Honeywell

Engineering Data

RP920A-D MODULAR PNEUMATIC CONTROLLER

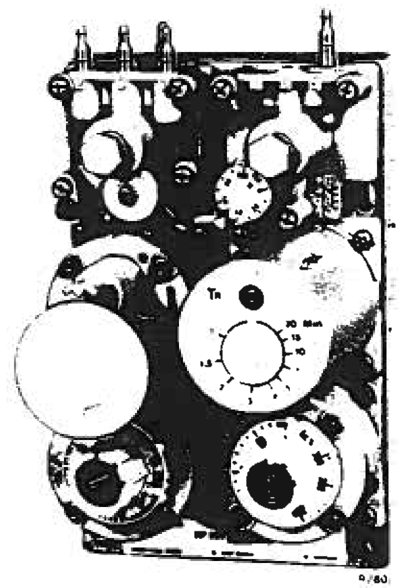
TABLE OF CONTENTS

Form No. 77-6082
Commercial Bldg. Group
MLF TAB: II. C. 6.

TABLE OF CONTENTS (Continued)

OVERVIEW

The RP920 Modular Pneumatic Controllers, in conjunction with remote sensors, provide proportional or proportional plus integral control of temperature, humidity, pressure, or dewpoint in heating and air conditioning systems.



SPECIFICATIONS

MODELS:
- RP920A: Single Input Proportional Controller.
- RP920B: Dual Input Proportional Controller.
- RP920C: Single Input Proportional plus Integral Controller.
- RP920D: Dual Input Proportional plus Integral Controller.

All models available in direct or reverse acting, and with or without Control Point Adjustment (CPA). Order cover separately.

AIR CONNECTION: Combination 5/32-inch (4mm) and 1/4-inch (6mm) push-on barb.

MAIN AIR SUPPLY (MLP): 18 psi (125 kPa) minimum.

MAXIMUM SAFE AIR PRESSURE: 30 psi (207 kPa).

INPUT SIGNAL (PRIMARY AND COMPENSATION SENSOR, CPA, AND REMOTE SETPOINT): 3 to 15 psi (21 to 103 kPa).

BRANCHLINE (BLP): 3 to 13 psi (21 to 91 kPa). Output signal maximum is MLP minus 1.5 psi (10 kPa).

AIR CONSUMPTION:
- RP920A and C: 0.021 scfm (9.91 ml/s).
- RP920B and D: 0.046 scfm (21.7 ml/s).

AIR CAPACITY: 0.07 scfm (2000 ml/min) at 1 psi (7kPa) pressure difference and 18 psi MLP.

AMBIENT TEMPERATURE AND HUMIDITY LIMITS:
- 40 TO 130F (5 to 55C).
- 5 TO 95% rh.

SETPOINT SCALE: 0 to 100% (See Table 1 for available scale overlays).

DIMENSIONS: See Figures 1 and 2.

ACCESSORIES:
1. Barb fitting (14003755-001) for Port 4, 6, 7, or 8 if connection is required.
2. Gages and Sensors (see Table 1).
3. Remote setpoint device, SP970 or equivalent.
4. Cover-RP920A: 43188057-001 (1 each), -010 (10 each).
5. Cover-RP920B,C,D: 43188123-001 (1 each), -010 (10 each).
6. Static Pressure Setpoint Scale Overlay Kit: 14004267-002.
7. Rail Mounting Kit: 14004322-001. (Provides parts to mount 25 controllers).
8. Mounting Rail:
   - 4-inch 14505694-001
   - 9-inch 14505694-002
   - 14-inch 14505694-003
   - 18-inch 14505694-004
9. BLP Tap Repair Kit 14002172-001
10. Spare standard setpoint scale overlays 14004267-001

Table 1. Receiver Gages and Sensors.

Gages △1	Scale Range	For Use with Sensor
	Temperature	
14000786-001	25 to 125F △2	LP914
305929	-40 to 160F △2	
305931	40 to 240F △2	
305986	-20 to 80F △2	
305930	0 to 200F △2	LP915
305972	50 to 100F △2	TP974 and TP925
14000786-002	-5 to 55C	
305932	-40 to 70C	
305934	5 to 115C	LP914
305987	-30 to 30C	
305933	-18 to 93C	LP915
305973	10 to 38C	TP974 and TP925
	Relative Humidity	
14000786-003	15 to 75% rh △2	HP971
14000786-004	65 to 95% rh △2	
14000786-005	15 to 85% rh △2	
	Dew Point	
305988	40 to 75F △2	TP925/SSP129
305989	5 to 25C	
	Pressure	
305965	0 to 30 psi △3	All
305966	0 to 2 kg/cm^2 △3	
305615	-1 to +1 in. H_2O △3	
305616	0 to 2 in. H_2O △3	
305617	1 to 3 in. H_2O △3	
305618	2 to 4 in. H_2O △3	
305619	3 to 5 in. H_2O △3	
305620	4 to 6 in. H_2O △3	PP905
305621	-25 to 25 mm H_2O	
305622	0 to 50 mm H_2O	
305623	25 to 75 mm H_2O	
305624	50 to 100 mm H_2O	
305625	75 to 125 mm H_2O	
305626	100 to 150 mm H_2O	

△1 Gage: 1-1/2-inch (38.1 mm) diameter, 1/8 NPT back connection.
△2 Matching setpoint scale overlay included with RP920. Spare kit 14004267-001.
△3 Matching overlay included with Static Pressure Overlay Scale Kit: 14004267-002.

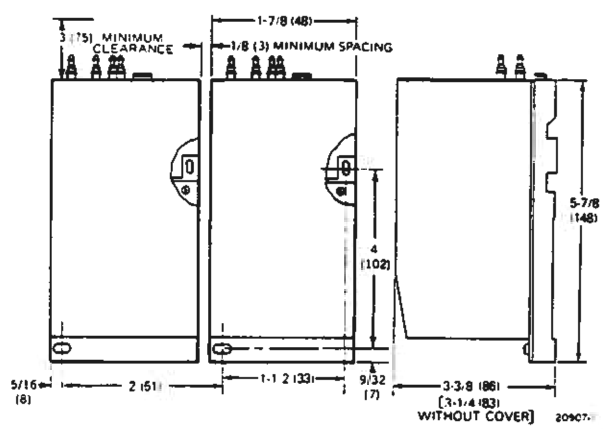


Fig. 1. RP920A Dimensions in Inches (Millimeters).

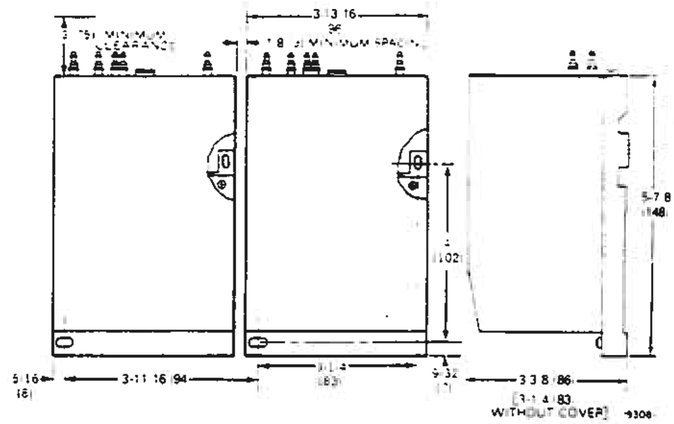


Fig. 2. RP920B, C, and D Dimensions in Inches (Millimeters).

PORT IDENTIFICATION

Use Table 2 to identify port functions.

Table 2. Port Identification.

Port Fig. 3	Function	Field Option	Model
1	Main Line Pressure(MLP)	None	
2	BLP: Maximum BLP = MLP - 1.5 psi (10 kPa)	None	All
3	Primary Sensor	None	
4	BLP Exhaust	Limit Control	
5	Compensation Sensor	None	B,D
6,7	None	Integral Cut Off	C,D
8	None	Setpoint Calibration or Remote Setpoint	All
9	Vent or CPA if ordered	None	

ADJUSTMENTS AND OPTIONS

The controller, with the calculated settings, operates satisfactorily without calibration in all but the most critical applications. Adjusting one setting will not affect the remaining settings.

Use Table 3 to determine which adjustments and options are available for the specific application. Refer to the specific section for instructions on calculations and adjustments, or enabling the options.

Table 3. Factory Settings, Options, and Adjustments.

Function	Factory Settings	Field Options	Module	Section Reference
ALL MODELS				
Gage, Primary Sensor	Loose Plug ⚠1	Tighten Plug or Field Install Gage	Connector Block	GAGES MOUNTED ON CONTROLLER
Primary Sensor Restriction	Restricted Air to Primary Sensor	No Restricted Air to Sensor. External Restriction or Nonbleed Sensor Required.	Connector Block	SENSORS USED FOR INDICATION AND CONTROL
Limit Control	Disabled	Requires External Device	Connector Block	BRANCHLINE LIMIT
Direct-Reverse Acting	As Ordered	Field Change	Proportional Module	PROPORTIONAL CONTROL
Proportional Band (Xp)	⚠2	2.5 to 50%	Proportional Module	PROPORTIONAL CONTROL
Setpoint (W1)	⚠2	0 to 100%—Other Scales Supplied with Controller	Setpoint Module	PROPORTIONAL CONTROL
Control Point Adjustment (CPA)	Optional	No Option	Setpoint Module	PROPORTIONAL CONTROL
Remote Setpoint	Disabled	Requires External Device	Setpoint Module	PROPORTIONAL CONTROL
DUAL INPUT MODELS RP920 B AND D				
Gage, Branchline	Loose Plug ⚠1	Tighten Plug, or Field install BLP Gage, or Select and Field Install Compensation Sensor Gage	Switch Block	SENSORS USED FOR INDICATION AND CONTROL
Compensation Start-Point (Wc)	⚠2	0 to 100% of Compensation Sensor Range	Switch Block	COMPENSATION
Negative-Positive Compensation	Negative	Positive	Compensation Module	COMPENSATION
Authority (Ac)	⚠2	5 to 300% (Scale 20 to 300%)	Compensation Module	COMPENSATION
P + I MODELS RP920C and D				
Reset Time (T_R)	⚠2	0.5 to 20 minutes	Integral Module	PROPORTIONAL PLUS INTEGRAL CONTROL
Integral Action Cut-off	Disabled	Enabled (Requires External Devices)	Switch Block	PROPORTIONAL PLUS INTEGRAL CONTROL
Branch Line Gage (RP920C)	Loose Plug ⚠1	Tighten Plug or Field Install BLP Gage	Switch Block	SENSORS USED FOR INDICATION AND CONTROL

⚠1 Plug shipped installed loosely in port.

⚠2 Field settings required on all job drawings.

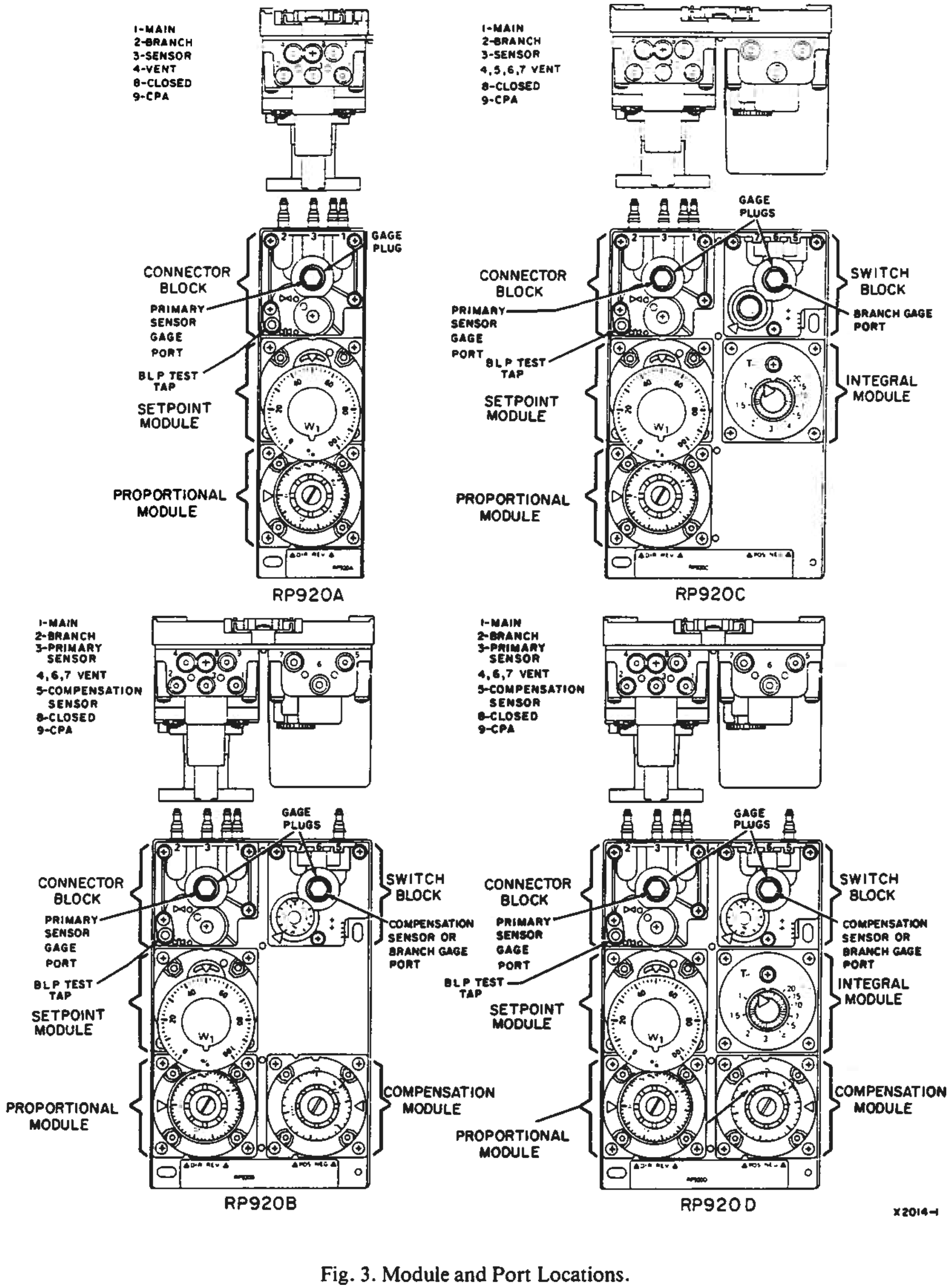


Fig. 3. Module and Port Locations.

