INSTRUCTION MANUAL for EPCON

ELECTRO-PNEUMATIC CONTROLLER (2.9 ver.)

■CONTENTS ■

■APPENDIX ■

B Y
CONTROLS,INC.

February 2005 Edition

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SPECIFICATIONS

01. Supply Voltage ----------	110 ~ 220V AC 50/60Hz, 24V DC
02. Operating Voltage Range ----------	90 ~ 110% of Rated Voltage
03. Power Consumption ----------	12 W (Max.), 9W (Steady State)
04. Input ----------	4~ 20mA / PT100 Ω
05. Output ----------	4~ 20mA, Accuracy ±0.5% Span
06. Control Action ----------	DIRECT or REVERSE
07. Control Functions ----------	P.I.D. Control Functions.
08. Local Set Point Adjustment ----------	UP/DOWN Push Button
09. Remote Set Point Adjustment ----------	4 ~ 20 mA Input
10. Adjustable Parameters (Normal Mode) ---	PV, SP, DEV, Max, Min, KP, KI, KD
(Additional Parameter Input Mode) ---	LCD, UNIT, Valve Action (DIRECT / REVERSE)
11. Communication (optional) ----------	RS232C Link Output Capability
12. Self-Diagnostic ----------	Service Mode Display / Error LED Lamp / Error Message
13. Alarm Relay (optional) ----------	N.C or N.O
14. Input Air Pressure ----------	100psig Max.
15. Output Air Pressure ----------	0 ~ 34psig
16. Air Consumption ----------	No Consumption at Steady State
17. Accuracy ----------	±0.5% of Full Span
18. Input Resistance to Current Loop ----------	100Ω x Current + 0.7V
19. Ambient Temperature ----------	-20 ~ 60 ℃
20. Overall Dimensions ----------	205(W) x 260(L) x 130(H) mm
21. Enclosure ----------	NEMA 4 x Polycarbonate

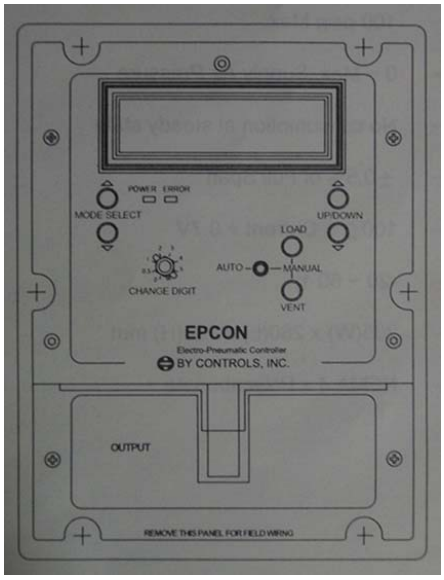
1. INTRODUCTION

BY EPCON, a digital type electro–pneumatic controller is designed to control process variables such as pressure, temperature, liquid level and etc.. It provides all the latest digital electronic control functions with reliability of a pneumatic controller.

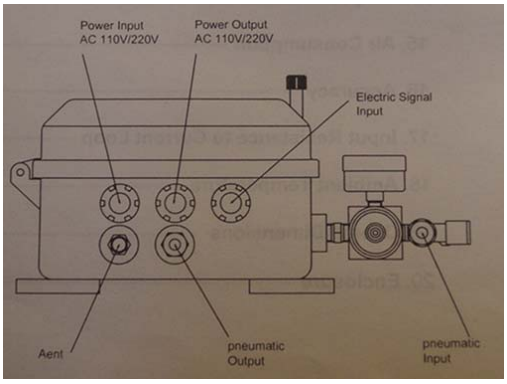
BY EPCON is composed of several major parts including Digital Signal Processor, flash ROM for program/data storaging, LCD display, signal processing & WatchDog circuits, digital signal filter, A/D converter, control buttons, RS232C communication interface (optional), a pair of solenoid valves and its driving unit, signal input/output terminals and etc.. The algorithm for PID control was adopted as control software.

BY EPCON operates on 110~220V AC (50/60 Hz) or 24V DC power. It accepts signals from standard 4~20 mA transmitter, and provides a pneumatic output to operate diaphragm or piston actuated control valves. The controller accommodates a maximum of 60 psig output to control pneumatic diaphragm or piston type actuator without using I/P transducer or valve positioner. BY EPCON has its own 24 volt DC power supply for the transmitter, simplifying the complexity of power supply with less cost.

