HEATEC TEC-NOTE

Publication No. 5-05-163

Setting Honeywell UDC2500 modulating controllers

This document provides information for setting two series of UDCDC2500 Honeywell controllers: DC2500-CE-0A00-200 and DC2500-CE-1A00-200 **(Figure 1).** These controllers are used to control *modulation* of the burner on Heatec HC and HCS heaters **(Figure 2)**. They are used on all sizes of HC and HCS heaters.

The two series of controllers are alike except that the series DC2500-CE-1A00-200 has an output used for the Chatterbox automated monitor, whereas the other series does not.

HONEYWELL MANUALS

This document along with Honewell manuals applicable to Honeywell UDC2500 controllers are furnished with Heatec HC and HCS heaters.

Note: printed copies of Honeywell manuals are no longer furnished. A computer CD, which contains PDF versions of their manuals, is furnished instead. The PDF file applicable to the UDC2500 is *51-52-25-127 UDC2500 Product Manual*.

If you need help on how to use the buttons on the controller, please refer to the Honeywell manual. You can call Honeywell for technical assistance at 1-800-423-9883. Their web site for assistance is www.honeywell.com/imc.

REPLACING AN OLD CONTROLLER

The UDC2500 Honeywell controllers replace Honeywell UDC3300 controllers used on Heatec heaters in the past. Honeywell has discontinued production of the UDC3300.

Consequently, if an old UDC3300 fails and has to be replaced, it should be replaced with a UDC2500. The new one will fit the same opening in the control panel as the old one. However, a minor change is required in the wiring connections as follows and as shown in Figure 3:

Connect wire from terminal 12 in the control panel to terminal 19 of UDC2500. (It was connected to terminal 2 on the UDC3300). Connect a jumper wire between terminals 5 and 21 on the UDC2500. (The jumper was between terminals 5 and 3 on the UDC3300).

If a Chatterbox automated monitor is used, make sure your controller is marked DC2500-CE-1A00-200. Connect a wire from terminal 15 in the control panel to terminal 12 of the controller. Connect another wire from terminal 16 in the panel to terminal 13 on the controller. (These two wires were connected to terminals 16 and 17 on UDC3300).

All other connections for the new controller are the same as for the UDC3300.

SETTINGS FOR HEATEC HEATERS

Settings for the DC2500-CE-0A00-200 modulating controller that apply to Heatec HC and HCS heaters are shown in **Figure 4, pages 1 and 2.** These settings are made

Figure 1.Honeywell UDC2500 modulating controller.

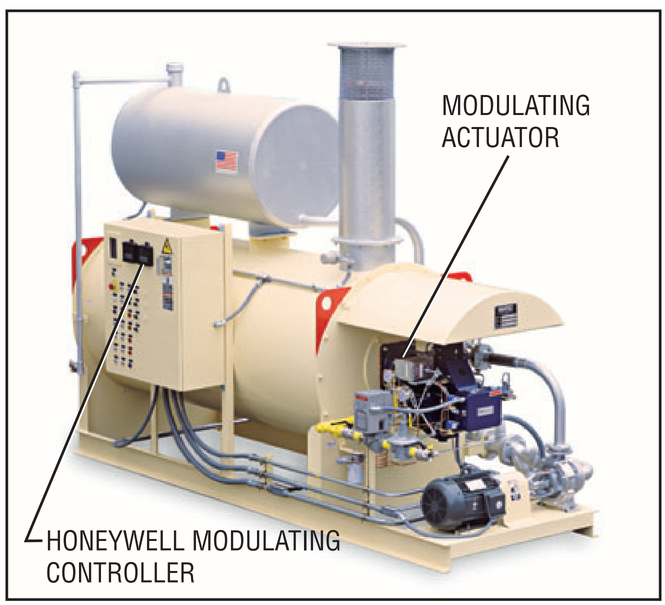

Figure 2. Heatec HC/HCS heater.

