MIL-HDBK-227A(SHIPS)
31 JANUARY 1969
SUPERSEDING
MIL-HDBK-227(SHIPS)
25 JANUARY 1968

MILITARY STANDARDIZATION HANDBOOK

SELECTION AND INSTALLATION OF REGULATING AND CONTROL VALVES FOR NAVAL SHIPBOARD USE

FSC 4820

DEPARTMENT OF THE NAVY
NAVAL SHIP ENGINEERING CENTER
WASHINGTON, D.C. 20360

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and Control Valves For Naval Shipboard Use
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1. This standardization handbook was developed by the Naval Ship Engineering Center with the assistance of the Valve and Shipbuilding Industry in accordance with established procedure.

2. This publication was approved on 31 January 1969 for printing and inclusion in the military standardization handbook series.

3. This document provides criteria for the selection and installation of regulating and control valves for Naval shipboard use. It will provide valuable information and guidance to personnel concerned with the preparation of specifications and the procurement and installation of regulating and control valves. The handbook is not intended to be referenced in purchase-specifications except for informational purposes, nor shall it supersede any specification requirements.

4. Every effort has been made to reflect the latest information on the installation of regulating and control valves. It is the intent to review this handbook periodically to insure its completeness and currency. Users of this document are encouraged to report any errors discovered and any recommendations for changes or inclusions to Commander, Naval Ship Engineering Center, Department of the Navy, Washington, D. C. 20360.

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1. SCOPE AND APPLICABILITY

1.1 Scope. This handbook provides criteria for the selection and installation of regulating and control valves for Naval shipboard use.

1.2 Applicability. This handbook is applicable to nuclear and non-nuclear ships. It does not apply to the primary systems on nuclear ships. Only a limited number of systems and services have been covered by the selection portion of this handbook.

1.3 Purpose. The purpose of this handbook is to furnish a guide for the selection and installation of regulating and control valves, to the extent to which it is applicable. Because of the many considerations which influence the final selection of a suitable valve for any particular application, which cannot be taken into account in this type of document, this handbook is intended as an advisory document furnished for guidance purposes only and therefore its use does not in any way relieve a shipbuilder of the final design responsibility in this area.

2. REFERENCED DOCUMENTS

2.1 The issues of the following documents in effect on the date of invitation for bids form a part of this handbook to the extent specified herein.

GOVERNMENTAL

MIL-V-2042 - Valves, Reducing, Water Service, For Naval Shipboard Use.
MIL-V-2961 - Valves, Pressure Reducing, For Gas Service (Sizes 1/4 to 2 Inches IPS).
MIL-V-17848 - Valves, Pressure Regulating, Steam Service.
MIL-V-18030 - Valves, Control, Air Diaphragm-Operated.
MIL-V-24336 - Valves, Pressure Reducing for Oxygen Service.

(Copies of specifications, standards, drawings, and publications required by suppliers in connection with specific procurement functions should be obtained from the procuring activity or as directed by the contracting officer.)

3. DEFINITIONS

3.1 Regulating valve. A self-contained device which utilizes the line media for operation. These valves can be divided into 4 main shipboard service categories as follows:

Service	Applicable specification
Steam	MIL-V-17848
Air/nitrogen	MIL-V-2961
Water	MIL-V-2042
Oxygen	MIL-V-24336

3.1.1 Steam, regulating valves. Steam regulating valves can be divided into the following types acccording to method of loading (which generally establishes the control characteristics) :

(a) Internal pilot operated (variable pressure loaded) - Class A of MIL-V-17848.
(b) Inverted, gas loaded, glycerine sealed (preset pressure loaded) - Class B of MIL-V-17848.
(c) Direct spring loaded - Class C of MIL-V-17848.

3.1.2 Air/nitrogen regulating valves. Air/nitrogen regulating valves can be divided into the following types according to method of loading:

(a) Direct spring loaded - Type I of MIL-V-2961.
(b) Gas dome loaded (preset pressure loaded) - Type II of MIL-V-2961.
(c) Gas dome loaded, pilot referenced (constant pressure loaded) - Type III of MIL-V-2961.
(d) Internal pilot operated (variable pressure loaded) - Type IV of MIL-V-2961.

3.1.3 Water regulating valves. Valves used for water pressure reduction are generally direct acting, spring diaphragm operated, balanced poppet valves as specified in MIL-V-2042. On some applications requiring larger size valves, self-contained, external pilot operated valves are used.