BY EPCON, adopting solenoid valves instead of small-bored orifices which is susceptible to fouling or lugging, provides high volume air output at pressures up to 60 psig to directly operate pneumatic actuators, either single or double acting. Because of this feature BY EPCON eliminates the usage of I/P transducer and valve positioner thus reducing the costs.



<Fig.1-1> Front View

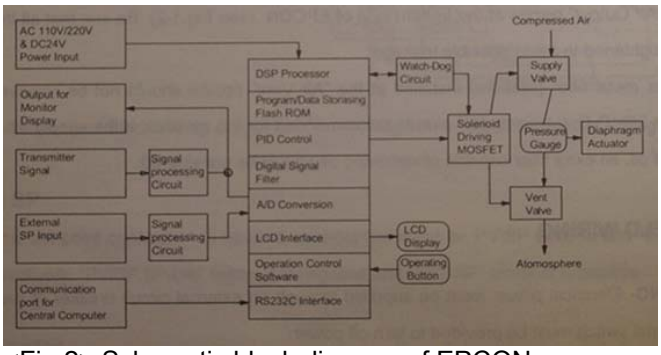


<Fig.1-2> Bottom View

2. OPERATING MECHANISM

The electronic circuit of the EPCON compares the input signal from the transmitter with the desired set point. If the deviation is greater than the dead band, electrical pulses are sent to one of the two solenoid valves – supply valve and vent valve. The supply valve increases output air pressure and the vent valve bleeds it.

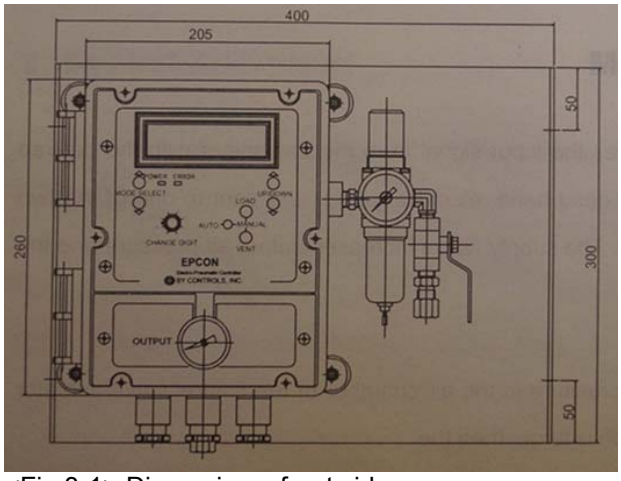
Each time a pulse is received, the resulting pressure in the air chamber of the control valve actuator increases or decreases slightly. If the deviation is large, then the solenoid valves are held open longer to accelerate the speed of output changes. For small deviations the pulse width is decreased to prevent overshoot.



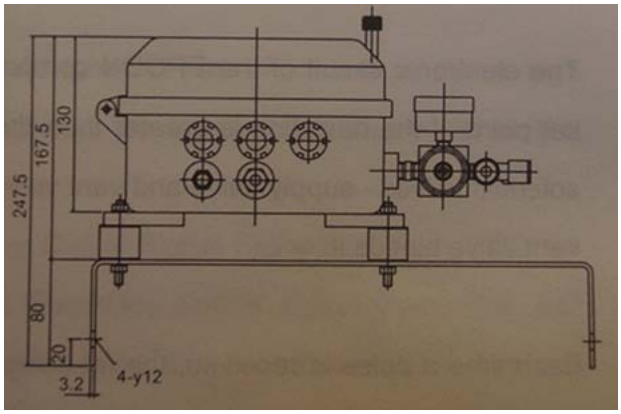
<Fig.2> Schematic block diagram of EPCON

3. INSTALLATION

BY EPCON is to be mounted in a location that allows easy access for adjustments or maintenance. See Fig. 3-1 / 3-2 for mounting dimensions.
The temperature around the mounting location is to be maintained between -20℃ and 60℃ for reliable performance. Temperatures above or below these limits will affect the LCD although the controller would still function.
A location within the distance of 15 meters from the control valve is recommended to prevent possible time lag (delay in response) in the pneumatic signal.



