HEATEC TEC-NOTE

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Programing and re-tuning Honeywell UDC3300 modulating controllers used on Heatec HC and HCS heaters

This document provides information for programing and re-tuning Honeywell UDC3300 controllers **(Figure 1)** used on Heatec HC and HCS heaters **(Figure 2)**. It applies to all sizes of HC and HCS heaters.

This document along with Honewell manuals applicable to Honeywell UDC3300 controllers are furnished with Heatec HC and HCS heaters. Note: printed copies of Honeywell manuals are now being replaced with a computer CD, which contains PDF versions of their manuals. If you need help on how to use the buttons on the controller, please refer to the applicable Honeywell manual. You can call Honeywell for technical assistance at 1-800-423-9883. Their web site for assistance is www.honeywell.com/imc.

Before attempting to retune the controller make sure it is properly programmed. The settings that apply to Heatec HC and HCS heaters are shown in **Figure 3, parts 1 and 2.** The information shown in figure 3 is the same as that shown on the laminated sheets stored inside the control panel. In case there are any differences, use the information shown on the laminated sheets.

On many heaters the controller's preset values provide satisfactory modulation control of the burner, so it is not necessary to re-tune it. However, it should be re-tuned if the temperature of the thermal fluid constantly overshoots its proportional band (PROP BD) causing the burner to frequently cycle *on* and *off*.

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 three the functions shown in **Figure 4.** Again, do not re-tune the controller unless the heater shuts *off* and *on* frequently. Instructions for using both of these tuning methods follow.

Figure 1.Honeywell UDC3300 modulating controller.

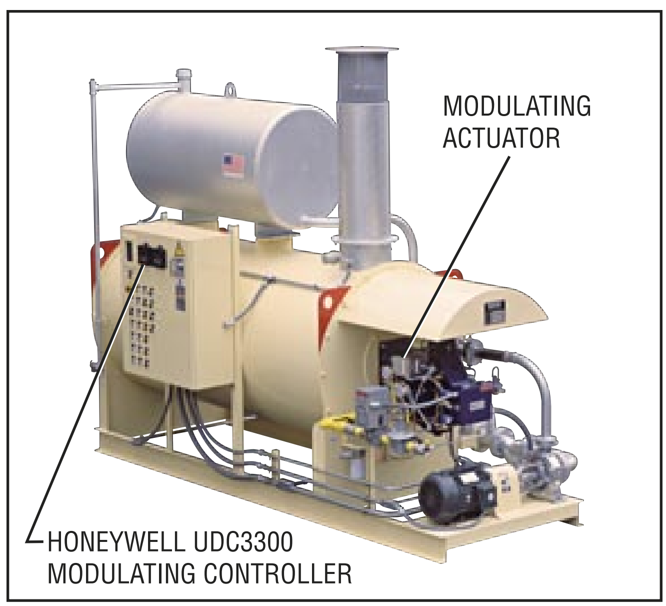

Figure 2. Heatec HC/HCS heater.

Figure 3 (Part 1). Programming Honeywell UDC3300 (Modulating Controller) for Heatec HC and HCS heaters					
Group Prompt (SET UP button)	**Function Prompt** (FUNCTION button)	**Value or Selection** (up / down arrows)	**Group Prompt**	**Function Prompt**	**Value or Selection**
TUNING	PROP BD	10.0	**ALGORTHM**	CONT ALG	PID A
	GAIN			TIMER	DISABL
	GAINVALn	Read Only		PERIOD	
	RATE MIN	1.00		START	
	RSET MIN			LDISP	
	RSET RPM	5.00		INP ALG1	
	MAN RSET			MATH K	
	PROPBD2			CALC HI	
	GAIN 2			CALC LO	
	RATE2MIN			ALG1 INA	
	RSET2MIN			ALG1 INB	
	RSET2RPM			ALG1 INC	
	CYC SEC			PCO SEL	
	CYC SX3			PCT CO	
	SECURITY	0		ATM PRES	
	LOCKOUT	CALIB			
	AUTO MAN		**OUT ALG**	OUT ALG	CURRNT
	SP SEL			4-20 RNG	
	RUN HOLD			OUT2 ALG	
				RLYSTATE	
SPRAMP	SP RAMP	DISABL		RLY TYPE	
	TIME MIN				
	FINAL SP		**INPUT 1**	IN1 TYPE	J TC L
	SP RATE	DISABL		XMITTER1	
	EU/HR UP			IN1 HI	770.0
	EU/HR DN			IN1 LO	20.00
				RATIO 1	1.000
				BIAS IN1	0.0
ACCUTUNE	FUZZY	DISABL		FILTER 1	1
	ACCUTUNE	DISABL		BURNOUT1	UP
	AT ERROR			EMMISIV1	
			INPUT 2	IN2 TYPE	
				XMITTER2	
				IN2 HI	
				IN2 LO	
				RATIO 2	
				BIAS IN2	
				FILTER 2	
				BURNOUT2	
				EMMISIV2	

