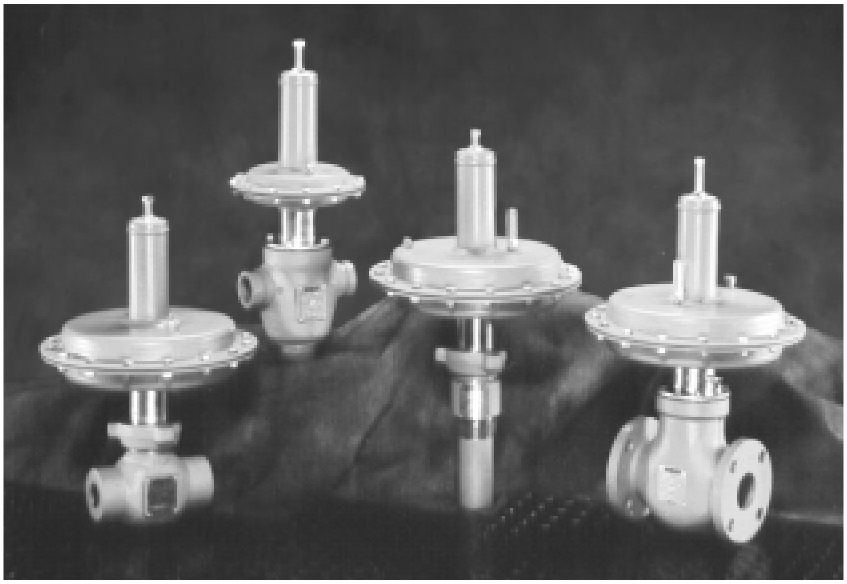
GUIDANT

Control Valve

Installation/Operation Manual

March 2000

Bulletin MNIV001



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Installation

INVALCO valves may be installed so that production can flow either over or under the seat. Flowing over the seat is not recommended when smooth operation is desired because flowing over the seat will cause the valve to 'slam' open and closed with erratic control and increased maintenance costs due to trim breakage in extreme cases. However, flowing over the seat will ensure 'fail closed' operation. If this is not a consideration, it is recommended that for most conditions the valve should be installed to flow under the seat.

In cases where a very large pressure differential exists across the valve, flowing under the seat may not be possible as the pressure may exceed the pressure rating of the spring in the diaphragm case, and cause the plug to lift causing leakage. Normally re-sizing the trim will correct the problem. Contact the factory for assistance should this occur.

Maintenance

INVALCO valves are designed for long life with a minimum among of maintenance. The valve trim is the most common item to need replacement due to erosion caused by high flow rates or abrasives in the flowing fluid.

Installation of Trim

To change the trim the valve should first be isolated in the line and all line pressure bled off. The spring adjusting screw should be removed before any disassemble is attempted. On valves with hammer nuts holding the topworks to the body, loosen (but do not totally unscrew or remove) the hammer nut with a hammer. Then rock the topworks until it is loose from the body and the seal between the two is broken to be certain that no pressure exists in the body. After determining that no pressure exists in the body, unscrew the hammer nut completely and pull the topworks straight away from the valve body to remove the trim. Slide the trim sideways to separate the plug stem from the upper diaphragm stem. The seat can now be unscrewed from the seat cage and the plug and stem slid out of the packing. It is recommended that the packing be replaced whenever a new trim set is installed in the valve.

On a 'low pressure' valve, the topworks is held to the valve body with bolts. The procedure is essentially the same as on 'high pressure' valves except, after isolating the valve and relieving all pressure from the valve body, loosen (but do not remove) the bolts securing the topworks to the valve body. Rock the topworks on the body to break the seal between them. Once the seal is broken and all pressure is relieved, it is safe to remove the bolts completely and separate the topworks from the body. The plug will come out with the topworks but the seat and/or seat cage will remain in the valve body and must be removed separately.

Diaphragm Replacement

The diaphragm is a fiber reinforced elastomer and seldom needs replacement. If it should fail it can be replaced by first relieving any pressure in the diaphragm case, then removing the spring adjusting screw and the bolts securing the two halves of the diaphragm case together. The self-locking nut is then removed from the top of the stem in the center of the diaphragm plate. It may be necessary to hold the stem with soft jawed locking pliers in order to remove the self-locking nut. If this is the case, use extreme care not to damage the surface of the stem as this will cause leakage through the packing. Lift off the upper diaphragm plate and the diaphragm can now be removed and replaced.

Packing Replacement

The stem packing is self-lubricating so no external grease injection fittings are required. However, abrasives in the flowing fluid can cause the packing to wear. To expose the packing for replacement, unscrew the seat cage from the stuffing box on hammer nut models or the packing nut from the body cover on 'low pressure' models and remove the packing follower. Be sure the new packing is of the same size and type as the original packing and that it is installed facing the same direction as the packing that was removed as most packing will only hold against pressure from one direction. For the correct packing for your model, consult the factory. On 'low pressure' models it will be necessary to open the diaphragm case so the stem can be slid down through the packing after it has been installed into the body cover. It is also recommended that the new packing be dipped in clean lubricating oil or be liberally coated with grease prior to installation. Replace the packing follower and seat cage (on hammer nut models) or packing nut (on 'low pressure' models) and reinstall the trim.

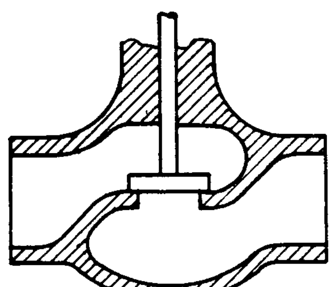
Valve Bodies

Valve bodies for INVALCO valves are available in the configurations illustrated in Figure 1. They include single-port (angle and globe), double-port (angle and globe, and 3-way. They are also available with threaded, grooved, and flanged end connections. Flanged end connections include flat-face (cast iron bodies only), raised face (ductile-iron and steel bodies), and RTJ (steel bodies only).

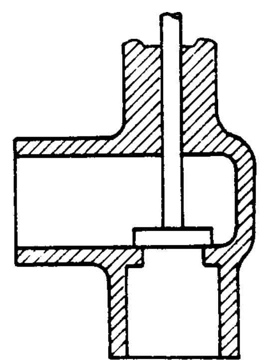
Cast iron has good corrosion resistance but has poor elasticity and poor fire resistance, therefore service conditions are limited. Cast iron bodies are considered nominally low pressure bodies and are normally identifiable by the flat-face flanges on flanged units or by the omission of any material reference on the body casting.

Ductile iron bodies have medium elasticity and fire and corrosion resistance and are good for general service conditions. Ductile iron bodies are identifiable by the work “ductile” or by the letters “DI” on the body casting.

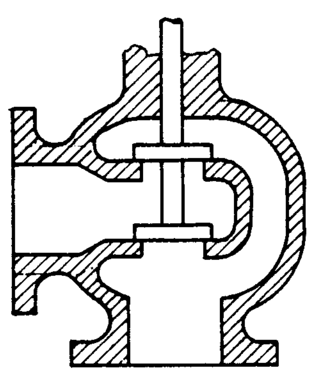
Steel has excellent elasticity, medium corrosion resistance and is good for almost unlimited service conditions. Steel body castings bear the identification “steel WCB”.



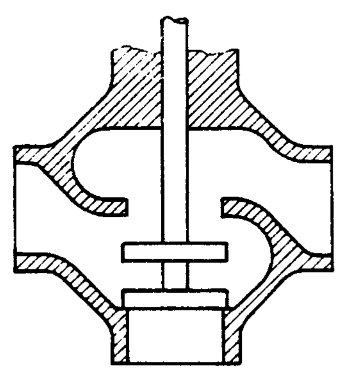
Single Port Globe



Single Port Angle



Double Port Angle



3 - Way

Figure 1. Body Configurations

Packing

Pressure Ring Packing

The standard stem packing used with INVALCO valves is "W" Ring packing. A "W" Ring packing set consists of molded elastomer pressure rings with a fabric insert. This type of packing is good for most pressure applications and for temperatures ranging from -40° F to +250°F.

For high temperature service to +450° F, most INVALCO valves are available with teflon "V" Rings.

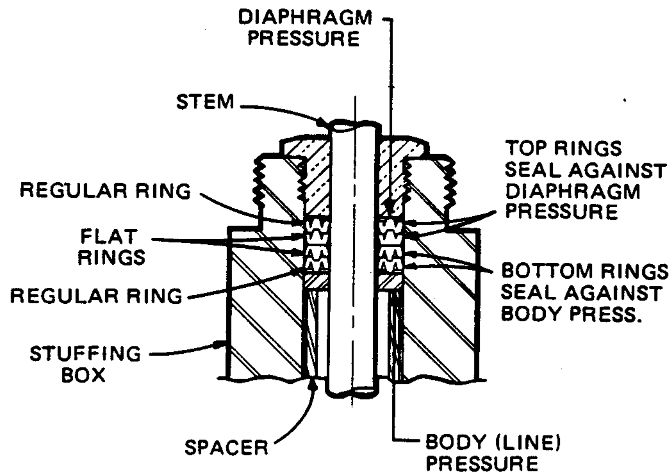


Figure 2.
Typical "W" Ring Installation in Low Pressure Valve

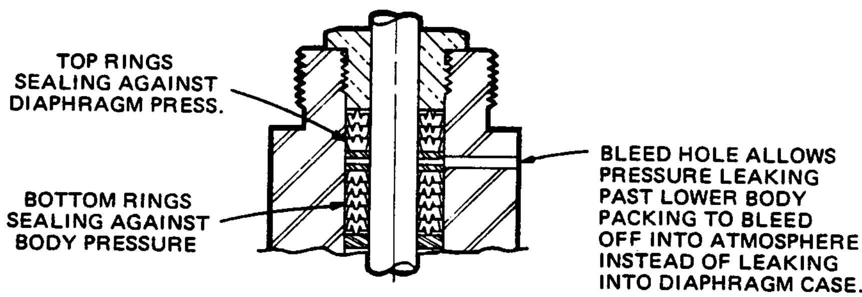


Figure 3.
Typical "W" Ring Installation in High Pressure Valve

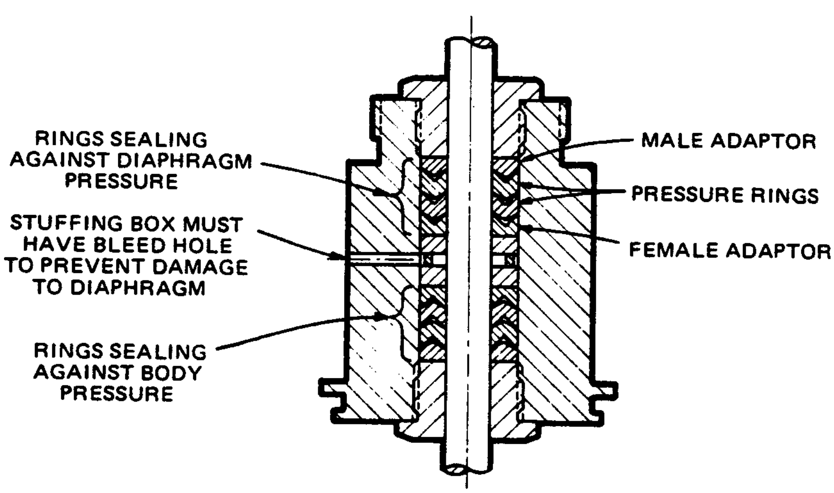


Figure 4.
Typical Installation of Teflon "V" Rings

O-Ring Packing

O-Rings are commonly used as seals throughout INVALCO valves. Figure illustrates several common O-Ring installations.

The standard O-Ring material used throughout INVALCO valves is Buna-N, and it is acceptable for temperatures ranging from -40° F to 250° F and for most solvent services.

INVALCO also offers O-Rings for their valves in various special material to suit extreme operating conditions.

Probably the most prominent extreme condition to be encountered would be that of extremely high temperature.

Viton O-Rings are good for most high temperature applications in that they will withstand continuous high temperatures of +350° F with intermittent high temperature of +450° F. Viton is not good for steam service however, and for this INVALCO recommends O-Rings made from EPR (Ethylene Propylene Rubber).

Teflon is good for continuous service at +450 F, but teflon O-Rings are difficult to work with and will occasionally break upon being stretched on to an O.D. groove. Teflon also tends to extrude and take a set under pressure. This condition is know as “cold flowing”. A teflon O-Ring that has cold flowed probably will not effect a completely functional seal and might tend to leak. If a slight leak is not objectionable, and if the O-Ring is not a small diameter O-Ring that must be installed in an O.D. groove, teflon is a good high temperature O-ring material selection.