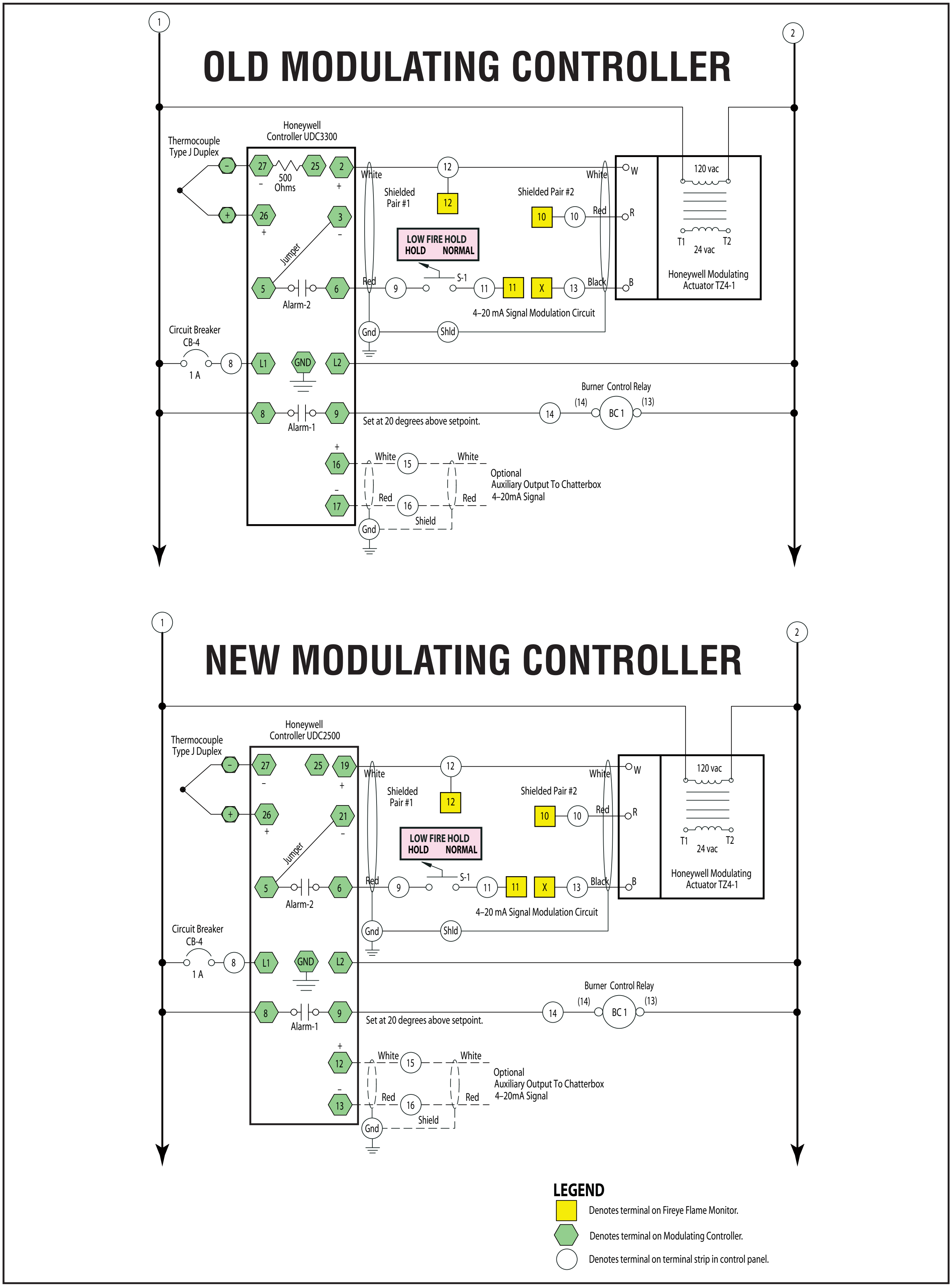

Figure 3. Wiring connections old Vs new modulating controllers.

Figure 4 (Page 1). Programming Honeywell DC2500-CE-0A00-200 Modulating Controller for Heatec HC and HCS heaters

Group Prompt (Setup button)	Function Prompt (Function button)	Value or Selection (up / down arrows)
TUNING	PB	4.00
or	GAIN	
or	GAINVALn	
	RATE T	1.00
	RSET MIN	
or	I RPM	5.00
or	MAN RSET	
	PROPBD2	
or	GAIN 2	
	RATE2MIN	
	RSET2MIN	
or	RSET2RPM	
	CYC SEC	
or	CYC SX3	
	CYC2 SEC	
or	CYC2 SX3	
	SECUR	0
	LOCK	CAL
	AUTO MAN	
	SP SEL	
	RUN HOLD	
SPRAMP	SPRAMP	DIS
	TIME MIN	
	FINAL SP	
	SPRATE	DIS
	EU/HR UP	
	EU/HR DN	
	SP PROG	
A TUNE	FUZZY	ENAB
	TUNE	DIS
	AT ERROR	