Figure 3 (Part 2). Programming Honeywell UDC3300 (Modulating Controller) for Heatec HC and HCS heaters

Group Prompt (SET UP button)	Function Prompt (FUNCTION button)	Value or Selection (up / down arrows)	Group Prompt	Function Prompt	Value or Selection
CONTROL	PV SOURCE		**COM**	ComSTATE	DISABL
	PID SETS	1 ONLY		ComADDR	
	SW VALUE			SHEDTIME	
	LSP'S	1 ONLY		PARITY	
	RSP SRC			BAUD	
	AUTOBIAS			DUPLEX	
	SP TRACK	NONE		TX DELAY	
	PWR MODE	A LSP		SHEDMODE	
	PWR OUT			SHEDSP	
	SP HiLIM	500.0		UNITS	
	SP LoLIM	20.00		CSP RATO	
	ACTION	REVRSE		CSP BIAS	
	OUT RATE	DISABL		LOOPBACK	
	PCT/M UP				
	PCT/M DN		**ALARMS**	A1S1 VAL*	20.0
	OUTHiLIM	100.0		A1S2 VAL	
	OUTLoLIM	0.0		A2S1 VAL*	200.0
	I Hi LIM	100.0		A2S2 VAL	
	I Lo LIM	0.0		A1S1TYPE	DEV
	DROPOFF	0.0		A1S2TYPE	NONE
	DEADBAND			A2S1TYPE	INP1
	OUT HYST			A2S2TYPE	NONE
	FAILMODE	NO LAT		A1S1 HL	HI
	FAILSAFE	0.0		A1S1 EV	
	MAN OUT	0.0		A1S2 HL	
	AUTO OUT	0.0		A1S2 EV	
	PBorGAIN	PB PCT		A2S1 HL	LO
	MINorRPM	RPM		A2S1 EV	
				A2S2 HL	
OPTIONS	AUX OUT			A2S2 EV	
	4mA VAL			AL HYST	3.9
	20mA VAL			ALM OUT1	NO LAT
	DIG IN 1			BLOCK	
	DIG1 COM				
	DIG IN 2		**DISPLAY**	DECIMAL	XXXX
	DIG2 COM			TEMPUNIT	F
				PWR FREQ	60 HZ
				RATIO 2	
				LANGUAGE	ENGLIS

***These Function Prompts will not appear until after the remaining prompts for ALARMS have been set.**

Re-tuning UDC3300 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 **SET UP** button repeatedly until the lower display shows **ACCUTUNE**.
2. Press the **FUNCTION** button to show **FUZZY** in lower display. Make sure upper display shows **DISABL**.
3. Press **FUNCTION** button until **ACCUTUNE** 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 **PROP BD, RATE MIN** and **RSET RPM. (**You can abandon this tuning process by pressing the **MANUAL/AUTO** button.) If **ACCUTUNE** settings do not provide suitable operation, press the **SET UP** button until **TUNING** appears. Then proceed with manual re-tuning.