Silicone, another high temperature seal compound, is also good for temperature of +450° F. Silicone O-Rings will normally effect and retain a better seal than teflon O-Rings, but silicone is not generally suited for service in the presence of hydrocarbons and since most INVALCO valves are used for oil and gas service, silicone seals are generally not recommended.

Consult the factory with problems pertaining to selection of special packing materials and configurations.

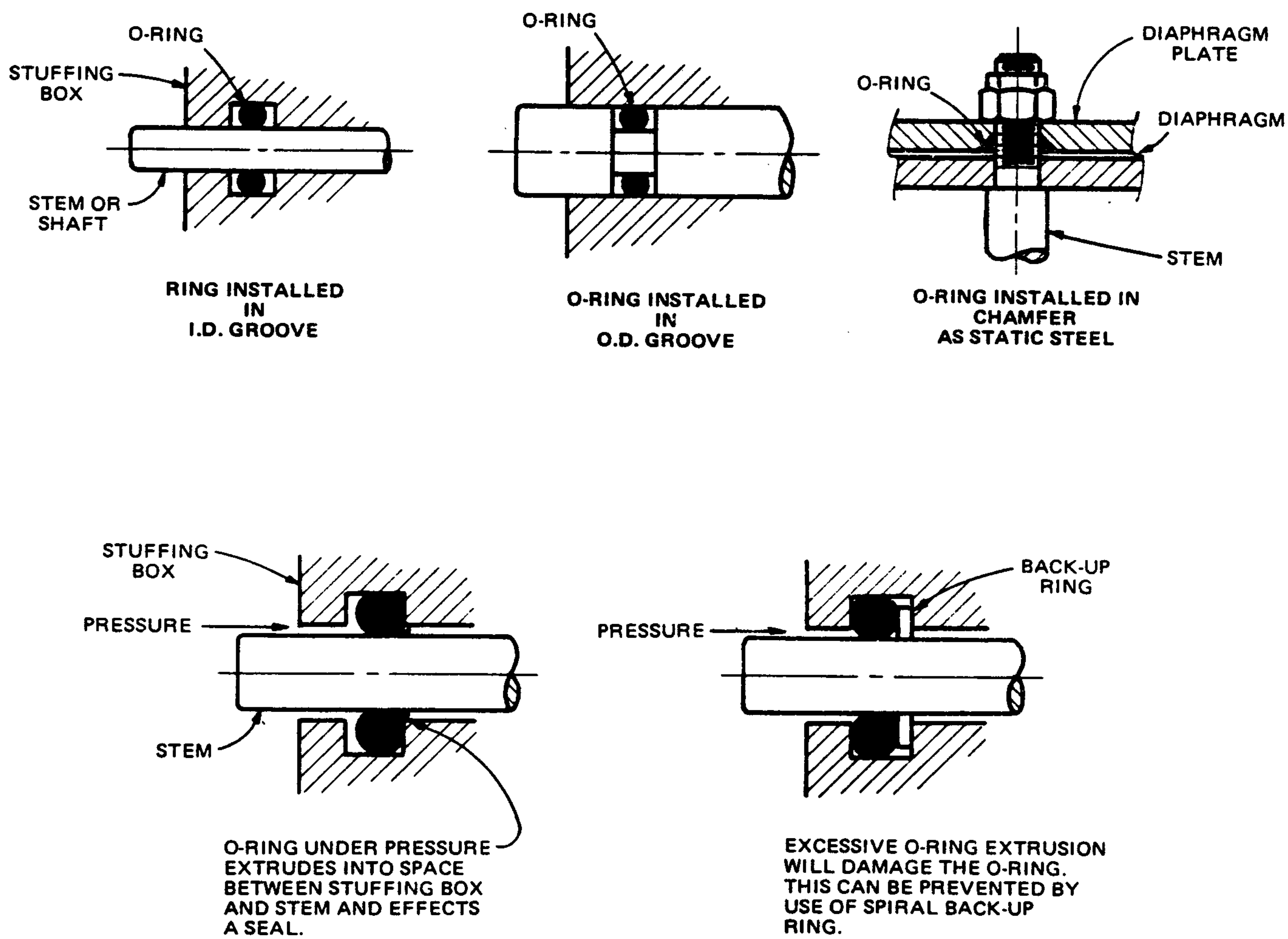


Figure 5.

Types and Configurations

"Valve Trim" is the term used to define the plug and seat combination of a valve. Trim for most INVALCO valves is available in various sizes (orifice size), materials and configurations.

The various trim configurations are illustrated in Figure 6.

Quick opening trim tends to "slug" fluid as the valve is opened and is recommended for service where rapid changes in fluid flow are acceptable.

Taper trim gives a gradual transition in flow rate as the position of the valve is altered. It is recommended for high pressure drops, medium erosion conditions, and where downstream processes cannot be "slugged" with fluid.

The characteristics for the various trim configurations for particular valves are shown in chart form in the Valve Section of the INVALCO Catalog. Figure 7 shows typical trim characteristics.

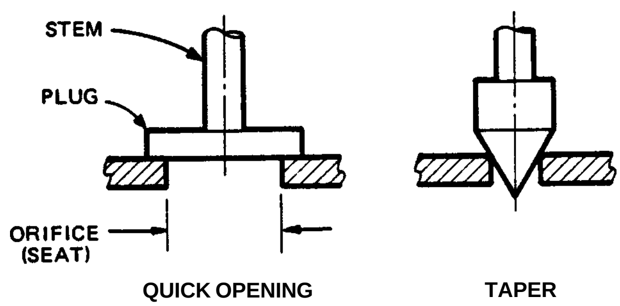


Figure 6.
Trim Configurations

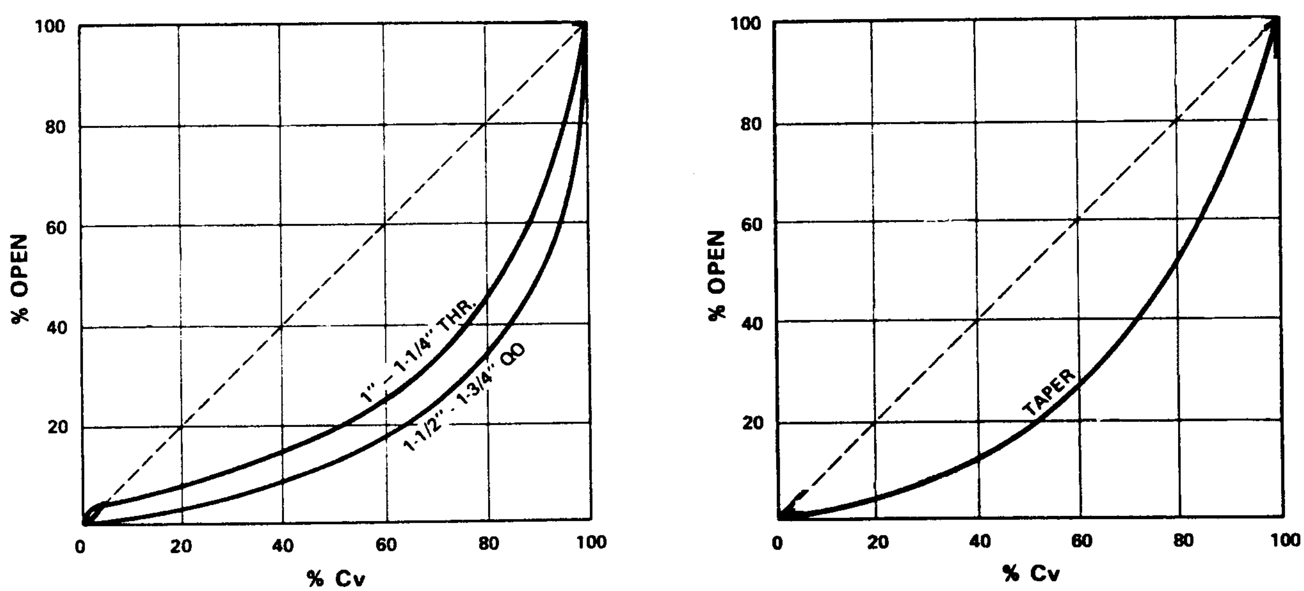


Figure 7.
Trim Configurations

Trim materials can be broken down into two major categories, metal to metal (hard seat) and soft seat. Examples of both hard and soft trims are illustrated in Figure 8.

Hard trim is generally used where high pressure drops taken across the valve orifice or where abrasive particles suspended in the process material would damage a softer seating surface. Hard trim is not generally used for tight shut-off.

440C Hardened stainless steel is the most conventional material for a metal-to-metal seat, but in instances where erosion is extreme and where an exceptionally hard trim material is required, tungsten carbide is used.

The plug and seat of the metal-to-metal trim set are lapped together at the factory to assure matching seating surfaces, therefore, when replacing metal-to-metal trim, the plug and seat must be replaced in matched sets.

In instances where a tight shut-off is required and where the abrasive action of the process fluid is relatively low, soft trim is used.

Buna-N rubber bonded to a stainless steel plug is the most common form of soft trim. It offers reasonable good abrasion resistance and will effect a positive seal.

In instances where abrasion is high enough to warrant frequent replacement of the soft plug, O-Ring trim is sometimes used. If the O-Ring becomes damaged, it is easily replaced without having to replace the entire plug. O-Ring trim also offers the advantage of facilitating experimentation with different seal compounds by simply installing O-Rings of various materials and durometers (hardness). Standard Buna-N O-Rings are 90 durometer, but are also available in 70 durometer (the greater the number, the harder the rubber). O-Rings are also readily available in viton, teflon, silicone and neoprene.

Sizing

The size of a valve's orifice determines its flow capacity. Larger orifices provide greater flow capabilities.

The flow capacity of a liquid valve is stated as "Cv". The flow capacity of a gas valve is stated as "Cg". The greater the Cv or Cg value, the greater the flow capacity of the valve.

"Full open" Cv and Cg values for particular valve and trim combinations are stated in the INVALCO Catalog on the page pertaining to the valve in question.

Figures 9 & 10 are charts used for determining required Cv and Cg for given flow conditions. These charts may also be used to determine the flow capacity in fluid volume when the other factors are known.

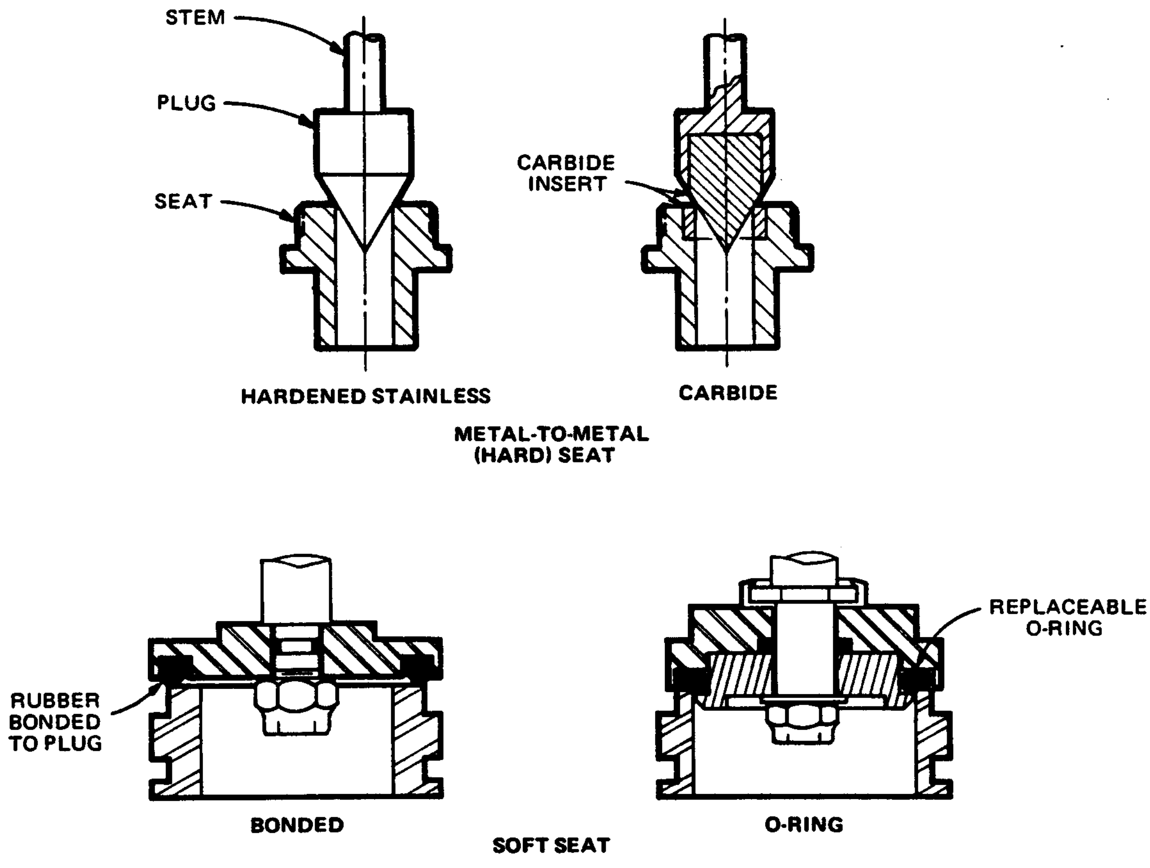


Figure 8.

