

CONTROL VALVE CHARACTERISTICS

Product Code: 318, 318B

Instruction manual



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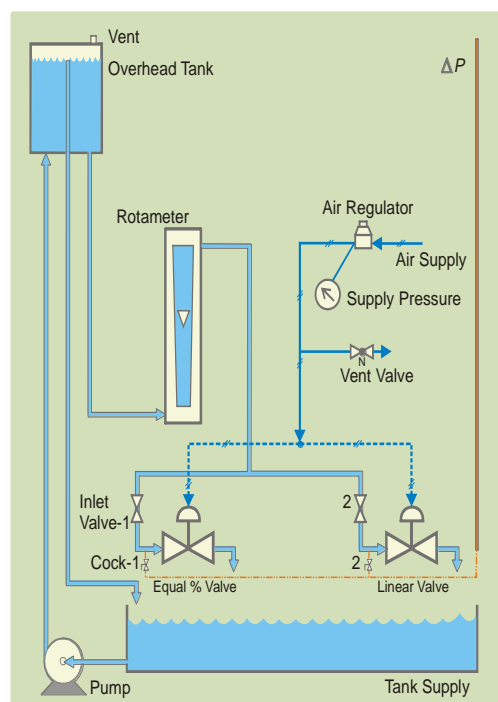
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Description

The setup is designed to understand the control valve operation and its flow characteristics. It consists of pneumatic control valves of linear, equal% (& quick opening for product 318B) type, stainless steel water tank with pump for continuous water circulation and rotameter for flow measurement. An arrangement is made to measure pressure at the valve inlet in terms of mm of water. An air regulator and pressure gauge is provided for the control valve actuation. In case of additional optional requirement a valve positioner is fitted on linear valve. The set up is stand-alone type.

The schematic shown is for product 318



Product schematic

Specifications

Product	Control valve characteristics	
Product code	318	318B
Control valve (Linear)	Type: Pneumatic; Size: 1/2", Input: 3–15 psig, Air to open, Characteristics: Linear	
Control valve (equal %)	Type: Pneumatic; Size: 1/2", Input: 3–15 psig, Action: Air to close, Characteristics: Equal %	
Control valve (quick opening)	Not provided	Type: Pneumatic; Size: 1/2", Input: 3–15 psig, Air to open, Characteristics: Quick opening
Rotameter	40-400 LPH	60-600 LPH
Overhead tank	SS304, cylindrical	
Receiving tank	SS304, water reservoir	
Pressure indication	Tube with graduated scale at control valve inlet	
Pump	Fractional horse power, type submersible	
Air Regulator	Range 0-2.5 kg/cm ²	
Pressure gauge	Range 0-2.5 kg/cm ²	
Overall dimensions	735Wx550Dx2020H mm	
Optional	Valve positioner fitted on linear valve Mini Compressor	

Installation

Installation requirements

Electric supply

Provide 230 VAC +/- 10V (5A) single phase electric supply with proper earthing.

(Neutral – Earth voltage less than 5 VAC)

- 5A, three pin socket with switch (1 No.): For the product

Water supply

Distilled water @16 liters

Air supply

Clean, oil and moisture free air, pressure 2 Bar, consumption 50 LPH

Installation

- Unpack the boxes) received and ensure that all material is received as per packing slip (provided in instruction manual). In case of short supply or breakage contact Apex Innovations / your supplier for further action.
- Assemble the set up. Refer schematic drawing.
- Pierce hole on the pressure gauge with pin or needle.
- Connect air supply to the regulator and electric supply to the pump
- **For arresting float movement in the rotameter, packing rod is inserted inside it. Remove the packing rod.**

Commissioning

Water circulation

- Fill distilled water in the supply tank.
- Close the hose cocks provided to the pressure indication tube.
- Open the regulating valves (provided at the inlet of control valves).
- Keep open the vent valve (fitted to the overhead tank at the top of the set up) and ball valve (fitted in the overflow line from overhead tank to supply tank).
- Switch on the pump.
- Close the vent valve and ball valve, when water overflows to supply tank. Open the ball valve and vent valve when rotameter lifts to its maximum range.
- Repeat above step till air from rotameter is removed.

- Open the hose cocks and remove air bubbles from the pressure indication tube. Close the hose cocks. Close the regulating valves.

Control valve operation:

- Open the regulating valve for control valve under test & keep regulating valves of other control valves closed.
- The pneumatic signal line from regulator is connected to one of the control valves. Adjust air regulator to open the control valve fully. (0 psig for equal% valve or 15 psig for linear / quick opening valve). Open the hose cock. Manipulate the air regulator for achieving different stem positions. Observe flow and inlet pressure variations. (If valve positioner is provided adjust 20 psig air supply to positioner by manipulating separate regulator provided for it. Then connect the pneumatic signal line to the valve positioner)

Troubleshooting

Note: For component specific problems refer Components' Manuals

Problems	Possible causes / remedies
No full flow through rotameter	<ul style="list-style-type: none"> • Air trapped in rotameter. Close the vent valve on overhead tank and ball valve in the overflow line to apply full pressure of the pump to the rotameter. Open both the valves after removal of air. • Vent valve on overhead tank may be closed. • Regulating valves at the control valve inlet may be closed. • Choked pump suction causing insufficient water flow.
Rotameter flow fluctuates	<ul style="list-style-type: none"> • Vent valve on overhead tank not fully open or choked.
No pressure indication	<ul style="list-style-type: none"> • Air bubbles in the pressure measurement tube
Improper control valve stem movement	<ul style="list-style-type: none"> • Disturbed spring setting. • Diaphragm breakage
Valve positioner	<ul style="list-style-type: none"> • Refer valve positioner manual separately provided.