Re-tuning UDC3300 controller manually

To re-tune the controller manually, reset the values for the *three* tuning functions shown in **Figure 4**. This figure presently shows their *initial* preset values. These values are the same as shown on the laminated sheets of supplementary information furnished with your heater and duplicated in **Figure 3.** You will need to change these values.

Figure 4. Three key burner functions

Group Prompt	Function Prompt	Value or Selection
TUNING	PROP BD	10.0
	RATE MIN	1.00
	RSET 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 PROP BD to 15.0. 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 MIN 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 RSET 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 PROP BD try values from 2.0 to 15.0.
- For RATE MIN try values from 0.08 to 2.00 (0.08 or less disables this function)
- For RSET 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 of the UDC3300 Controller

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 5.**

Understanding the proportional band (PROP BD)

The UDC3300 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.

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 **Fig. 6** 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 **Fig. 6** 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

Figure 5. Meaning of three key burner functions

PROMPT ON CONTROLLER	MEANING
PROP BD	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 MIN	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.
RSET 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 RSET RPM governs how many times or **resets per minute** the controller makes a correction.

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.

Fig. 7 shows the proportional control for a hypothetical heater that is *oversized* with an assumed constant of 25 percent. **Fig. 8** 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 what thermocouple is used to sense the temperature of the thermal fluid flowing out of the heater coil. The thermocouple most frequently used with Heatec heaters is a type J with a low range. It is known as "J-LOW" and appears on the controller as JTCL. Its low range can measure temperatures as low as 20 degrees F and as high as 770 degrees F. Accordingly, it has a range of 750 (770 minus 20) degrees and this becomes the PV (process variable) range. Thus, the value you set for the proportional band is a percentage of 750.

Setting the PROP BD to a value of 2 means 2 percent of 750 (or 15 degrees). Thus, a span of 15 degrees F is used as the proportional band. Accordingly, the output of the controller will be proportional over a span of 15 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 312.5 to 327.5 degrees F as shown in **Fig. 6, 7 and 8.** 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 **Fig. 6, 7 and 8.**

Fig. 6 shows the controller output for a heater of *optimum* size. Its output is at 100 percent when the temperature is at 312.5 degrees F. Its output is at 50 percent when the temperature is at the set point of 320 degrees F. Its output is at zero percent (or low fire) when the temperature is at 327.5 degrees F.

Fig. 7 shows the controller output for a heater that is *oversized*. Its output is at 50 percent when the temperature is at 312.5 F. Output is at 25 percent when the temperature is at the set point of 320 degrees F. Its output is at zero percent (or low fire) when the temperature is at 327.5 F.

Fig. 8 shows the controller output for a heater that is *undersized*. Its output is at 100 percent when the temperature is at 312.5 F. Its output is at 75 percent when the temperature is at the set point of 320 degrees F. Its output is at 50 percent when the temperature reaches 327.5 F. Its output is at zero percent (or low fire) if the temperature exceeds 327.5 degrees F.

Understanding RSET 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 RSET RPM means *reset in repeats per minute*. The value you set as RSET RPM governs how frequently proportional action is repeated *within* each minute. Be careful not to confuse that term with RSET MIN, which means *reset 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. **Fig. 9** 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.

Fig. 10 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 MIN

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 MIN refers to rate per minute, which can range from 0.00 to 10.00 (0.08 or less = OFF). The value you set as RATE MIN 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.

Fig. 11 shows the effect of both integral and derivative actions to reduce overshoot and eliminate offset in proportional control.