Group Prompt (Setup button)	Function Prompt (Function button)	Value or Selection (up / down arrows)
ALGOR	CTRALG	PIDA
	TIMER	DIS
	PERIOD	
	START	
	L DISP	
	INP ALG1	
	MATH K	
	CALC HI	
	CALC LO	
	ALG1 INA	
	ALG1 INB	
	ALG1 INC	
	PCO SEL	
	PCT CO	
	ATM PRES	
OUTALG	OUTALG	CUR
	CRANGE	4-20
	OUT2 ALG	
	RLYSTATE	
	RLY TYPE	
INPUT 1	IN1TYP	J M
	XMITTER1	
	IN1 HI	900.0
	IN1 LO	20.00
	RATIO1	1.00
	BIAS 1	0.0
	FILTR1	1
	BRNOUT	UP
	EMMISIV1	

Figure 4 (Page 2). Programming Honeywell DC2500-CE-0A00-200 Modulating Controller for Heatec HC and HCS heaters

Group Prompt (Setup button)	Function Prompt (Function button)	Value or Selection (up / down arrows)
CONTRL	PV SOURC	
or	PIDSET	ONE
	SW VALUE	
	LSP'S	ONE
	RSP SRC	
or	AUTOBIAS	
	SP TRK	NONE
or	PWR UP	ALSP
	PWR OUT	
	SP Hi	500.0
or	SP Lo	20.00
	ACTION	REV
or	OUT RATE	
	PCT/M UP	
or	PCT/M DN	
	OUT Hi	100.0
	OUT Lo	0.0
	IHiLIM	
	ILoLIM	
	DROPOFF	
	DEADBAND	
	OUT HYST	
	FAILSF	0.0
	FSmode	NO L
	MAN OUT	
	AUTO OUT	
	PBorGN	PB
	MINRPM	RPM
OPTION	AUXOUT	
	4mA VAL	
	20mA VAL	
	DIGIN1	
	DIG1 COM	
	DIGIN 2	
	DIG2 COM	

Group Prompt (Setup button)	Function Prompt (Function button)	Value or Selection (up / down arrows)
COM	ComADR	3
	ComSTA	DIS
	IRENAB	ENAB
	SHEDTIME	
	PARITY	
	BAUD	19.2K
	DUPLEX	
	TX DLY	1
	SHEDMODE	
	SHEDSP	
	UNITS	
	CSP RATO	
	CSP BIAS	
	LOOPBACK	
ALARMS	A1S1TY	DE
	A1S1VA*	25.00
	A1S1HL*	HIGH
	A1S2TY	NONE
	A2S1TY	IN 1
	A2S1VA*	120.0
	A2S1HL*	LOW
	A2S2TY	NONE
	ALHYST	3.3
	ALARM1	NO L
	BLOCK	DIS
	DIA AL	DIS
DISPLY	DECMAL	NONE
	UNITS	F
	FREQ	60
	NOLDSP	DIS
	LNGUAG	ENGL

Programming order: CONTRL, OPTION, COM, ALARMS, DISPLAY, TUNING, SPRAMP, A TUNE, ALGOR, OUTALG, INPUT 1, INPUT 2.
***These Function Prompts will not appear until after the remaining prompts for ALARMS have been set.**

at Heatec before each new heater is shipped. However, if you obtain a Honeywell controller directly from Honeywell as a warranty replacement you will have to make these settings before putting the heater back into operation.

SETTINGS FOR CONTROLLER USED WITH CHATTERBOX

Settings for controller DC2500-CE-1A00-200 used with the Chatterbox automated monitor are the same as those shown in **Figure 4** for controller DC2500-CE-0A00-200, except for settings under **OPTION**. These should be set as follows:

Special Settings for Controller DC2500-CE-1A00-200		
OPTION	AUXOUT	IN 1
	0 PCT	100.0
	100PCT	800.0
	CRANGE	4-20
	DIGIN1	NONE
	DIGIN2	
	DIG2 COM	

RE-TUNING

On many heaters the Heatec settings provide satisfactory modulation control of the burner, so it is not necessary to change those settings. However, the settings on the controller should be changed if the temperature of the thermal fluid constantly overshoots its proportional band (PB) causing the burner to frequently cycle *on* and *off*. The process of changing these settings to achieve better control of the burner operation is known as *re-tuning*.

Re-tuning should be done only after the heater and thermal fluid circuits have been filled with thermal fluid and purged free of air and water.

There are two methods of re-tuning. One method is to use the *Accutune* function of the controller, which automatically tunes the controller. The other method is to manually reset the three functions shown in **Figure 5.** Again, do not re-tune the controller unless the heater shuts *off* and *on* frequently. Instructions for using both of these tuning methods follow.