<Fig.3-1> Dimensions, front side



<Fig.3-2> Dimensions, bottom side

3.1 PNEUMATIC CONNECTIONS :

CAUTION – Some lubricating oil in the supply air could permanently damage solenoid valves.

Connect air supply line to the “Air Filter Regulator” at the right side of EPCON. Connect air output line to the “Air Output” nozzle at the bottom side of EPCON (see Fig.1-2). Be use that all the connection be fully tightened to avoid possible leakage.
A porous metal filter (silencer) installed at the “Air Vent” nozzle should not be removed. Corrosion resistant 8 mm pipe is recommended for the air lines. If the supply air is mixed with traces of oil, an extra filter capable of removing oil should be considered.

CAUTION – All pneumatic connections must be tight enough to be leak proof for uninterrupted operation. Air connections MUST be checked with a soapy water solution and be bubble-tight.

3.2 FIELD WIRING

WARNING- Electrical power must be supplied through an external circuit breaker or fuse protection. An external switch must be provided to turn off power.

WARNING- Turn off electrical power before removing the internal field wiring panel.

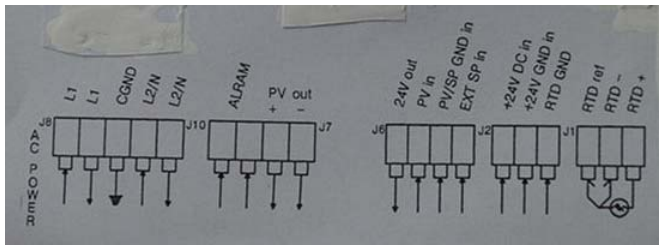
After mounting the EPCON at the desired location, open the cover by loosening the locking screws on it. Then remove the field wiring panel by loosening two captive screws. The terminal block wiring diagram shown in Fig. 3-3 appears on the back of the panel. Signal lines should be routed through different conduits from that of power line to avoid any possibility of interference. Shielded cable is to be used as transmitter signal line to prevent RF interference.

1) 2-wire Transmitter Sensor Line

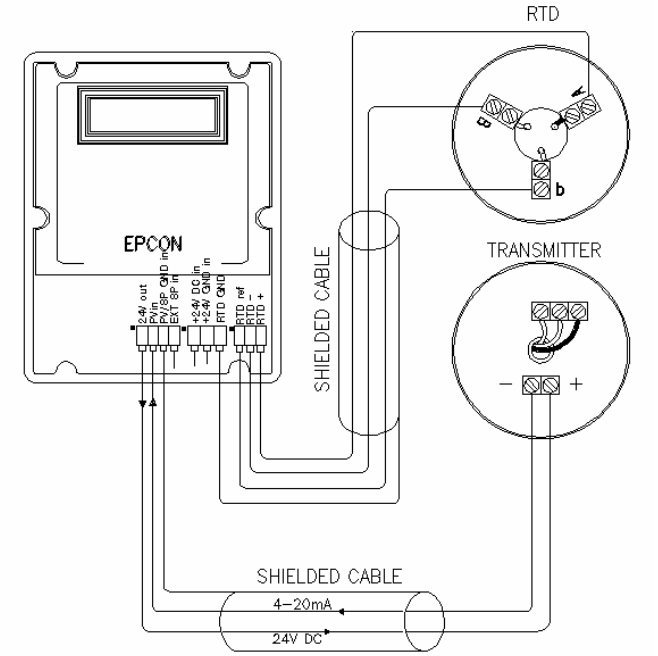
Electronic transmitter used to measure temperature, pressure, level and other variables are classified as 2-wire or 4-wire types, depending on how they are powered. The most common transmitter type is the 2-wire transmitter, which has one power input wire (24V DC nominal) and one signal output wire (4~20mA). The former is normally used for EPCON. Connect the transmitter wires as shown in Fig. 3-4. A two wire transmitter should be powered with the 24 volt DC supply from the EPCON by connecting the positive wire to “+24volt OUT” terminal and the other wire to the “PV in” terminal. If a shielded pair of wires is used, connect the ground of shielded wire to the “PV/SP GND in” terminal.