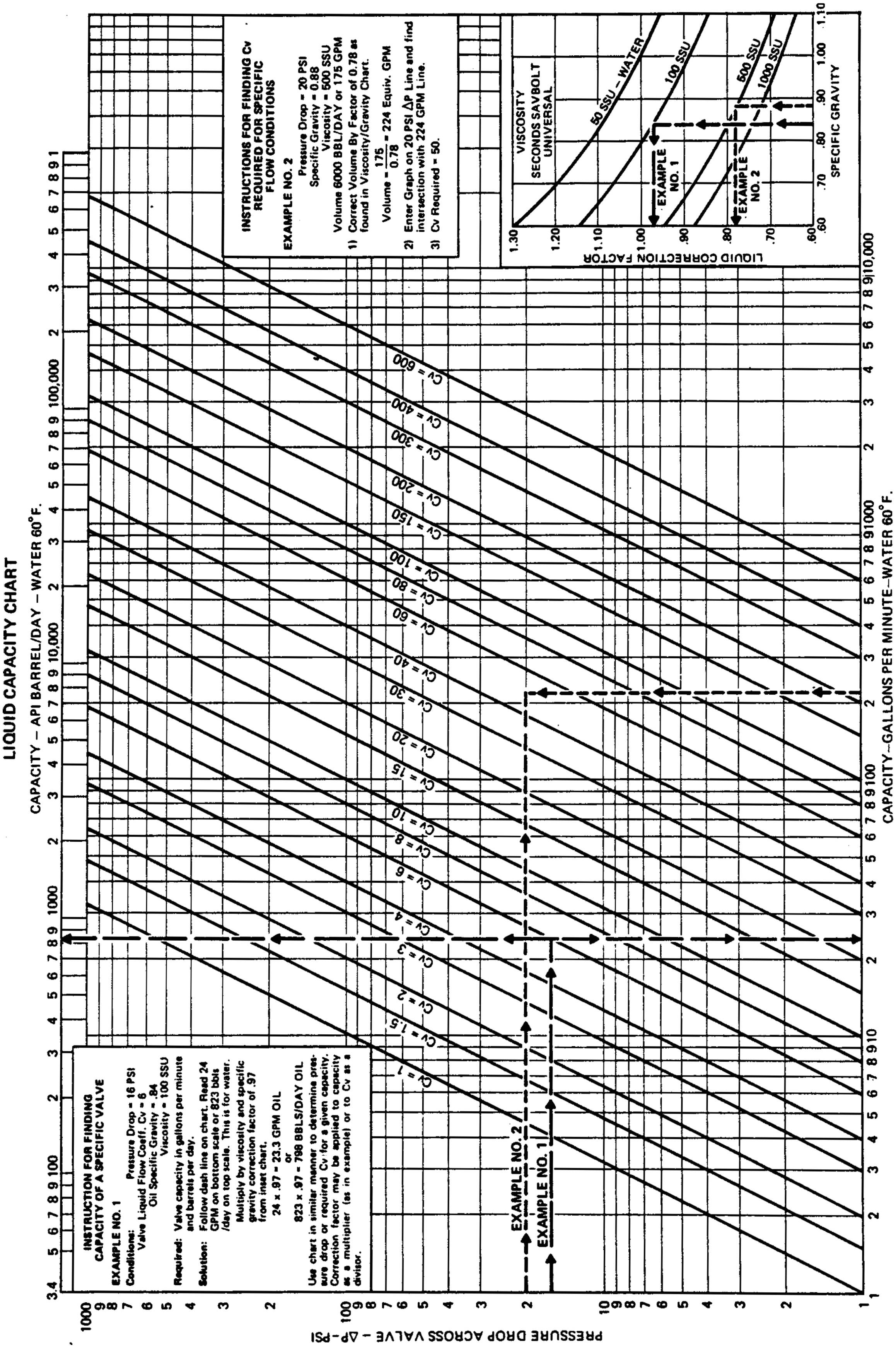

LIQUID CAPACITY CHART
CAPACITY – API BARREL/DAY – WATER 60°F.
CAPACITY–GALLONS PER MINUTE–WATER 60°F.
PRESSURE DROP ACROSS VALVE – ΔP–PSI
Cv = 1
Cv = 1.5
Cv = 2
Cv = 3
Cv = 4
Cv = 6
Cv = 8
Cv = 10
Cv = 15
Cv = 20
Cv = 30
Cv = 40
Cv = 60
Cv = 80
Cv = 100
Cv = 150
Cv = 200
Cv = 300
Cv = 400
Cv = 600
EXAMPLE NO. 1
EXAMPLE NO. 2
INSTRUCTION FOR FINDING CAPACITY OF A SPECIFIC VALVE
EXAMPLE NO. 1
Conditions: Pressure Drop = 16 PSI
Valve Liquid Flow Coeff. Cv = 6
Oil Specific Gravity = .84
Viscosity = 100 SSU
Required: Valve capacity in gallons per minute and barrels per day.
Solution: Follow dash line on chart. Read 24 GPM on bottom scale or 823 bbls /day on top scale. This is for water.
Multiply by viscosity and specific gravity correction factor of .97 from inset chart.
24 x .97 = 23.3 GPM OIL
or
823 x .97 = 798 BBLS/DAY OIL.
Use chart in similar manner to determine pressure drop or required Cv for a given capacity. Correction factor may be applied to capacity as a multiplier (as in example) or to Cv as a divisor.
INSTRUCTIONS FOR FINDING Cv REQUIRED FOR SPECIFIC FLOW CONDITIONS
EXAMPLE NO. 2
Pressure Drop = 20 PSI
Specific Gravity = 0.88
Viscosity = 500 SSU
Volume 6000 BBL/DAY or 175 GPM
1) Correct Volume By Factor of 0.78 as found in Viscosity/Gravity Chart.
Volume = 175/0.78 = 224 Equiv. GPM
2) Enter Graph on 20 PSI ΔP Line and find intersection with 224 GPM Line.
3) Cv Required = 50.
VISCOSITY SECONDS SAVBOLT UNIVERSAL
50 SSU – WATER
100 SSU
500 SSU
1000 SSU
EXAMPLE NO. 1
EXAMPLE NO. 2
LIQUID CORRECTION FACTOR
SPECIFIC GRAVITY

Figure 9.

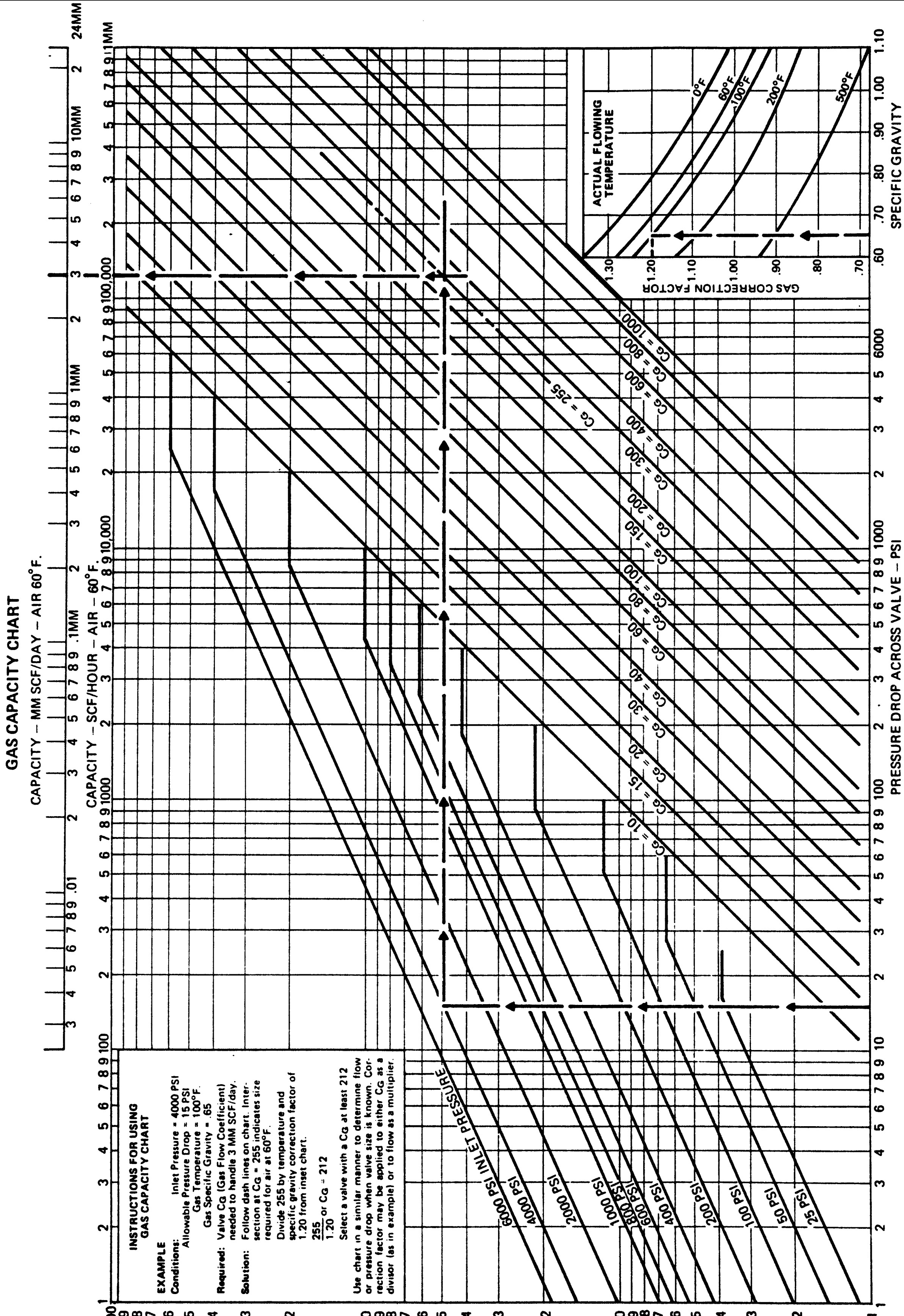

GAS CAPACITY CHART
CAPACITY – MM SCF/DAY – AIR 60°F.
CAPACITY – SCF/HOUR – AIR – 60°F.
PRESSURE DROP ACROSS VALVE – PSI
SPECIFIC GRAVITY
GAS CORRECTION FACTOR
ACTUAL FLOWING TEMPERATURE
0°F
60°F
100°F
200°F
500°F
INLET PRESSURE
6000 PSI
4000 PSI
2000 PSI
1000 PSI
800 PSI
600 PSI
400 PSI
200 PSI
100 PSI
50 PSI
25 PSI
Cg = 1000
Cg = 800
Cg = 600
Cg = 400
Cg = 300
Cg = 255
Cg = 200
Cg = 150
Cg = 100
Cg = 80
Cg = 60
Cg = 40
Cg = 30
Cg = 20
Cg = 15
Cg = 10
INSTRUCTIONS FOR USING GAS CAPACITY CHART
EXAMPLE
Conditions: Inlet Pressure = 4000 PSI
Allowable Pressure Drop = 15 PSI
Gas Temperature = 100°F.
Gas Specific Gravity = .65
Required: Valve Cg (Gas Flow Coefficient) needed to handle 3 MM SCF/day.
Solution: Follow dash lines on chart. Intersection at Cg = 255 indicates size required for air at 60°F.
Divide 255 by temperature and specific gravity correction factor of 1.20 from inset chart.
255/1.20 or Cg = 212
Select a valve with a Cg at least 212
Use chart in a similar manner to determine flow or pressure drop when valve size is known. Correction factor may be applied to either Cg as a divisor (as in example) or to flow as a multiplier.