TERMS AND DEFINITIONS

AUTHORITY—The ratio of the compensation sensor effect in a system to the primary sensor effect expressed as a percentage. The authority adjustment knob on the controller is labeled Ac.

CONTROLLED DEVICE—A valve, damper, actuator, or other mechanical device which changes position and controls the system environment.

COMPENSATION (NEGATIVE or WINTER)—A function that raises the setpoint of the primary sensor as the compensation variable decreases.

COMPENSATION (POSITIVE or SUMMER)—A function that raises the setpoint of the primary sensor as the compensation variable increases.

COMPENSATION STARTPOINT—A point, expressed as percent of the compensation sensor range, which limits the compensation sensor input. The compensation startpoint adjustment knob on the controller is labeled Wc.

CONTROL POINT ADJUSTMENT (CPA)—The local setpoint modified +/- 15 percent of the primary sensor span from a remote pneumatic source.

INTEGRAL RESET TIME—The speed at which a P + I controller reacts to deviation in a controlled variable from setpoint. The reset time adjustment knob on the controller is labeled T_R.

LOCAL SETPOINT—The setpoint adjustment on the controller labeled W1.

MEASURED VARIABLE—The parameter that a sensor measures (e.g., temperature).

OFFSET—The deviation between the setpoint and primary sensor value in a proportional control system at equilibrium.

OPERATING POINT—The factory setting determining Branch Line Pressure (BLP) when setpoint and primary sensor value are equal. The RP920A and B operating point equals 8 psi (55 kPa). The RP920C and D operating point is floating.

PROPORTIONAL BAND—The amount of change in a measured variable needed to change BLP from minimum to maximum, expressed as a percentage of primary sensor span. The proportional band adjustment knob on the controller is labeled Xp.

RANGE—The numerical designation of the minimum and maximum limits of a device or controller. Example: -40 to 160F (-40 to 71C).

REMOTE SETPOINT (RSP)—The setpoint adjusted remotely with a pneumatic device.

RESET—The amount of setpoint shift added to the setpoint on a dual input controller through action of the compensation sensor.

SENSOR OPERATING SPAN—The effective span of the sensor as determined by the system reset schedule.

SETPOINT—The primary sensor value which determines the point of control.

SPAN—The total numerical distance between range limits. Example: The range of -40 to 160F (-40 to 71C) is a span of 200F (111K).

THROTTLING RANGE—The amount of change in a measured variable needed to change BLP from 3 psi (21 kPa) to 13 psi (91 kPa) expressed in units of the measured variable.

INTERNAL OPERATION

RP920A

The functional hub of the controller is the three-stage proportional comparator. In a direct acting controller (Fig. 4), the primary sensor input from Port 3 feeds chamber P2 and is compared with the setpoint pressure (W1) in chamber P3 generated by the setpoint PRV. For reverse action, inputs to chambers P2 and P3 are reversed (Fig. 4 inset).

Chamber P4 uses BLP to provide negative feedback, and Chamber P1 uses the output from the Proportional Band (PB) setting pnuematic potentiometer to provide positive feedback. The PB potentiometer is fed by the operating point PRV, factory set at 8 psi (55 kPa), and the BLP. (The operating point PRV should not be adjusted in the field.) The PB potentiometer provides a signal that is proprtional to a ratio (determined by PB setting) between the BLP and 8 psi (55 kPa). The pilot pressure of the capacity amplifier is controlled by the nozzle of the comparator.

Controllers, with the CPA option (Fig. 5), require an external 3 to 15 psi (21 to 103 kPa) signal fed in Port 9 to change the output of the Setpoint PRV.

Remote setpoint (RSP) feature (Fig. 5) is activated by removing the screw plugging Port 8, setting setpoint PRV (W1) to 100%, and bleeding the setpoint PRV output through an external device (e.g., SP970).

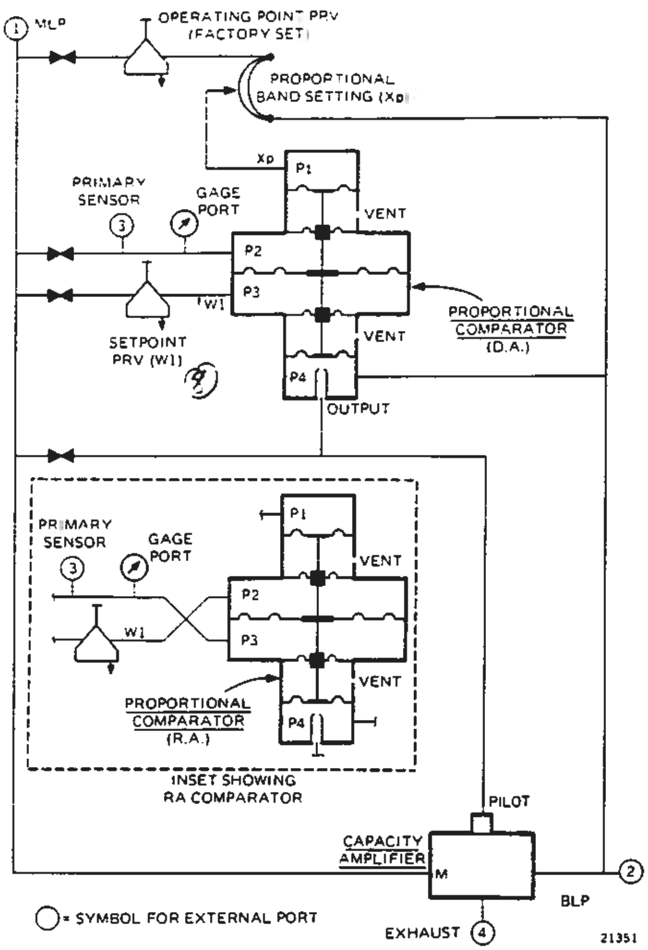


Fig. 4. RP920A Simplified Internal Schematic.

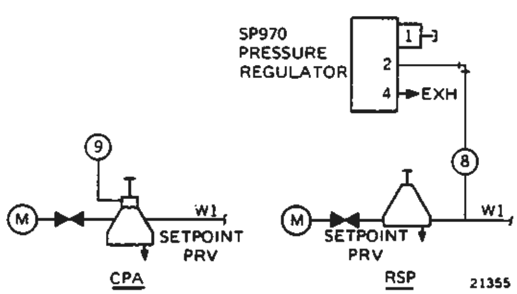


Fig. 5. CPA and Remote Setpoint Functions.

RP920B

The RP920B operates like the RP920A except Setpoint pressure is modified by a two-stage compensation comparator before feeding chamber P3 (Fig. 6).

The compensation comparator bottom stage is a 1:1 repeater. The top stage, with negative compensation, compares the compensation startpoint PRV signal (Wc) with the output from the authority setting potentiometer. The authority (Xc) potentiometer provides a signal that is proportional to a ratio (determined by authority setting) between the compensation sensor pressure and the compensation startpoint PRV output. The top stage affects the bottom stage only when chamber C1 is at a higher pressure than chamber C2 (Fig. 7). Therefore the compensation sensor can only add to the setpoint pressure.

For positive compensation, the signals to the top stage of the compensation comparator are reversed (Fig. 8).

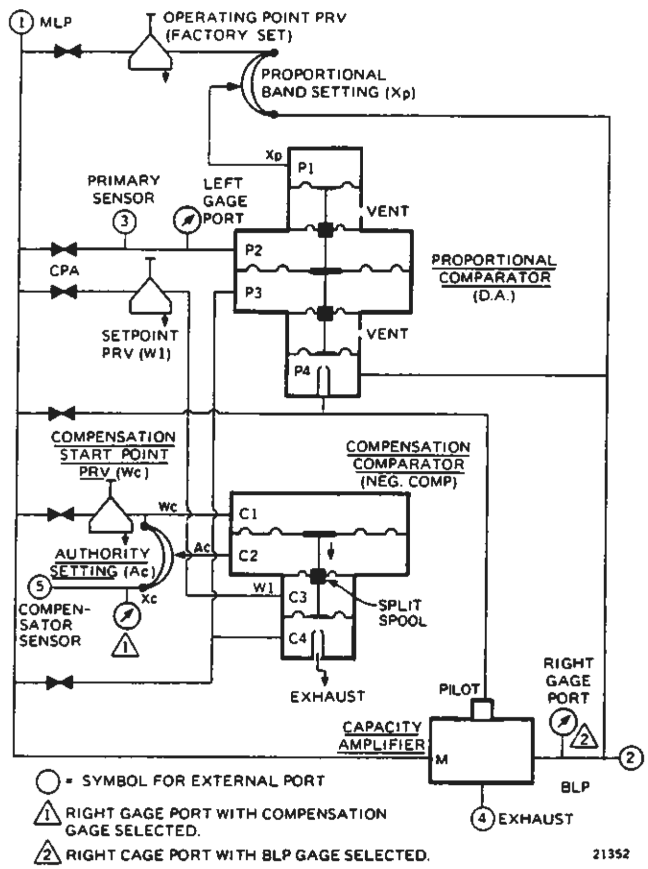


Fig. 6. RP920B Simplified Internal Schematic.

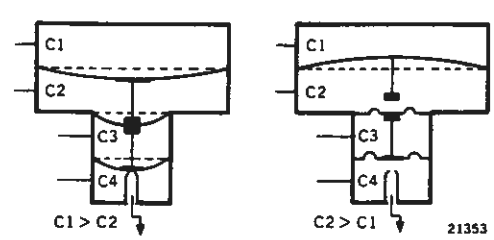


Fig. 7. Compensation Comparator Operation.

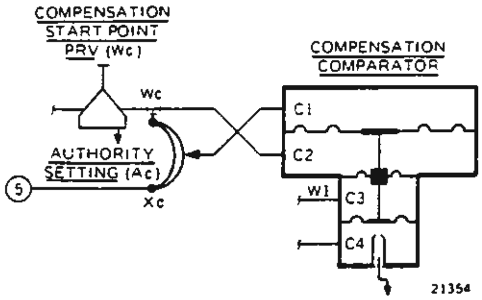


Fig. 8. RP920B and D Positive Acting Compensation Comparator.

RP920C

The RP920C is similar to the RP920A with the addition of an integral module (Fig. 9). The integral module consists of the reset time setting (T_R) adjustable restrictor, and a reset volume chamber (V2) with a 1:1 repeater (V1).

BLP changes are fed through the reset time restrictor to the volume chamber (V2), with a delay determined by the reset time setting. The 1:1 repeater bleeds the output from the operating point PRV changing the operating point pressure providing a floating control point according to load conditions. The operating point PRV is factory set to 17.5 psi (120 kPa) determining the maximum limit to the reset pressure.

The field enabled integral action cut-off function, when used with external snap-acting switches (Fig. 10A), prevents overshoot on startup or with a large system upset. The function is enabled by positioning the switch block module gasket. When BLP is less than the LOW switch setting (Fig. 10B), restricted MLP is fed to Chamber V2, raising the operating point pressure and therefore raising BLP. When BLP is between the LOW and HIGH switch settings (Fig. 10C), the controller operates normally. When BLP is greater than the HIGH switch setting (Fig. 10D), Chamber V2 is vented over time, lowering the operating point pressure and therefore lowering BLP. The effect of these actions tends to drive the BLP into its normal operating range.

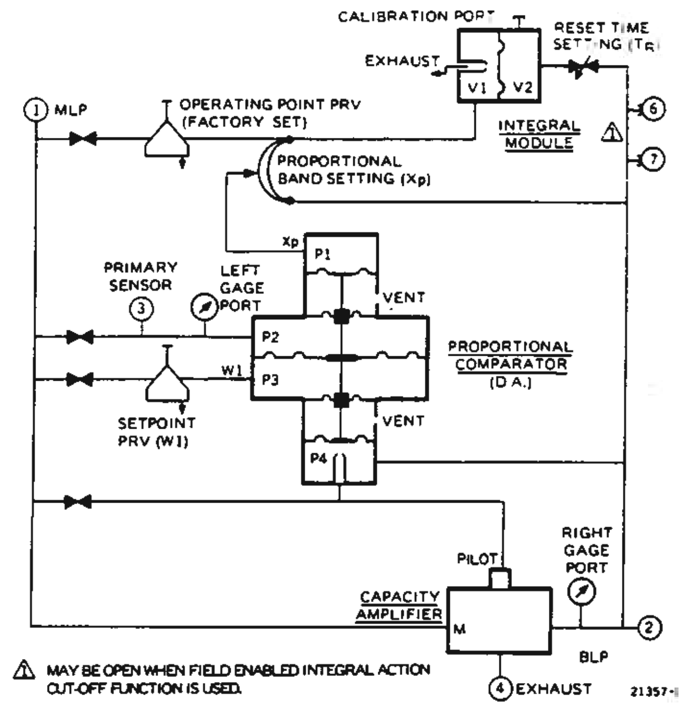


Fig. 9. RP920C Simplified Internal Schematic.