3.2 Control valves. "A device which operates on an external source of power. In this handbook the term "control valve" will specifically refer to either an air diaphragm or air cylinder operated valve as specified in MIL-V-18030. Control valves are divided into 4 types according to construction:

(a) Single-seated, unbalanced - Type I of MIL-V-18030.
(b) Single-seated, direct piston balanced - Type II of MIL-V-18030.
(c) Single-seated, piston balanced incorporating an equalizing valve - Type III of MIL-V-18030.
(d) Double-seated, semi-balanced - Type IV of MIL-V-18030.

3.2.1 Control valve instrumentation. The term instrumentation when used in this handbook will refer to all pneumatic components utilized for control valve operation. This includes such items as control pilots (controllers), transmitters, amplifiers, selectors, and positioners, as defined in 3.2.1.1 through 3.2.1.15.

3.2.1.1 Constant bleed instrument. An instrument which continually exhausts or bleeds a certain amount of the control air to atmosphere, even when the control valve actuator pressure is being maintained at a constant value.

3.2.1.2 Intermittent bleed instrument. An instrument which only exhausts or bleeds control air to atmosphere when is necessary to decrease the control valve actuator pressure. Under steady load conditions where no change in actuator pressure is required, both the supply and vent functions are shut and there is no waste of control air to atmosphere.

3.2.1.3 Control pilot (or controller). A device which compares the controlled variable with a reference load and delivers a pneumatic output signal which is a predetermined function of any error or deviation sensed. The control pilot most commonly provides a 3-15 pounds per square inch gage (psig) output range.

3.2.1.4 Transmitter. A device which delivers a pneumatic output which is proportional to the value (pressure, temperature, etc.) of the measured variable. A transmitter may be used as a part of, or in conjunction with, a control pilot. However, some control pilots convert the measured variable directly to a mechanical signal and thereby eliminate the need for a transmitter.

3.2.1.5 Amplifier. A device which modifies a signal which is being transmitted from one part of a pneumatic system to another. Amplifiers utilize a separate source of air and provide an output which modifies the input signal in one or more of the following ways.

(a) Booster amplifier - Increases or boosts the volume of the input signal. Serves to speed control valve response to a change in controller output.
(b) Computing amplifier - Multiplies or divides the input signal. The output is some ratio (e.g. 1:2, 1:3, 3:1 etc.) of the input signal received.
(c) Bias amplifier - Adds (or subtracts) a bias to (or from) the input signal. For example may add 5 pounds per square inch (psi) to any input signal received.
(d) Inverting amplifier - Reverses the input signal (i.e. delivers a decreasing output with increasing input and vice versa) .

Note: The term "relay" is also used to refer to these devices.

3.2.1.6 Selector. A device which selects and transmits either the lower of 2 pneumatic inputs (low pressure selector) or the higher of 2 pneumatic inputs (high pressure selector) .

3.2.1.7 Positioner. A device mounted directly on a control valve for the primary purpose of bringing the valve to the required position called for by the instrument signal. There are 2 basic types of positioners; position-balance and force-balance. Both types receive 2 inputs (controller (or other instrument) output signal and a direct mechanical feedback of the control valve stem position). They compare these 2 inputs and load or unload the control valve actuator in such a way as to balance out any difference. The controller output then serves only as a signal to the positioner which in turn utilizes a separate source of air (usually a higher pressure than that available to the controller) to provide whatever force is necessary to move the valve stem to the correct position as dictated by the controller output signal. The fundamental difference between the 2 types of positioners is that the position-balance type converts the controller output pressure into a displacement so that it can be directly compared to the stem displacement, and the force-balance type converts both the controller output and the stem displacement into forces which can be directly compared with each other. A positioner can be used to accomplish the following:

(a) Improve control by correcting for unbalance non-linear forces created by the line fluid and the unbalanced areas of the valve plug. A positioner can also be used in open loop applications to overcome a certain degree of sluggish or erratic valve response. However, in closed loop (automatic control feed-back) applications, a positioner, will generally tend to aggravate the effects of sluggish or erratic valve response caused by stem friction, breakloose friction, corrosion, sludge, and abrupt force reversals. The nature of positioner operation in this type of situation will tend to produce significant overshoot in stem position for each controller output change. This overshoot can, in itself, cause a change in the controller output with the result being a cycling of the control system around the desired control point.
(b) Permit accurate control over a wide throttling range. When throttling over a wide range, it may be necessary to have extremely precise positioning (i.e. fine resolution) particularly in the low range. Inherent control valve resolution is normally limited to approximately 0.1 to 0.25 psi (resolution being defined as the smallest change in the controller output to which the valve will respond). With a positioner installed, resolution in the neighborhood of 0.010 to 0.015 psi can be attained.
(c) Permit split range operation of 2 or more control valves operated by a single controller.
(d) Reverse control valve operation.
(e) Provide a volume boost effect to speed response and/or permit control valve location further from the controller.