Re-tuning UDC2500 controller using "Accutune"

Due to wide variations in heating systems and heater capacities, *Accutune* works fine on some heating systems, but not well on others. Accordingly, try *Accutune* before re-tuning the controller manually. If it does not work as well as expected, try re-tuning it manually. Follow these steps to use *Accutune:*

1. Press the **Setup** button repeatedly until the lower display shows **A TUNE**.
2. Press the **Function** button to show **FUZZY** in lower display. Make sure upper display shows **DIS**.
3. Press **Function** button until **A TUNE** shows in lower display. Use arrow key so that **TUNE** shows in upper display.
4. Press **Lower Display** button to return to main display. Make sure the letter **A** (auto) shows in the display.
5. Press **Lower Display** button and up arrow button simultaneously. The letter **T** should appear in the upper display. This indicates that *Accutune* is underway. It could take from a few minutes to several hours. When it is complete the **T** will disappear and new values should appear for **PB, RATE T** and **I RPM. (**You can abandon this tuning process by pressing the **Manual/Auto** button.) If **A TUNE** settings do not provide suitable operation, press the **Setup** button until **TUNING** appears. Then proceed with manual re-tuning.

Re-tuning DC2500-CE controller manually

To re-tune the controller manually, reset the values for the *three* tuning functions shown in **Figure 5**. This figure presently shows their *initial* preset values. You will need to change these values.

Figure 5. Three key burner functions		
Group Prompt	**Function Prompt**	**Value or Selection**
TUNING	PB	4.00
	RATE T	1.00
	I RPM	5.00

Resetting the values of the three functions is a matter of trial and error. It may be possible to improve control by increasing the values of all three. However, the value of only one function should be reset at a time.

Start by increasing PB to 8.0. Operate the heater at its new setting to see its effect before making any other changes.

If you think further improvement is needed, reset RATE T to 2.00. Again, operate the heater at its new setting to see its effect before making any other changes.

If you think further improvement is needed, reset I RPM to 8.0. Again, operate the heater at its new setting to see its effect before making any other changes.

If you think further improvement is needed after resetting all three, repeat the sequence of changing the values of each function, one at a time. Here are some values to try:

- For PB try values from 2.0 to 15.0.
- For RATE T try values from 0.08 to 2.00 (0.08 or less disables this function)
- For I RPM try values from 3.00 to 8.00 (Setting it to 1.00 is too low)

You don't have to know what these functions do and how they work to achieve satisfactory operation. However, some understanding of them should be helpful, so please read on for an explanation.

UNDERSTANDING TUNE FUNCTIONS

Understanding the three tuning functions mentioned above is helpful when re-tuning the controller. These three functions are widely known as PID or Proportional-Integral-Derivative.

When combined, the **proportional**, **integral**, and **derivative** actions provide quick response to error, close adherence to set point, and control stability. A brief overview of these three functions is shown in **Figure 6.**

Understanding the proportional band (PB)

The controller has an *output* used to control heating of thermal fluid to maintain a temperature that the operator presets on the controller. This preset is known as *set point* or SP.

Figure 6. Meaning of three key burner functions

PROMPT ON CONTROLLER	MEANING
PB	A **band** of temperatures in which a change in the controller's output is **proportional** to a change in temperature. The preset value for this band is a **percentage** of the process variable (PV) range. (PV range is the temperature range for the thermocouple used in the thermal fluid circuit.)
RATE T	A correction to the controller's proportional output based on the difference in thermal fluid temperature and its set point and the *rate* it is changing. This correction is obtained using a mathematical **derivative** and uses the preset value as a factor in the equation.
I RPM	A correction to the controller's output based on the difference in thermal fluid temperature and the set point and *how long the difference has existed* (**integral** time). The preset value for I RPM governs how many times or **resets per minute** the controller makes a correction.

The controller senses thermal fluid temperature (known as process variable or PV) from a thermocouple. The controller processes the thermocouple signal and produces a control signal or *output* that it sends to Honeywell modulating actuator TZ4-1. The actuator responds by either increasing or decreasing the burner firing rate as required to maintain fluid temperature at the set point. Output of the controller is proportional when the thermal fluid temperatures are within a certain range known as the *proportional band*.

Please see **Figure 7** for a graph that depicts the characteristics of proportional control for a heater that is theoretically the *optimum* size. It helps in understanding the explanations given below.