2) 3-Wire RTD (PT 100ohm) Sensor Line

Wiring of Sensor shall be fitted up with shielded and AWG20 or above cable.
Each “A”, “B” and “b” wire of sensor to be connected to each “RTD+”, “RTD-“ and “RTD Ref” terminal.
In case of using the covered wire which ground wire made of twisted cover to be connected to “RTD GND” terminal



<Fig.3-3>Terminal Block Wiring Diagram>



<Fig.3-4>2-Lined Transmitter & 3-Lined RTD Wiring

2) External SP

In case external set point connection is needed, connect the(4~20mA) external cable to "PV/SP GNDin" and "EXT SP" terminals respectively. "PV/SP GNDin" terminal is negative and "EXT SP" terminal is positive.

3) Power Source

A power source of 110~220 V AC (free voltage) is used for the main power supply. Make sure the power switch and the AC power circuit breaker are all OFF. Connect power leads to "L1, L2/N" terminals and the ground line to "CGND" terminal.
If the EPCON is powered by 24V DC (J6 terminal) Instead of AC power, connect the positive line to "+24VDCin" terminal and the negative line to "24V GNDin" terminal. Do not connect any wire to (L1,L2/N) AC Input terminal.
(Note: Figure 4)

4. OPERATION

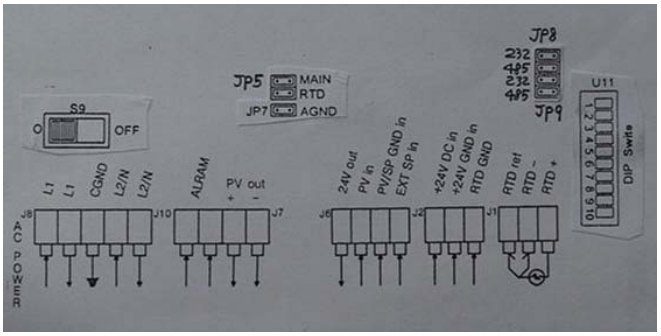
Basically four (4) operation modes are available depending on the manipulating methods of U11 DIP switches. They are Normal Mode (DIP switch No.1/2/3/4 pin OFF), Service Mode (DIP switch No.1 pin ON, 2/3/4 pin OFF), Additional Parameter Input Mode (DIP switch No. 2 pin ON, 1/3/4 pin OFF) and External SP Input Mode (DIP Switch No.4 pin ON, No.1/2/3 OFF) respectively.
Initial commissioning of EPCON is proceeded under both the Normal Mode and Additional Parameter Input Mode. Service Mode is selected when diagnosis or checking of the system is needed. External SP Input Mode is selected only when external controller is applied. DIP switch No.5/6/7 pins have not any relationship with the operation modes since they are the pins used to adjust the location of decimal points only.

Function of Individual DIP Switch Pin	
Pin No.	**Mode Functions**
1	Service Mode
2	Additional Parameter Input Mode
3	Communication Mode (RS232)
4	External Set Point Mode
5	Decimal Point Mode
6	Decimal Point Mode
7	Decimal Point Mode
8	None (spare)
9	Communication mode (RXTX485)
10	RTD (PT 100Ω)

Since almost all of the parameters such as SP, MAX, MIN, UNIT, KP, KI, KD, Actuator Action and etc. had already been input at the manufacturer's shop in the course of assembling, it is generally not necessary to change or re-input the parameter values unless correction is specifically needed. Because of this, the major works for start-up operation is usually consisted of confirming the operability of the system components including switches, buttons and control valves as well as the performance of the controller under auto operation mode.

4.1 Close the stop valves installed upstream and downstream of the control valve.

4.2 Energize the EPCON using S9 slider switch on the PCB. Confirm if Power LED lamp located under LCD display lights on.



<Fig.4> PCB Layout Diagram

4.3 Select the location of decimal point using No. 5, 6 & 7 pins of U11 DIP switch referring to the table below. Keep No. 1/2/3/4 pins at OFF position.

Decimal Pont Location	0	0.0	0.00	0.000	0.0000
DIP S/W Pin "ON"	5,6,7	6,7	5,7	7	5,6

4.4 While staying under normal mode (No.1/2/3/4 pins OFF), if necessary, change the set point values as well as the other parameters using Mode Select Button and Up/Down Change Button referring to the instructive procedure as below.