It should be noted that a positioner should not be used when only operation reversal or where only volume boosting is required. Inverting amplifiers and boosting amplifiers (see 3.2.1.5) are specifically designed for these purposes and are smaller, simplier, and less expensive than a positioner. Positioners normally incorporate an internal by-pass to permit the option of isolating the positioner and connecting controller output directly to the control valve actuator.

3.2.1.8 <u>Direct acting control pilot or transmitter.</u> The output signal increases as the measured variable or input signal increases.

3.2.1.9 <u>Reverse acting control pilot or transmitter.</u> The output signal decreases as the measured variable or input signal increases.

3.2.1.10 <u>Direct acting actuator.</u> An increase in the pressure to the actuator results in a downward stroke of the stem.

3.2.1.11 <u>Reverse acting actuator.</u> An increase in the pressure to the actuator results in an upward stroke of the stem.

3.2.1.12 <u>Air-to-open (normally closed).</u> A control valve (actuator plus body sub-assembly) is of air-to-open construction if an increase in pressure to the actuator causes the plug to move away from the seated position. Also referred to as a reverse acting control valve.

3.2.1.13 <u>Air-to-close (normally open).</u> A control valve (actuator plus body sub-assembly) is of air-to-close construction if an increase in pressure to the actuator causes the plug to move toward the seated position. Also referred to as a direct acting control valve.

3.2.1.14 <u>Direct acting positioner.</u> A single acting positioner is direct acting if the air output from the positioner increases with an increasing input signal to the positioner. Normally direct acting positioners are used on both air-to-close and air-to-open control valves. When the control valve incorporates a reverse acting actuator (see 3.2.1.11) , a direct acting positioner is mounted in an inverted position to provide the proper travel feedback to the positioner.

3.2.1.15 <u>Reverse acting positioner.</u> A single acting positioner is reverse acting if the air output from the positioner decreases with an increasing input signal to the positioner. Reverse acting positioners can be used to meet special system requirements. For example if the control pilot choice would normally dictate the use of an air-to-close valve but it is mandatory to have the valve close on loss of air supply, an air-to-open valve fitted with a reverse acting positioner can be used. It should be noted that an inverting amplifier (see 3.2.1.5(d)) could also be used for this purpose if a positioner were not required.

3.3 Flow coefficient (C_v). Flow coefficient (C_v) is a basic capacity rating of a valve which relates flow rate to the inlet and outlet pressure. Since the capacity rating of a valve is a complex function of the port areas, plug design, and body contour, the C_v is normally determined from flow test data. Any given C_v rating is applicable for liquid, gas, or steam service and once determined using any of the above medias, the C_v value can be used with suitable formulas to determine the actual flow under any set of conditions and with any other media (within certain limits of accuracy). For water service, defined as the number of gallons per minute (gpm) of 60°F. water that will flow through the valve with a 1 psi pressure drop across the valve.

3.4 Rangeability. Rangeability is a measure of the usable range of a control valve (i.e. a high rangeability makes it possible to control over a wide range with only one valve size). Defined as the ratio of the maximum to the minimum controllable C_v or the throttling range over which a given control characteristic can be maintained. The rangeability of a given design is limited by the difficulty of accurately throttling at very low flow rates (i.e. when the plug is very close to the seat). The rangeability of a given design will tend to increase with size, since as the seat diameter increases, the maximum C_v increases at a faster rate than the minimum controllable C_v. Although a given control device may have a rangeability greater than 10:1 and can exhibit satisfactory control characteristics at minimum flow requirements, rangeability alone should not be the only criteria considered when sizing a control station. From the viewpoint of valve trim (plug and seat) life and reduced maintenance, valves should not be sized to operate below 10 percent of their rated flow during any extended portion of their service life, even though they may have a controllable range far in excess of 10:1. In other words, wide rangeability should not be considered a criteria or justification for oversizing valves.