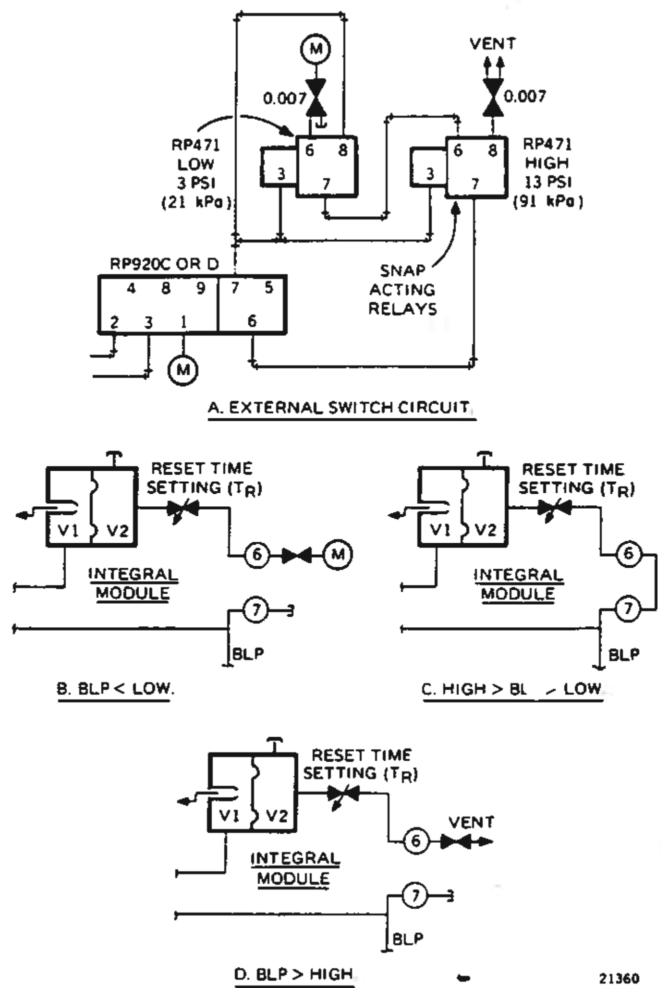


Fig. 10. Integral Action Cut-off.

The RP920D combines the floating operating point of the RP920C with the setpoint reset of the RP920B providing integral action with compensation (Fig. 11).

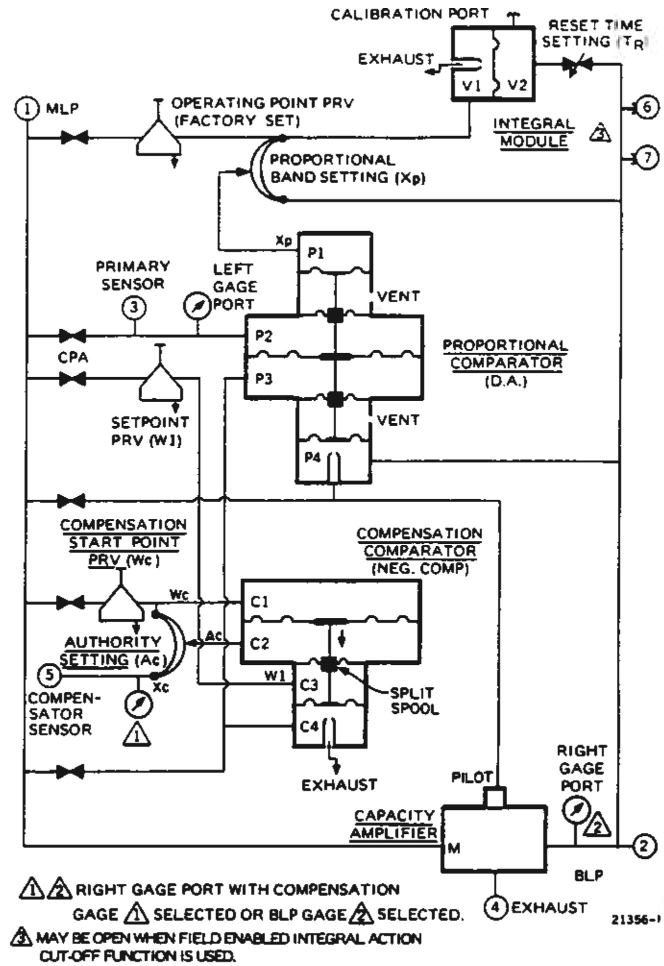


Fig. 11. RP920D Simplified Internal Schematic.

SENSORS

COMMON SENSORS

Sensors provide a direct acting (unless noted) 3 to 15 psi (21 to 103 kPa) pneumatic output, proportional to the measured variable. Any change in the measured variable is reflected as a linear change in the sensor output.

Refer to Figure 12 and Table 4 for sensor parameters and standard Honeywell sensor specifications.

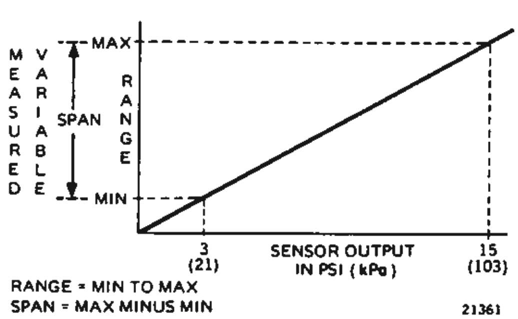


Fig. 12. Sensor Parameters.

Table 4. Sensor Specifications.

Sensor	Measured Variable	Range in F(C) unless noted: Minimum	Maximum	Span in F (K)	Output/Unit of Measured Variable
LP914	Temperature	-40 (-40)	160 (71)	200 (111)	0.06 psi/F (0.75 kPa/C)
		40 (4.4)	240 (116)		
		-20 (-29)	80 (27)	100 (55)	0.12 psi/F (1.5 kPa/C)
		25 (-3.9)	125 (52)		
LP915	Temperature	0 (-18)	200 (93)	200 (111)	0.06 psi/F (0.75 kPa/C)
TP974 TP975	Temperature	50 (10)	100 (38)	50 (28)	0.24 psi/F (2.9 kPa/C)
TP975/ SSP129	Dew Point	40 (5)	75 (25)	35 (20)	0.34 psi/F (4.2 kPa/C)
PP905	Differential/ Static Pressure	Setpoint minus 1.0 in. wc (0.25 kPa)	Setpoint plus 1.0 in. wc (0.25 kPa)	2.0 in. wc (0.5kPa)	6.0 psi/in wc (166 kPa/kPa)
HP971	Humidity	65% rh	95% rh	30% rh	0.40 psi/% rh (2.8 kPa/% rh)
		15% rh	75% rh	60% rh	0.20 psi/% rh (1.4 kPa/% rh)
		15% rh	85% rh	70% rh	0.17 psi/% rh (1.2 kPa/% rh)

OTHER SENSORS

When using other sensors (industrial, etc) or when using other devices as sensors (e.g., thermostats), determine sensor minimum and maximum values. The maximum is the value of the measured variable that produces the maximum output pressure from the device, e.g., 13 psi (91 kPa), and the minimum is the value of the measured variable (MV) that produces the minimum output pressure, e.g., 3 psi (21 kPa). Calculate range, span, and output/unit of measured variable from the following formulas or use Table 5, Sensor Value to Pressure or Percentage Conversion, in the APPENDIX.

Range = Actual minimum to actual maximum
Span = Maximum minus minimum

$$\text{Output/Unit of MV} = \frac{\text{Output}}{\text{Span}}$$

EXAMPLE:
A TP970 thermostat with a 72F (22C) setpoint and an 8F (4.4K) Throttling Range (TR). A thermostat setpoint is centered in its 3 to 13 psi (21 to 91 kPa) output.

English

MIN = 72F − (8 F/2)
= 68F

MAX = 72F + (8 F/2)
= 76F

Span = MAX − MIN
= 76F − 68F
= 8F

Output = Pressure at MAX − Pressure at MIN
= 13 psi − 3 psi
= 10 psi

$$\text{Output/Unit of MV} = \frac{\text{Output}}{\text{Span}} = \frac{10\text{ psi}}{8\text{F}} = 1.25\text{ psi/F}$$

Metric

MIN = 22C − (4.4K/2)
= 19.8C

MAX = 22C + (4.4K/2)
= 24.2C

Span = MAX − MIN
= 24.2C − 19.8C
= 4.4C

Output = Pressure at MAX − Pressure at MIN
= 95 kPa − 20 kPa
= 70 kPa

$$\text{Output/Unit of MV} = \frac{\text{Output}}{\text{Span}} = \frac{70\text{ kPa}}{4.4\text{C}} = 15.9\text{ kPa/C}$$

SPECIAL SENSOR CONSIDERATIONS

PP905 DIFFERENTIAL PRESSURE SENSOR

The PP905 setpoint determines the midpoint of the fixed 2 in. wc (0.50 kPa) span. The setpoint allows adjustment from 0 to 7.0 in. wc (1.7 kPa). The sensor permits reverse or direct action. For standard indication gages, adjust setpoint to 0, 1, 2, 3, 4, or 5 in. wc to match gage midpoint.

LP914 AND LP915 INTERNAL DUCT MOUNTING

The LP914 and LP915 sensors normally mount with only their sensing elements in a duct. If the entire device is mounted inside the duct, consider the error added to the sensor output signal by duct static pressure (Fig. 13) and adjust calculations if necessary.

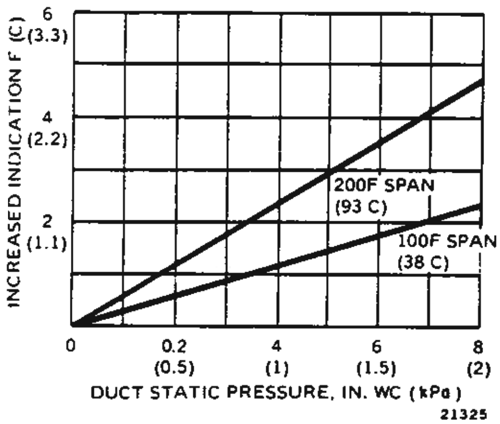


Fig. 13. Internal Duct Mounting Error.

SENSORS USED FOR INDICATION

Since sensor output is linear and directly proportional to the measured variable, a sensor, a gage (calibrated in the measured variable), a 0.007-inch restrictor, and a main air supply provide remote indication of the measured variable. See Figure 14 for one-pipe and two-pipe applications. For best results locate the restrictor near the sensor. Observe line length limits in Figure 15.

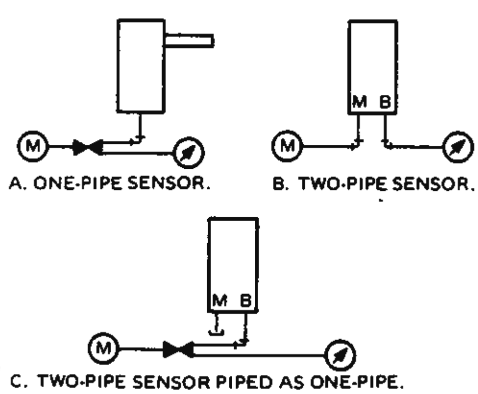


Fig. 14. Sensor Indication Only.

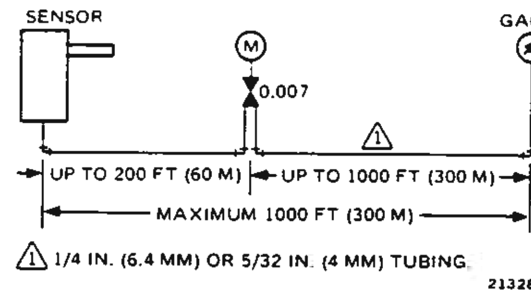


Fig. 15. Sensor Indication Line Lengths.

SENSORS USED FOR INDICATION AND CONTROL

PRIMARY SENSOR

Normally the RP920 provides restricted main air for the primary sensor if the sensor is within 200 feet (60 m) of the controller (Fig. 16.).

For sensor locations from 200 to 1000 feet (60 to 300 m), or if main air is not to be supplied by the controller, block internal primary sensor restricted air supply, add external restricted (0.007 inch) main air, and use piping shown in Figure 17.

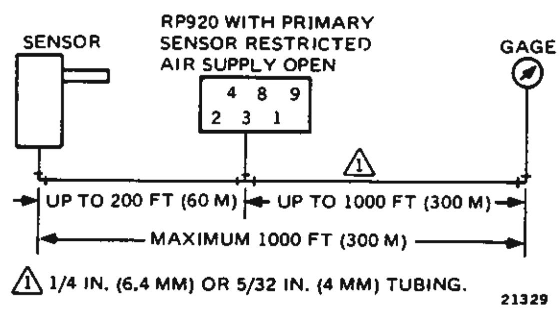


Fig. 16. Primary Sensor Piping Using Controller Restricted Main Air.

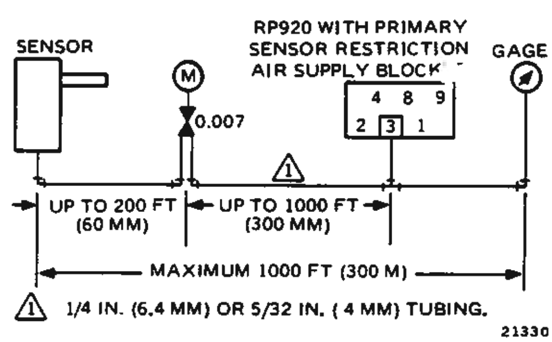


Fig. 17. Primary Sensor Piping Using External Restricted Main Air.

COMPENSATION SENSOR

Sensors piped to Port 5 must have a main air supply and an external 0.007-inch restrictor (Fig. 18).

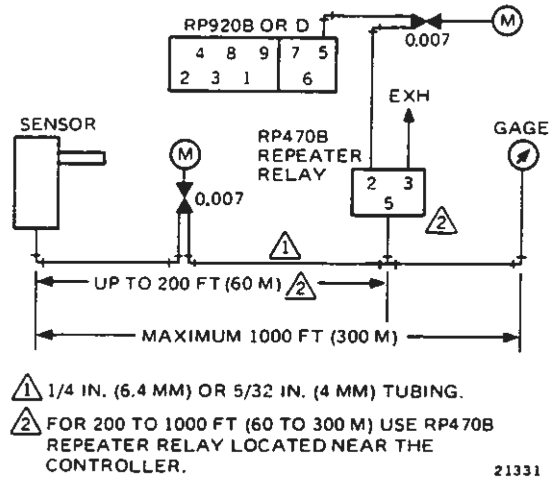


Fig. 18. Compensation Sensor Piping.

SINGLE SENSOR WITH MULTIPLE CONTROLLERS

When multiple controllers receive primary sensor inputs (Port 3) from a single sensor, use piping shown in Figure 19. Note, with the internal restrictor blocked to each additional controller beyond the first, the controller consumes no primary sensor air.