Components used

Product	Control valve characteristics
Product code	318/318B
Control valve	Make Pneucon valves Pvt. Ltd., Model 110/PDC-030, Size ½" x ¼", Body CCS, Trim SS316, Travel 9/16", Spring range 0.2-1.0, Characteristics linear, Action air to open
Control valve	Make Pneucon valves Pvt. Ltd., Model 110/PDO-030, Size ½" x ¼", Body CCS, Trim SS316, Travel 9/16", Spring range 0.2-1.0, Characteristics equal%, Action air to close
Control valve (For 318B)	Make Pneucon valves Pvt. Ltd., Model 110/PDC-030, Size ½" x ½", Body CCS, Trim SS316, Travel 9/16", Spring range 0.2-1.0, Characteristics quick opening, Action air to open
Rotameter (For318)	Make Eureka Model PG 6, Range 40-400 lph, Connection ¾" BSP vertical, screwed, Packing neoprene
Rotameter (For318B)	Make Eureka, Model PG 7, Range 60-600 lph, Connection ¾" BSP vertical, screwed, Packing neoprene
Pump (For318)	Make U.P. National Mfrs. Ltd., Model THS 3000, Type submersible, Head 3 m, 1200 lph discharge, Watts 35, Volts 240 AC, 50Hz
Pump (For318B)	Submersible pump, Model HQB 4500, Head max. 4.5m, Output 4500 lph, Watts 100, Volts 220-240 AC, 50Hz
Air Regulator	Make Airmatic, Model MR10-021PA, Mounting panel, Connection ¼" BSP, Range 0-2 Kg/Cm ² , with lock nut.
Pressure gauge	Make Waaree, Code: PW2.5GNNS9 0-2.5 1/4"B, Dia.2.5", Gly. filled, Brass internals, S.S. casing, Range 0-2.5 Kg/cm ² , 1/4"BSP (M) back connection
Valve positioner (Optional)	Make Pneucon valves pvt. Ltd., Model PVP-1, Action direct, Input signal 0.2-1.0 Kg/cm ² , Supply connection 1/4"NPT

Packing slip

Control valve characteristics, Product no.318

Shipping details

Total no. of boxes: 4, Volume: 0.63m³/0.67m³ Gross weight: 158/167 kg. Net wt.: 84/88kg

Box No.1/4	Bottom Structure assembly Size L900xW640xH435 mm; Vol:0.25m ³	Gross weight:44 kg Net weight:21 kg
	Bottom structure assembly	
	Loose material consisting of: Control valve support bracket (1) Inlet water header CPVC (1No) Inlet water pipe assembly (2 Nos) Outlet water bend (2 Nos) Overflow pipe (1No) Measuring jar (1No) CPVC pipe fittings (spare 2 Nos) Tool kit (1No)	
Box No.2/4	Support structure assembly Size L 1775 xW 345 xH 385 mm; Vol: 0.24 m ³	Gross weight:50 kg Net weight:25 kg
	Support structure assembly	
	Set of instruction manuals consisting of: Instruction manual CD (Apex) User's manual Control valve (Pneucon)	
Box No.3/4	Control valve assembly Size L 655xW 315xH 325mm; Vol:0.07m ³	Gross weight: 32 kg Net weight:19 kg
Box No.4/4	Control valve assembly (/+VP) Size L 655xW 315xH 325mm; Vol:0.07m ³ /Size L 680xW 430 xH 390mm; Vol:0.11m ³	Gross weight: 32 kg/41kg Net weight:19 kg/23kg

Control valve characteristics, Product no.318B

Shipping details

Total no. of boxes: 5, Volume: 0.70m³/0.74m³ Gross wt.: 190/199 kg. Net wt.: 103/107 kg

Box No.1/5	Bottom Structure assembly Size L900xW640xH435 mm; Vol:0.25m ³	Gross weight:44 kg Net weight:21 kg
	Bottom structure assembly	
	Loose material consisting of: Control valve support bracket (1) Inlet water header CPVC (1No) Inlet water pipe assembly (3 Nos) Outlet water bend (3 Nos) Overflow pipe (1No) Measuring jar (1No) CPVC pipe fittings (spare 2 Nos) Tool kit (1No)	
Box No.2/5	Support structure assembly Size L 1775 xW 345 xH 385 mm; Vol: 0.24 m ³	Gross weight:50 kg Net weight:25 kg
	Support structure assembly	
	Set of instruction manuals consisting of: Instruction manual CD (Apex) User's manual Control valve (Pneucon)	
Box No.3/5	Control valve assembly Size L 655xW 315xH 325mm; Vol:0.07m ³	Gross weight: 32 kg Net weight:19 kg
Box No.4/5	Control valve assembly (/+VP) Size L 655xW 315xH 325mm; Vol:0.07m ³ /Size L 680xW 430 xH 390mm; Vol:0.11m³	Gross weight: 32 kg/ 41kg Net weight:19 kg/ 23kg
Box No.5/5	Control valve assembly Size L 655xW 315xH 325mm; Vol:0.07m ³	Gross weight: 32 kg Net weight:19 kg

Warranty

This product is warranted for a period of 12 months defect in the system noticed during the warranty period. On receipt of your written notice, Apex at its option either repairs or replaces the product if proved to be defective as stated above. You shall not return any part of the system to us before receiving our confirmation to this effect.

The foregoing warranty shall not apply to defects resulting from:

Buyer/ User shall not have subjected the system to unauthorized alterations/ additions/ modifications.

Unauthorized use of external software/ interfacing.

Unauthorized maintenance by third party not authorized by Apex.

Improper site utilities and/or maintenance.

We do not take any responsibility for accidental injuries caused while working with the set up.

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Theory

Types of Control valves

Valve is essentially a variable orifice.

Control valve is a valve with a pneumatic, hydraulic, electric (excluding solenoids) or other externally powered actuator that automatically, fully or partially opens or closes the valve to a position dictated by signals transmitted from controlling instruments. Control valves are used primarily to throttle energy in a fluid system and not for shutoff purpose. The figure shows basic elements and internal parts of typical pneumatic control valve. Depending upon the valve plug design the control valves can be classified as quick opening, linear and equal percent type.

Linear: Flow is directly proportional to valve lift.

$$Q = ky$$

Where

Q = flow at constant pressure drop

y = valve opening

k = constant

Equal%: Flow changes by a constant percentage of its instantaneous value for each unit of valve lift.

$$Q = b \times e^{ay}$$

Where

Q = flow at constant pressure drop

y = valve opening

e = base of natural logarithms

a and b = constants

Constants a and b can be evaluated to give more convenient form

$$Q = Q_0 \times e^{\{(\log R / y_{\max}) \times y\}}$$

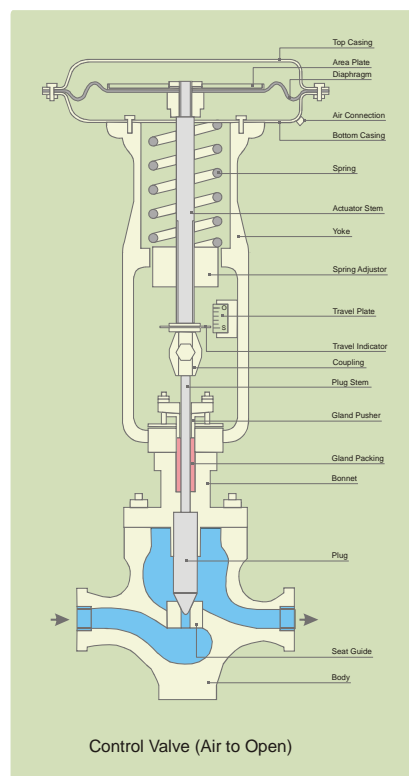
Where

Q_0 = Flow at constant drop at zero stroke

R = Flow range of valve, maximum to minimum at constant drop.

y_{\max} = maximum rated valve opening

Quick opening: Flow increases rapidly with initial travel reaching near its maximum at a low lift. It is generally not defined mathematically.



