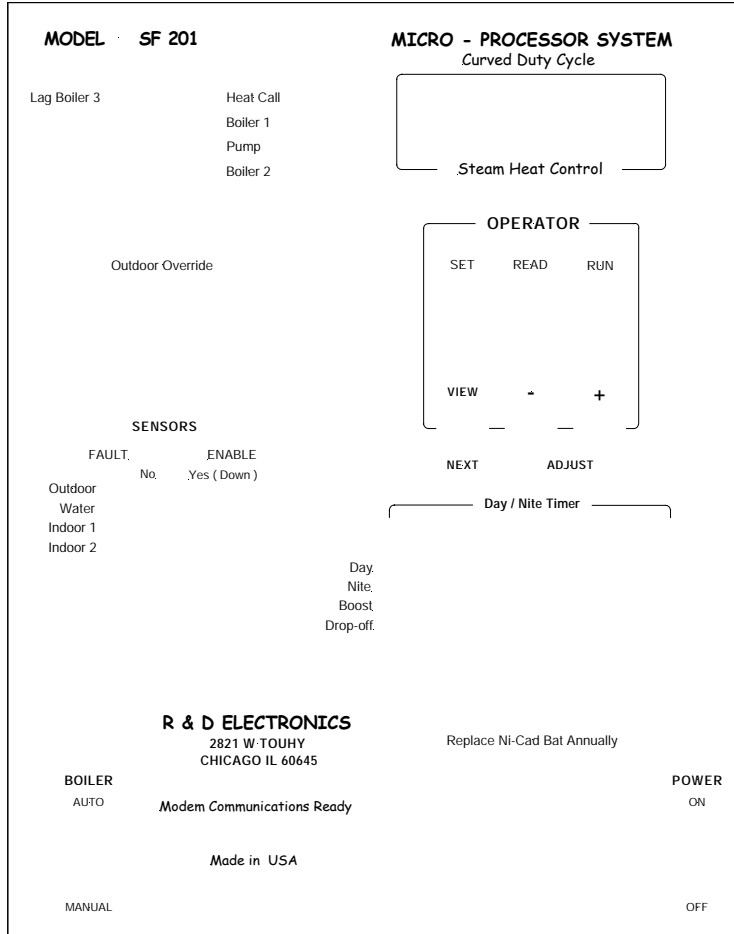


-- OWNERS MANUAL --



Model SF201 -- Dual Slope Steam Duty Cycle Control

Duty cycle controls (Heat Timing Devices) have been around for over 50 years. In the past, owners have been dissatisfied with them because: (1) *Duty Cycle controls would "stair case" building temperatures after each heating cycle. This was a result of having only a first operating curve to calculate how long to run the boiler, while the OFF period remained fixed. Now a second operating curve calculates how long the boiler should be held OFF after each heating cycle.* (2) It was nearly impossible for the operator to adjust meaningless dial scales. Now you can specifically set "time" and "temperature". (3) The old technology couldn't provide the correct amount of night setback and morning boost and involved too many dial settings. A new mathematical model was developed eliminating the separate boost dial.

The SF201 considers many factors before calculating the next time delay or heating cycle length. This is especially important before going into a set period change. A few of these factors are: (a) how long its been since the last heat cycle, (b) whether the boiler is presently ON or OFF, (c) did the outdoor temperature change in the middle of the delay period? In order to

accomplish all this, the five operator setpoints, the outdoor temperature, and the time remaining on the countdown clock had to be integrated into a mathematical relationship involving state variables and multiple equations.

Only the SF201's computer program can: (A) calculate both the heating cycle length and the length of the off period. (B) performs a true correction for the night setback and morning boost temperatures with only one operator setting, the desired night setback measured in deg. F. (C) intelligently integrate 1 or 2 room zone sensors to act as a min. and max. indoor temperature range.

How do the room zone sensors work? The operator can activate one or both room zone sensors from a DIP switch on the front panel. The desired room temperature setpoint will be compared to the average of the two zones. If the

average zone temperature is below or above the range limit (typically +/-4 deg. F.), the boiler will immediately turn on or off respectively. This results in a “rescheduling” of subsequent time delays and heating cycles to account for the one time error.