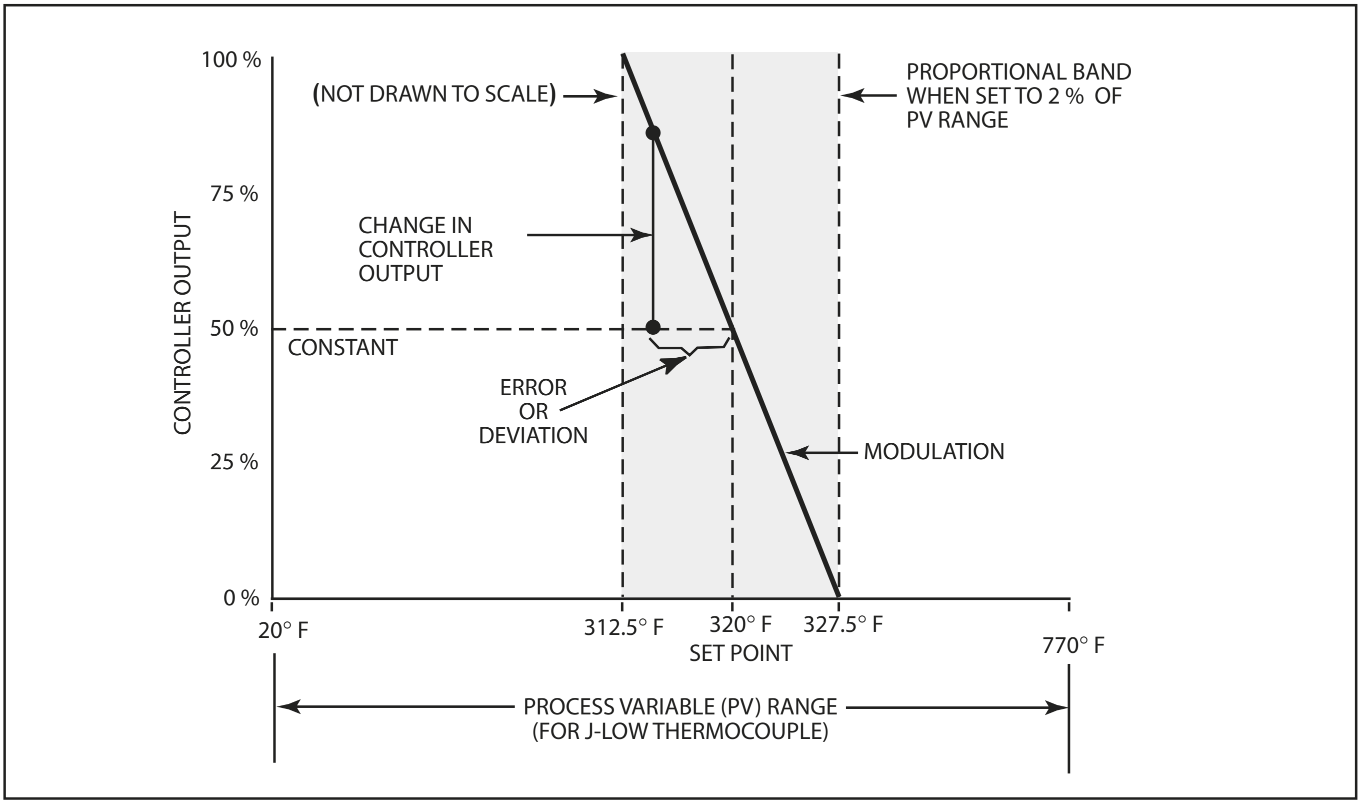

Figure 6. Understanding proportional control (optimum heater size).