Valve actions and actuator mechanism

Different types of actuators are used to control the stem travel of the valve, like electrical actuators, pneumatic actuator, Hydraulic actuators etc.

In this product pneumatic actuators are used for control valves.

Spring opposed diaphragm actuator positions the valve plug in response to the controller signals.

Mostly the controller signals are in the range of 3 - 15 psig.

Direct acting actuator (air to close):

Direct acting actuators basically consist of a pressure tight housing sealed by a flexible fabric reinforced elastomer diaphragm. A diaphragm plate is held against the diaphragm by a heavy compression spring. Signal air pressure is applied to upper diaphragm case that exerts force on the diaphragm and the actuator assembly. By selecting proper spring rate or stiffness, load carrying capacity, and initial compression, desired stem displacement can be obtained for any given input signal.

Reverse acting actuator (air to open):

In case of reverse acting actuators the stem gets retracted with increase in pressure.

Control valve flow coefficient

A control valve regulates the flow rate in a fluid delivery system. In general a close relation exists between the pressure along the pipe and the flow rate so that if pressure is changed, then the flow rate is also changed. A control valve changes the flow rate by changing the pressure in the flow system because it introduces the constriction in the delivery system so we can say that the flow rate through the constriction is given by

$$Q = K\sqrt{\Delta P} \text{ -----(1)}$$

The correction factor K in above equation allows selection of proper size of valve to accommodate the rate of flow that the system must support. This correction factor is called as valve coefficient and is used in valve sizing.

Valve coefficient:

$$C_v = 1.16 \times Q \times \sqrt{\frac{G}{\Delta P}} \text{ (In S I Units)}$$

Where G is specific gravity of liquid, Q flow in m³/h, ΔP pressure drop in bar.

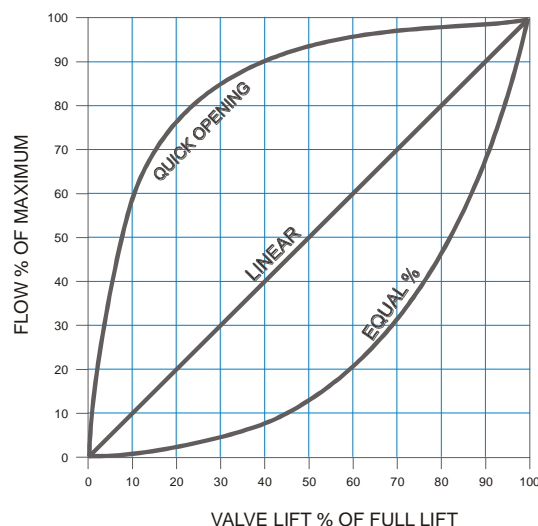
Valve Characteristics

The amount of fluid passing through a valve at any time depends upon the opening between the plug and seat. Hence there is relationship between stem position, plug position and the rate of

flow, which is described in terms of flow characteristics of a valve. Inherent and Installed are two types of valve characteristics.

Inherent characteristics:

The inherent flow characteristic of control valve is the relation between the flow and the valve travel at constant pressure drop across the valve. Following are the inherent characteristics for different types of valves.



Installed characteristics:

The Inherent characteristics of the valves described are subject to distortion due to variations in pressure drop with flow. Line resistance distorts linear characteristics towards that of quick opening valve and equal% to that of linear.

Hysteresis of control valve

Hysteresis is a predictable error resulting from the differences in the transfer functions when a reading is taken from above and below the value to be measured. In case of control valves for same actuator signal different stem travel (hence valve coefficients) are obtained depending upon the direction of change in the signal. The maximum error in stem travel (or valve coefficient) expressed in % for same actuator pressure while opening and closing the valve is indicated as hysteresis.

Rangeability of equal % valve

Equal% valve has characteristics such that given percent change in stem position produces an equivalent change in flow. Generally this type of valve does not shut off the flow completely in its

limit of stem travel. The Rangeability (R) is defined as the ratio of maximum to minimum controllable flow.

$$R = \frac{F_{\max}}{F_{\min}}$$

Where F max is the flow when the valve stem is at extreme open position F min is the flow when valve stem is at extreme closed position.

(F_{max}, F_{min} represents flow rates measured at constant pressure drop across control valve. Hence rangeability R also can be defined as ratio of Cv max to Cv min.)

For equal percent valve flow have exponential characteristics of rangeability,

$$F = R^{m-1}$$

Where R is the rangeability of the valve and m is its fractional stem position.

Valve positioner

Valve positioner is a device used with actuator. The actuator stem motion is accurately compared with the signal from controller. Any deviation from the desired position results in an error signal which activates pneumatic relay having an independent air supply. Some of the advantages of positioner are as follows:

- Helps in overcoming valve stem friction
- Matches input signal with valve stroke
- Increases speed of response of control valve

Possibility of split ranging, alteration in valve characteristics and action reversal

Experiments

1. Study of valve flow coefficient

Procedure

- Start up the set up. Open the flow regulating valve of the control valve to be studied (Linear/ Equal%/quick opening). Open the respective hose cock for pressure indication. (Close the flow regulating valves and hose cocks of other control valves.)
- Ensure that pressure regulator outlet is connected to the valve actuator of the control valve under study. Keep the control valve fully open by adjusting air regulator.
- Adjust the regulating valve and set the flow rate. (Set 400 LPH flow for linear/equal% valve or 600 LPH for quick opening valve). Note for measuring flow rates below rotameter minimum range use measuring jar.