How does setback work? Immediately after the time clock switches to night, an extra long time delay causes room temperatures to drift towards the desired night temperature. While in night setback, a time delay greater than the day time delay, but less than the drop-off time delay maintains the building at the desired nighttime temperature. The contractor may calibrate night setback by adjusting the building heat loss factor in the system menu list.

What about morning boost? Morning boost will lengthen the first morning heating cycle. The amount of the boost will automatically change to equalize the amount of the night setback.

DESIGN HIGHLIGHTS

- * Motorola MC68HC11 operates in single chip mode. Internal ram, rom, and eeprom.
- * Modem operation from any PC with standard communications software.
- * Operator setpoints are retained in eeprom (permanent memory).
- * Includes (1) one outdoor, (1) one room zone, (1) return steam sensor. Optional (1) additional room sensor.
- * Warm Weather Shutdown or outdoor cutoff .
- * Resets the time between heating cycles for outdoor temperatures between -20F and +60F.
- * Resets the length of heating cycles for outdoor temperatures between -20F and +60F.
- * Monitors actual building temperatures in up to two room zones.
- * Average of the two room zones can be used as a minimum or maximum limit.
- * Temperature data logging for 48 hrs. Select either room zone sensor.
- * All sensor have fault protection circuits and LED indicators.
- * Morning Boost is automatically determined. Results in accurate return to daytime room temperatures.
- * Weekend Weekday Programmable Setback Timer with 4 mo. battery backup.
- * 32 Character BACKLIT LCD display, setpoints are in *time and temperature*, not A,B,C or higher and lower.
- * Controls a combustion air damper, and multiple boilers with early shut down for the second stage.
- * Pre starts a vacuum pump, and delays pump turnoff.
- * Manual bypass for all relay outputs.
- * Plug-in panel for quick service *without having to disconnect the field wiring*.
- * 16 Gauge steel enclosure with means for a padlock.

OPERATOR ADJUSTMENT

SET

Place OPERATOR switch in SET. Press VIEW NEXT. Press + or - to change.
Software version dc1g.f will have #1 and #3 in this list reversed.

1 HEAT DUTY CYCLE @ -20F Outdoors { :40 } { maximum :59 }

2	OUTDOOR CUTOFF TEMP	{56}
3	MANUAL RESET (advance to the next ON or OFF cycle)	{NO}
4	HEAT CYCLE LENGTH @ +60F Outdoors	{Auto}
5	DESIRED DAY TEMPERATURE	{72}
6	DESIRED NIGHT TEMPERATURE	{68}

1 HEAT DUTY CYCLE -- **This is the main heat adjustment.** (a) Sets the Heat Cycle Length or ON cycle in minutes at the -20F outdoor reference point along a “first curve” which calculates Heat Cycle Lengths at all other outdoor temperatures. (b) Indirectly determines the *Heat Time Delay* or OFF delay in minutes at the -20F outdoor reference point along a “second curve” which calculates *Heat Time Delays* at all other outdoor temperatures. The *Heat Time Delay* at -20F outdoors = (60 - Heat Duty Cycle). Example, if the outdoor temperature is -20F, and the Heat Duty Cycle is set to 00:35, then the boiler will run for 35 minutes after reaching return steam setpoint, followed by an off delay of 25 minutes. (c) As outdoor temperature increases, the *Heat Time Delay* follows a differential curve and approaches a maximum of 10 hrs. at outdoor cutoff temperature. (d) The Heat Duty Cycle will be recalculated ½ way through the delay period. The countdown clock will be corrected to account for an increase or decrease in the outdoor temperature. (e) The Heat Duty Cycle is one of many factor determining the length of the boost period (See Boost Below). (f) The Heat Duty Cycle setpoint is limited to :59 by the software program.