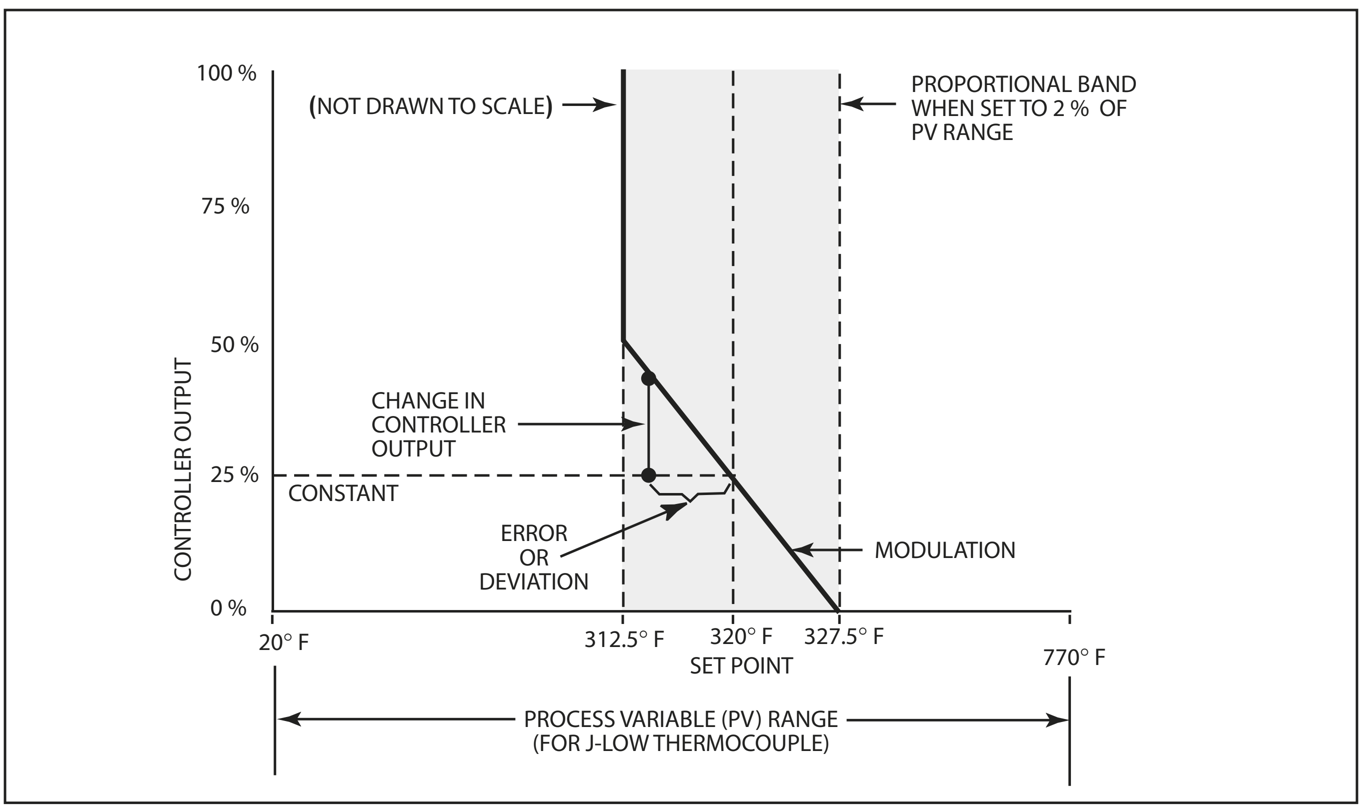

Figure 7. Understanding proportional control (oversized heater).