When multiple controllers receive compensation sensor inputs (Port 5) from a single sensor, add a RP470 repeater relay to each additional controller beyond the first (Fig. 20) because Port 5 consumes air.

There is no practical limit to the number of controllers in the above applications, but the total line length must not exceed 1000 feet (300 meters).

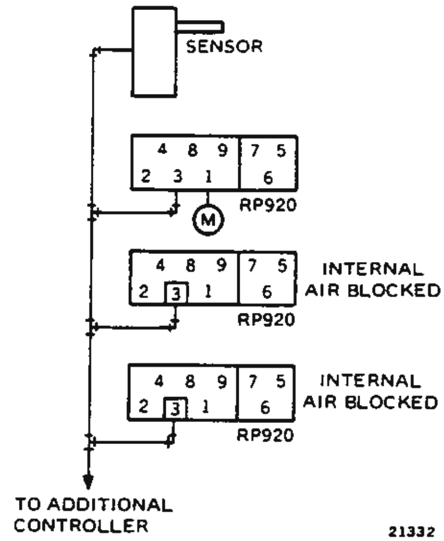


Fig. 19. Single Primary Sensor to Multiple Controllers.

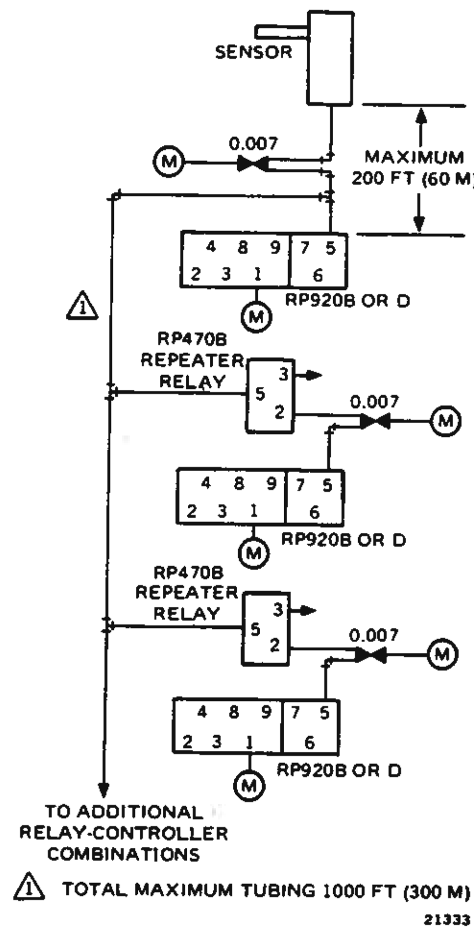
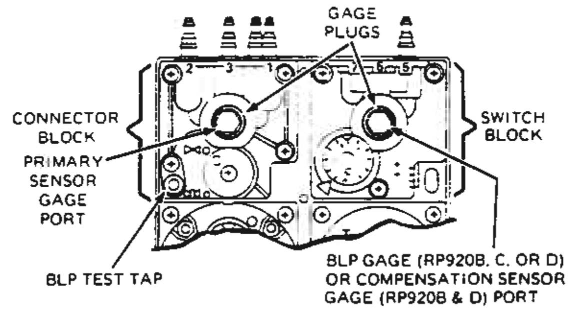


Fig. 20. Single Compensation Sensor to Multiple Controllers.

SENSORS WITH RELAYS

If desired, sensor outputs can pilot averaging, booster, and certain other relays. Use care when applying sensor outputs to relays. Insure that small changes in pressure output per measured variable produce the desired results. In general, relays with narrow differential, low hysteresis, and low reversal work well with sensors. Useful relays include RP973A Averaging Relay, RP470A Selector Relay, RP470B Lockout Relay, RP922 Pneumatic Potentiometer, and RP972A Reversing Relay.



GAGE OPTIONS

MODEL	FACTORY SET	FIELD OPTION
RP920A	SENSOR	N/A
RP920B & D	PRIMARY SENSOR AND BLP GAGE	PRIMARY SENSOR AND COMPENSATION GAGE
RP920C		N/A

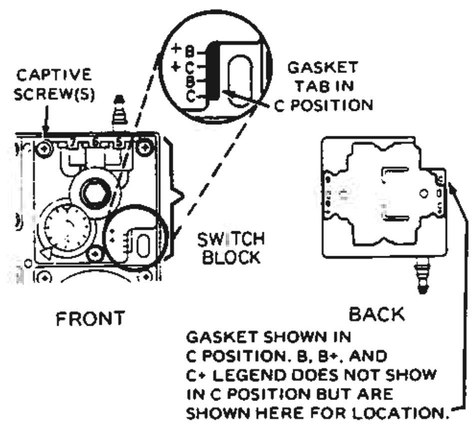
21370

Fig. 21. Controller Gage Location.

GAGES MOUNTED ON CONTROLLER

The RP920 left gage port allows installation of a primary sensor gage (Fig. 21). The right gage port on the RP920B, C, and D allow installation of a BLP gage. The right gage port on the RP920B and D allows installation of a compensation sensor gage with a switch block gasket position change. The position of the gasket located under the switch block module determines the function of the field installed gage on the switch block and determines if integral action cut-off function is enabled or disabled. See Figure 22 for factory and field settings.

If needed for checkout or testing, install a 0 to 30 psi (0 to 207 kPa) gage and a CCT729 Gage Adapter into BLP test tap.



SWITCH BLOCK GASKET POSITION

MODEL	FACTORY SETTINGS	FIELD OPTIONS
RP920B	B	C
RP920C	B	B+
RP920D	B	C, C+, B+

B = BRANCH LINE GAGE.
C = COMPENSATION SENSOR GAGE.
\+ = INTEGRAL ACTION CUT-OFF ENABLED.

21326

Fig. 22. Integral Action Cut-Off and Gage Function Gasket Position.

CONTROLLERS

GENERAL

A controller is a device which takes a small pressure change from a sensor, amplifies it, and changes its BLP in proportion to the change in sensor input. The change in BLP actuates the final control device which adjusts the final controlled variable (Fig. 23).

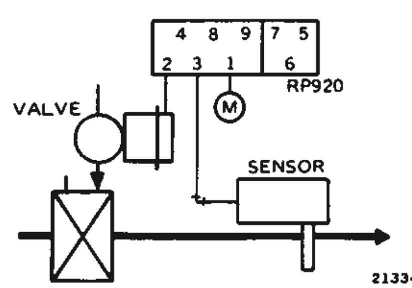


Fig. 23. Typical Controller System.

PROPORTIONAL CONTROL

DIRECT ACTING VS REVERSE ACTING

Direct acting means that when the primary sensor input increases the BLP increases. Reverse acting means that when primary sensor input increases the BLP decreases. All RP920 controllers are factory set as ordered but can be changed in the field. Specify action on the job drawing.

PROPORTIONAL BAND (Xp)

THROTTLING RANGE

A controller uses only a portion of the sensor span, called the Throttling Range (TR), to control the system. TR is the amount of change in a measured variable needed to change BLP from minimum to maximum, expressed in units of the measured variable or in pressure.

In general a wide TR gives a system stable control with large offsets, and a narrow TR gives a system less stable control with small offsets.

If needed, convert from throttling range stated in the measured variable units to pressure units using the following formulas for 3 to 15 psi (21 to 103 kPa) sensors:

$$TRp = \frac{TR}{SPs} \times (12 \text{ psi or } 82 \text{ kPa})$$

or

$$TRp = TR \times Out/mv$$

Where:

Out/mv = Pressure output per unit of measured variable.
SPs = Primary sensor span (measured variable).
TR = Throttling range (measured variable).
TRp = Throttling range (pressure).

PROPORTIONAL BAND SETTING

The throttling range expressed as a percentage of the Primary Sensor Span is the proportional band (PB). The proportional band (Xp) adjustment range on the RP920 is graduated in percentage (2.5 to 50%) of sensor span. The formula for converting TR to proportional band (Xp) for a system using a typical 10 psi (70 kPa) BLP span is:

$$Xp = \frac{TR}{SP_S} \times 100$$

Where:

SP_S = Primary sensor span.
TR = Throttling range.
Xp = Proportional band in percent.

NOTE: A controlled device other than a 10 psi (70 kPa) span may be used in a 10 psi (70 kPa) span system. For example, a 5 to 10 psi (34 to 70 kPa) operator may be used in a 10 psi (70 kPa) system.

EXTENDED PROPORTIONAL BAND FROM 50 TO 80 PERCENT (DA Only)

Proportional bands for DA controllers of 50 to 80% are obtained by feeding the BLP back into the optional CPA port (Fig. 24). When setting PB subtract 30% from the proportional band calculation for the actual Xp setting.

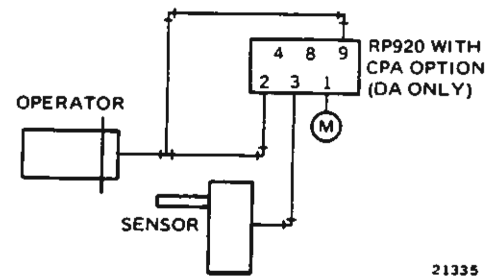


Fig. 24. Piping for Proportional Band from 50 to 80%.

SETPOINT (W1)

GENERAL

Setpoint on the RP920A (Fig. 25) determines the sensor value (measured variable) at which the controller BLP equals 8psi (55kPa). The setpoint on the RP920B (Fig. 26) is the same as the RP920A except the setpoint is reset by the compensation sensor. The setpoint on the RP920C (Fig. 27) determines the sensor value at which the system controls. With a change in the measured variable, the PI controller initially acts similar to a proportional-only controller giving a change in BLP proportional to the difference between the setpoint and the measured variable. After the initial BLP pressure change, the operating point (BLP output when setpoint and primary sensor pressures are equal) is automatically adjusted until the measured variable and the setpoint are equal.

The setpoint on the RP920D is the same as the RP920C except the setpoint is reset by the compensation sensor.

The setpoint knob is embossed with 0 to 100% of primary sensor span. Scaleplate overlays are included or available that read directly in the measured variable units (Refer to Table 1).

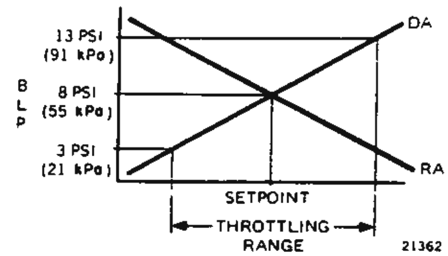


Fig. 25. RP920A and C Setpoint vs BLP.

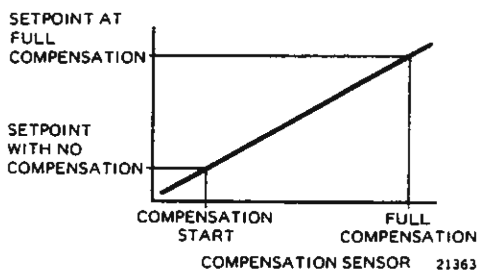


Fig. 26. RP920B and D Setpoint vs Compensation Sensor (Positive Shown).

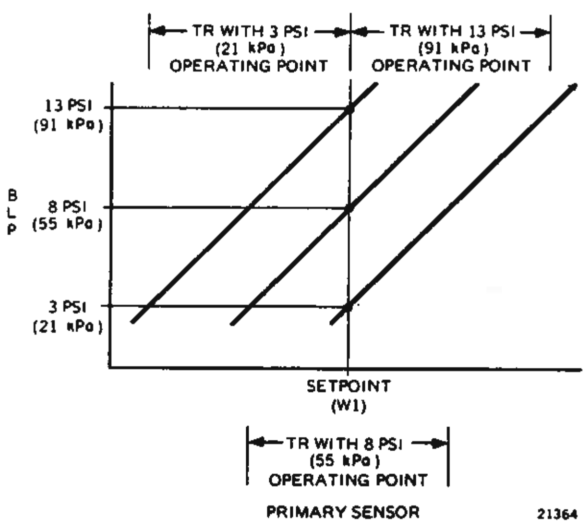


Fig. 27. RP920C and D Setpoint vs BLP at Various Operating Points (Load Conditions).

LOCAL SETPOINT

Local Setpoint controls the setpoint (W1) with the controller setpoint knob only.

CONTROL POINT ADJUSTMENT (CPA)

CPA (option must be Factory ordered) allows local setpoint to be adjusted on the controller and then reset +/- 15 percent of the primary sensor span using a remote pneumatic source. CPA modifies the setpoint (W1) with a remote 3 to 15 psi (21 to 103 kPa) pneumatic signal to Port 9 (Fig. 28). A change of 1 psi (7 kPa) in the CPA signal resets the setpoint 2.5 percent of the primary sensor span.

A 9 psi (62 kPa) signal on Port 9 causes no change in the setpoint. Other CPA ranges are available but the controller must be calibrated with a pressure other than 9 psi at Port 9 (e.g. CPA range = 0 to 30 percent with calibration at 3 psi (21 kPa) CPA pressure).

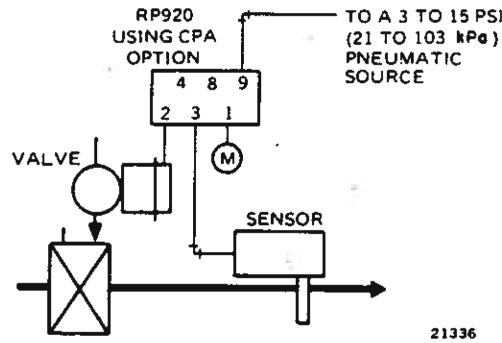


Fig. 28. CPA Piping.

REMOTE SETPOINT

NOTE: Remote setpoint can not be used in combination with CPA.

The remote setpoint (RSP) feature controls the setpoint (W1) from 0 to 100 percent of the sensor span with a remote 3 to 15 psi (21 to 103 kPa) signal. To use remote setpoint, remove the screw in Port 8, install barb fitting 14003755-001, and pipe a remote pneumatic bleed-type device to Port 8 (Fig. 29). To use the full setpoint range, set local setpoint knob (W1) to 100%. If an upper limit on the setpoint is desired, set local setpoint knob (W1) to that limit.