Figure 10.

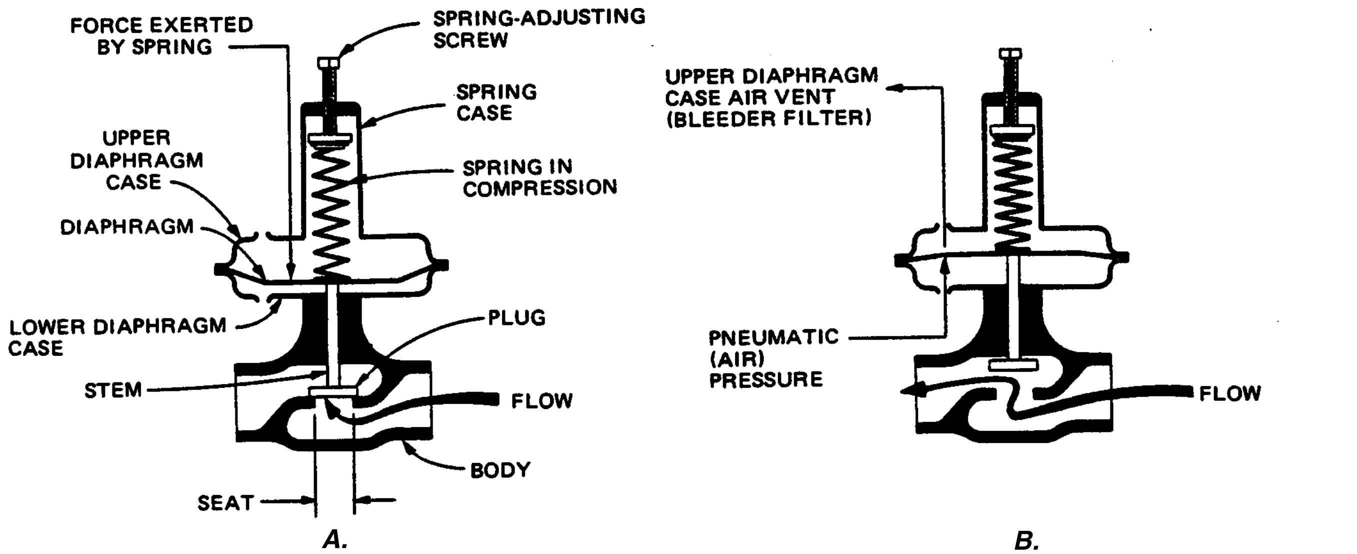


Figure 11.
Valve with Direct-Acting (Normally Closed) Topworks
Model Number Symbol "D"

Types

The Diaphragm Topworks employed by INVALCO Valves are three distinctive types; direct-acting, reverse-acting, and double-acting.

Direct-acting: The most common of the topworks employed by INVALCO is the type shown in Figure 11.

A spring exerts a force onto the top side of the diaphragm, pushing the plug against the seat (Figure 11A).

To open the valve pneumatic pressure must be applied to the lower side of the diaphragm overcoming the load imposed by the spring and lifting the plug from the seat, allowing flow through the valve (Figure11B).

Reverse-acting: The reverse-acting topworks (Figure 12) utilize a tension spring, as opposed to the compression spring utilized by the direct-acting topworks. This spring pulls on the stem, holding the valve in a normally open position.

To close the valve, a pneumatic signal must be applied to the top side of the diaphragm.

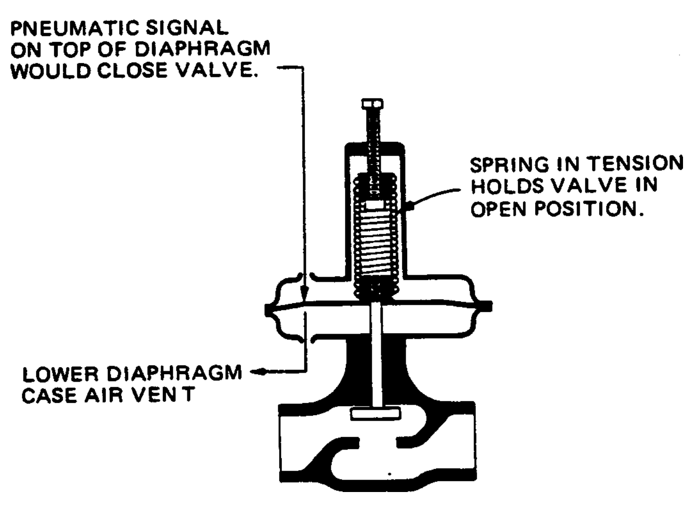


Figure 12.
Valve with Reverse-Acting (Normally Open) Topworks
Shown in Normal (Open) Condition
Model Number Symbol "DX"

Analyzing The Direct-Acting and Double-Acting Topworks

Springs

The degree of force, or load, imposed upon the plug by the spring in a direct-acting topworks may be varied to suit the application by means of the spring adjusting screw located in the top of the spring housing.

For more coarse spring adjustments, the spring is removed and replaced with a heavier or lighter spring depending on the situation.

The degree of spring load required is determined by the degree and direction of load imposed upon the valve plug by the process pressures.

Generally, INVALCO recommends that its single port valves be installed in such a manner that flow is introduced into the valve through the port that flows under the seat (see Figure 13D). Installed in this manner, line pressure exerted upon the plug must be counteracted by spring load in order to hold the valve closed. The greater the line pressure the greater the spring load required to seal the valve.

Valves in which flow is introduced over the seat require less spring load to seat the plug since line pressure is utilized to aid in forcing the plug onto the seat and although this method is satisfactory for some applications such as full-open, full-closed service, it is not recommended for throttling service where high pressure drops are expected across the valve (see Figure 13D).

Besides the normal physical dimensions characterizing them, such as outside diameter, inside diameter, and length, valve compression springs are also categorized by the following terms:

A. Rate: This term is given in pounds of force per inch of compression. A spring with a rate of 700 pounds per inch produces 700 pounds of force when compressed on inch, 1400 pounds of force when compressed two inches etc.

B. Maximum Deflection: The distance a spring may be compressed or deflected, before going solid.

C. Maximum Load: The theoretical force a spring will produce at maximum deflection. Maximum load can occur before going solid. Maximum load is in actuality a load producing overstressing of the spring.

   Note: Compressing a valve spring to maximum deflection or to nearly maximum deflection under actual operating circumstances sets up severe stresses within the spring and hastens spring failure. Eighty-five percent of the maximum deflection should be the most a spring is ever compressed.

The following table lists the standard springs utilized in the various INVALCO topworks.

It should be noted that any of the springs listed in the chart can be used with any of the INVALCO topworks, sizes 20 through 80.

Valve springs are normally manufactured from oil-tempered steel spring wire and for most applications this material is satisfactory. There are, however, conditions such as corrosive atmospheres or operation in the presence of hydrogen sulfide gas that warrant special spring materials. For these severe conditions, monel or 302 S.S. springs may be special ordered. These materials are readily identifiable as their appearance is generally that of bright metal (while the steel springs are painted black) but will sometimes assume an oxidized coating after having been in service.

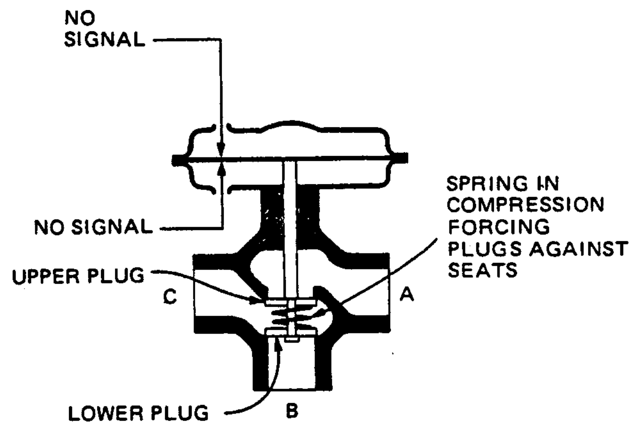
Standard Springs

Spring Part No.	Max. Load +/-10%	Rate Lbs./In. +/-10%	Max. Defl.	Outside Dia.	Inside Dia.	Wire Dia.	Total No. of Coils	Free Lgth.	Norm. Used in T.W.	Comm. Used in T.W.
45002688	242	88	2.76	1.75	1.312	0.219	12.50	5.50	20	
45002044	568	190	3.00	1.688	1.187	0.250	12.00	6.00	20	35, 50
45008406	1510	752	2.01	1.906	1.181	0.362	11.00	6.00	50, 80	

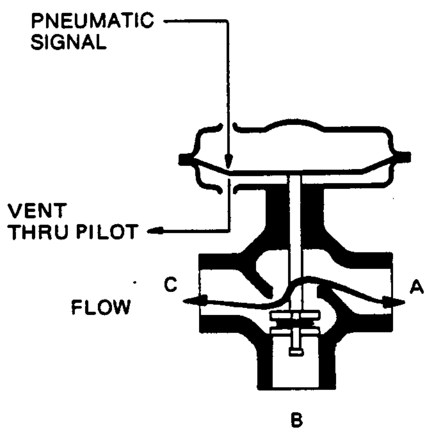
Double-acting: The double-acting topworks (Figure 13) is normally used with a 3-way, 3 position configuration valve.

No spring is utilized in the topworks. A spring is normally placed between the two plugs of the 3-way, 3-position valve trim, holding the plugs against the seats (Figure 13A)

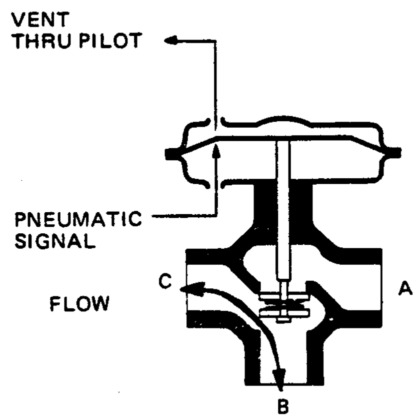
A pneumatic signal to either side of the diaphragm will open the valve to one of two outlet ports. (Figures 13B & 13C).



13A Valve in Normal Position



13B Port "C" Open to Port "A"



13C Port "C" Open to Port "B"

Figure 13.
Valve with Double-Acting Topworks
Model Number Symbol "DD"

Diaphragm - Materials and Limits

The working pressure of the diaphragm topworks is limited by the diaphragm at 100 psig. Twenty-five psig is normally considered adequate for diaphragm supply pressure. Higher pressure reduces the service life of the diaphragm.

The standard diaphragm material is Buna-N with nylon webbing which produces a diaphragm with temperature limits of -20 F to +250 F. Operating at either of the temperature extremes will decrease diaphragm life. Extremely low temperatures cause diaphragms to become brittle and crack. Extremely high temperatures cause diaphragms to become soft and rupture.

Consult the factory for special diaphragm materials for unusual operating conditions.

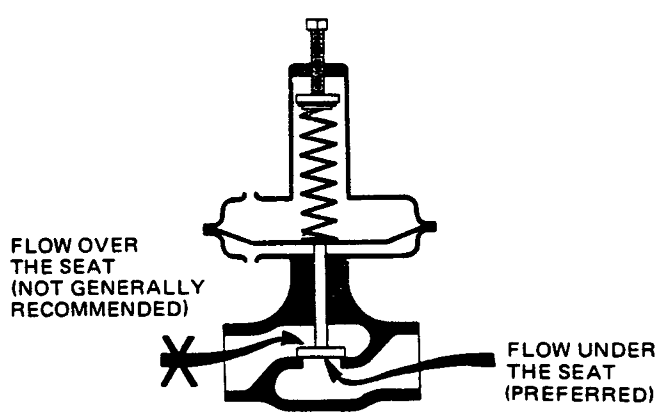


Figure 13D.

The upper diaphragm cases considered most standard by INVALCO utilize a spring case cylinder fabricated from 2.38" O.D. x .12" wall tubing. The distance from the bottom of the bolt flange to the top of the spring case cap is about 7.25" limiting spring dimensions to about 2" O.D. x 6" long.