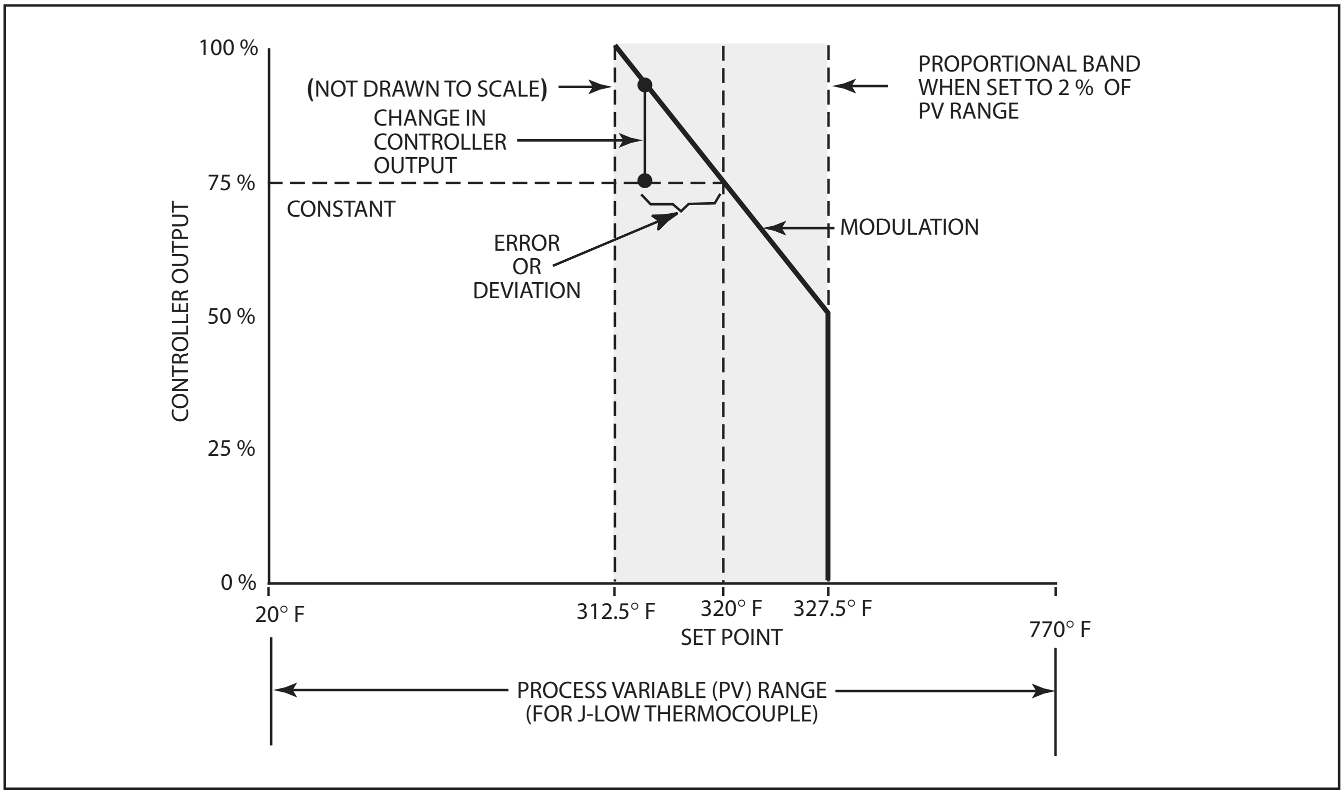

Figure 8. Understanding proportional control (undersized heater).

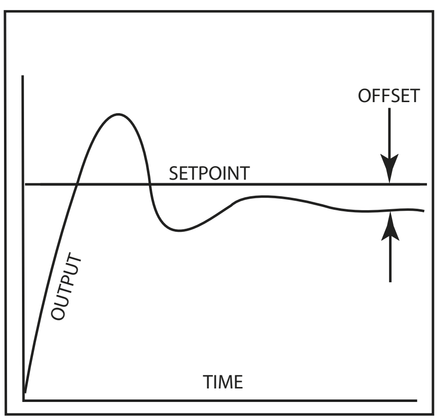

Figure 9. Proportional control .

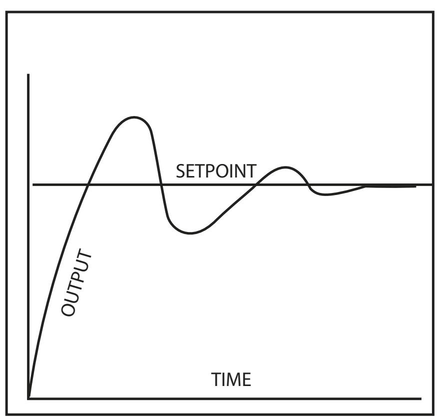

Figure 10. Proportional control with integral correction.

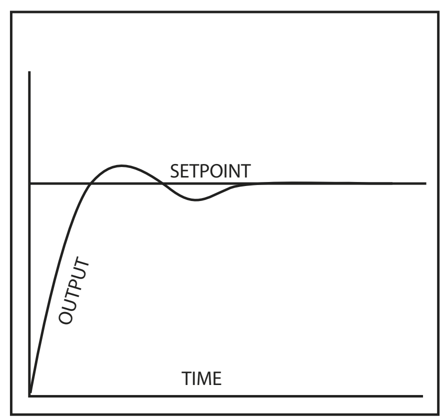

Figure 11. Proportional control with integral and derivative correction.