2 OUTDOOR CUTOFF (a) Stops the boiler above the outdoor setpoint. (b) Lowering the outdoor setpoint proportionally increases *Heat Time Delays* between 45 to 60F outdoors (changes the shape of *Heat Time Delay* curve). The logic for longer time delays with lower outdoor cutoff temperatures is that of simplifying the number of adjustment for operators desiring to maximize fuel savings.

3 IMMEDIATE RESET Pressing the + or - Key when reading screen 1 of SET menu causes an immediate reset of the ON cycle or OFF delay period. If the indoor zones sensors are enabled, and they are out of range, immediate reset will not occur. Allow the zone sensor to return to range, or disable from panel DIP switches.

4 HEAT CYCLE LENGTH This is the ON cycle in minutes at the +60F outdoor reference point along a “first curve” which calculates Heat Cycle Lengths at any outdoor temperature. (a) If set to AUTO, and as outdoor temperature increases, the Heat Cycle Length follows a linear curve and will approach the (Duty Cycle)/2 at 60F outdoors. Example, if the outdoor temperature is 20F and the duty cycle is 00:40 , then the actual Heat Cycle Length at 20F outdoors is 00:30 . (b) A fixed value may be selected, but allowing the Heat Cycle Length to change automatically with changes to the Heat Duty Cycle reduces the number of required operator adjustments to only the Heat Duty Cycle, and the Outdoor Cutoff.

5,6 DAY and NIGHT setpoints (a) Determine Night Setback. (b) Set the min. and max. range for indoor zone sensors. If during the Day period, the indoor temperatures become greater or less than the Day setpoint by +/- 4 F., an immediate reset of the ON cycle or OFF delay occurs. (c) If two sensors are enabled, the software program

takes the average. (d) If the DIP switches on the front panel are disabled, indoor temperature is used only for monitoring and data logging. (e) The +/- 4 F. range may be changed in SYSTEM menu.

READ

Place the OPERATOR slide switch in READ. Press the VIEW NEXT. The READ menu will display the outdoor temp., the return steam temp., and up to two optional indoor zone sensors.

RUN

(1) Countdown clock displays time until the end of the current ON cycle or OFF delay period. (2) most recent *total* OFF delay period, (3) most recent *total* ON cycle period, (4) output relays and day/night period status, (5) total boiler runtime during the last 24 hrs., (6) total boiler runtime during the previous 24 hr. period, (7) indoor zone sensor data logging for the last 2 hrs. in six 20 minute measurements, (8-11) data logging for the last 48 hrs. There are 4 data screens of six 2 hr. measurement periods. Data logs reads oldest first (upper left) and most recent measurement last (lower right). Each reading is the average of multiple readings over the 20 minute or 2 hour measurement period (Also see SYSTEM: Screens 4 and 5). The 4 fault LED's indicate conditions where an outdoor, water, or indoor zone sensor is reading out of range *or is defective*.

SYSTEM INITIAL SETUP

SYSTEM: -- INITIAL SETUP: (Press the + plus and - minus keys together).

- | | | | |
|----|------------------------|---------------------------------|-------|
| 1. | RETURN STEAM SETPOINT | (starts heat cycle timing) | {120} |
| 2. | ZONE AUTO RESET | (indoor zone sensor +/- range) | {4} |
| 3. | VACUUM PUMP DELAY | (turn on lead, turn off lag) | {:30} |
| 4. | DATA LOGGING ITEMS 1-7 | (changes length of RUN menu) | {1-7} |
| 5. | ZONELOG APT. # 1-2 | (selects data log apartment) | {1} |
| 6. | BLDG. HEAT LOSS DEG/HR | (calibrates night setback dial) | {6} |

Note: The bldg. heat loss factor represents the number of degrees the building temp. will decrease during a one hour period when the boiler is off, the radiators are cold, and the outdoor temp. is -20F. If the night setback selected in the SET menu is greater than the value you have measured, increase the Heat Loss Factor.