For applications where an exceptionally powerful spring is desired, INVALCO manufactures upper diaphragm cases which utilize spring cases that are larger, both in diameter and length, than the standard spring case. Figure 14 illustrates the approximate dimensions for the various spring case/-upper diaphragm case configurations

Figure lists the more powerful springs available from INVALCO. It should be mentioned that special spring rests are required with these springs.

Spring Case Dimensions

Description or Normal Use	A (OD WALL)	B
Standard	2.38 x .12	7.25
Standard Large	3.50 x .12	10.81
D-35, D-50, D-80 Diaphragm Actuator	4.25 x .12	10.56
D-160-A Diaphragm Actuator	4.25 x .12	16.41
D-160-1000 Diaphragm Actuator	6.00 x .18	16.62

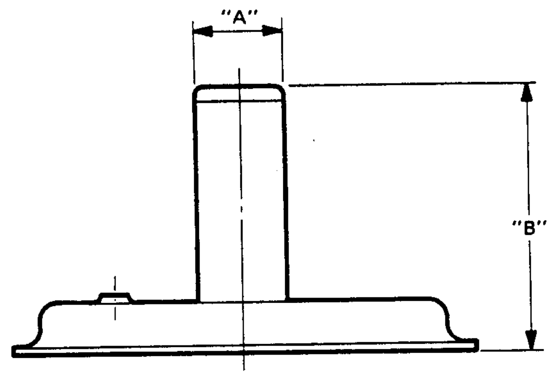


Figure 14.

Heavy Springs

Spring Part No.	Max. Load +/-10%	Rate Lbs./In. +/-10%	Max. Defl.	Outside Dia.	Inside Dia.	Wire Dia.	Total No. of Coils	Free Lgth.	Material	Used with Spring Case
45003086	757	146	5.20	3.000	2.250	0.375	12.80	10.00	Steel	3.5 Dia.
45003741	1823	501	3.65	3.062	2.062	0.500	12.70	10.00	Steel	3.5 Dia.
45010278	796	157	5.07	3.750	2.875	0.438	11.25	10.00	Steel	4.25 D. x 10.56
45010279	954	208	4.60	3.750	2.812	0.469	11.50	10.00	Steel	4.25 D. x 10.56
45010280	1171	176	4.25	3.750	2.750	0.500	11.50	10.00	Steel	4.25 D. x 10.56
45010281	1406	362	3.89	3.750	2.688	0.531	11.50	10.00	Steel	4.25 D. x 10.56
45010282	1883	495	3.81	3.750	2.625	0.562	11.00	10.00	Steel	4.25 D. x 10.56
45010336	2909	602	4.84	3.750	2.438	0.656	17.00	16.00	Steel	4.25 D. x 16.41
45010337	5126	1002	5.12	5.500	3.688	0.906	12.00	16.00	Steel	6.00 Dia.

Occasionally flow conditions will require a spring rate so great that two springs must be utilized. This conditions is illustrated in Figure 15.

This type of spring arrangement utilizes a topworks with one of the larger spring cases and special spring rests.

The spring rate for dual springs is equal to the combined rate of the two springs.

The dual spring chart on the following page lists the various dual spring combinations offered by INVALCO.

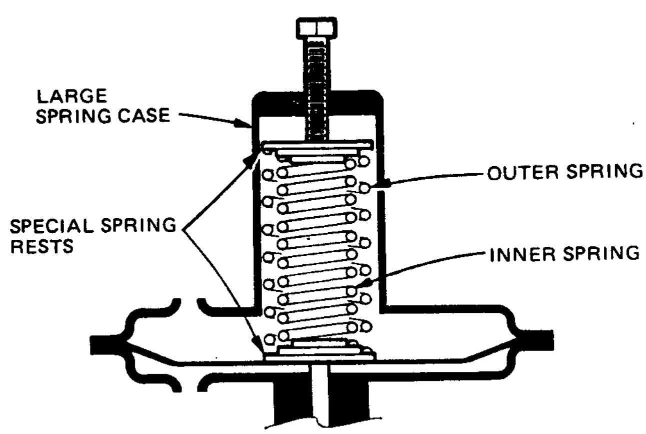


Figure 15.

Dual Spring Chart

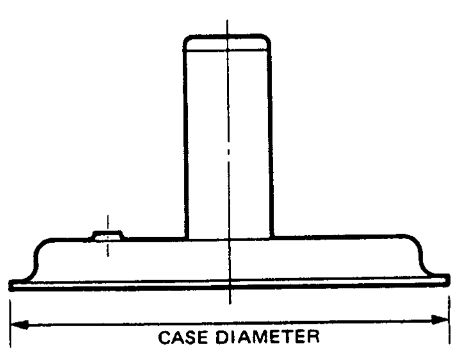
Outer Spring Inner Spring	Comb. Max. Load +/-10%	Comb. Rate Lbs./In. +/-10%	Max. Defl.	Outside Dia.	Inside Dia.	Wire Dia.	Total No. of Coils	Free Lgth.	Material	Used with Spring Case
45003086	1124	227	4.95	3.000	2.250	0.375	12.80	10.00	Steel	3.50 Dia.
45003421				2.000	1.475	0.262	18.25	9.75		
45003941	2752	756	3.65	3.062	2.062	0.500	12.70	10.00	Steel	3.50 Dia.
45003940				1.937	1.276	0.331	18.40	9.75		
45010280	1840	433	4.25	3.750	2.750	0.500	11.50	10.00	Steel	4.25 x 10.56
45010287				2.625	1.900	0.362	15.75	10.00		

Diaphragm Area

The forces to be acting on a valve in service conditions should be analyzed to assure the topworks and spring will function adequately to open and position the valve correctly. INVALCO offers topworks with nominal diaphragm areas of 20 sq. in., 50 sq. in., and 160 sq. in. The word “nominal” has been used, since as the diaphragm moves around within the topworks its shape changes, causing the actual effective area to vary. Figure 16 shows the average actual effective area for the different INVALCO topworks.

Utilizing the chart, a pneumatic signal of 3 psi applied to a No. 50 topworks will produce a force of 3 x 65, or 195 pounds. Three to seven psi is the normally accepted pressure required for starting a valve to open.

Fifteen psi applied to a No. 50 topworks will balance 15 x 65, or 975 pounds of opposing force. Fifteen psi diaphragm pressure is the normally accepted standard for driving a valve fully open. Twenty-five psi is the maximum pressure normally considered in topworks design for fully stroking a valve.



Diaphragm Effective Area

Nominal Topworks Size	Actual Avg. Eff. Area	Case Diameter
No. 20	26 Sq. In.	8.44
No. 35	46 Sq. In.	11.38
No. 50	65 Sq. In.	12.5
No. 80	77 Sq. In.	14.25
No. 160	158 Sq. In.	18.62

Figure 16.

In analyzing the topworks/spring combination for actuating a valve several factors must be considered:

I. Type of inner valve configuration.
   A. Single-port (Figure 17)
      1. Balanced (Figure 17)
      2. Unbalanced (Figure 18)
   B. Double-Port (Figure 19)
   C. 3-Way (Figure 20)
      1. 2-Position (Figure 20)
      2. 3-Position (Figure 21)

II. Trim (Plug & Seat) Material
   A. Hard (Metal to Metal)
   B. Soft (Buna-N, O-Ring, etc.)

III. Direction of Flow (Figure 13D)
   A. Under the seat
   B. Over the seat

IV. Pressure drop, the maximum expected differential in pressure across a valve. A valve with an upstream pressure of 100 psi and a downstream pressure of 50 psi would have a pressure drop of 100 (-)50 or 50 psi. In cases where a valve flows to atmospheric pressure, the pressure drop would be 100% of the upstream pressure.

V. Seat and stem area.

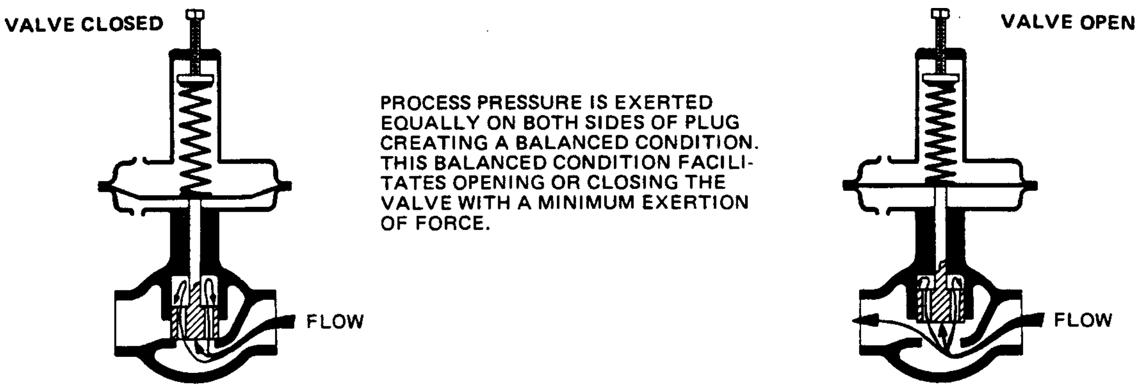


Figure 17.
Single-Port Valve with Balanced Trim

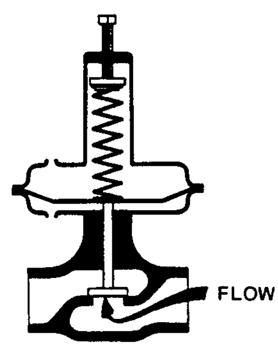
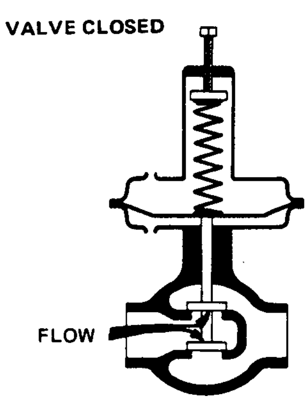