Observations

Type of control valve: Linear/ Equal%/ Quick opening

(Fill up the column "valve coefficient" after calculations)

Sr. No	Pressure drop ΔP (mm of H ₂ O)	Flow (LPH)	Valve coefficient Cv.
1			
2			
3			

Calculations

$C_v = 1.16 Q \sqrt{G/\Delta P}$ where,

Q = Flow (m³/h) = Q in LPH/1000

ΔP = Pressure drop across valve (bar) = ΔP in mm of H₂O $\times 1.013 / (10.33 \times 10^3)$.

G = Specific gravity = 1 for water

Sample calculations & results:

Refer worksheet "PR318" in MS Excel file "318.xls" for calculation and graph plotting. Worksheet "PR318B" is for quick opening valve.

Conclusions

Keep the valve opening undisturbed and vary the flow rate. Note that the valve coefficient remains constant for different flow rates.

2. Study of inherent characteristics

Procedure

- Start up the set up. Open the flow regulating valve of the control valve to be studied (Linear/ Equal%/quick opening). Open the respective hose cock for pressure indication. (Close the flow regulating valves and hose cocks of other control valves.)
- Ensure that pressure regulator outlet is connected to the valve actuator of the control valve under study. Keep the control valve fully open by adjusting air regulator.
- Adjust the regulating valve and set the flow rate. (Set 400 LPH flow for linear/equal% valve or 600 LPH for quick opening valve). Note for measuring flow rates below rotameter minimum range use measuring jar.
- Note the pressure drop at control valve at full open condition.
- Slowly increase/decrease air pressure by regulator and close the control valve to travel the stem by 4mm. Note the pressure drop at control valve and corresponding flow rate.
- Repeat above step and take the readings at each 2mm-stem travel till the valve is fully closed.

Observations

Type of control valve: Linear/ Equal%/ Quick opening

(Fill up the column "valve coefficient" after calculations)

Sr. No	Lift (mm)	Flow (LPH)	Pressure drop ΔP (mm of H ₂ O)	Valve coefficient Cv
1				
2				
3				
4				
5				
6				

Plot the graph of valve coefficient versus lift to obtain inherent characteristic of the control valve.

Calculations:

$C_v = 1.16 Q \sqrt{G/\Delta P}$ where,

Q = Flow (m³/h)= Q in LPH/1000

ΔP = Pressure drop across valve (bar)= ΔP in mm of H₂O $\times 1.013 / (10.33 \times 10^3)$.

G = Specific gravity = 1 for water

Sample calculations & results:

Refer worksheet "PR318" in MS Excel file "318.xls" for calculation and graph plotting. Worksheet "PR318B" is for quick opening valve.

Conclusions

- The inherent valve characteristics plotted for each valve fairly tallies with theoretical valve characteristics.
- Inherent characteristics of control valve can also be studied by keeping constant pressure drop across the control valve.
 - Keep the valve fully open and adjust the flow rate. (400 LPH for linear/equal% valve or 600 LPH for quick opening valve). Note the pressure drop.
 - Gradually close the control valve in steps of 4mm of stem travel. The pressure drop across the valve increases. Manipulate flow rates to maintain pressure drop constant. Note the flow rates.

Plot the graph of flow versus lift.

- Note that the nature of the graph is same as inherent valve characteristics.

3. Study of installed characteristics

Procedure

- Start up the set up. Open the flow regulating valve of the control valve to be studied (Linear/ Equal%/quick opening). Open the respective hose cock for pressure indication. (Close the flow regulating valves and hose cocks of other control valves.)
- Ensure that pressure regulator outlet is connected to the valve actuator of the control valve under study. Keep the control valve fully open by adjusting air regulator.
- Adjust the regulating valve and set the flow rate. (Set 400 LPH flow for linear/equal% valve or 600 LPH for quick opening valve). Note for measuring flow rates below rotameter minimum range use measuring jar.
- Note the flow rate at full open condition.
- Slowly increase/decrease air pressure by regulator and close the control valve to travel the stem by 4mm. Note the flow rate.
- Repeat above step and take the readings at each 4mm stem travel till the valve is fully closed.

Observations:

Type of control valve: Linear/ Equal%/ Quick opening

Sr. No	Lift (mm)	Flow (LPH)
1		
2		

Plot the graph of flow versus lift to obtain installed characteristic of the control valve.

Sample calculations & results:

Refer worksheet "PR318" in MS Excel file "318.xls" for calculation and graph plotting. Worksheet "PR318B" is for quick opening valve.

Conclusions

- Installed characteristics of linear valve slightly approaches to the characteristic of quick opening valve because of the pipe friction and other resistance to the flow.
- Installed characteristics of equal % valve approaches to the characteristics of linear valve because of the pipe friction and other resistance to the flow.

4. Study of hysteresis of control valve

Procedure

- Start up the set up. Open the flow regulating valve of the control valve to be studied (Linear/ Equal%/quick opening). Open the respective hose cock for pressure indication. (Close the flow regulating valves and hose cocks of other control valves.)
- Ensure that pressure regulator outlet is connected to the valve actuator of the control valve under study. Keep the control valve fully open by adjusting air regulator.
- Adjust the regulating valve and set the flow rate. (Set 400 LPH flow for linear/equal% valve or 600 LPH for quick opening valve). Note for measuring flow rates below rotameter minimum range use measuring jar.
- Note the pressure drop at control valve at full open condition.
- Slowly increase/decrease air pressure in the step of 3 psi by regulator to close the control valve fully. Note the actuator pressure, pressure drop across the control valve and the flow rate. (Do not try to correct the actuator pressure by reversing the regulator direction if it inadvertently exceeds desired value.)
- Slowly decrease/increase air pressure in the step of 3 psi by regulator to open the control valve fully. Note actuator pressure, pressure drop across control valve and the flow rate.

Observations

Type of control valve: Linear/ Equal%/ Quick opening

(Fill up columns "valve coefficient" and " Hysteresis" after calculations).

Sr No	Actuator pressure (psig)	Flow (LPH)	Pressure drop (mm of H ₂ O)	Valve coefficient Cv	Flow (LPH)	Pressure drop (mm of H ₂ O)	Valve coefficient Cv	Hysteresis (%)
		Increasing actuator pressure			Decreasing actuator pressure			
1	0							
2	3							
3	6							
4	9							
5	12							
6	15							
7	18							

Plot the graph of actuator pressure versus valve coefficient. Ratio of maximum difference between flow coefficients at same actuator pressure, to that of maximum flow coefficient is termed as hysteresis.