Note: For the convenience, optimum design values for all of the parameters are normally inputted at the manufacturer's shop before EPCON is delivered to the customer.

Parameter Input Procedure under Normal Mode

a. Under normal condition the first line on the LCD indicates PV, and the second line displays a specific parameter selected by the Mode Select Button. At this time the display is continuous without any blinks. But when you select a specific parameter using Mode Select Button to change its set value, this selected parameter will continue to "blink" on the LCD.

b. Input or change the parameter value as needed using Up/Down Change Button and let it be automatically saved by waiting for about 10 seconds for each parameter.

Each input value will be saved 10 seconds after the last touch on Up/Down switch automatically. This can be recognized by confirming the Error Led Light which lights up after the lapse of 10 seconds with a message "OK: Programming!" displayed on the LCD for a very short moment.

In case "ERROR: Programming!" is displayed instead of "OK: programming!" it means that the programming is not normal. If this continues despite several times of re-trial PCB should be replaced.

This 10-second Auto-Save feature is the same as in the case of Parameter Mode operation, which will be explained in this manual later.

Note: In case other parameter than PV, such as DEV, SP, MAX, MIN, KP, KD, etc., has only been checked without being accompanied by any actual adjustment, the display will be automatically returned to its original state.

c. Go through all of the eight (8) parameter, referring to the parameter table below, to finish to input the parameter values.

Menu No.	LCD Display	Changeability	Description
1	PV	No (Display only)	Process Value
2	DEV	No (Display only)	Difference between PV & SP
3	SP	Yes	Set point
4	MAX	Yes	Sensor maximum value
5	MIN	Yes	Sensor minimum value
6	KP	Yes	Proportional Gain Value
7	KI	Yes	Integral Value
8	KD	Yes	Derivative Value

4.5 Change the mode to Additional Parameter Input Mode (No.2 pin of DIP Switch ON) and, if necessary, further change the value of various detailed parameters following the Parameter Input Procedure in the step 4) above.

Note: In actual case, only the valve action, Direct or Reverse, is needed to be selected according to the actuator type. The other parameters, except for special cases, are not necessary to be changed since the optimum design value had already been input.

Additional Parameter Mode

Menu No.	LCD display	Changeability (std. value)	Function
1	UNIT	Yes	Unit selection
2	LCD	Yes [150]	LCD Contrast
3	TPLANT	Yes [60]	<sec> time needed for the control output to reach 63.2% of normal output
4	NCONTROL	Yes [30]	<step> number of control steps
5	BWfilt	Yes [10]	<Hz> bandwidth for filtering sensor signals
6	Pwidth	Yes [20.48]	<msec> length of air output solenoid ON time
7	Pthresh	Yes [1.0]	Determines the pulse output timing
8	HoldDis	Yes [256.0]	<msec> interval of display input change
9	Dbdispl	Yes [1.0]	<%> histerisis span
10	Action	Yes -	<direct / reverse> type of action
11	Damping	No [0.7%]	Tuning Parameter
12	U-Satu	No [25%]	
13	Turn	No [70%]	
14	ValveTC	No [60sec]	
15	ProceTC	No [600sec]	

4.6 Change to Service Mode (No.1 pin of DIP Switch ON) and just confirm if all the display appears normal. This mode is just for display, not for input.

Service Mode			
Menu No.	LCD Display	Change-ability	Description
1	Press.	Display Only	Press. Sensor voltage value [1V/bar+0.1V]
2	POT	Display Only	Potentiometer Value [0~5V]
3	EXT_SP	Display Only	External SP Value [0.1V/1mA]
4	PV	Display Only	Actual Sensor Value [0.1V/1mA]
5	i OUT	Display Only	4~20mA Output [0.1V/1mA]
6	i OUT_V	Display Only	4~20mA Output Line Voltage [1V/11V]
7	LCD	Display Only	LCD Contrast Output Voltage [output voltage/2 +2.5V]
8	RTD	Display Only	RTD sensor voltage value [0.4V~4.0V]
9	WDCLK	Display Only	Low pass filtered watch dog clock voltage value [0~5V] Normal value: 1.6-1.8 V
10	WDCOMP	Display Only	Solenoid oper. value by watch dog clock [0~5V]
11	+24V	Display Only	+24V Monitor Voltage [1V/11V]
12	+2.5V	Display Only	+2.5V Monitor Voltage [1V/1V]
13	-5V	Display Only	-5V Monitor Voltage [(10V + output voltage)/3]
14	SOL_V	Display Only	Solenoid oper. Voltage [1V/11V]
15	LOAD_V	Display Only	Load Solenoid Voltage [1V/11V]
16	VENT_V	Display Only	Vent Solenoid Voltage [1V/11V]
17	AUTO_SW	Display Only	AUTO/MANUAL Action Switch [ON/OFF]
18	WDCOMP	Display Only	Solenoid oper. value by watch dog clock [ON/OFF]
19	CONTROL	Display Only	Temporary Variable
20	DEV_SUM	Display Only	Temporary Variable