In **Figure 7** the output of the controller that maintains the temperature of the thermal fluid at SP is labeled CONSTANT. This is the output of the controller when the error or deviation is zero while the heater is in a *steady state*. Theoretically, when the set point is the midpoint of the PV range, the constant will be 50 percent. However, the constant for our heaters is *usually* much less than 50 percent and in rare instances more than 50 percent. It varies because of numerous factors, such as the size of the heater, how well the piping is insulated, etc.

Figure 8 shows the proportional control for a hypothetical heater that is *oversized* with an assumed constant of 25 percent. **Figure 9** shows the proportional control for a hypothetical heater that is *undersized* with an assumed constant of 75 percent.

In all cases, the proportional band is a percentage of the PV (process variable) range. The PV range is determined by the type of thermocouple used to sense the temperature of the thermal fluid flowing out of the heater and the range setting used on the controller. The thermocouple most frequently used with Heatec heaters is a type J.

The controller is set for its *medium* range and appears on the controller as J M. Its medium range is from 20 degrees F to 900 degrees F. Accordingly, it has a range of 880 (900 minus 20) degrees and this becomes the PV (process variable) range. Thus, the value you set for the proportional band is a percentage of 880.

Setting the PB to a value of 4.00 means 4 percent of 880 (or 35.2 degrees). Thus, a span of 35.2 degrees F is used as the proportional band. Accordingly, the output of the controller will be proportional over a span of 35.2 degrees, and this is the full modulating range or proportional band of the controller.

The SP (set point) is always somewhere within that proportional band, usually the center of the band. (The set point is the thermal fluid temperature you wish to maintain.) Heaters at most asphalt plants use a set point of 320 degrees F. So, we will use that as the set point in our explanations.

Using 320 degrees F as the SP, the proportional band will range from 302.4 to 337.6 degrees F as shown in **Figures 7, 8 and 9.** Controller outputs for temperatures between those two points are proportional.

However, the size or the heater in relation to the heat load affects the firing rate needed to maintain set point and other temperatures within the proportional band. Note the differences in firing rates for a heater of *optimum* size compared to heaters that are *oversized* and *undersized* as shown in **Figures 7, 8 and 9.**

Figure 7 shows the controller output for a heater of *optimum* size. Its output is 100 percent when the temperature is at 302.4 degrees F. Its output is 50 percent when the temperature is at the set point of 320 degrees F. Its output is zero percent (or low fire) when the temperature is at 337.6 degrees F.

Figure 8 shows the controller output for a heater that is *oversized*. Its output is 50 percent when the temperature is at 302.4 degrees F. Output is 25 percent when the temperature is at the set point of 320 degrees F. Its output is zero percent (or low fire) when the temperature is at 337.6 degrees F.

Figure 9 shows the controller output for a heater that is *undersized*. Its output is 100 percent when the temperature is at 302.4 F. Its output is 75 percent when the temperature is at the set point of 320 degrees F. Its output is 50 percent when the temperature reaches 337.6 F. Its output is zero percent (or low fire) if the temperature exceeds 337.6 degrees F.

Understanding I RPM

This setting of the controller results in a correction to the controller's proportional output. The correction is based on both the size of the error (the difference between the SP and PV) and how long it lasts.

The term I RPM means *integral* time in *repeats per minute*. The value you set as I RPM governs how frequently proportional action is repeated *within* each minute. Be careful not to confuse that term with I MIN, which means *integral* time in *minutes per repeat*. The latter means there is one or more minutes *between* each repeat of proportional action. In either case, the reset is for **integral** time.

This correction is needed because of an inherent weakness of proportional control. Proportional control requires a significant error condition to create an output signal. Accordingly, proportional control alone can never actually achieve the desired condition. Some small amount of error, known as system *offset* will always be present. **Figure 10** shows the type of control response typical of proportional control alone. Note the offset from set point.

The **integral** action is designed to eliminate offset. Because the offset's magnitude is relatively small, it cannot change the control signal significantly by itself. An *integrating* term is used to observe *how long* the error condition has existed, summing the error over time. The summation value becomes the basis for an additional control signal, which is added to the signal produced by the proportional term. The control loop then continues to produce a control action over time, allowing the elimination of offset.

Adding integral action to the controller output can:

- Respond to the presence of error in the control loop.
- Relate the magnitude of the control signal to that of the error.
- Respond to offset over time to achieve zero error—set point.

Figure 11 shows the control response typically produced with proportional-integral control. The significant difference is the elimination of offset once the system has stabilized.

Understanding RATE T

This setting of the controller results in a correction to the controller's proportional output. The correction is based on both the size of the error (the difference between the SP and PV) and the *rate* it is changing.