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Calculations

$C_v = 1.16 Q \sqrt{G/\Delta P}$ where,

Q = Flow (m^3/h) = Q in LPH/1000

ΔP = Pressure drop across valve (bar) = ΔP in mm of $H_2O \times 1.013 / (10.33 \times 10^3)$.

G = Specific gravity = 1 for water

Sample calculations & results:

Refer worksheet "PR318" in MS Excel file "318.xls" for calculation and graph plotting. Worksheet "PR318B" is for quick opening valve.

Conclusions

The experiment gives idea about hysteresis of control valve.

5. Study of rangeability of equal percent control valve

Procedure

- Start up the set up. Open the flow regulating valve of equal % control valve. Open the respective hose cock for pressure indication. (Close the flow regulating valves and hose cocks of other control valves.)
- Ensure that pressure regulator outlet is connected to the valve actuator of the equal % valve. Keep the control valve fully open by adjusting air regulator.
- Adjust the regulating valve and set the flow rate to 400 LPH.
- Set actuator air pressure to 3 psig.
- Note the flow rate and pressure at inlet of control valve.
- Set actuator air pressure to 15 psig
- Note down the flow rate and pressure at inlet of control valve.

Observations:

Type of control valve: Equal%

Pressure (Psig)	Pressure drop (mm of H ₂ O)	Flow (LPH)	Valve coefficient Cv	Rangeability Cv max/ Cv min
3			Cv max	
15			Cv min	

Calculations:

$C_v = 1.16 Q \sqrt{G/\Delta P}$ where,

Q = Flow (m³/h) = Q in LPH/1000

ΔP = Pressure drop across valve (bar) = ΔP in mm of H₂O $\times 1.013 / (10.33 \times 10^3)$.

G = Specific gravity = 1 for water

Rangeability $R = C_v \text{ max} / C_v \text{ min}$

Conclusions

- Many times the control valve remains completely closed at 3 psig actuator pressure and no flow can be measured. Hence it is difficult to calculate the rangeability. Repeat the experiment by keeping constant pressure drop across the control valve and note the flow rates. Try to calculate by selecting different valve opening.
- The rangeability can also be calculated by keeping constant pressure drop across the valve.

6. Study of valve positioner

- 1) To study the hysteresis of control valve without positioner (Valve Positioner in “bypass” mode).
- 2) To study the hysteresis of control valve with positioner (Valve Positioner in “Auto” mode).

Working of valve positioner (VP):

VP is a type of cascade controller, which receives set point from E/P converter or air to control valve (shown as Input on VP). VP requires individual 20-PSI air supply to operate and this connection is shown as supply on VP. Bottom most gauge shows this pressure. The O/P of VP is connected to control valve actuator and upper most gauge shows this pressure. Middle gauge indicates input pressure from the lower regulator to operate the valve. Upper regulator is provided to supply 20-PSI pressure for VP.

If we consider VP as controller then following readings can be observed.

Set point = Pressure on middle gauge

Output = Pressure on uppermost gauge

Measurement = Stem position.

By turning the slot by loosening the allen screw in clockwise direction, we can take VP to bypass mode and by turning in reverse direction VP can be taken in Auto mode.

In bypass mode the air from input directly goes to diaphragm/actuator and in auto mode the supply air goes to output by comparing Input & stem position.

VP adjusts the position of stem as per the requirement by lowering or increasing the pressure.

Adjustment of VP:

Remove the cover on VP by removing the two screws. Inside this a spring loaded circular disc is provided for adjusting the pressure. When VP is working accurately in auto mode, output gauge shows pressure of 3-15 PSI as per the input signal. If pressure slashes down 3 PSI the output shows 0 PSI & if exceeds 15 PSI then shows @ 20PSI. If VP is not working as above then adjust it as follows:

Adjust VP input pressure to 5 PSI by regulator and see the output pressure, if 5PSI pressure is not achieving adjust the circular disc to set 5 PSI pressure. Then adjust VP input pressure to 13 PSI & to adjust output to same pressure adjust the slotted lever on the VP.

Do these adjustments carefully without disturbing the settings a lot.

Procedure:

- Start up the set up. Open the flow regulating valve of linear control valve. Open the respective hose cock for pressure indication. (Close the flow regulating valves and hose cocks of other control valves.)
- Ensure that pressure regulator outlet is connected to the valve actuator of the linear valve. Keep the control valve fully open by adjusting air regulator.
- Adjust the regulating valve and set the flow rate to 400 LPH.
- Keep VP in bypass mode.
- Keep the control valve fully open by adjusting lower air regulator.
- Adjust the regulating valve and set the flow rate to 400 LPH.
- Note the pressure drop at control valve at full open condition.
- Slowly increase/decrease air pressure in the step of 3 psi by regulator to close the control valve fully. Note the actuator pressure, pressure drop across the control valve and the flow rate. (Do not try to correct the actuator pressure by reversing the regulator direction if it inadvertently exceeds desired value.)
- Slowly decrease/increase air pressure in the step of 3 psi by regulator to open the control valve fully. Note actuator pressure, pressure drop across control valve and the flow rate.

Observations:

Type of control valve: Linear

Observation table (Fill up columns "valve coefficient" and "Hysteresis" after calculations).

Sr No	Actuator pressure (psig)	Flow (LPH)	Pressure drop (mm of water)	Valve coefficient	Flow (LPH)	Pressure drop (mm of water)	Valve coefficient	Hysteresis (%)
		Increasing actuator pressure			Decreasing actuator pressure			
1	0							
2	3							
3	6							
4	9							
5	12							
6	15							
7	18							

(Repeat the experiment with valve positioner in Auto mode)

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- Plot the graph of actuator pressure versus valve coefficient. The ratio of maximum difference between flow coefficients at same actuator pressure to that of maximum flow coefficient is termed as hysteresis.

Calculations:

$C_v = 1.16 Q \sqrt{G/\Delta P}$ where,

Q = Flow (m^3/h) = Q in LPH/1000

ΔP = Pressure drop across valve (bar) = ΔP in mm of $H_2O \times 1.013 / (10.33 \times 10^3)$.

G = Specific gravity = 1 for water

(C_v at decreasing pressure - C_v at increasing pressure)

Hysteresis % = ----- x 100

Maximum C_v

Sample calculations & results:

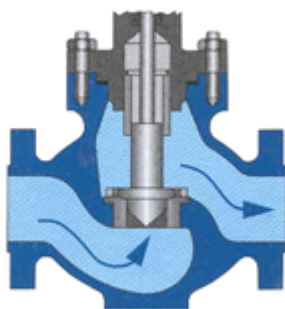
Refer worksheet "PR318" in MS Excel file "318.xls" for calculation and graph plotting. Worksheet "PR318B" is for quick opening valve.