4.7 Change to initial Normal Mode (No.1/2/3/4 pin of DIP Switch OFF). Now, the system is ready for Performance Test Operation.

- For the purpose of operational safety, put EPCON under manual mode using Auto / Manual Selector Switch.
- Confirm the spring range of the actuator which is attached on the actuator body, and adjust the output pressure of the air pressure regulator.
-

Spring range, kg/cm2	Output press., kg/cm2
0.4 ~ 2.0	2.4

- Using the Load/Vent button, check and confirm if the movements of solenoid valves and control valve are normal by repeating full-open and full-close action for two or three times. Even when full open-close time takes longer than 3 seconds, it's enough to press the push button for only three seconds.
- Pressurize the air output side of the EPCON at approx. 1 kg/cm2, isolate the system and check if there is any change in pressure due to leakage atching the pressure gage.

- If the valve movements are normal without any leakage of air being found, open the upstream and downstream stop valves of the control valve for process service.

- If no specific problems are found, switch the operation mode to Auto, firstly by adjusting the PV to the same value as SP using Load/Vent buttons, and then switching the change lever from Manual to Auto.

4.8 In case the performance of controller is not satisfactory due to continued fluctuations,adjust the KP and KD values referring to step 4.4 above and Appendix 1 General Procedure for Setting and Tuning of EPCON.

5. TROUBLESHOOTING

5.1 Controller does not function properly.

a. Check if AC power and cable wire connections are correct and of no problem. Also check if S9 Slider Switch is ON.
b. Check if LED error lamp is ON.
c. Check if the LCD panel is unreadable in black color. In case back, check the LCD constant in the Change Digit Mode is set at 150. If it is, then the LCD panel would have to be replaced.
d. Check if the solenoid valve action is normal using the Load Button under Manual Mode and watching the output pressure change. Replace the solenoid valve if needed.
e. Check if terminal connections are all right.
-24~-40: transmitter output signal disconnected
-10~-30: sensor(-) signal disconnected
+150~+170: sensor(+)signal disconnected
f. Check if any error message - "ER SENSOR Open" or "ER: SENSOR Short" - is found on the LCD display.

5.2 Unsteady process fluctuation

a. Put EPCON on MAN mode, pressurize the air output side of the EPCON at approx. 1 kg/cm2, and check if there is any change in pressure due to leakage watching the pressure gage at least for 10 seconds.
In case the pressure increases load sol. valve may be leaky; in case the pressure decreases either vent sol. valve or diaphragm or connection tubes may be leaky. Confirm and locate the specific problem and fix it.
b. Adjust KP and KD values. See Appendix 1 for further reference.

c. Check if the control valve is operating smoothly within its desirable operating range (usually 10-90% of full span), and valve stem doesn't stick.
d. Check if the solenoid valve functions normally.

5.3 Control valve operates in the opposite direction

Check if the Direct/Reverse in the "Valve Action" menu of Additional Parameter Mode is set correctly.

5.4 Controller does not respond to changes in local set point adjustment.

a. Check if set point jumper (DIP switch pin No.4) is in the right position (OFF for local control, ON for remote control).

5.5 Controller does not respond to changes in the process value, PV.

a. Check if the transmitter connections are normal. Take reference to the error message on LCD "ER SENSOR Open" or "ER: SENSOR Short
b. Check if Auto/Manual switch is set on Auto.