The term RATE T refers to *rate time* (rate per minute), which can range from 0.00 to 10.00 (0.08 or less = OFF). The value you set as RATE T governs how much braking action is applied to the output of the controller as it corrects for error. This correction is applied only when the error is changing and increases when error changes faster.

This correction is needed because proportional control has a tendency to *overshoot*. Overshoot refers to a control loop's tendency to overcompensate for an error condition, causing a new error in the opposite direction. Overshoot can cause unnecessary overheating.

Overshooting is corrected by a **derivative** action that provides an anticipatory function to exert a "braking" action on the control loop. The derivative term is based on the error's *rate* of change. It observes how fast the PV approaches SP and produces a control action based on this rate of change. This additional action anticipates the convergence of PV and SP, in effect counteracting the control signal produced by the proportional and integral terms. The result is a significant reduction in overshoot.

Figure 12 shows the effect of both integral and derivative actions to reduce overshoot and eliminate offset in proportional control.

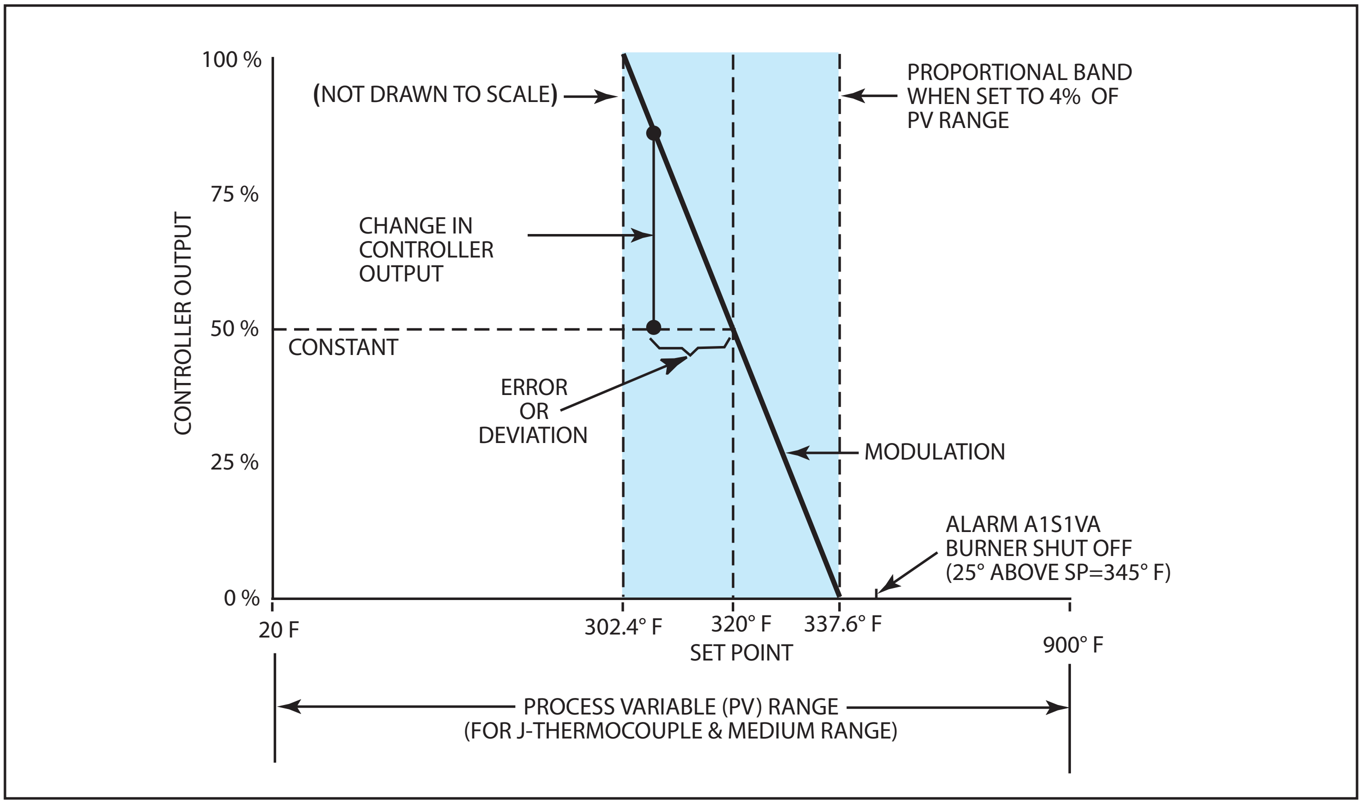

Figure 7. Understanding proportional control (optimum heater size).