Discussions on results

- The experiment gives idea about hysteresis of control valve with and without VP.
- Compare the hysteresis of control valve with VP in bypass mode and hysteresis of control valve with VP in auto mode. We can see that the hysteresis is reduced in the later case.

Components' manuals

Pneumatic Control Valve



Introduction

This type of valve with its globular body shape, which stylizes its name, uses the variable area generated between the plug and seat to control fluid flow. Designed in accordance with ANSI B16-34. It is a single seated, (Pressure balanced / unbalanced) and are preferred for tight shut – off, positioning accuracy, high rangeability and simplified maintenance, satisfy the majority of control applications throughout the process and power industries. Hence, this valve finds application in Air, Steam, Water, Gas and Chemical services etc.

1 : Technical specifications

Make	Pneucon Valves Pvt. Ltd.		
Model	110-PDC-030	110-PDO-030	110-PDC-030
Flow	Linear	Equal%	Quick opening
Valve size	15mm (1/2" BSP)		
Rating	ANSI 150 & equivalents in BS10, DIN, IS, JIS.		
End connection	Screwed (Female)		
Material	Carbon steel		
Bonnet	Standard		
Trim forms	Top guided contoured		
Trim material	Stainless steel		
Travel	28mm		
CV	2		
Seat leakage	Class III		
Gland packing	PTFE		
Actuator form	Diaphragm		
Action	Air to open, On air	Air to close, On air	Air to open, On air

	failure valve closes	failure valve opens	failure valve closes
Spring rating	3 – 15PSIG (0.2 – 1.0 kg/cm ²)		
Air supply	20 – 35 PSIG (1.4 – 2.5 kg/cm ²)		
Air connection	¼" BSP		

Principle of operation

- 1. Field adjustments:** While piping contractor's carrying out installation, the field corrections must be performed by those experienced in the instrumentation field.
- 2. Valve spring adjustment:** The spring compression is already set at the manufactures works generally as per the bench range or, at times, to match the operating pressure specified. Bench range is the operating air pressure range under no load conditions for rated stroke. The bench range is usually 3-15 psig. Therefore, unless the maximum pressure drop has been changed from that specified, no further field adjustment should be necessary. However, the operating air pressure range can be shifted as follows, if desired:
To increase the spring compression and in turn, the air pressure at which the plug would just begin to move, turn the spring adjustment screw clockwise, and vice-versa.
- 3. Packing:** The gland nut slightly more than hand tighten-ing should be adequate to stop any stem leakage. Over-tightening will restrict stem movement.
- 4. Diaphragm replacement:** Back off the spring adjusting screw until spring compression has been completely relieved. Remove diaphragm case bolts and replace diaphragm assembly and readjust spring compression.

Troubleshooting

Problem	Check
Control valve travel range less than the corresponding input signal ran	<ul style="list-style-type: none"> Faulty operation of the valve positioner if incorporated. Bypass valve positioner and check control valve operation with direct signal. Check signal line and actuator diaphragm chamber for air leaks. Check valve stem movement whether it is free – loosen gland if necessary. For single seated valve, check if line pressure has increased and compression spring need readjustment.
Control valve travels more than the corresponding input signal	<ul style="list-style-type: none"> Faulty valve positioner if incorporated; Bypass positioner and check. Faulty spring or permanent set due to aging. Readjust zero setting at 3 psig signal and check the travel range.

Control valve movement sluggish	<ul style="list-style-type: none">• Bypass valve positioner if incorporated and check the movement.• Loosen gland packing and check the stem movement.• Check for air leaks in the diaphragm chamber and signal line.• Bypass controller signal and apply direct air pressure to the diaphragm chamber and check the operation.• If the above checks do not reveal the problem, it may be desirable to dismantle valve body and check the internals.
Control valve hunting	<ul style="list-style-type: none">• Provide steady input signal either through the controller taken on manual or through a separate air supply source and check valve response.• Check for back-lack in the mechanical moving parts.• Presence of oil or moisture in the air line can cause hunting.
Excessive noise	<ul style="list-style-type: none">• Flashing or cavitations in the control valve creates excessive noise if proper care is not taken at the design stage.• When control valve operates almost in closed position under high pressure drop it can create chattering sound.• Loose supports.• Too much clearance in the guide bushing.• Damaged trim assembly.

Test and calibrations

1. Diaphragm chamber for 'Pneuco' actuators are tested for air leaks at air pressure around 50 psig using soap solution round the flange.
2. A hysteresis test of the 'Pneuco' actuator is made before the actuator is mated with the body assembly to determine that there is no binding of components within the actuator, as under;

Record air loading pressure required to stroke the actuator at every 10% increment of its travel. Then while returning the stem to the at-rest position, record the air loading once again at every 10% of travel. Compare the air loading pressures in the two directions for each increment of travel. The differential pressure between the two readings at each increment should not exceed 0.1psig, which is approximately within 1% of stroke.
3. The hysteresis check on the assembled control valve is carried out in the same manner, however, at 25% increment of its travel with gland packing loose and no differential pressure applied across the valve body.

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Hysteresis error should be within 5% of the stroke or ± 0.25 psig. The prime object of this test is to determine that proper alignment of all the components has been achieved. Higher error indicates that binding is occurring somewhere within the inner valve mechanism.

Manufacturer's address

Pneucon Valves Pvt. Ltd.

Plot No. 1/235-B, Behind SKM steels,

Near Bayer India, Kolshet Balkum Road,

Thane – 400 607.

E-Mail : pneucon@vsnl.com Web : www.pneuconvalves.com

Valve positioner

Introduction

The valve positioner is an instrument working on force balance principle to position the control valve stem in accordance to a pneumatic signal received from a controller or manual loading station, regardless of packing box friction, actuator hysteresis or unbalanced forces on the valve plug. Thus the positioner ensures a reliable and accurate operation of control valve.