Restoring Factory Default Operator and System Settings: To Reset the SET and SYSTEM user variables to factory default settings. Turn Power OFF. Hold the NEXT key while turning the Power ON. *Consult your contractor before resetting to factory defaults. This reset will change items 1-6 in the SYSTEM menu (described above) which are specific to your application.*

Manual Bypass: Turn POWER switch OFF. Place BOILER switch in MANUAL to activate main boiler (most cases). Manual bypass switch for additional boilers are behind the front panel on the terminal wiring board. Auto position is DOWN, Bypass is UP. Extra2 -- ry2, Vacuum pump -- ry3, Extra3 -- ry4, LagBoiler -- ry5.

Setback Timer: If the Day/Night Timer display indicates ON, control is in the DAY period, whereas OFF is Night. Timer memory allows 6 ON and 6 OFF entries. A 5-day (MO thru FR) and a 2-day (SA SU) group schedule will program the entire week in only 4 program steps. The rechargeable battery will fully charge in 24

Hrs., and maintain the timer for 4 mo. without power. The rechargeable battery receives charging current even when the front panel power switch is turned off.

Notes on 48 hr. data logging: The six displayed numbers are the average of readings every 30 seconds and update every two hours. The min. or max. room temperatures could be +/- 2 degrees above or below the recorded average temperature over time. You may choose to calibrate the time scale by resetting control power *before* collecting the data 48 hrs. later. Special data collection sheets from R&D Electronics are available.

SET PERIOD OPERATION

Drop-off Begins when the Setback Timer switches from Day to Night. To increase the length of the drop-off period, increase the amount of night setback. Other factors determining the length of the drop-off period are: (1) the building heat loss factor in the SYSTEM menu, (2) the present outdoor temperature. (a) If the boiler is OFF at moment the Set Back Timer switches from Day to Night, the software program immediately adds the correct amount of drop-off time to the countdown clock. (b) If the boiler was ON, the software program waits until the end of the current heat cycle and resets the countdown clock with the sum of the drop-off time plus the normal night *Heat Time Delay* component.

Night Begins after the end of the heat cycle following drop-off. Increasing the amount of night setback does two things: (1) increases the length of the drop-off period. (2) increases the night *Heat Time Delay*.

Boost You cannot singularly adjust the length of boost period. Factors determining the length of the boost period are: (1) the duty cycle, (2) the building heat loss factor, (3) the amount of night setback, (4) the present outdoor temperature. (5) the moment in time when the Setback Timer changes from Night to Day. (a) If the boiler is ON at the moment the Setback Timer switches from Night to Day, the software program immediately adds the correct amount of boost time to the countdown clock. (b) If the boiler was OFF, the program immediately turns on the boiler and resets the countdown clock to the sum of the boost time plus a normal heat cycle component proportional to the *Heat Time Delay* which remained in the countdown clock prior to reset. If for example, the boiler just turned off, the normal heat cycle component would be small.

MODEM OPERATION

If a modem is installed, any communications program such as Microsoft HyperTerminal, Works, or Procomm will work. Use the special cable provided from the 25 pin RS232 port on the modem to the 6 pin modular jack on the SF201. (1) Choose a name and setup a new dial-up connection. Data will be sent to the modem in the same format that it is displayed in the 32 character LCD. (2) Set your PC Modem Baud Rate to 9600 N, 8, 1 . All functions are available through the modem except for programming the time clock, and enabling the zone sensor limit feature. (3) Your computer keyboard emulates the SF201 front panel switches as follows:

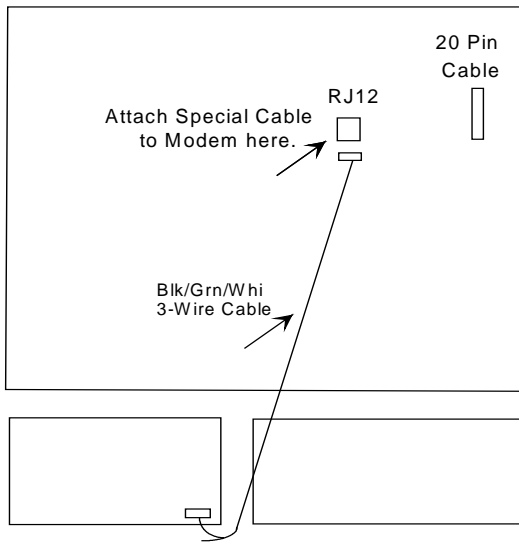
1 = SET 4 = SYSTEM ENTER = NEXT

2 = READ
3 = RUN

(+)
(-)

= INCREASE
= DECREASE

-- MODEM CONNECTIONS -- front panel rear view --



Note:

(1) Blk, Whi and Grn connection from processor brd. to main brd.