The RSP control device, e.g.,SP970A field set for 12 psi (82 kPa) span (this should be noted on the job drawings), must be a bleed type device as Port 8 is provided with restricted air from within the controller. An increase of 1 psi (7 kPa) in RSP pressure raises the setpoint 8.3 percent of the primary sensor span.

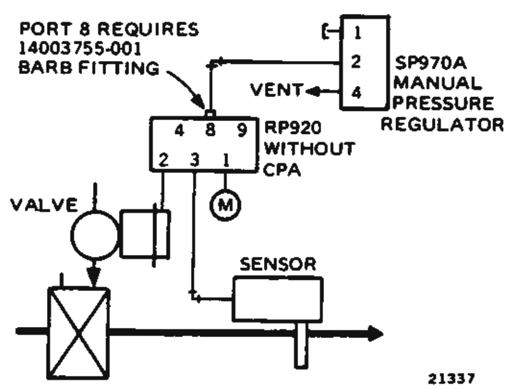


Fig. 29. Remote Setpoint Piping.

BLP NOT EQUAL TO 8 PSI (55 kPa) AT SETPOINT (RP920A or B only)

If a BLP other than 8 psi (55 kPa) is required at the setpoint, calibrate the controller to the desired parameters, or use the following formulas to adjust the setpoint knob, then remove the setpoint knob and reinstall it at the desired setpoint value.

For DA controllers:

English

$$TS = W1 + TR \left(\frac{8 - BLP}{10}\right)$$

Metric

$$TS = W1 + TR \left(\frac{55 - BLP}{69}\right)$$

For RA controllers:

English

$$TS = W1 - TR \left(\frac{8 - BLP}{10}\right)$$

Metric

$$TS = W1 - TR \left(\frac{55 - BLP}{69}\right)$$

Where:
BLP = Desired BLP at setpoint.
TR = Throttling range.
TS = Temporary setpoint.
W1 = Desired setpoint.

EXAMPLE:
BLP = 13 psi (91 kPa) at 70F (21C) setpoint.
TR = 16F (8.9K).
DA controller.

English

$$TS = W1 + TR \left(\frac{8 - BLP}{10}\right)$$
$$= 70F + 16F \left(\frac{8 - 13\text{ psi}}{10}\right)$$
$$= 70F + (-8F)$$
$$= 62F$$

Metric

$$TS = W1 + TR \left(\frac{55 - BLP}{69}\right)$$
$$= 21C + 8.9K \left(\frac{55 - 91\text{ kPa}}{69}\right)$$
$$= 21C + (-4.6K)$$
$$= 16.4C$$

Adjust setpoint W1 to 62F (16.4C), carefully remove the knob without changing shaft position, and reinstall the knob to read 70F (21 C).

COMPENSATION

GENERAL

Often, control of a building is more efficient if the setpoint of the controller is reset to a different value as a function of some parameter other than the controlled variable. For example, a heating coil discharge temperature of 90F (32C) may be required when the outdoor air temperature is 60F (16C), but may require a discharge temperature of 130F (54C) with an outdoor air temperature of 0F (-18C). A dual input controller (RP920B or D) provides this reset capability (Fig. 30). To use compensation, set up a system reset schedule (Fig. 31).

Use a P + I controller rather than a reset controller in applications requiring only elimination of offset. A P + I controller system is more cost efficient and provides more accurate control than the traditional two-input proportional control system.

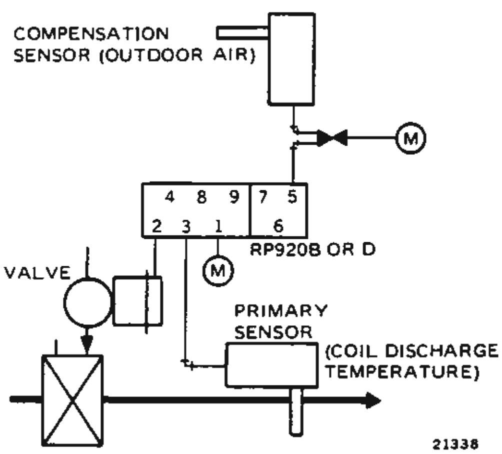


Fig. 30. Typical Dual Input Controller System.

Compensation Range	Primary Sensor	Compensation Sensor
Start	A	C
Full	B	D
Operating Span	A-B	C-D

Where:

Ⓐ = Lowest value of controlled variable.

Ⓑ = Highest value of controlled variable.

Ⓒ = Value of compensation variable when controlled variable is at its lowest value.

Ⓓ = Value of compensation variable when controlled variable is at its highest value.

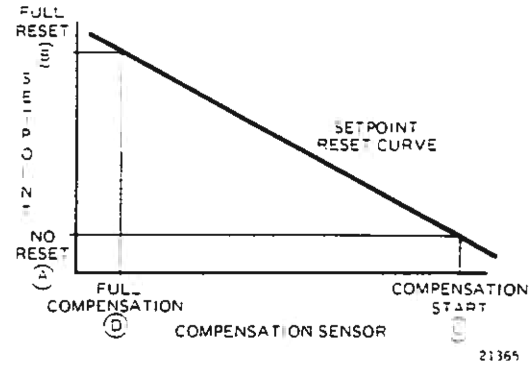


Fig. 31. Compensation Reset Schedule.

POSITIVE VS NEGATIVE COMPENSATION

Negative (winter) compensation adds reset to the setpoint as the compensation variable decreases. Positive (summer) compensation adds reset to the setpoint as the compensation variable increases. All controllers are factory set for negative compensation. If positive compensation is required, specify on job drawings for field adjustment.

EXAMPLE 1 NEGATIVE COMPENSATION

Assume a system with the following parameters (Fig. 32):

Coil discharge temperature = 130F (54C) when outdoor air temperature is 0F (-18C).

Coil discharge temperature = 90F (32F) when outdoor air temperature is 60F (16C).

Compensation Range	Primary Sensor (Discharge)	Compensation Sensor (OA)
Start	90F (32C)	60F (15C)
Full	130F (54C)	0F (-18C)
Operating Span	40F (22K)	60F (33K)

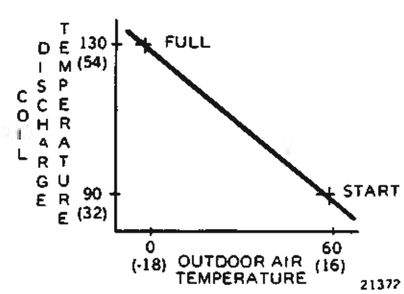


Fig. 32. Negative Compensation Reset Schedule in F (C).

EXAMPLE 2 POSITIVE COMPENSATION

Assume a system with the following parameters (Fig. 33):

Space temperature = 73F (23C) when outdoor air temperature is 80F (27C).

Space temperature = 80F (27C) when outdoor air temperature is 100F (38F).

Compensation Range	Primary Sensor (Space)	Compensation Sensor (OA)
Start	73F (23C)	80F (27C)
Full	80F (27C)	100F (38C)
Operating Span	7F (5K)	20F (11K)

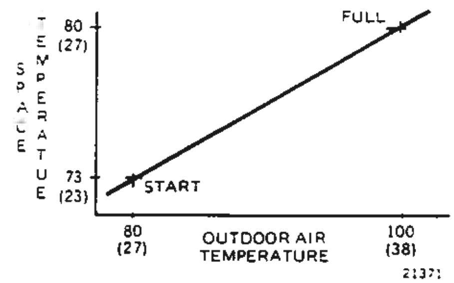


Fig. 33. Positive Compensation Reset Schedule in F (C).

SETPOINT AND COMPENSATION STARTPOINT

Setpoint (W1) and compensation startpoint (Wc) settings are determined by the compensation start values on the system reset schedule (Fig. 34 and 35). Setpoint is the primary sensor component of the point and compensation startpoint is the compensation sensor component of the point. Use Table 5 in the APPENDIX (Sensor Value to Pressure or Percentage Conversion Chart) or the following formula to convert setpoint (when scaleplate overlay is not used) and compensation startpoint into percentage for common sensors:

$$\frac{mv - MIN}{Ss} \times 100 = \text{Setting in \%.}$$

Where:

MIN = Sensor minimum.

mv = Wc or W1 in measured variable units.

Ss = Sensor span.

EXAMPLE:

Wc = 60F (16C) and the compensation sensor range is −40 to 160F (−40 to 71C) (from Fig. 32).

English

$$Wc\ \% = \frac{mv - MIN}{Ss} \times 100$$

$$= \frac{60F - (-40F)}{200F} \times 100$$

$$= 50\%$$

Metric

$$Wc\ \% = \frac{mv - MIN}{Ss} \times 100$$

$$= \frac{16C - (-40C)}{111K} \times 100$$

$$= 50\%$$

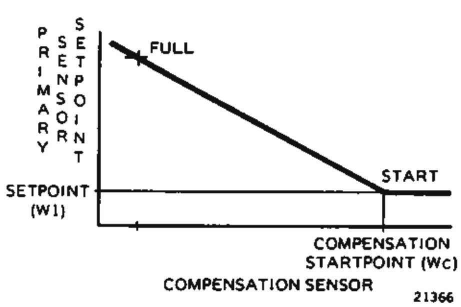


Fig. 34. Setpoint and Negative Compensation Startpoint Reset Graph.

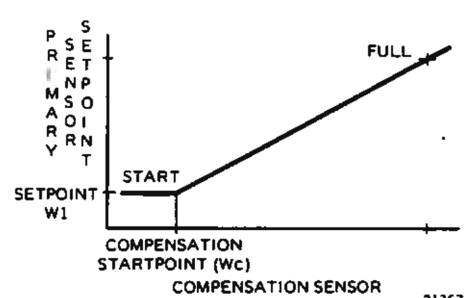


Fig. 35. Setpoint and Positive Compensation Startpoint Reset Graph.

AUTHORITY (Ac)

General

Authority is the ratio of the effect of the compensation sensor in a system relative to the effect of the primary sensor expressed as a percentage. Authority determines the slope of the compensation reset graph.

Two methods are used to calculate authority (Ac). One uses the measured variable units and is advantageous when both sensor types (e.g., both temperatures) are identical. The other method uses the measured variable in pressure and is advantageous when sensor types are mixed or non-standard sensors are used.

Authority Setting Using Measured Variable Units

To perform authority (Ac) setting calculations in the actual measured variable units determine sensor operating range from the building schedule and apply the following formulas:

For Negative Compensation:

$$Ac = \frac{SCs}{SPs} \times \frac{\Delta SP + TR^{*}}{\Delta SC} \times 100$$

For Positive Compensation:

$$Ac = \frac{SCs}{SPs} \times \frac{\Delta SP - TR^{*}}{\Delta SC} \times 100$$

*TR element is equation not required for RP920D applications.

Where (in the measured variable units):

- Ac = Authority
- ΔSC = Compensation sensor operating span.
- SCs = Compensation sensor span.
- ΔSP = Primary sensor operating span.
- SPs = Primary sensor span.
- TR = TR in measured variable (Use 0 for RP920D).

EXAMPLE:

Assume a system with the parameters in Figure 36:

Outdoor air sensor range = -40 to 160F (-40 to 71C) = 200F (111K) span.

Coil discharge sensor range = 40 to 240F (5 to 115C) = 200F (11K) span.

Throttling range = 10F (5.6K).

1. Setpoint = 90F (32C) or 25%.
2. Compensation startpoint setting (Wc) = 60F (16C) or 50%.
3. Compensation mode = negative (winter)
4. Authority (Ac):

Compensation Range	Primary Sensor (Discharge)	Compensation Sensor (OA)
Start	90F (32C)	60F (15C)
Full	130F (54C)	5F (-15C)
Operating Span	40F (22K)	55F (30K)

Fig. 36. Example Compensation Reset Schedule.

English

$$Ac = \frac{SCs}{SPs} \times \frac{\Delta SP + TR}{\Delta SC} \times 100$$

$$= \frac{200F}{200F} \times \frac{(130F - 90F) + 10F}{(60F - 5F)} \times 100$$

$$= 91\%$$

Metric

$$Ac = \frac{SCs}{SPs} \times \frac{\Delta SP + TR}{\Delta SC} \times 100$$

$$= \frac{111K}{111K} \times \frac{(54C - 32C) + 5.6K}{(15C - [-15C])} \times 100$$

$$= 92\%$$

NOTE: The small percentage difference in this example is a result of rounding off Fahrenheit to Celsius to the nearest whole degree Celsius. A similiar difference occurs in some of the following examples.

Authority Setting Using Pressure Units

Performing authority (Ac) setting calculations in pressure units rather than actual measured variable units prevents confusion when sensors of different types are connected to the same controller and eliminates span corrections. To perform authority (Ac) setting calculations in the pressure units, determine sensor operating range from the building schedule, convert to pressure, and apply the following formulas:

With Negative Compensation:

$$Ac = \frac{\Delta SP + TRp^{*}}{\Delta SC} \times 100$$

With Positive Compensation:

$$Ac = \frac{\Delta SP - TRp^{*}}{\Delta SC} \times 100$$

Where:

Ac = Authority.
ΔSC = Compensation sensor operating span in psi (kPa).
ΔSP = Primary sensor operating span in psi (kPa).
TRp = TR in psi (kPa). Use 0 for RP920D controllers.

*TR_p element is equation not required for RP920D applications.

EXAMPLE:

Assume a building with the following parameters:
Outdoor air sensor span = 200F (111K)
Coil discharge sensor span = 100F (55.5K)
Compensation Mode = Negative (winter)
See Figure 36 for system reset schedule.