Technical specifications

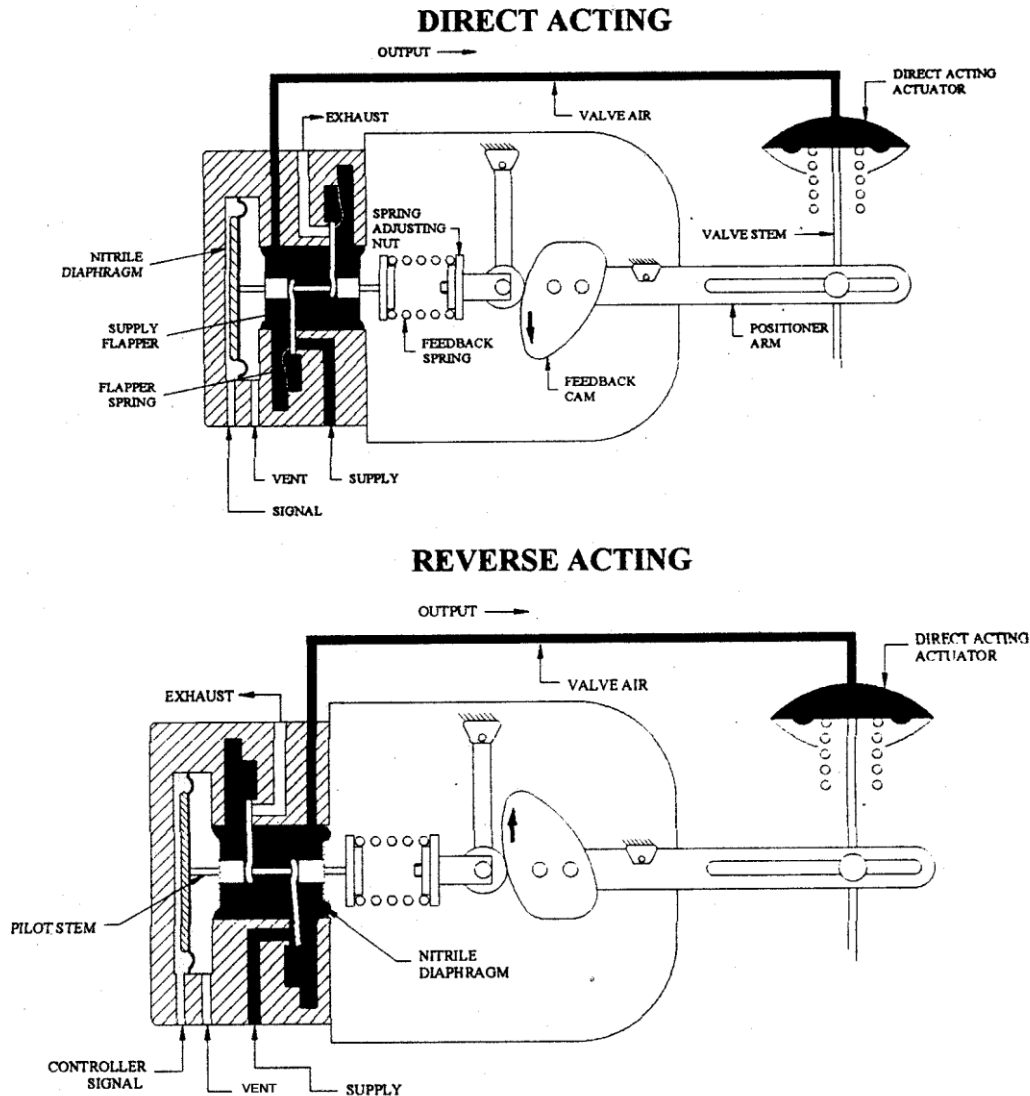
Model	PVP-1 Single acting, Direct action.
Supply connection	¼" NPT, (F)
Supply air pressure	1.4 to 3.5 kg/cm ²
Input	0.2 to 1 kg/cm ²
Stroke	14 mm to 100 mm
Stroke speed	10 mm/sec
Hysteresis, linearity	within +/- 1% of FS
Air consumption	7.0 NL / Hr (Normal), 200 NL / Hr (Maximum).

Principle of operation

The instrument signal is applied to the signal diaphragm. An increasing signal will drive the diaphragm and flapper-connecting stem to the right. The flapper-connecting stem will then open the supply flapper admitting supply pressure in to the output, which is connected to the actuator diaphragm. The exhaust flapper remains closed when the flapper-connecting stem is deflected to right. The effect of increasing signal is to increase the pressure in the actuator. This increased pressure in the actuator drives the valve stem downwards and rotates the positioner lever clockwise. This clockwise rotation of the lever results in a compression of range spring through cam. When the valve stem reaches the position called for by the controller, the compression in the range spring will give a balance force resulting the closure of both the flapper.

If the control signal is decreased the force exerted by the signal diaphragm will also decrease and the force from the range spring will push the flapper-connecting stem to the left, opening the exhaust flapper. This causes a decrease in actuator diaphragm pressure and allows the valve stem to move upward until a new force balance is established.

Schematic diagrams



By passing

PVP-1 model is available with bypass system. Bypass system facilitates to cut off the positioner and to pass the signal pressure to valve actuator directly. This enables to short time servicing of positioner, without affecting the working of the valve.

To bypass the positioner

- 1 Loosen the bypass knob fixing screw
- 2 Rotate selector knob clockwise and set to "bypass" position
- 3 Tighten the bypass knob fixing screw. The positioner is ready for "Bypass".

Maintenance

Replacing pilot relay assembly:

Pilot relay assembly is factory calibrated and sealed, field disassembly is not recommended. If required replace factory calibrated spare pilot relay assembly in following steps:

- a) Before removing pilot relay assembly, note whether action of positioner is direct or reverse to avoid misalignment when reassembly.
- b) Remove three screws fastening assembly to body
- c) Inspect existing gasket and replace if necessary
- d) Check the action by reversing the positioner relay assembly and mount in the desired position
- e) Fix the 3 screws to securely fasten assembly to the body

Gasket replacement:

When manifold or pilot assembly removed, if the gasket found to be worn out, change the same

Calibration

The positioner is mounted on the control valve and calibrated in factory. Hence calibration is not required. However if positioner has been disconnected for some reasons and if it is to be reconnected then calibration is required.