5.6 The displayed process value excessively deviates from the local temp. or pressure gage readings.

a. Check if the gages are correct.
b. Check the Min/ Max range selection is correct.
c. Carefully check for any slight leakage of output air (Repeat 5.2a taking longer time, i.e. for 20~30 seconds)

5.7 Control valve does not respond to controller Air output.

a. Check if filter(regulator) supply pressure is maintained 5~10 psig higher than the pressure required to fully stroke the valve.
b.Check the operability of actuator, using Load and Vent push button under MANUAL operation mode.
c.Check for air leakage between the EPCON and the Valve actuator.
d. Check for any abnormality with the solenoid valves. (If needed sol. valves are to be dismounted and cleaned.)

5.8 Examples of most common problems encountered (for quick reference).

- Leaky air connections - must be tested bubble tight with soapy water solution.
- Incorrect field wiring – re-check connections in reverse order of how they were connected.
- Loose connections
- Insufficient air pressure supply
- Poor condensate drainage from heat exchangers

Appendix-1

General Procedure for Setting and Tuning of EPCON

1. Confirm that Power LED is lit on (Red Color).

2. Confirm that LCD display is showing "PV" and "SP" values

3. Select below **"Parameters"** using Mode Selector push button and input required set point value using UP/DOWN push buttons.
"SP," "MAX," "MIN," "UNIT," "KP," "KI," "KD"

4. Proceed with tuning according to the adjustment guide lines in the table below if the process control shows fluctuating tendency with the initial set values. It is preferable to adjust KP first and then KI or KD for easy tuning. Every adjustment needs proper time for confirming the result prior to proceed with the next adjustment.

Note:

- KP is a constant affecting the amplitude of signal to actuator. Thus, the larger this value is the greater the rate of response is, and vice versa. But too high a value can cause overshoot which will make the system unstable.

- KI is a constant which reduces the steady state error. Improperly high value leads to increased overshoot resulting in longer control time. Since BY Diaphragm Actuator has its own integral function this value is not actually needed.

- KD is a constant which increases damping effect thus expediting the stability of the process system to be controlled. Without this function the system will continue to oscillate without settling down in a short span of time.

Appendix-2

PID Initial Setting Value

Tag Name of Control Valve \ Diaphragm Size(sq.in)		35	55		85	135	185
		Temp Press	Temp	Press	Temp Press	Temp Press	Temp
1. Central F.W. temp. control valve for central F.W. cooler	KP				2.0	2.5	3.0
	KD				40.0	45.0	50.0
2. M/E jacket cooling F.W. outlet temp. control valve	KP		0.4		0.35		
	KD		20.0		30.0		
3. G/E jacket cooling F.W. outlet temp. control valve	KP		0.4		0.3		
	KD		20.0		30.0		
4. M/E lube oil inlet temp. control valve	KP		0.5		2.0	2.5	
	KD		25.0		40.0	45.0	
5. M/E lube oil purifier outlet temp control valve	KP	0.25	0.3				
	KD	20.0	20.0				
6. G/E lube oil purifier outlet temp control valve	KP	0.25	0.3				
	KD	20.0	20.0				
7. HFO purifier outlet temp. control valve	KP	0.25	0.3				
	KD	20.0	20.0				
8. HFO settling tank temp. control valve	KP	0.8	0.4				
	KD	30.0	25.0				
9. HFO service tank temp control valve	KP	0.8	0.4				
	KD	30.0	25.0				
10. Calorifier temp. control valve	KP	0.7					
	KD	30.0					
11. Excess steam. dumping valve (16 – 0 K)	KP			10.0	10.0		
	KD			20.0	20.0		
12. Excess steam. dumping valve (10 –0 K)	KP			10.0	10.0		
	KD			20.0	20.0		
13. Excess steam. dumping valve (6 –0 K)	KP			10.0	10.0		
	KD			20.0	20.0		
14. Steam press. reducing valve (16 –10 K)	KP			0.3	0.5		
	KD			4.0	4.0		
15. Steam press. reducing valve (16 –6 K)	KP	3.0		0.3	0.5	0.7	
	KD	5.0		4.0	4.0	5.0	

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Adjustment

- In case of large OVERSHOOT, reduce KP values by small decrements, i.e. between approximately 0.02 and 0.2, depending on the diaphragm size
- In case of continuous FLUCTUATION, reduce the KD values by small decrements, i.e. between approximately 1.0 and 5.0, depending on the diaphragm size