1. Primary sensor operating span (ΔSP):

English	Metric
= (130F − 90F) x 0.12 psi/F	= (54C − 32C) x 1.5 kPa/C
= 4.8 psi.	= 33 kPa

2. Compensation sensor operating span (ΔSC):

English	Metric
= (60F − 5F) x 0.06 psi/F	= (15C − [−15C]) x 0.75 kPa/C
= 3.3 psi.	= 22.5 kPa

3. Throttling range (TRp):

English	Metric
= 10F x 0.12 psi/F	= 5.6K x 1.5 kPa/K
= 1.2 psi	= 8.4 kPa

4. Authority (Ac):

English

$$Ac = \frac{\Delta SP + TRp}{\Delta SC} \times 100 = \frac{4.8\text{ psi} + 1.2\text{ psi}}{3.3\text{ psi}} \times 100 = 182\%$$

Metric

$$Ac = \frac{\Delta SP + TRp}{\Delta SC} \times 100 = \frac{33\text{ kPa} + 8.4\text{ kPa}}{22.5\text{ kPa}} \times 100 = 184\%$$

PROPORTIONAL PLUS INTEGRAL CONTROL

GENERAL

Proportional controllers adjust the BLP to a value proportional to the difference between the setpoint and the primary sensor value. This gives offset which increases as the throttling range increases.

Proportional plus integral (P + I) control automatically adjusts the BLP to a value where the setpoint and the primary sensor value are equal. In a proportional control system needing a wide TR to achieve stable control, large offsets are created. P + I control allows wider TR for stable control without large offsets.

Apply a P + I controller in:

1. Systems which require a wide TR.
2. Close control applications (e.g., chillers).
3. Fast response systems (e.g., static pressure).

INTEGRAL ACTION

GENERAL

The setpoint on the RP920C determines the sensor value at which the system controls. With a change in the measured variable, the controller initially acts similar to a proportional only controller giving a change in BLP proportional to the difference between the setpoint and the measured variable. After the initial BLP pressure change, the Operating Point is automatically adjusted until the measured variable and the setpoint are equal. The setpoint on the RP920D is the same as the RP920C except the setpoint is reset by the compensation sensor. The operating point PRV is factory set at 17.5 psi (120 kPa) and must not be recalibrated in the field. See Figure 37 for a comparison of typical P + I operation to proportional operation.

To obtain initial settings for various HVAC control applications, refer to the Initial DIP Setting CAE Program for Temperature, CAE006. These settings may require further fine tuning to match specific system requirements.

RESET TIME (T_R)

Reset time determines the speed at which a P + I controller reacts to a change in a controlled variable. The Reset time adjustment knob on the controller is labeled T_R.

The system response time determines the T_R adjustment.

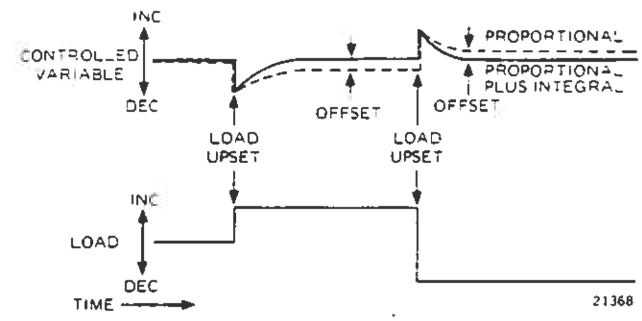


Fig. 37. Typical Proportional plus Integral Operation.

INTEGRAL ACTION CUT-OFF

In P + I control systems there can be a problem with overshoot on startup with large and/or sudden system upsets or with system overloads. The integral action cut-off is a reliable method to eliminate overshoot. Integral action cut-off will automatically switch off the BLP feedback to the integral module when the BLP is out of the operating range of the controlled device.

Using circuit shown in Figure 38, change the switch block gasket to position B+ or C+, and set pressures into the external snap-acting relays (e.g., RP471) according to the pressures of the controlled device range.

EXAMPLE:
Using a 3 to 13 psi (21 to 91 kPa) damper operator, the HIGH relay is set to 13 psi and the LOW relay is set to 3 psi (21 kPa).

If overshoot is expected in only one direction, use a single external snap-acting relay. Use the piping in Figure 39 if the BLP will be to high or in Figure 40 if the BLP will be too low.

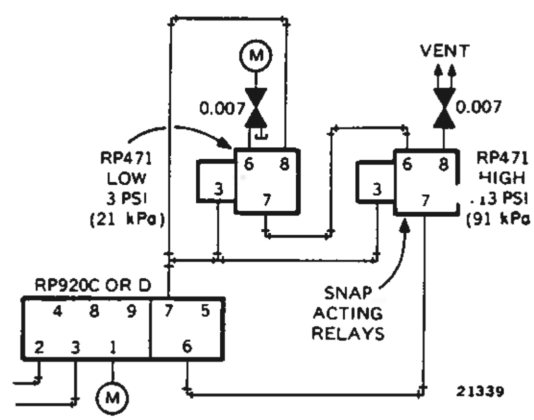


Fig. 38. High and Low Integral Action Cut-off.

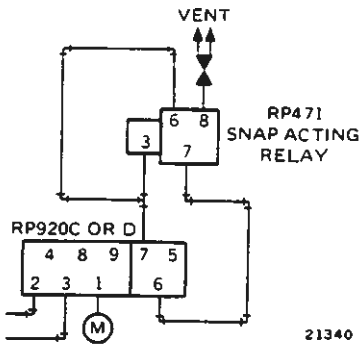


Fig. 39. High Integral Action Cut-off.

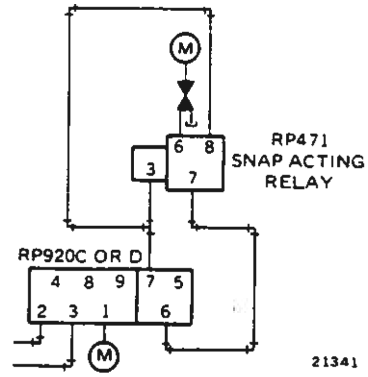


Fig. 40. Low Integral Action Cut-off.

APPLICATION

GENERAL

The Application section contains typical and special applications of the RP920.

AIR FLOW CONTROL

For Air Flow applications see Air Flow Systems Application Guide 77-5063.

AUTHORITY GREATER THAN 300 PERCENT USING ONE CONTROLLER

1. Determine authority required (standard piping):

$$\text{Authority} = \frac{SCs}{SPs} \times \frac{\Delta SP + TR}{\Delta SC} \times 100$$

Where:
ΔSC = Compensation sensor operating span.
SCs = Compensation sensor span.
ΔSP = Primary sensor operating span.
SPs = Primary sensor span.
TR = Throttling range.

If the authority is over 300 percent, reverse the sensor inputs (Fig. 41) and use the following controller setting formulas:

2. Determine authority setting (Ac):

$$Ac = \frac{1}{\text{Authority}} \times 10{,}000$$

NOTE: To determine authority setting (Ac) directly, use the following formula instead of Steps 1 and 2:

$$Ac = \frac{SPs}{SCs} \times \frac{\Delta SC\ (\text{Port } 3)}{\Delta SP + TR} \times 100$$

3. Determine proportional band setting (Xp):

$$Xp = \frac{TR}{SPs\ (\text{Port } 5)} \times Ac\ \%$$

Where:
SPs = Primary sensor span.
TR = Throttling range.
Xp = Proportional band setting.

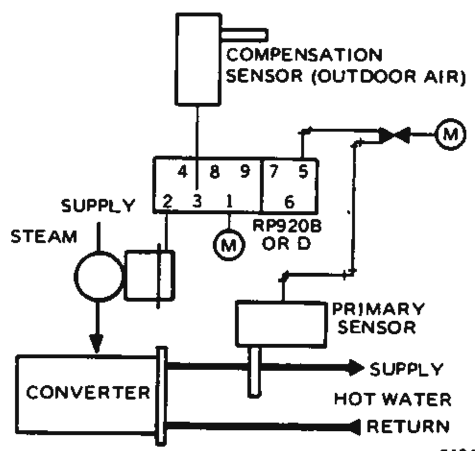


Fig. 41. Authority Greater Than 300% Using One Controller.

EXAMPLE:
Use the system parameters in Figure 42.
Primary sensor TR is 20F (11.1K).

Compensation Range	Primary Sensor (HWS)	Compensation Sensor (OA)
Start	100F (38C)	50F (10C)
Full	200F (93C)	20F (-6.7C)
Operating Span	100F (55K)	30F (16.7K)
Sensor Span	200F (111K)	200F (111K)
Sensor Range	40 to 240F (5 to 115C)	-40 to 160F (-40 to 71C)

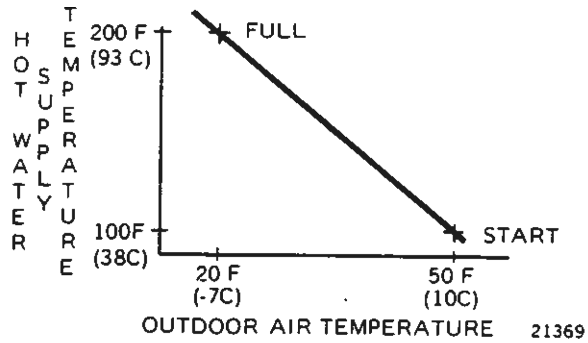


Fig. 42. Compensation Reset Schedule.

1. Determine authority:

English

$$\text{Authority} = \frac{SCs}{SPs} \times \frac{\Delta SP + TR}{\Delta SC} \times 100$$

$$= \frac{200F}{200F} \times \frac{(200F - 100F) + 20F}{(50F - 20F)} \times 100$$

$$= 400\%$$

Metric

$$\text{Authority} = \frac{SCs}{SPs} \times \frac{\Delta SP + TR}{\Delta SC} \times 100$$

$$= \frac{111K}{111K} \times \frac{(93C - 38C) + 11.1C}{[10C - (6.7C)]} \times 100$$

$$= 396\%$$

2. Determine authority setting (Ac):

English

$$Ac = \frac{1}{\text{Authority}} \times 10{,}000$$

$$= \frac{1}{400\%} \times 10{,}000$$

$$= 25\%$$

Metric

$$Ac = \frac{1}{\text{Authority}} \times 10{,}000$$

$$= \frac{1}{396\%} \times 10{,}000$$

$$= 25\%$$

3. Determine Proportional Band setting (Xp):

English

$$Xp = \frac{TR}{SPs\ (\text{Port } 5)} \times Ac\ \%$$

$$= \frac{20F}{200F} \times 25\%$$

$$= 2.5\%$$

Metric

$$Xp = \frac{TR}{SPs\ (\text{Port } 5)} \times Ac\ \%$$

$$= \frac{11.1K}{111K} \times 25\%$$

$$= 2.5\%$$

AUTHORITY GREATER THAN 300 PERCENT USING TWO CONTROLLERS

A method using two controllers for authority greater than 300 percent is shown in Figure 43. To determine the controller settings, use the following procedure:

1. Use the compensation sensor operating span as the TR for Controller II, and calculate the proportional band setting (Xp):

$$XpII = \frac{\Delta SC}{SCs} \times 100$$

Where:
XpII = PB for Controller II.
ΔSC = Compensation sensor operating span.
SCs = Compensation sensor span.

This gives a 10 psi (69 kPa) change into Controller I Port 5 over the compensation sensor operating span.

2. Use the midpoint of the compensation sensor operating span as the setpoint (W1II) for Controller II.

3. Calculate PB for Controller I(XpI).

Where:
TRI = TR for Controller I.
SPs = Primary sensor span.

4. Convert TR for Controller I and the primary sensor operating span to pressure units using Table 5 in the APPENDIX (Sensor Value to pressure or Percentage Conversion Chart) or the formula from the SENSOR section.

5. Calculate the authority setting (AcI) for Controller I:

English

$$AcI = \frac{SPp + TRp}{10\ psi} \times 100$$

Metric

$$AcI = \frac{SPp + TRp}{69\ kPa} \times 100$$

Where:
SPp = Primary sensor operating span in pressure.
TRp = TR in pressure. Use 0 for RP920D.
10 (69) = BLP Span from Controller II.

6. In this application, compensation startpoint (Wc) equals 83 percent with negative compensation and 0 percent with Positive compensation:

English

$$\frac{13 - 3\ psi}{15 - 3\ psi} \times 100 = 83\%$$

and

$$\frac{3 - 3\ psi}{3 - 3\ psi} \times 100 = 0\%$$

Metric

$$\frac{83 - 21\ kPa}{104 - 21\ kPa} \times 100 = 83\%$$

and

$$\frac{21 - 21\ kPa}{21 - 21\ kPa} \times 100 = 0\%$$

7. Calculate setpoint according to system schedule (primary sensor at compensation start).

This system can have a maximum authority of 600 percent.

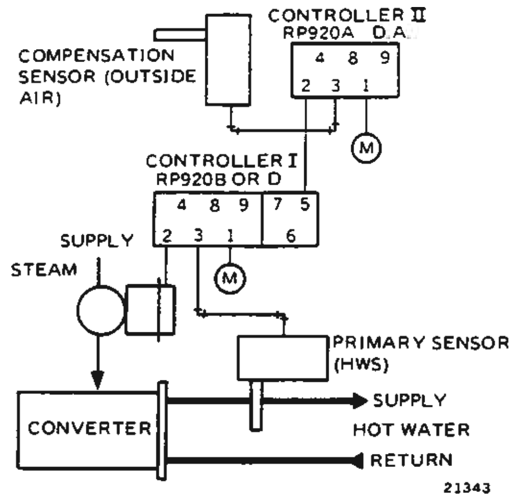


Fig. 43. Authority Greater Than 300 Percent Using Two Controllers.

EXAMPLE:

Use the system parameters in Figure 42.
Primary sensor TR is 20F (11.1K).