Figure 18.
Single-Port Valve with Unbalanced Trim



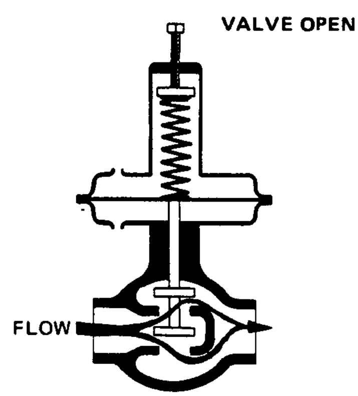


Figure 19.
Valve with Double-Port Trim

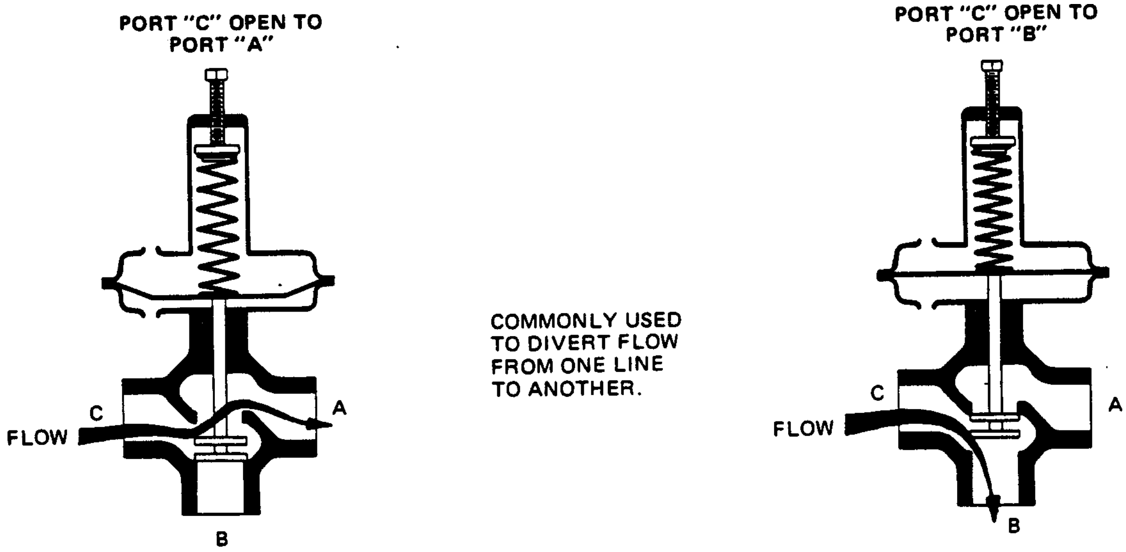


Figure 20.
3-Way Valve with 2-Position Trim

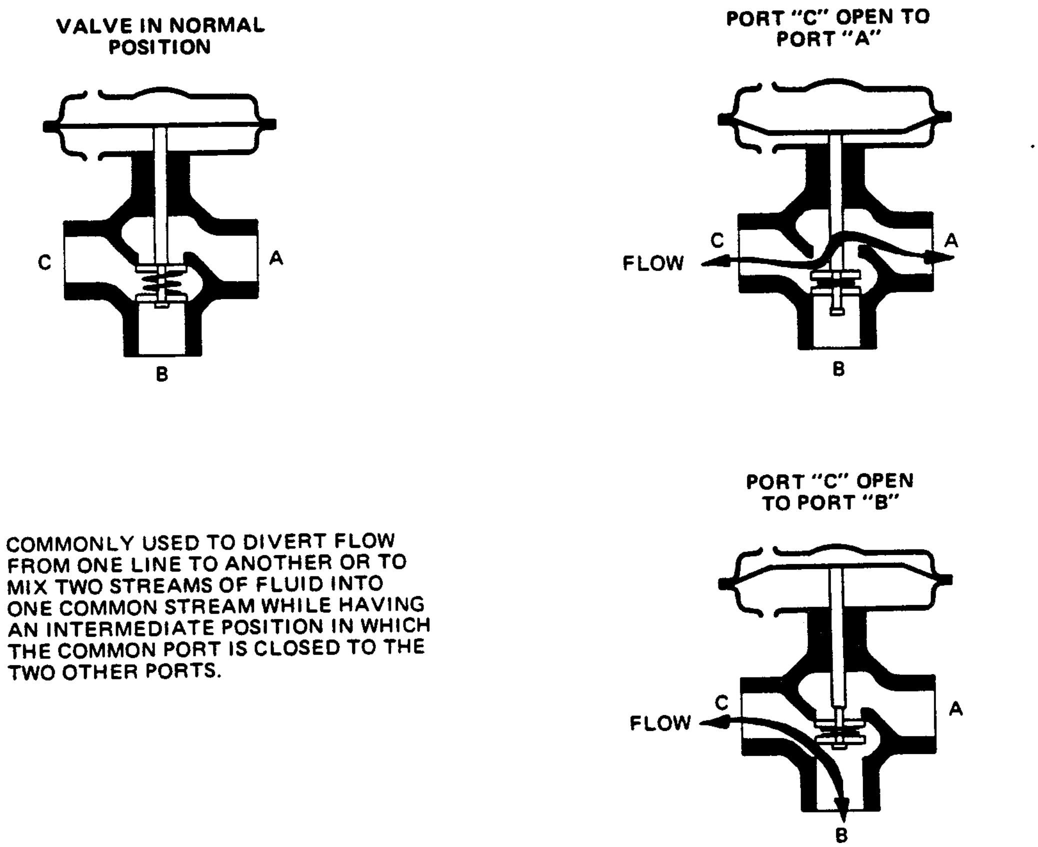


Figure 21.
3-Way Valve with 3-Position Trim

Sample Analysis of Valve Operation

Spring Analysis

In Figure 22, the following conditions exist:

1. Force pushing up on plug
   (100 x 1.767) 176.70
2. Force pushing down on plug
   (50 x 1.767) 88.35
3. Force pushing up on stem
   (50 x .196) 9.80
4. Net force pushing up
   (Line 1-2+3) 98.15

Taking nothing else into account, it would take 98.15 lbs. of spring force to close the valve in question. The following other conditions must be considered.

5. Packing Drag
   (20 lbs.+ 10% highest internal press.) 30.00
6. Sealing Force
   (hard trim=100 lbs., soft trim=50 lbs.) 50.00
7. Total
   (Lines 4+5+6) 178.15

178.15 lbs is the spring force required to seal the valve in the closed position.

To this sealing force, we much add the spring compression force created when the valve is fully opened. The added compression is the valve stroke (normally .875) multiplied by the spring rate.

Spring force to seal valve — Full open travel (.875 is req. for most valves.)

178.15 + (.875 x 752) = 836.15

Spring rate from standard spring and dual spring charts.

Total spring force with valve full-open.

836.15 is about 58% of the 1510 lb. max load for the standard 45008406 spring, therefore, the spring is suitable for the application. If the total spring force had exceeded the 85% of max. load limit previously discussed, a heavier spring would be in order.

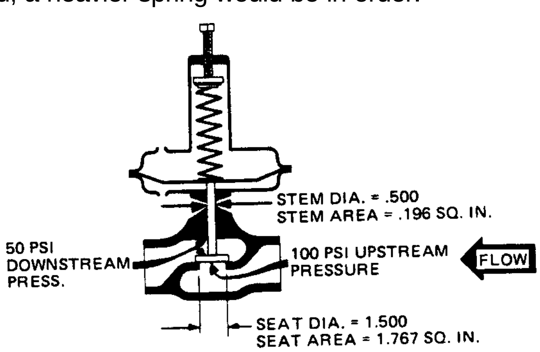


Figure 22.
Single-Port Valve Flowing Under The Seat and with a Pressure Drop of 50 psi.

Single port valve flowing under the seat and with a pressure drop of 50 psi.

Valve Model Number DSG-201-414
Orifice .... 1-3/4” Quick-open
Topworks .... Std. No. 50
Spring .... Std. P/N 45008406

Topworks Analysis

Now that we have decided that the standard spring is suitable, we shall investigate the suitability of the standard no. 50 top.

With the valve in the closed position, the following conditions exist:

Forces pushing or holding down.

Spring Force 178.15
Packing Drag 30.00
Force Pushing down on plug .
(50 psi downstream x 1.767) 88.35
Total force pushing down 296.50

Forces pushing up.

Force pushing up on plug
(100 psi upstream x 1.767) 176.70
Force pushing up on stem
(50 psi downstream x .196) 9.80
Total force pushing up 186.50

Net force pushing down
(total down (-) total up) 110.00

Dividing the 110 lbs. net force pushing down by the effective diaphragm area of lb./sq. in. (as noted in Figure) gives us the diaphragm pressure in psi required to just crack the valve open.

PSI to “crack” valve open: 1.692

If the diaphragm pressure required to start opening the valve had exceeded 7 psi, we could consider choosing a larger topworks, but so far the standard no. 50 top appears suitable.

Now we must ascertain if the no. 50 top is sufficient to drive the valve fully open, for which the following force conditions must be known:

Forces pushing or holding down:

Total spring force 836.15
Packing drag 30.00
Total force pushing down 866.15

Forces pushing up:

Force pushing up on stem
(100 psi upstream x .196) 19.60

(Note that since the valve is almost fully open, the 100 psi is working on both sides of the seat, cancelling out upward and downward forces on the plug, and pushing the stem upward with 100 psi instead of 50 psi).

Net forces pushing down

(total down (-) total up) 846.55

Dividing the 846.55 lb. net force pushing down by the effective diaphragm are of 65 sq. in. gives the diaphragm pressure in psi required to drive the valve fully open.

13.02 psi to drive valve fully open: 13.02

As previously stated, 25 psi diaphragm pressure is normally considered the maximum allowable for fully opening a valve. If the pressure required to fully open the valve in question had exceeded 25 psi, we would consider choosing a larger topworks. 25 psi is about the maximum output for most pilots. Since the required pressure was less than 25 psi, we have established that the std. no. 50 topworks is acceptable for the existing conditions.

Although the preceding dissertation applies specifically to the single-port valve illustrated in Figure 22, it should be readily apparent how to apply the same parameters to the other various trim and topworks configurations shown in Figures 17 thru 21.

Following are forms which should simplify the task of sizing springs and topworks for the various valve configurations offered by INVALCO. The first form in the series is for use with single-port valves with unbalanced trim and flow under the seat, and a copy of the form has been filled out for the valve in Figure 22.

Valve Force Calculations
Single Port, Unbalanced, Flow Under Seat

Orifice Dia. 1.500 Orifice Area 1.767

Stem Dia. .500 Stem Area .196

Press: Above Seat 50 Below Seat 100 Diff. 50

Valve Open Force To Close	1. Stem Area x Highest Internal Pressure	19.60
	2. Orifice Area x Pressure Below Seat	176.70
	3. Enter Largest Line 1 or Line 2	176.70
	4. Stem Area x Pressure Above Seat	9.80
	5. Orifice Area x Max. Expected Diff. Press.	88.35
	6. Total Force Pushing Up (Line 4 + 5)	98.15
	7. Select Design Force (Line 3 or 6)	98.15
	A. Normal Applications Select Line 6 B. Stem Larger than Orifice Select Line 3 C. To Insure Valve will Close with Line Break Downstream Select Line 3	
	8. Packing Friction (20 lbs. + 10% Highest Internal Pressure)	30.00
	9. Sealing Force (Hard Trim = 100 lbs., Soft Trim = 50 lbs.)	50.00
	10. Spring Load to Seal Valve (7 + 8 + 9)	178.15
Valve Closed Diaph. Press. To "Crack" Open	11. Orifice Area (-) Stem Area (May be Negative)	1.571
	12. Press. Above Seat x Line 11 (May be Negative)	78.55
	13. (Orifice Area) x (Press. Below Seat) x (-1) [Must be Negative]	(-)176.70
	14. Packing Friction from Line 8	30.00
	15. Diaphragm Force to "Crack" Valve Open (Lines 10 + 12 + 13 + 14)	110.00
	(If Less than Line 9, Increase Line 10) 16. Effective Diaph. Area (See Figure 16)	65.00
	17. Diaph. Press. To "Crack" Valve Open (Line 15 divided by Line 16)	1.692
	(If Greater than 7 psi, Consider a Larger Topworks)	
Spring	18. Travel Req'd for Full Open (Avg. = .875) (Series 438 = 1.281)	.875
	19. Spring Rate (See Single and Dual Spring Tables)	752.00
	20. Spring Force Full Open (18 x 19 + 10)	836.15
Diaph. Press. For Full Open	(If Answer Exceeds 85% of Max. Spring Load, Adjust 19 by Choosing Heavier Spring) 21. Diaph. Force Full Open (20 + 8 (-) 1)	846.55
	22. Diaph. Press. Full Open (21 divided by 16)	13.02
	(If Greater than 25 psi, Consider a Larger Topworks.	

Valve Force Calculations
Single Port, Unbalanced, Flow Under Seat
Valve Model No.__________________

Orifice Dia. __________ Orifice Area __________

Stem Dia. __________ Stem Area __________

Press: Above Seat ______ Below Seat ______ Diff. ______

Valve Open Force To Close	1. Stem Area x Highest Internal Pressure
	2. Orifice Area x Pressure Below Seat
	3. Enter Largest Line 1 or Line 2
	4. Stem Area x Pressure Above Seat
	5. Orifice Area x Max. Expected Diff. Press.
	6. Total Force Pushing Up (Line 4 + 5)
	7. Select Design Force (Line 3 or 6)
	A. Normal Applications Select Line 6 B. Stem Larger than Orifice Select Line 3 C. To Insure Valve will Close with Line Break Downstream Select Line 3 8. Packing Friction (20 lbs. + 10% Highest Internal Pressure)
	9. Sealing Force (Hard Trim = 100 lbs., Soft Trim = 50 lbs.)
	10. Spring Load to Seal Valve (7 + 8 + 9)
Valve Closed Diaph. Press. To "Crack" Open	11. Orifice Area (-) Stem Area (May be Negative)
	12. Press. Above Seat x Line 11 (May be Negative)
	13. (Orifice Area) x (Press. Below Seat) x (-1) [Must be Negative]
	14. Packing Friction from Line 8
	15. Diaphragm Force to "Crack" Valve Open (Lines 10 + 12 + 13 + 14)
	(If Less than Line 9, Increase Line 10) 16. Effective Diaph. Area (See Figure 16)
	17. Diaph. Press. To "Crack" Valve Open (Line 15 divided by Line 16)
	(If Greater than 7 psi, Consider a Larger Topworks)
Spring	18. Travel Req'd for Full Open (Avg. = .875) (Series 438 = 1.281)
	19. Spring Rate (See Single and Dual Spring Tables)
	20. Spring Force Full Open (18 x 19 + 10)
Diaph. Press. For Full Open	(If Answer Exceeds 85% of Max. Spring Load, Adjust 19 by Choosing Heavier Spring) 21. Diaph. Force Full Open (20 + 8 (-) 1)
	22. Diaph. Press. Full Open (21 divided by 16)
	(If Greater than 25 psi, Consider a Larger Topworks.