(2) RJ12 connection to modem on back of panel. The wireless receiver connects to the terminal board, not at the back of the front panel.

FIELD SERVICING -- Testing the remote sensors.

MAIN PANEL AND TERMINAL BOARD

If the 3AG 1A fuse on the terminal board is bad, you may try replacing it. On rare occasions, there may be a fault on the terminal board. It is easiest to replace the main panel with a known good panel before attempting to determine whether the terminal board is defective. You may order field replacements for either board.

Room Sensors: If a sensor warning light is on, you will need to know if the sensor wiring is open, shorted, or whether the sensor is actually defective. The sensors are extremely reliable, and wiring defects occur 50 times as frequently as defective sensors. If the radiators are turned off within an apartment where there is a remote sensor, the sensor warning light may turn on and falsely indicate a bad sensor, or if the sensor high limit in the SYSTEM menu is set below the current room temperature, the warning light will also turn ON.

Problem: All the sensor warning lights are ON. You must determine whether the panel is good.

1. Connect a digital volt meter DVM (-) lead to **TS1** terminal 2 [outdoor sensor (-)] or sensor common. Connect the DVM (+) lead to the (+) terminal of any sensor input. Verify dvm read 12.8 to 13.8 Vdc. If not true, then the main panel is defective.

2. Sometimes a (+) lead sensor wire will short to ground elsewhere in the building. If there is an additional system short to conduit ground, it will be necessary to trace both shorts before reconnecting the defective sensor line. Two shorts in your system can result in the “grounding” of the +13Vdc. Isolate each sensor from the terminal board one at a time to locate the second short.

3. *Test the microprocessor analog inputs:* Connect the DVM (-) lead to the outdoor sensor (-) terminal or common. Connect the DVM (+) lead to the zone sensor (-) terminal under test. The voltage at the (-) terminal should be directly proportional to **Table 2**, the room sensor temperature chart. The sensors should read between 2.1 and 3.1 volts (60 to 85 F). The display should read the correct temperature.

4. *Testing for reversed sensor polarity and shorted lines:* If in step 1 the DVM reads 12 to 13 Vdc, then the sensor wiring is either shorted, or the sensor polarity is reversed. Try disconnecting the sensor and reversing the wiring polarity.

5. *Testing for an open line:* If in step 1 the DVM reads 0, then the line is either open, or the sensor is defective. Try disconnecting the sensor and using your DVM in the Ohms position to read the resistance of the line and the sensor. For most DVM's, the resistance of a sensor will be between 1 and 10 Meg. Ohms. If you can read the resistance correctly, then the wire is probably OK, and the sensor itself is defective. Otherwise, you may have to go to the apartment and measure the voltage across the sensor. If you measure +13Vdc without the sensor connected, then the line is good. If the sensor is good, you will read approx. 13Vdc - 2.5Vdc or 10.5Vdc across the sensor.

6. If the results of the above steps indicate a shorted line, then you will either have to replace the entire line, or cut the line in half, then half again, etc. to determine where the short is located. Most often, it will be due to a staple through a wire within an apartment, or the wire got cutoff at the floor.