1. Calculate PB for Controller II.

English

$$XpII = \frac{\Delta SC}{SCs} \times 100$$

$$= \frac{30F}{200F} \times 100$$

$$= 15\%$$

Metric

$$XpII = \frac{\Delta SC}{SCs} \times 100$$

$$= \frac{17K}{111K} \times 100$$

$$= 15\%$$

2. Midpoint of the compensation sensor operating range for setpoint (W1II) for Controller II is:

English

$$W1II = \frac{(50F + 20F)}{2}$$

$$= 35F$$

or

$$= \frac{35F - (-40F)}{200F} \times 100$$

$$= 37.5\%$$

Metric

$$W1II = \frac{[10C + (-7C)]}{2}$$

$$= 1.5C$$

or

$$= \frac{1.5C - (-40C)}{111K} \times 100$$

$$= 37.5\%$$

3. Calculate PB for Controller I.

English

$$XpI = \frac{TR}{SPs} \times 100$$

$$= \frac{20F}{200F} \times 100$$

$$= 10\%$$

Metric

$$XpI = \frac{TR}{SPs} \times 100$$

$$= \frac{11.1K}{111K} \times 100$$

$$= 10\%$$

4. Convert TR for Controller I and the primary sensor operating span to pressure units.

English

TRI = 20F x 0.06 psi/F

= 1.2 psi

ΔSPp = 100F x 0.06 psi/F

= 6.0 psi

Metric

TRI = 11.1K x 0.75 kPa/C

= 8.3 kPa

ΔSPp = 55K x 0.75 kPa/C

= 41 kPa

5. The authority setting (AcI) for Controller I is:

English

$$AcI = \frac{\Delta SPp + TRp}{10\ psi} \times 100$$

$$= \frac{6.0\ psi + 1.2\ psi}{10\ psi} \times 100$$

$$= 72\%$$

Metric

$$ACI = \frac{\Delta SPp + TRp}{69\ kPa} \times 100$$

$$= \frac{41\ kPa + 8.3\ kPa}{69\ kPa} \times 100$$

$$= 71\%$$

This value can be set on the controller.

6. Compensation startpoint (WcI) equals 83%.

7. Setpoint (W1I) is 100F (38C) or:

English

$$W1I = \frac{mV - MIN}{Ss} \times 100$$

$$= \frac{100F - 40F}{200F} \times 100$$

= 30% or 100F

Metric

$$W1I = \frac{mV - MIN}{Ss} \times 100$$

$$= \frac{38C - 5C}{111K} \times 100$$

$$= 30\%$$

LIMIT CONTROL

Two limit control applications are used depending on the type of limit, the type of control, and the action of the controlled device. Select the parameters of the system and use the Limit Control Action Chart to select the limit piping application and the action of the controllers.

In the applications using Figure 44A, the primary controller operates the valve normally through the lower-of-two-pressure relay until the limit variable comes into the throttling range of the limit controller. When the limit controller BLP falls below the primary controller BLP, the lower-of-two-pressure relay allows the limit controller to assume control of the valve. Make all settings to both controllers normally. The lower-of-two-pressure relay is required because the controller will not function properly with a varying Main 1 input.

In applications using Figure 44B, the limit controller allows the primary controller to operate normally until the limit variable comes into the throttling range of the limit controller, where it prevents the primary BLP exhaust from bleeding off. Make all settings to the Primary controller normally. Set the Limit controller setpoint to the limit value required and set TR for the specific application.

If both high and low limit control are required, use the piping shown in Figure 45 and detemine the action of the controllers from the Limit Control Action Chart.

In some applications the limit controller can be a device other than the RP920, such as an LP920.

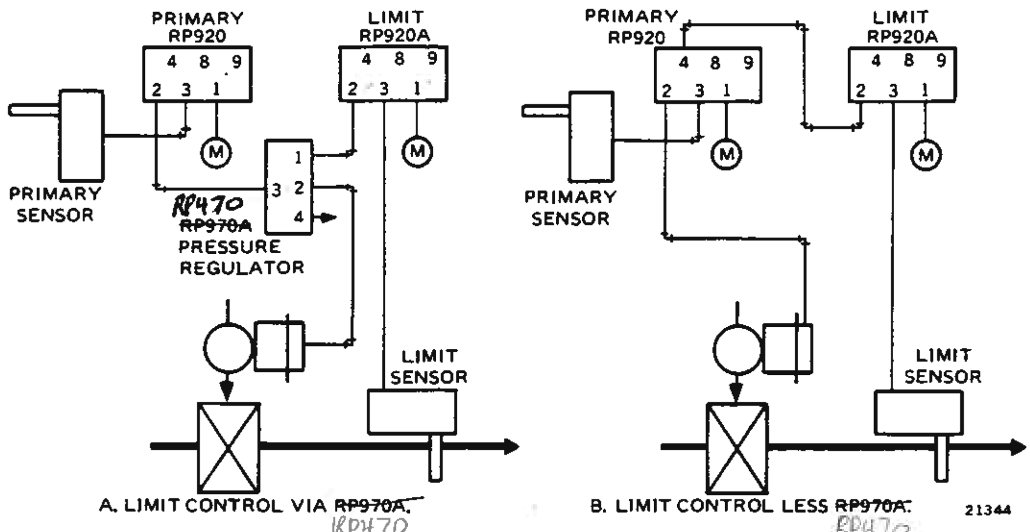


Fig. 44. Limit Control Piping and System Parameters.

Limit Control Action Chart.

Application	Limit	Valve	Primary Action	Limit Action	Fig. 44
Heating	LOW	N.O.	DA	DA	A
		N.C	RA	RA	B
	HIGH	N.O.	DA	DA	B
		N.C.	RA	RA	/
Cooling	LOW	N.O.	RA	RA	B
		N.C	DA	DA	A
	HIGH	N.O.	RA	RA	A
		N.C.	DA	DA	B
Humidification	HIGH	N.C.	RA	RA	A

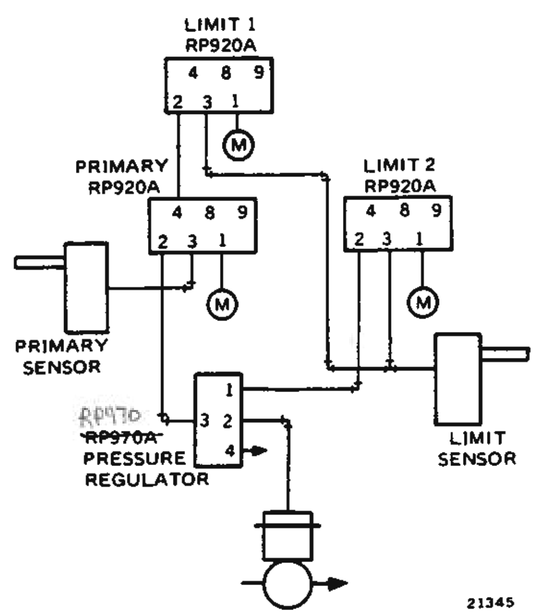


Fig. 45. High and Low Limit Control.

MIXED AIR CONTROL WITH HIGH LIMIT

In a mixed air application (Fig. 46), the primary sensor modulates the outdoor and return air dampers through the primary controller maintaining a constant mixed air temperature.

When the OA temperature rises above the setpoint of the primary controller, the limit controller prevents 100 percent outdoor air from being taken into the system. An outdoor air temperature sensor and limit controller prevents unnecessary energy being required to cool the excess outdoor air by closing the outdoor air damper to a minimum position set on the minimum position regulator and closing the outdoor air damper.

Set a narrow TR on the limit-controller.

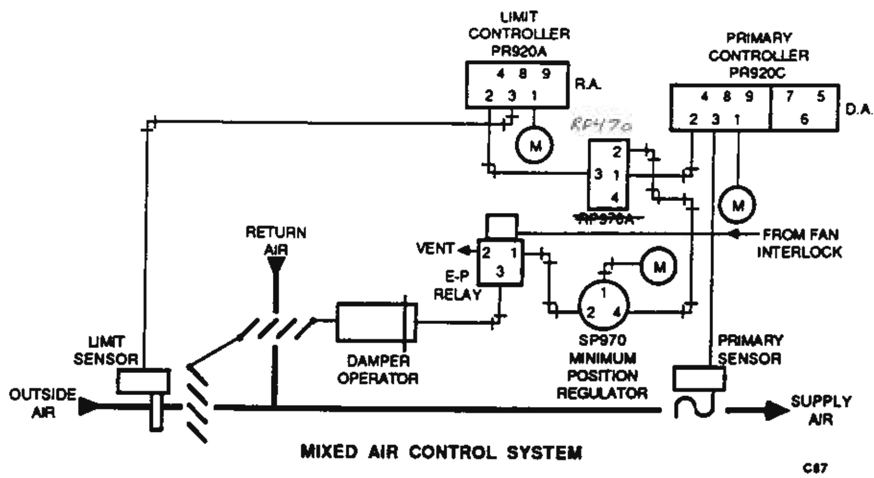


Fig. 46. Mixed Air Control with High Limit.

FLOOR AND CEILING

The compensation startpoint setting automatically puts a floor on the compensation schedule. If a floor and a ceiling on the compensation schedule is desired, install a minimum position pressure regulator in the compensation circuit as shown in Figures 47 and 48.

Set the regulator to the pressure equivalent of the Compensation sensor value at which the ceiling is required using Table 5 in the APPENDIX (Sensor Valve to Pressure or Percentage Conversion Chart) or the following formula:

English

Regular setting in psi

$$= \frac{C - MIN}{SCs} \times 12 + 3 \text{ psi}$$

Metric

Regular setting in kPa

$$= \frac{C - MIN}{SCs} \times 83 + 21 \text{ kPa}$$

Where:

C = Ceiling required in measured variable.
MIN = Minimum sensor value at 3 psi (21 kPa) output.
SCs = Compensation sensor span.

EXAMPLE:

Use the system parameters in Figure 42.

Ceiling is the full compensation point = 20F (-7C).

English

Regular setting in psi

$$= \frac{C - MIN}{SCs} \times 12 + 3 \text{ psi}$$

$$= \frac{20F - (-40F)}{200F} \times 12 + 3 \text{ psi}$$

$$= 6.6 \text{ psi}$$

Metric

Regular setting in kPa

$$= \frac{C - MIN}{SCs} \times 83 + 21 \text{ kPa}$$

$$= \frac{-7 - (-40C)}{111K} \times 83 + 21 \text{ kPa}$$

$$= 46 \text{ kPa}$$

Set the mininum position regulator to 6.6 psi (46 kPa).

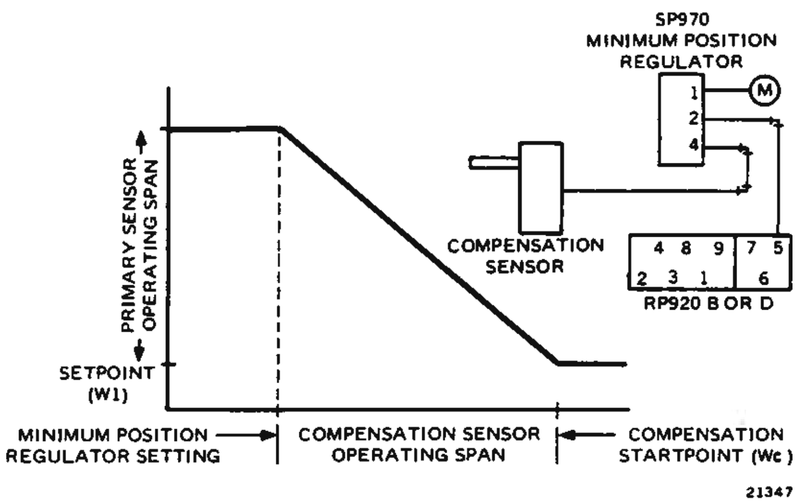


Fig. 47. Floor and Ceiling with Negative Compensation.

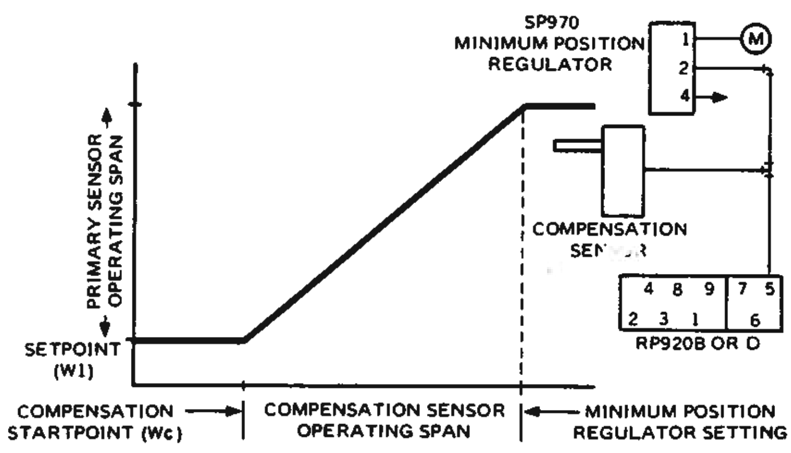


Fig. 48. Floor and Ceiling with a Positive Compensation.

DIFFERENTIAL TEMPERATURE CONTROL

Differential temperature control (Fig. 49) uses two identical range sensors (Sensor 1 and Sensor 2) and a P-E relay. In this application, the output of the controller is 8 psi with no differential between Sensor 1 and Sensor 2, and when Sensor 1 is greater than Sensor 2 the output is 8 psi plus the normal sensor output. Control point 1 and control point 2 refer to two system points each consisting of a known BLP at a known sensor differential.

1. Calculate proportional band setting (Xp):

English

$$XP = \frac{1000 \times (\Delta T1 - \Delta T2)}{Ss \times (BLP1 - BLP2)} \%$$

Metric

$$XP = \frac{7500 \times (\Delta T1 - \Delta T2)}{Ss \times (BLP1 - BLP2)} \%$$

Where:
- BLP1 = BLP required at T1.
- BLP2 = BLP required at T2.
- Ss = Sensor span.
- $\Delta T1$ = Temperature differential at Control Point 1 (Sensor 1 − Sensor 2).
- $\Delta T2$ = Temperature differential at Control Point 2.
- Xp = Proportional band in %.
- 1000 = Constant for English (10 psi x 100).
- 7500 = Constant for metric (75 kPa x 100).

2. Set the initial setpoint (W1) to 0 percent.
3. Set the compensation startpoint (W_c) to 0 percent.
4. Set the authority (Ac) to 100 percent (a one-to-one resetting action).

EXAMPLE:

In a solar system, a pump starts when Collector Sensor 1 (200F, 100K span) is 5F (2.8K) above Storage Sensor 2. The pump stops when the differential between the sensors equals zero. The P-E relay switches on at 10 psi (69 kPa) and off at 8 psi (55 kPa). Control Point 1 is therefore 10 psi (69 kPa) BLP at 5F (2.8K) differential temperature and Control Point 2 is 8 psi (55 kPa) BLP at 0F (0K) differential temperature.