Valve Force Calculations
Single Port, Unbalanced, Flow Over Seat
Valve Model No.____________________

Orifice Dia. __________ Orifice Area __________

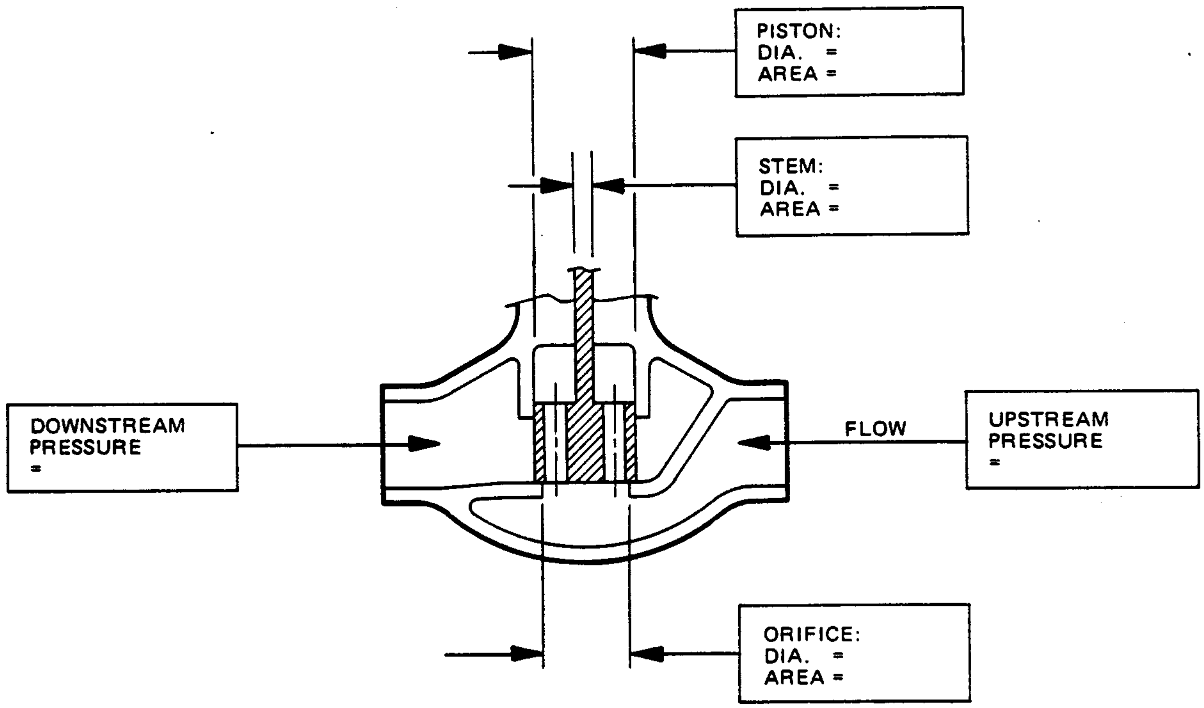
Stem Dia. __________ Stem Area __________

Press: Above Seat ______ Below Seat ______ Diff. ______

Valve Open Spring Force To Close	1. Stem Area x Highest Internal Pressure
	2. Packing Friction (20 lbs. + 10% Highest Internal Pressure)
	3. Sealing Force (Hard Trim = 100 lbs., Soft Trim = 50 lbs.)
	4. Spring Load To Close Valve (1 + 2 + 3)
Valve Closed Diaph. Press. to "Crack" Open	5. Orifice Area (-) Stem Area (May be Negative)
	6. Press. Above Seat x Line 5 (May be Negative)
	7. (Orifice Area) x (Press. Below Seat) x (-1) [Negative]
	8. Packing Friction from Line 2
	9. Diaphragm Force to "Crack" Valve Open (Lines 4 + 6 + 7 + 8)
	(If Less than Line 3, Increase Line 4) 10. Effective Diaph. Area (See Figure 16)
	11. Diaph. Press. To "Crack" Valve Open (Line 9 divided by Line 10)
	(If Greater than 7 psi, Consider a Larger Topworks)
Spring	12. Travel Req'd for Full Open (Avg. = .875) (Series 438 = 1.281)
	13. Spring Rate (See Single and Dual Spring Tables)
	14. Spring Force Full Open (12 x 13 + 4)
	(If Answer Exceeds 85% of Max. Spring Load, Adjust 19 by Choosing Heavier Spring)
Diaph. Press. For Full Open	15. Diaph. Force Full Open (14 + 2 (-) 1)
	16. Diaph. Press. Full Open (15 divided by 10)
	(If Greater than 25 psi, Consider a Larger Topworks. Note: If Line 15 is Less than Line 9, Valve will Travel Full Open when Diaph. Press. Reaches Line 11.

Valve Force Calculations
Single Port, Balanced (Series 438), Flow Under Seat

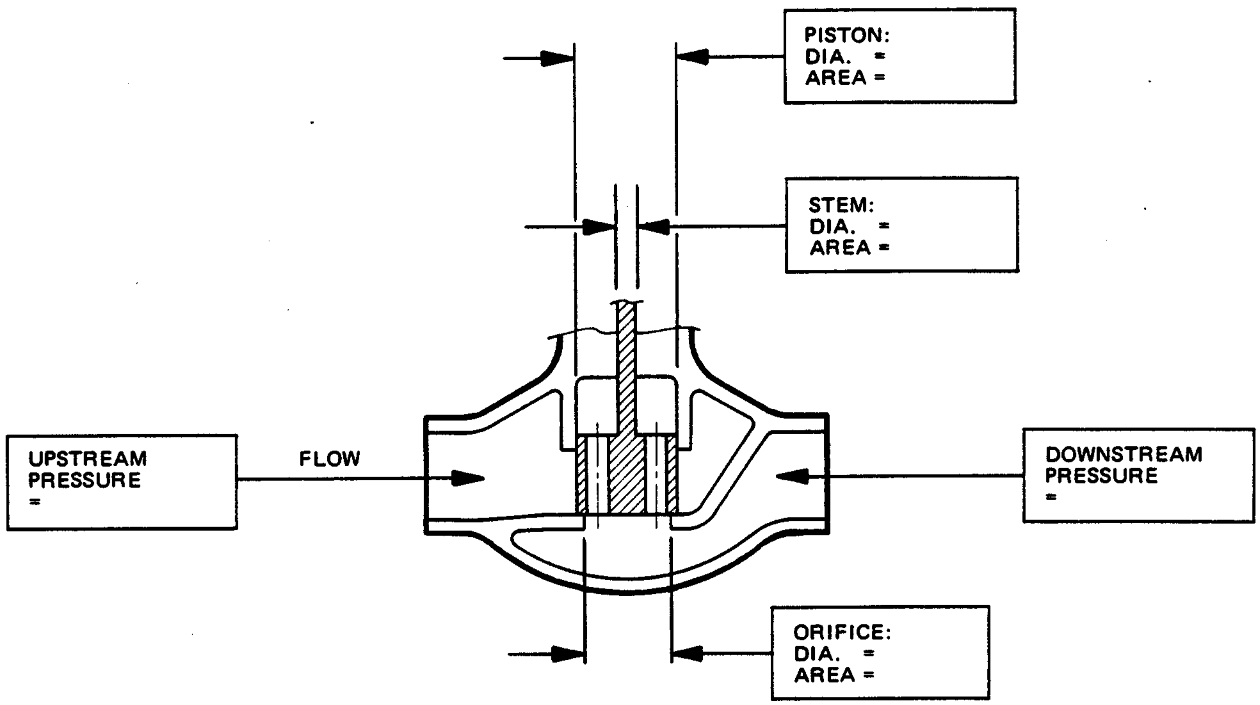
Valve Model No.___________________



Valve Open	1. Stem Area x Highest Internal Pressure
Spring	2. Packing Friction (20 lbs. + 10% Highest Internal Pressure)
Force	3. Sealing Force (Hard Trim = 100 lbs., Soft Trim = 50 lbs.)
To Close	4. Spring Load To Close Valve (1 + 2 + 3)
	5. Piston Area (-) Orifice Area (May be Negative)
Valve	6. Upstream Press. x Line 5 (May be Negative)
Closed	7. Multiply (-1) (Line 5) (Downstream Press.)
Diaph.	8. Stem Area x Downstream Press x (-1)
Press. to	9. Force to "Crack" Valve Open (2 + 4 + 6 + 7 + 8)
"Crack"	10. Effective Diaph. Area (See Figure 16)
Open	11. Diaph. Press. To "Crack" Valve Open (Line 9 divided by Line 10)
	(If Greater than 7 psi, Consider a Larger Topworks)
	12. Travel Req'd for Full Open (Max. = 1.281)
Spring	13. Spring Rate (See Single and Dual Spring Tables)
	14. Spring Force Full Open (12 x 13 + 4)
	(If Answer Exceeds 85% of Max. Spring Load, Adjust 13 by Choosing Heavier Spring)
Diaph.	15. Diaph. Force Full Open (14 + 2 (-) 1)
Press. For	16 Diaph. Press. Full Open (15 divided by 10)
Full Open	(If Greater than 25 psi, Consider a Larger Topworks.

Valve Force Calculations
Single Port, Balanced (Series 438), Flow Over Seat

Valve Model No.__________________



Valve Open	1. Stem Area x Highest Internal Pressure
Spring	2. Packing Friction (20 lbs. + 10% Highest Internal Pressure)
Force	3. Sealing Force (Hard Trim = 100 lbs., Soft Trim = 50 lbs.)
To Close	4. Spring Load To Close Valve (1 + 2 + 3)
	5. Orifice Area (-) Piston Area (May be Negative)
Valve	6. Upstream Press. x Line 5 (May be Negative)
Closed	7. Multiply (-1) (Line 5) (Downstream Press.)
Diaph.	8. Stem Area x Downstream Press x (-1)
Press. to	9. Force to "Crack" Valve Open (2 + 4 + 6 + 7 + 8)
"Crack"	10. Effective Diaph. Area (See Figure 16)
Open	11. Diaph. Press. To "Crack" Valve Open (Line 9 divided by Line 10)
	(If Greater than 7 psi, Consider a Larger Topworks)
	12. Travel Req'd for Full Open (Max. = 1.281)
Spring	13. Spring Rate (See Single and Dual Spring Tables)
	14. Spring Force Full Open (12 x 13 + 4)
	(If Answer Exceeds 85% of Max. Spring Load, Adjust 13 by Choosing Heavier Spring)
Diaph.	15. Diaph. Force Full Open (14 + 2 (-) 1)
Press. For	16 Diaph. Press. Full Open (15 divided by 10)
Full Open	(If Greater than 25 psi, Consider a Larger Topworks.