TABLE 1 -- ROOM SENSOR VOLTAGE TO TEMPERATURE CONVERSION

SENSOR		SENSOR		SENSOR	
Vdc	Deg.F	Vdc	Deg.F	Vdc	Deg.F
2.10	60	2.46	69	2.82	78
2.14	61	2.50	70	2.86	79
2.18	62	2.54	71	2.90	80
2.22	63	2.58	72	2.94	81
2.26	64	2.62	73	2.98	82
2.30	65	2.66	74	3.02	83
2.34	66	2.70	75	3.06	84
2.38	67	2.74	76	3.10	85
2.42	68	2.78	77		

Outdoor, and Water or Return Steam Sensors: 1. Place 3 1/2 digit volt meter or DVM (-) at **TS1** terminal 2 [outdoor sensor (-)], and DVM (+) at **TS1** terminal 3 [pipe temperature sensor (+)]. Verify that dvm reads 13 Vdc, or replace front panel.

2. Move DVM (+) to **TS1** terminal 1 [outdoor sensor (+)] and measure the outdoor sensor voltage, then look up the corresponding temperature on the chart in Table 2. Replace the sensor if the DVM reading does not correspond with the outdoor temperature. Replace panel if outdoor temp. reading on control is not within +/- 3 F. of the measured value.

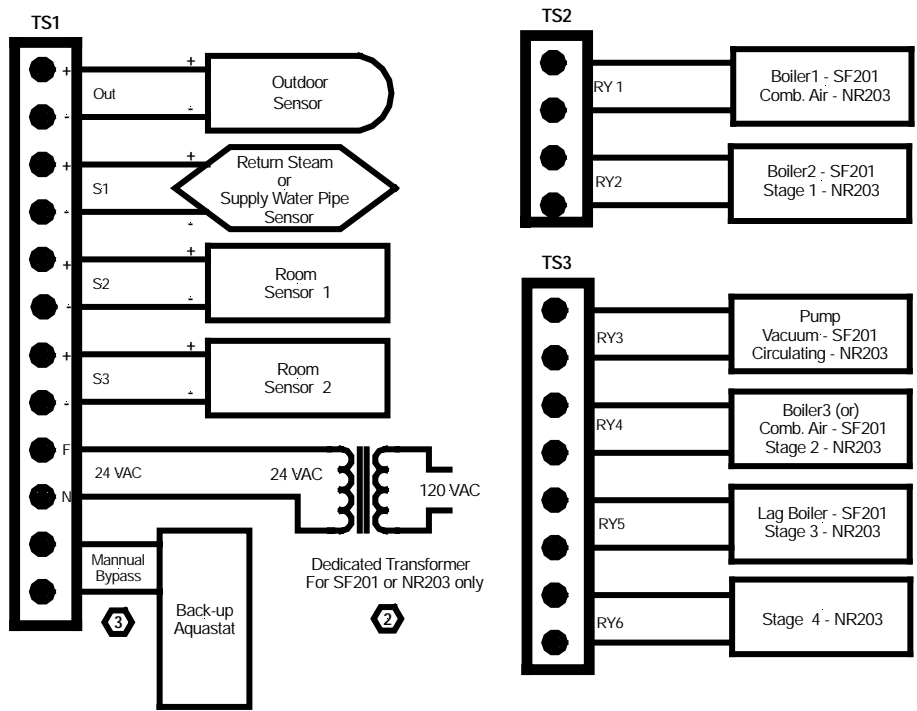
3. Move DVM (+) to **TS1** terminal 5 [water sensor (-)] and measure the water temp. voltage, then look up the corresponding temp. on the chart in Fig. 1. Replace the sensor if the DVM reading does not correspond with the pipe temperature. Replace panel if water temp. reading on control is not within +/- 4 F. of the measured value.

TABLE 2 -- VOLTAGE TO TEMP. CONVERSION (Water or Outdoor sensors)