3.5 Control sensitivity (or gain). Control sensitivity (or gain) is the change in C_v per increment of lift.

3.6 Unit sensitivity. Unit sensitivity is the change in C_v per increment of lift (control sensitivity) divided by the C_v at that point, or in other words the percentage change in C_v per increment of lift.

3.7 Quick change cage trim. Quick change cage trim consists of a gasket sealed seat ring which is held in position a cage (which may be either separate from or integral with the seat ring) which is in turn held in position by either the bonnet or bottom cover. This insures maximum replaceability by avoiding the use of threads which are located within the valve body. This type of construction is specified in 4.1.4 (table I) for the most severe services, however because of the maintenance advantages offered by this construction, the use of this trim should be encouraged for other services when practical from a cost and availability standpoint.

4. SELECTION

4.1 General.

4.1.1 Selection criteria. The selection criteria specified in 4.1.1.1 and 4.1.1.2 may be used as a guide for the selection between regulating valves and control valves:

4.1.1.1 Generally the following conditions would favor the choice of a self-contained regulating valve:

(a) During normal operation, a rangeability in excess of 10:1 is not required.
(b) Rapid response characteristics are required.
(c) The pressure differential across the valve, and the line meaia, are suitable for self operation.
(d) Control air is limited or unavailable, or the exhaust of control air into the ship compartment during valve operation is undesirable.
(e) From a system standpoint, a self-contained mechanism is required.
(f) Small capacity is required (save on initial cost).
(g) Compactness is desired.

4.1.1.2 Generally the following conditions would favor the choice of an air operated control valve:

(a) During normal operation, a rangeability in excess of 10:1 is required.
(b) The ability to vary the control characteristics (response, control band, etc.) is required.

(c) The line meaia is not a suitable operating media either because of contamination, temperature, or because of the magnitude of the operating forces required.
(d) Extremely precise regulation over widely varying operating conditions is required.
(e) Intermittent service at a relatively low set pressure is required.
(f) Large capacity is required (save on initial cost).

4.1.2 Interactions between valves should be carefully considered when making a selection of pressure regulating or control valves for a particular system. In general to reduce the pipe volume required between valves installed in series, consideration should be given to using valves with different response characteristics, with the faster valve installed upstream. When this is not practical or desirable (for example, under some circumstances it is advisable to use air pilot operated control valves for primary steam reduction), consideration must be given to insure that all subsequent downstream regulators or control valves have operating characteristics which are compatible.

4.1.3 In general, all valves used on submarine applications should be self-contained.

4.1.4 Selection guide. Table I is a general guide to the selection of requlating and control valves for shipboard application. Table I is based primarily on experience from past installations as to what valves have proven to be most satisfactory and practical for each particular application.

Table I - Guide to the selection of regulating and control valves.

System - service	Military specification	Type or class	Body material	Trim	Remarks
AUXILIARY STEAM					
1200/600 psig 1200/150 psig (trim size above 2 inches)	MIL-V-18030	Type I	Steel	Quick change stellited	
1200/600 psig 1200/150 psig (trim size 2 inches and below)	MIL-V-18030 or MIL-V-17848	Type I Class A	Steel	Quick change stellited	
600/150 psig	MIL-V-18030 or MIL-V-17848	Type I, II Class A	Steel	Hardened CRES plug, stellited seat	
150/100 psig 150/50 psig (trim size above 2 inches)	MIL-V-18030	Type I, II	Steel	Hardened CRES plug, stellited seat	
150/100 psig 150/50 psig (trim size 2 inches and below)	MIL-V-18030 or MIL-V-17848	Type I Class A	Steel	Hardened CRES plug, stellited seat	
Gland seal augment (150 psig-1/2 psig)	MIL-V-18030	Type I	Steel	Quick change stellited	
Gland seal unloading	MIL-V-18030	Type III	Steel	Hardened CRES plug, stellited seat	
Steam to evaporators 150/15 psig 15/5 psig	MIL-V-18030	Type I, III	Steel	Hardened CRES plug, stellited seat	

Table I - Guide to the selection of regulating and control valves (cont'd).