1. Calculate proportional band setting (Xp):

English

$$Xp = \frac{1000 \times (\Delta T1 - \Delta T2)}{Ss \times (BLP1 - BLP2)} \%$$

$$= \frac{1000 \times (5F - 0F)}{200F \times (10\,psi - 8\,psi)} \%$$

$$= 12.5\%$$

Metric

$$Xp = \frac{1000 \times (\Delta T1 - \Delta T2)}{Ss \times (BLP1 - BLP2)} \%$$

$$= \frac{7500 \times (2.8K - 0K)}{111 \times (69\,kPa - 55\,kPa)} \%$$

$$= 13.5\%$$

. Set the initial setpoint (W1) to 0 percent.
3. Set the compensation startpoint (Wc) to 0 percent.
4. Set the authority (Ac) to 100 percent.

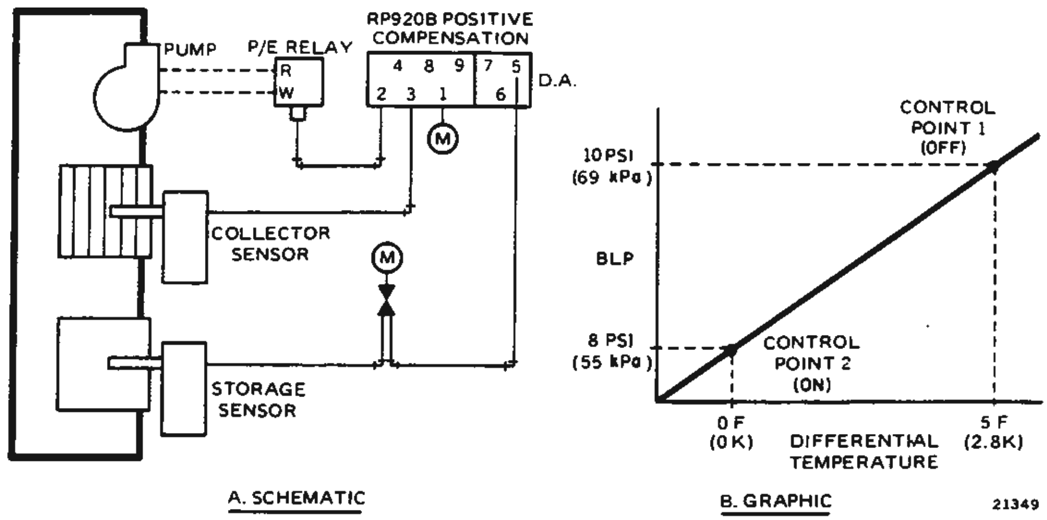


Fig. 49. Differential Temperature Control.

THREE INPUT CONTROL

Three input applications (Fig. 50) use a second element of compensation to fine tune the system. Controller II output (Port 2) acts like a compensation sensor for Controller I. To set up a system, use the following steps:

1. Determine a TR for the primary sensor which gives the system stability.
2. Calculate proportional band setting (XpI) for Controller I:

$$XpI = \frac{TR}{SPs} \times 100$$

Where:
SPs = Primary sensor span.
TR = Throttling range of primary sensor.

3. Calculate authority setting (AcI) for Controller I using pressures:

English

$$AcI = \frac{\Delta SP + TRp}{10\ psi} \times 100$$

Metric

$$AcI = \frac{\Delta SP + TRp}{69\ kPa} \times 100$$

Where:
ΔSP = Primary sensor operating span in pressure.
TRp = Throttling range in pressure (use 0 psi for RP920D).
10 psi = BLP span from Controller II (acts like a (69 kPa) compensation sensor).

4. Use the relationship between the primary sensor and Compensation Sensor 1 to determine positive or negative compensation for Controller I.(For example, if setpoint increases when Compensation Sensor 1 increases, set Controller I for positive compensation. Set Controller I action according to the valve action.
5. Compensation startpoint, WcI, equals 83% with Controller I set for negative compensation (13-3 psi/15-3 psi or 83-21 kPa/103-21 kPa) and 0 percent when set for positive compensation (3-3 psi/3-3 psi or 21-21 kPa/21-21 kPa).
6. Use the primary sensor start value from the system schedule to adjust Controller I Setpoint (W1I).

7. Calculate the proportional band setting (XpII) for Controller II:

$$XpII = \frac{\Delta SC1}{SCs1} \times 100$$

Where:

$\Delta SC1$ = Operating span of Compensation Sensor 1 (Port 3, Controller II).
$SCs1$ = Span of Compensation Sensor 1.

8. Use the relationship between primary sensor (Controller I) and Compensation Sensor 2 to determine positive or negative compensation for Controller II. Use Controller II in the DA mode to act as a sensor.
9. Calculate authority setting for Controller II (AcII) using pressures:

$$AcII = \frac{\Delta SC1 \text{ (Port 3)}}{\Delta SC2 \text{(Port 5)}} \times 100$$

Where:

$\Delta SC1$ = Compensation Sensor 1 operating span in pressure.
$\Delta SC2$ = Compensation Sensor 2 operating span in pressure.

10. Use the Compensation Sensor 1 start value from the system schedule to adjust Controller II setpoint (WIII).
11. Adjust Controller II compensation startpoint (WcII) to the Compensation Sensor II start value.
12. Calibrate according to Installation Instructions 95-7392.

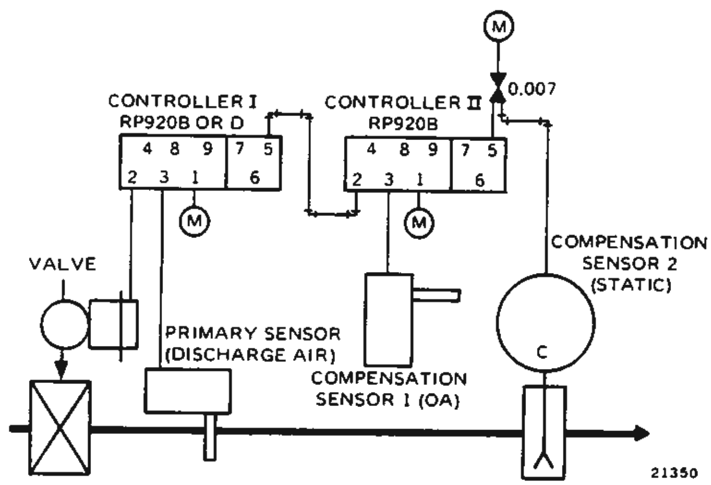


Fig. 50. Three Input Control.

EXAMPLE:

Figure 51 shows a heating coil discharge controller system schedule with its setpoint reset by an outdoor air sensor. The second element of compensation is a static pressure sensor.

Compensation Range	Primary Sensor (Discharge)	Compensation Sensor 1 (Outdoor Air)	Compensation Sensor 2 (Duct Static)
Start	80F (27C)	60F (16C)	4 in. wc (1 kPa)
Full	130F (54C)	0F (-18C)	3 in. wc (0.75 kPa)
Operating Span	50F (27K)	60F (33C)	1 in. wc (0.25 kPa)
Sensor Span	200F (111K)	200F (111K)	2 in. wc (0.5 kPa)
Sensor Range	40 to 240F (5 to 115C)	-40 to 160F (-40 to 71C)	2 to 4 in. wc (0.5 to 1 kPa)

Fig. 51. Three Input Reset Schedule.

The OA sensor provides the first element of compensation; as the OA temperature decreases, the setpoint of Controller II (discharge temperature) increases. The duct static sensor provides the second element of compensation. When the duct static sensor pressure decreases (air flow increases), the setpoint of Controller II decreases, raising the Controller I setpoint (discharge temperature).

1. TR = 10F (5.6K).
2. The proportional band setting (XpI) for Controller I is:

English

$$XpI = \frac{TR}{SPs} \times 100 = \frac{10F}{200F} \times 100 = 5\%$$

Metric

$$XpI = \frac{TR}{SPs} \times 100 = \frac{5.6K}{111K} \times 100 = 5\%$$

3. The Authority setting for Controller I (AcI) is:

English

$$AcI = \frac{\Delta SP + TRp}{10\ psi} \times 100 = \frac{3\ psi + 0.6\ psi}{10\ psi} \times 100 = 36\%$$

Metric

$$AcI = \frac{\Delta SP + TRp}{69\ kPa} \times 100 = \frac{21\ kPa + 4.14\ kPa}{69\ kPa} \times 100 = 36\%$$

Where:

English

$$\Delta SP = (130F - 80F) \times 0.06\ psi/F = 3\ psi$$

$$TRp = 10F \times 0.06\ psi/F = 0.6\ psi$$

Metric

$$\Delta SP = (54C - 27C) \times 0.75\ kPa/C = 21\ kPa$$

$$TRp = 5.6K \times 0.75\ kPa/C = 4.14\ kPa$$

4. Set Controller I for negative compensation and DA.
5. Compensation startpoint for Controller I equals 83%.
6. Controller I Setpoint (W1I) = 80F (27C) or 20%.
7. The proportional band setting (XpII) for Controller II is:

English

$$XpII = \frac{\Delta SC1}{SCs1} \times 100 = \frac{60F}{200F} \times 100 = 30\%$$

Metric

$$XpII = \frac{\Delta SC1}{SCs1} \times 100 = \frac{33K}{111K} \times 100 = 30\%$$

Where:

$\Delta SC1$ = Operating span of Compensation Sensor 1.

$SCs1$ = Span of Compensation Sensor 1.

8. Set Controller II for negative compensation and DA.
9. The authority setting for Controller II (AcII) is:

English

$$AcII = \frac{\Delta SC1}{SC2} \times 100$$

$$= \frac{3.6\ psi}{6\ psi} \times 100$$

$$= 60\%$$

Metric

$$AcII = \frac{\Delta SC1}{SC2} \times 100$$

$$= \frac{25.5\ kPa}{41.5\ kPa} \times 100$$

$$= 61\%$$

Where:

English

$$\Delta SC1 = (60F - 0F) \times 0.06\ psi/F$$

$$= 3.6\ psi$$

$$\Delta SC2 = \frac{(4\ in.\ wc - 3\ in.\ wc)}{\times 6\ psi/in.\ w.c.}$$

$$= 6\ psi$$

Metric

$$\Delta SC1 = [16C - (-18C)] \times 0.75\ kPa/C$$

$$= 25.5\ kPa$$

$$SC2 = \frac{(1\ kPa - 0.75\ kPa)}{\times 166\ kPa/kPa}$$

$$= 41.5\ kPa$$

10. Controller II setpoint (W1II) is 60F (16C) or 0%.
11. Controller II compensation startpoint (WcI) = 4 in. wc (1 kPa) = 100%.

APPENDIX

Table 5. Sensor Value to Pressure or Percentage Conversion Chart.

% of Span	-40 to 160F	0 to 200F	40 to 240F	25 to 125F	-20 to 80F	50 to 100F	15 to 75%	15 to 85%	65 to 95%	PSI
0	-40	0	40	25	-20	50	15	15	65	3
2	-37	3	43	27	-19	51	17	16	66	3.2
3	-33	7	47	28	-17	52	19	17	67	3.4
5	-30	10	50	30	-15		21	18	68	3.6
7	-27	13	53	32	-13	53		19	69	3.8
8	-23	17	57	33	-12	54	24		70	4
10	-20	20	60	35	-10	55	25		71	4.2
12	-17	23	63	37	-8	56		23		4.4
13	-13	27	67	38	-7	57	28	24		4.6
15	-10	30	70	40	-5			25	73	4.8
17	-7	33	73	42	-3	58	31	26	74	5
18	-3	37	77	43	-2	59	32			5.2
20	0	40	80	45	0	60	33		75	5.4
22	3	43	83	47	2	61	34	30		5.6
23	7	47	87	48	3	62			76	5.8
25	10	50	90	50	5					6
27	13	53	93	52	7	63	37	34	77	6.2
28	17	57	97	53	8	64	38	35		6.4
30	20	60	100	55	10	65	39	36	78	6.6
32	23	63	103	57	12	66	40			6.8

Table 5. Sensor Value to Pressure or Percentage Conversion Chart. (Continued)

% of Span	-40 to 160F	0 to 200F	40 to 240F	25 to 125F	-20 to 80F	50 to 100F	15 to 75%	15 to 85%	65 to 95%	PSI
33	27	67	107	58	13	67	41		79	7
35	30	70	110	60	15		42	40		7.2
37	33	73	113	62	17	68	43	41	80	7.4
38	37	77	117	63	18	69	44	42		7.6
40	40	80	120	65	20	70	45			7.8
42	43	83	123	67	22	71	46		81	8
43	47	87	127	68	23	72	47	46		8.2
45	50	90	130	70	25		48	47		8.4
47	53	93	133	72	27	73	49	48	82	8.6
48	57	97	137	73	28	74		49		8.8
50	60	100	140	75	30	75		50	83	9
52	63	103	143	77	32	76	51			9.2
53	67	107	147	78	33	77	52			9.4
55	70	110	150	80	35		53		84	9.6
57	73	113	153	82	37	78				9.8
58	77	117	157	83	38	79		56		10
60	80	120	160	85	40	80	55	57	85	10.2
62	83	123	163	87	42	81	56	58		10.4
63	87	127	167	88	43	82	57			10.6
65	90	130	170	90	45		58		86	10.8
67	93	133	173	92	47	83	59			11
68	97	137	177	93	48	84	60	63		11.2
70	100	140	180	95	50	85	61	64	87	11.4
72	103	143	183	97	52	86	62	65		11.6
73	107	147	187	98	53	87	63			11.8
75	110	150	190	100	55		64		88	12
77	113	153	193	102	57	88	65			12.2
78	117	157	197	103	58	89		70		12.4
80	120	160	200	105	60	90	66	71	89	12.6
82	123	163	203	107	62	91	67	72		12.8
83	127	167	207	108	63	92	68			13
85	130	170	210	110	65		69		90	13.2
87	133	173	213	112	67	93				13.4
88	137	177	217	113	68	94	70	77		13.6
90	140	180	220	115	70	95	71	78	92	13.8
92	143	183	223	117	72	96	72			14