Valve Force Calculations
Double Port, Balanced, Flow Between Seats

Valve Model No.____________________

Upper Orifice: Dia. _________ **Area _________**

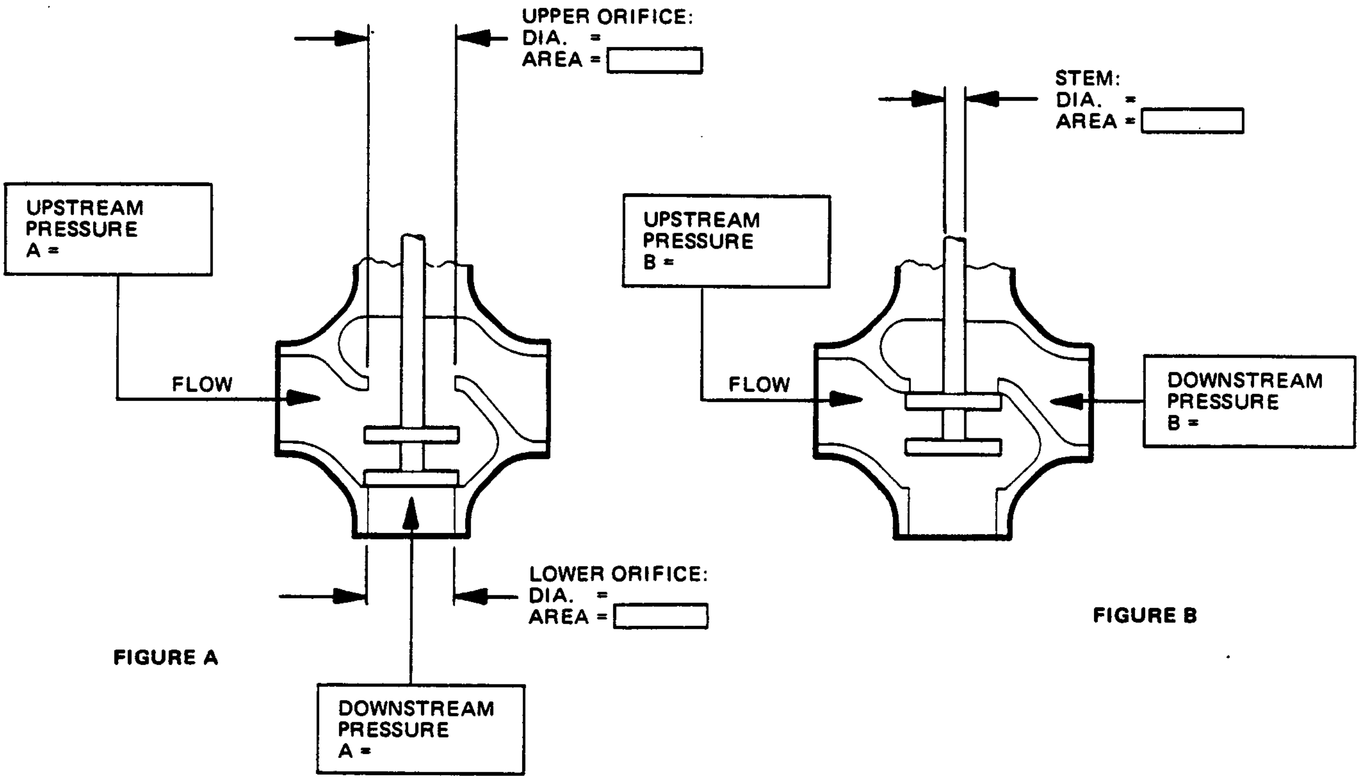
Lower Orifice: Dia. _________ **Area _________**

Stem: Dia. _________ **Area _________**

Pressure: Upstream _________ **Downstream _________** **Diff. _________**

Valve Open Force To Close	1. Upper Orifice Area x Upstream Pressure
	2. Lower Orifice Area x Downstream Pressure
	3. Stem Area x Downstream Pressure
	4. Packing Friction (20 lbs. + 10% Highest Internal Pressure)
	5. Sealing Force (Hard Trim = 200 lbs., Soft Trim = 100 lbs.)
	6. Total Force Pushing Up (Line 1 + 2 + 3 + 4 + 5)
	7. Upper Orifice Area x Downstream Pressure
	8. Lower Orifice Area x Upstream Pressure
	9. Total Force Pushing Down (Line 7 + 8)
	10. Spring Load to Seal Valve (6-9)
Valve Closed Diaph. Press. To "Crack" Open	11. Total Force Pushing Down (Line 4 + 7 + 8 + 10)
	12. Total Force Pushing Up (Line 1 + 2 + 3)
	13. Diaphragm Force to "Crack" Valve Open (Line 11 - 12)
	14. Effective Diaph. Area (See Figure 16)
	15. Diaph. Press. To "Crack" Valve Open (Line 13 divided by Line 14)
	(If Greater than 7 psi, Consider a Larger Topworks)
Spring	16. Travel for Full Open (Avg. = .875)
	17. Spring Rate (See Single and Dual Spring Tables)
	18. Spring Force Full Open (16 x 17 + 10)
	(If Greater than 85% of Max Spring Load, Adjust 17 by Choosing Heavier Spring)
Diaph. Press. For Full Open	19. Stem Area x Highest Internal Pressure
	20. Diaph. Force Full Open (18 + 4 (-) 19)
	21. Diaph. Press. Full Open (20 divided by 14)
	(If Greater than 25 psi, Consider a Larger Topworks)

Valve Force Calculations
3-Way, 2-Position, Flow in Common Port for Divert Service
Valve Model No.____________________



Forces in Figure "A"	
1. Upstream Press. "A" x Stem Area	
2. Upstream Press. "A" x Lower Orifice Area	
3. Downstream Press. "A" x Lower Orifice Area	
Forces in Figure "B"	
4. Upstream Press. "B" x Upper Orifice Area	
5. Downstream Press. "B" x Upper Orifice Area	
6. Downstream Press. "B" x Stem Area	
Other Forces	
7. Packing Friction (20 lbs. + 10% Highest Internal Press.)	
8. Sealing Force (Hard Trim = 100 lbs., Soft Trim = 50 lbs.)	
9. Force to Crack Upper Plug Off Seat (4 + 6 + 7 - 5)	
10. Force to Seat Lower Plug (1 + 7 + 8)	

Valve Force Calculations
3-Way, 2-Position, Flow in Common Port for Divert Service
(Continued)

11. Travel (See Chart Below)

Valve Model	Travel
DQY-204-2-475 DQY-204-2-476 DSY-204-2-475 DSY-204-2-476	0.625
DFY-2XX-2-487 DSY-2XX-2-487 DFY-2XX-2-487	0.875

12 Spring Rate (See Single and Dual Spring Tables)

13 Force to Seat Lower Plug + Additional Force Exerted by Spring with Stem in Full Up Position ([11 x 12] + 10)

14 Spring Force with Stem in Full Up Position (Choose Greater of 9 and 13)

(If Greater than 85% of Max. Spring Load, Adjust 12 by Choosing Heavier Spring.

15 Spring Force with Stem in Down Position (14 - [11 x 12])

16 Force to Crack Lower Plug Off Seat (2 + 7 + 15 - 1 - 3)

17 Effective Diaphragm Area (See Fig. "16")

18 Diaph. Press to Crack Lower Plug Off Seat (16 div. by 17)

(If Greater than 7 psi, Consider a Larger Topworks)

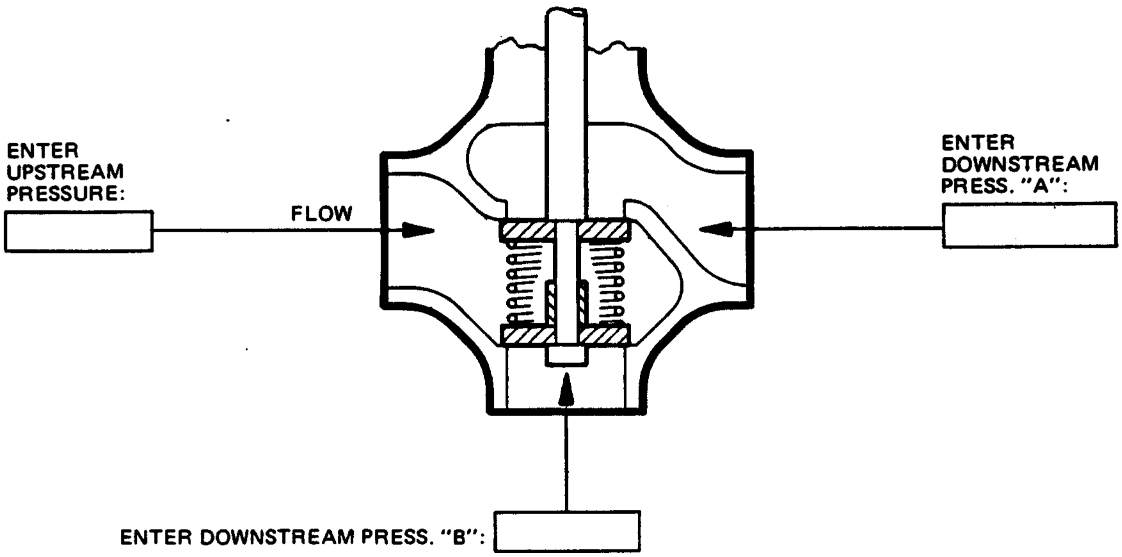
19 Diaph. Force to Seat Upper Plug (5 + 7 + 8 + 14 - 4 - 6)

20 Diaph. Press. To Seat Upper Plug (19 divided by 17)

(If Greater than 25 psi, Consider a Larger Topworks)

Valve Force Calculations
3-Way, 3-Position, Flow in Common Port

Valve Model No.__________________



3-Way, 3-Position Valve Basic Model No.	Orifice A Minus Lower Stem Area	Stem Area		Inner Valve Spring Force	
		Upper	Lower	In Normal Position	At Full Travel
-204 (475, 476)	2.209	0.196	0.196	66	88
(-2XX, 3XX)-485 1-1/4 Trim	1.167	0.196	0.110	53	83
(-2XX, 3XX)-485 2-1/8 Trim	3.437	0.196	0.110	53	83
-304-480	6.873	0.442	0.196	103	255
-404-480	12.370	0.442	0.196	151	283

Forces Imposed by Line Pressure
1. Upstream Pressure x (Orifice Area minus Lower Stem Area [See Chart]
2. Upstream Pressure x Upper Stem Area (chart)
3. Upstream Pressure x Lower Stem Area (chart)
4. Downstream Pressure "A" x (Orifice Area minus Lower Stem Area) [See Chart]
5. Downstream Pressure "A" x Upper Stem Area (chart)
6. Downstream Pressure "A" x Lower Stem Area (chart)
7. Downstream Pressure "B" x (Orifice Area minus Lower Stem Area) [See Chart]
8. Downstream Pressure "B" x Lower Stem Area (chart)

Valve Force Calculations
3-Way, 3-Position, Flow in Common Port
(Continued)

Other Forces 9. Packing Friction (20 lbs. + 10% Highest Internal Pressure
10. Inner Valve Spring Force in Normal Position (chart)
11. Inner Valve Spring Force at Full Travel
12. Force to Crack Upper Plug off Seat (1 + 5 + 8 + 9 + 10) (-) (5 + 7 + 8)
13. Effective Diaphragm Area (See Figure 16)
14. Diaphragm Pressure to Crack Upper Plug off Seat (12 divided by 13)
(If Greater Than 7 psi, Consider Larger Topworks) 15. Force to Crack Lower Plug Off Seat (1 + 6 + 9 + 10) (-) (5 + 7 + 8)
16. Diaphragm Pressure to Crack Lower Plug Off Seat (15 divided by 13)
(If Greater Than 7 psi, Consider Larger Topworks) 17. Force to Drive Upper Plug Fully Open (2 + 7 + 8 + 9 + 11) (-) (3)
18. Diaphragm Pressure to Drive Upper Plug Fully Open (17 divided by 13)
(If Greater Than 25 psi, Consider Larger Topworks) 19. Force to Drive Lower Plug Fully Open (4 + 6 + 9 + 11) (-) (3 + 5)
20. Diaphragm Pressure to Drive Lower Plug Fully Open (19 divided by 13)
(If Greater Than 25 psi, Consider Larger Topworks)

The Reverse Acting Topworks

All the same general spring and diaphragm force calculation rules which apply to the direct-acting topworks also apply to the reverse-acting topworks (see Figure 12). Just remember that the spring is pulling up on the stem instead of pushing down on the stem. The load imposed by a reverse acting spring increases as the spring is stretched. The table below shows the standard INVALCO reverse acting spring assemblies will fit directly into the direct acting spring case replacing the direct acting spring, spring rests, etc.

Reverse Acting Springs

Spring Assy. Part No.	Max. Load	Rate Lbs./In.	Max. Defl.	Spr. O.D.	Spr. I.D.	Wire Dis.	Total Coils	Spr. Lgth.	Spring Part No.	DX Spring For (Normal Use)
48006582	300	143	2.10	1.660	1.160	0.250	16.00	4.00	45006552	Most No. 20 Tops
48010812	305	85	3.60	1.973	1.447	0.263	19.25	5.06	45006749	Series 509, 510 4" valve
48006583	512	313	1.57	1.784	1.160	0.312	16.00	5.00	45006581	Most 5 & 80 Tops
48007324	604	149	4.00	2.723	1.973	0.375	20.00	7.50	45006587	Series 480 valves
48011533	604	149	4.00	2.723	1.973	0.375	20.00	7.50	45006587	Series 454 6" valves
48012438	604	149	4.00	2.723	1.973	0.375	20.00	7.50	45006587	Series 438 valve

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