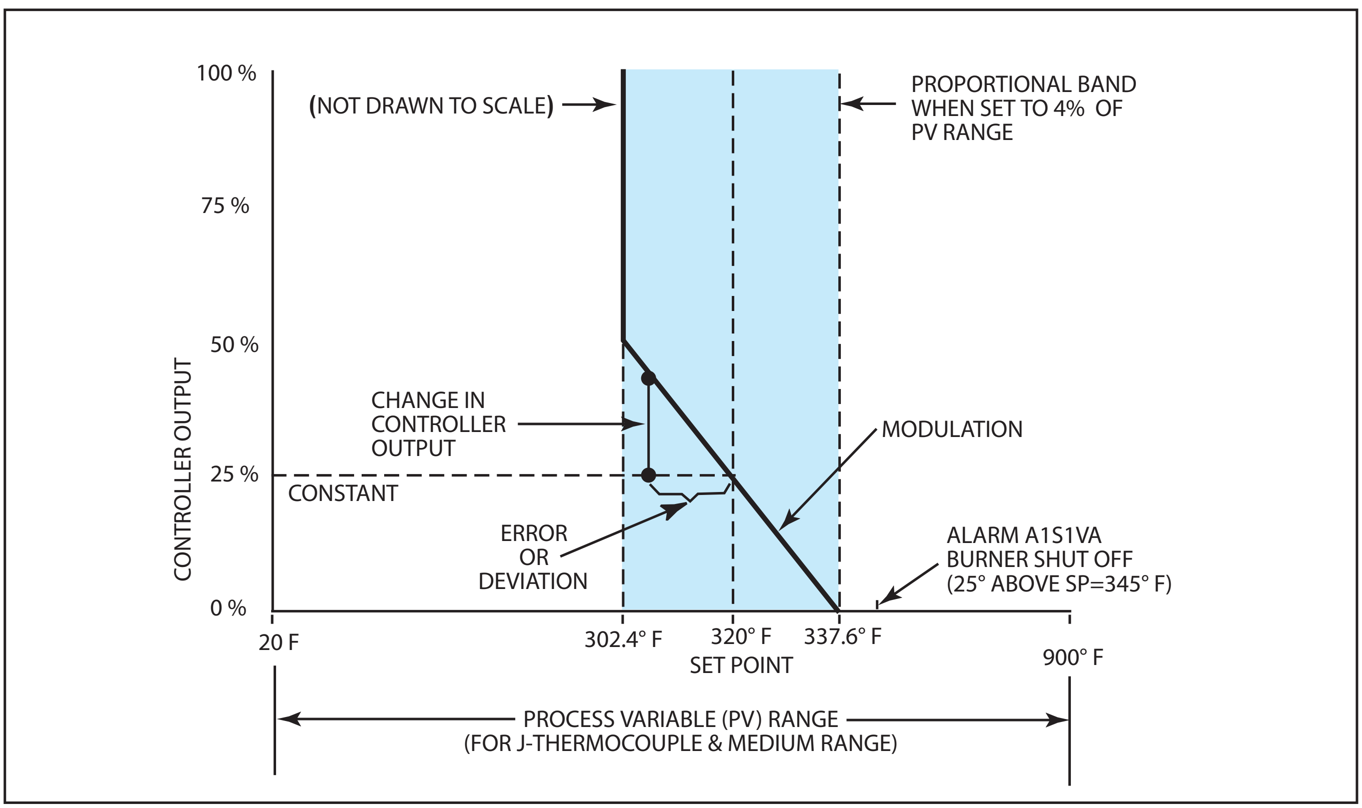

Figure 8. Understanding proportional control (oversized heater).