Voltage = deg. F.	Voltage = deg. F.	Voltage = deg. F.	Voltage = deg. F.
2.43 = -22	2.79 = 42.8	3.15 = 107.6	3.49 = 168.8
2.45 = -18.4	2.81 = 46.4	3.17 = 111.2	3.51 = 172.4
2.47 = -14.8	2.83 = 50.0	3.19 = 114.8	3.53 = 176
2.49 = -11.2	2.85 = 53.6	3.21 = 118.4	3.55 = 179.6
2.51 = -7.6	2.87 = 57.2	3.23 = 122	3.57 = 183.2
2.53 = -4.0	2.89 = 60.8	3.25 = 125.6	3.59 = 186.8
2.55 = - .4	2.91 = 64.4	3.27 = 129.2	3.61 = 190.4
2.57 = 3.2	2.93 = 68	3.29 = 132.8	3.63 = 194
2.59 = 6.8	2.95 = 71.6	3.31 = 136.4	3.65 = 197.6
2.61 = 10.4	2.97 = 75.2	3.33 = 140	3.67 = 201.2
2.63 = 14	2.99 = 78.8	3.35 = 143.6	3.69 = 204.8
2.65 = 17.6	3.01 = 82.4	3.37 = 147.2	3.71 = 208.4
2.67 = 21.2	3.03 = 86	3.39 = 150.8	3.73 = 212
2.69 = 24.8	3.05 = 89.6	3.41 = 154.4	3.75 = 215.6
2.71 = 28.4	3.07 = 93.2	3.43 = 158	3.77 = 219.2
2.73 = 32	3.09 = 96.8	3.45 = 161.6	3.79 = 222.8
2.75 = 35.6	3.11 = 100.4	3.47 = 165.2	3.81 = 226.4
2.77 = 39.2	3.13 = 104		

ORDERING INFORMATION: The model SF201 comes standard with 2 relay outputs for controlling (1) boiler, and (1) air damper or a second boiler. Order Model SF201M to operate a vacuum pump, a second boiler, and a third boiler which can be “staged” for early shutdown.

SF201 and NR203 WIRING DIAGRAM
 ISSUE "A" 6-3-99



- ① Dry Contacts, rated 24 vac. No power is supplied to the burner control circuit.
- ② Do not power the NR203 with a RELAY TRANSFORMER WHICH ALSO POWERS A GAS VALVE OR A RELAY.
- ③ Remove jumper when installing a manual bypass control.

Note :
 When using shielded sensor wire DO NOT BRING SHIELD INTO HEATING CONTROL,
 Join the shields together outside the control and connect to electrical conduit ground.

SF201 Heating Cycle - Outdoor Temperature Curves - May 30, 2003

Table shows calculated Heat Cycle OFF Period as a function of (1) measured outdoor temperature, (2) outdoor override setpoint, (3) duty cycle setpoint.

Table shows calculated Heat Cycle ON Period increasing linearly from ½ to the absolute duty cycle setpoint as outdoor temperature decreases from + 60 to -20 Deg. F.

The Heat Cycle ON Period count begins after steam circulation is established. Operator may change the calculated Heat Cycle ON Period curve by choosing a value for the Heat Cycle Length at +60 Deg. F. (Instead of the default value AUTO) in the SET menu.

Increasing the outdoor override setpoint above 60 Deg. F. will have little effect upon the Heating Cycle outdoor temperature curves. Settings below 55 Deg. F. are not recommended.

<u>Measured</u> Outdoor Temp.	<u>Setpoint</u> Initial Duty Cycle	<u>Calculated</u> OFF Period	<u>Calculated</u> OFF Period	<u>Calculated</u> ON Period
	at -20 Deg. F. Outdoors	Outdoor Override <u>Setpoint</u> 55 F.	Outdoor Override <u>Setpoint</u> 60 F.	Default <u>Setpoint</u> Auto
55	:30	10:00	5:51	:15
50	:30	7:30	4:23	:16
40	:30	4:15	3:00	:18
20	:30	2:02	1:40	:22
0	:30	1:05	:58	:26
-20	:30	:30	:30	:30
55	:40	10:00	3:54	:21
50	:40	5:00	2:55	:22
40	:40	2:47	2:00	:25
20	:40	1:26	1:10	:30
0	:40	:43	:39	:34
-20	:40	:20	:20	:40
55	:50	10:00	2:15	:26
50	:50	3:05	1:37	:28
40	:50	1:35	1:04	:31
20	:50	:43	:34	:37
0	:50	:21	:19	:43
-20	:50	:10	:10	:50