- 1 Apply regulated air pressure to actuator and adjust pressure until stem is positioned at midstroke.
- 2 Adjust motion connector assembly until positioner lever and motion connector are parallel and horizontal at midstroke.
- 3 Disconnect regulated air supply to diaphragm and connect tubing from output port of positioner to diaphragm.
- 4 Check numbers stamped on the positioner lever and move stroke-adjusting pin to desired stroke and tighten.
- 5 To set positioner's start point, apply desired starting pressure (usually 3 PSI) and adjust the spring adjuster until valve stem starts moving.
- 6 Set desired maximum pressure of signal range (usually 15 psi) and check for the stem stroke. If stroke is less, move stroke-adjusting pin to the higher value i.e. right. If stroke is achieved at pressure lesser than desired pressure, move to lower value i.e. left.
- 7 Recheck the start point.
- 8 Repeat step 5 & 6 until travel is found within acceptable limits.

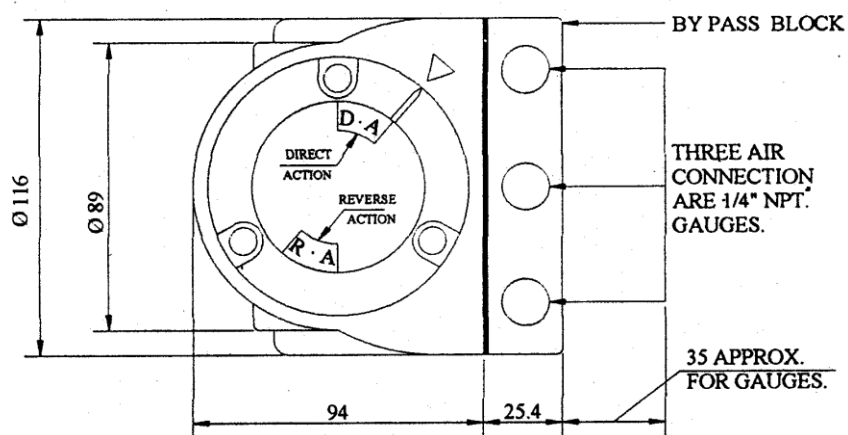
Changing positioner action

PVP positioner can be changed from direct action to reverse action or vice versa without additional parts or special tools. The same does not demand repositioning of positioner or tubing.

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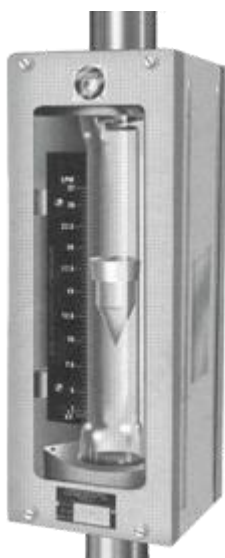
To change the action, follow the steps given below:

- 1 Release feed back spring and remove travel pin.
- 2 Remove the 3 Nos screws, which fasten the pilot assembly to the housing.
- 3 Rotate the pilot by 180° and remount it to the housing. Make sure that DA or RA marking is properly lined with arrow mark.
- 4 Remove the cam and fasten it in the opposite direction.
- 5 Readjust the travel pin and feedback spring.
- 6 Recalibrate as illustrated in "Calibration".



Rotameter

Rotameter works on the principle of variable area. Float is free to move up & down in a tapered measuring glass tube. Upward flow causes the float to take up a position in which the buoyancy forces and the weight are balanced. The vertical position of the float as indicated by scale is a measurement of the instantaneous flow rate.



Technical specifications

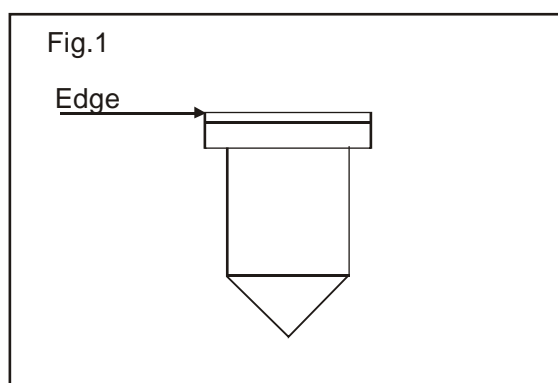
Model	PG-1 to 21
Make	Eureka Industrial Equipments Pvt. Ltd.
Flow Rate Max.	4000 to 40000 Lph
Packing/Gaskets	Neoprene
Measuring tube	Borosilicate glass
Float	316SS
Cover	Glass
Accuracy	+/-2% full flow
Range ability	10:1
Scale length	175-200mm.

Max. Temp. 200°C

Connection Flanged and Threaded, Vertical

Principle of operation

The rotameter valves must be opened slowly and carefully to adjust the desired flow rate. A sudden jumping of the float, which may cause damage to the measuring tube, must be avoided.



The upper edge of the float as shown in fig. 1 indicates the rate of flow. For alignment a line marked R.P. is provided on the scale which should coincide with the red line provided on measuring tube at the bottom.

Maintenance

When the measuring tube and float become dirty it is necessary to remove the tube and clean it with a soft brush, trichloroethylene or compressed air.

Dismantling of the measuring tube

- Shut off the flow.
- Remove the front and rear covers.
- Unscrew the gland adjusting screws, and push the gland upwards incase of bottom gland and downwards incase of top gland. Then remove the glass by turning it to and fro. Care should be taken, not to drop down the glands. Float or float retainers. The indicating edge of the float should not be damaged.

Fitting of the measuring tube

Normally the old gland packing is replaced by new ones while fitting back the measuring tube.

- Put the glands first in their position and then put the packing on the tube.
- Insert the tube in its place.
- Push the glands downwards and upwards respectively and fix them with the gland adjusting screws.
- Tighten the gland adjusting screws evenly till the gap between the gland and the bottom plate is approximately 1mm. In case, after putting the loflometer into operation, still there is leakage, then tighten the gland adjusting screw till the leakage stops.
- Fix the scale, considering the remark given in the test report.
- Fix the front and rear covers.

Troubleshooting

Problem	Check
Leakage on glands	Replace gland packing
Showing high/low flow rate than expected	Consult manufacturers
Showing correct reading initially but starts showing high reading after few days	Replace float Incase of gases, check also leakage
Showing correct reading initially but starts showing high reading after some	Clean the rotameter by suitable solvent or soft brush

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months.	
Fluctuation of float	Maintain operating pressure as mentioned in test report.
Frequent breakage of glass tube	Use loflometer to accommodate correct flow rate. Maintain operating pressure below pressure rating of the tube. Check piping layout.

Manufacturer's address

Eureka Industrial Equipments Pvt. Ltd.

17/20, Royal Chambers,

Paud Road, Pune – 411 038.

Email: eureka.equip@gems.vsnl.net.in