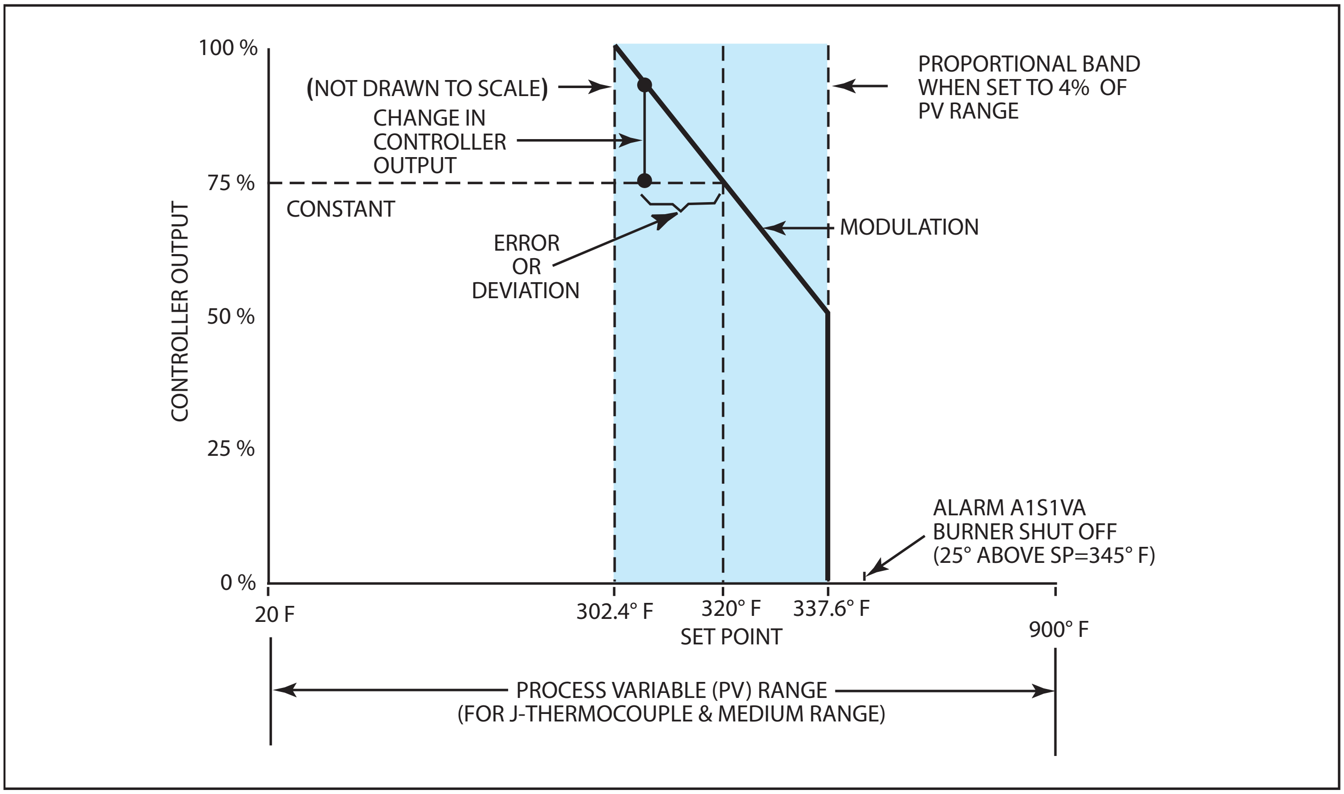

Figure 9. Understanding proportional control (undersized heater).

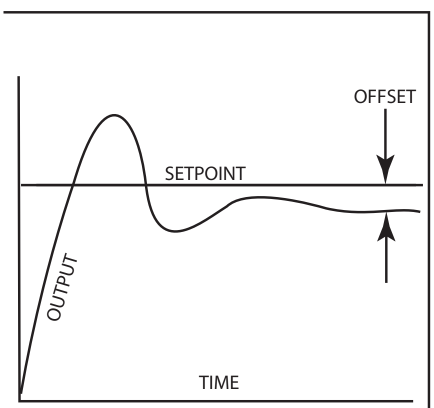

Figure 10. Proportional control .

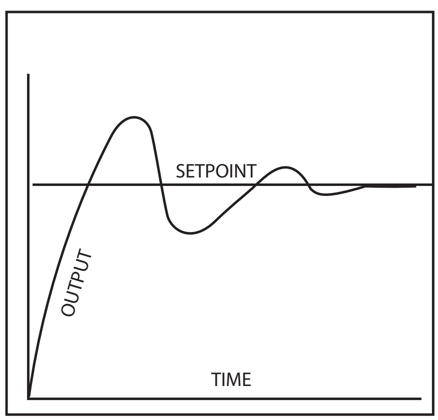

Figure 11. Proportional control with integral correction.

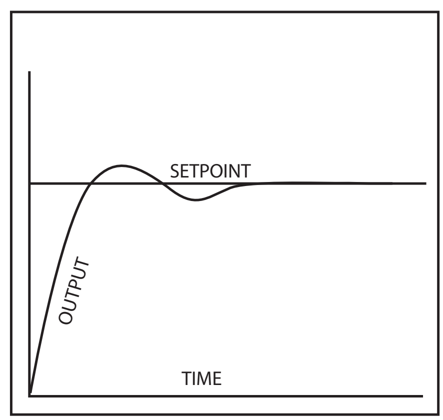

Figure 12. Proportional control with integral and derivative correction.