System - service	Military specification	Type or class	Body material	Trim	Remarks
AUXILIARY EXHAUST					
Dump to main condenser Dump to turbo-condenser (trim size above 2 inches)	MIL-V-18030	Type III (see 4.3.5)	Steel	Hardened CRES plug, stellited seat	Close on loss of control or actuating air
Dump to main condenser Dump to turbo-condenser (trim size 2 inches and below)	MIL-V-18030	Type I, III (see 4.3.5)	Steel	Hardened CRES plug, stellited seat	
Augmenting steam 1200/12 psig 600/12 psig 150/12 psig	MIL-V-18030 MIL-V-18030	Type I Type I, II	Steel	Quick change stellited	
Turbine bleed	MIL-V-18030	Type I, II	Steel	Hardened CRES plug, stellited seat	Close on loss of control or actuating air
Unloading to atmosphere	MIL-V-18030	Type II, III	Steel	Hardened CRES plug, stellited seat	Open on loss of control or actuating air
FEEDWATER					
Auxiliary desuperheater water control valve	MIL-V-18030	Type I	Steel	Quick change stellited	Manual or pnuematic operation as specified. Pnuematic operated to fail closed on loss of control air and to include a manual override.

Table I - Guide to the selection of regulating and control valves (cont'd).

System - service	Military specification	Type or class	Body material	Trim	Remarks
CONDENSATE					
Dump to reserve feed tank	MIL-V-18030	Type I	Bronze	18-8 CRES	Close on loss of control or actuating air
Make-up feed to condenser Condensate recirculating (trim size above 2 inches)	MIL-V-18030	Type III (see 4.3.5)	Bronze	18-8 CRES	Close on loss of control or actuating air for Make-up valve. Open on loss of control or actuating air for recirculating valve.
Make-up feed to condenser Condensate recirculating (trim size 2 inches and below)	MIL-V-18030	Type I, III (see 4.3.5)	Bronze	18-8 CRES	
FRESH WATER DRAINS					
Drain tank to condensate system	MIL-V-18030	Type I, II, IV	Bronze	18-8 CRES	
Drain tank to condenser	MIL-V-18030	Type III	Bronze	18-8 CRES	
Service steam drain to condensate system	MIL-V-18030	Type I, II, IV	Bronze	18-8 CRES	
LUBE OIL AND FUEL OIL					
Lube oil unloading Fuel oil unloading	MIL-V-18030	Type I	Steel	Hardened CRES plug, stellited seat	Close on loss of control or actuating air, manual override.

4.2 Regulating valves.

4.2.1 In general, all class A regulating valves of MIL-V-17848 should incorporate an internally ported impulse line. External impulse connections may be considered under high pressure drops when relatively low reduced pressure settings are to be maintained. The internal sensing port provides the fastest possible feedback, consistent with the fast response of the self-contained, internal pilot, piston operated valve. There are conditions under which it is desirable to accept the somewhat slower feedback associated with an external feedback; these are:

(a) To minimize the effect of pressure losses between the outlet of the valve and the downstream piping.
(b) To obtain a less turbulent location for sensing pressure.

Both of these effects are of significance in a low reduced pressure system. As a rule, whenever the reduced pressure is less than 25 percent of the inlet pressure and less than 100 psig, there is advantage to the external impulse line. For reduced pressures above 100 psig, an internal impulse line should be used, even though the reduced pressure is less than 25 percent of the inlet pressure.

4.3 Control valves.

4.3.1 Generally it is desirable to use type I control valves of MIL-V-18030 wherever practical because of the inherent simplicity and stability of this design. However, in order to limit the required actuator size, type I valves are normally not used in the larger sizes, particularly where high pressure drops are present. Type I valves are occasionally used on applications requiring large actuator thrusts by using some combination of high control air pressure, moderate to large size actuator, and mechanical leverage. Types II, III, and IV valves permit the use of smaller actuators on large size and/or pressure drop applications by balancing out a portion of the force unbalance transmitted to the stem by the pressure forces. Type II valves do not provide tight shutoff, except for lower temperature applications where a non-metallic seal can be used for the balance piston. Type III valves can provide tight shutoff by using an auxiliary valve for balancing the main valve. Type IV valves also provide a partial balancing of the pressure forces, and are actually more effectively balanced during the flow conditions than types II and III. However type IV valves cannot provide tight shutoff.

4.3.2 To insure maximum stability, all MIL-V-18030 control valves (except type III) should have flow in the direction of valve plug opening (flow tending to open valve). This provides inherent stability and makes the valve relatively easy to position and control by providing a unidirectional stem thrust which opposes the actuating force. As the valve plug moves toward the seat, an increasing pressure unbalance will tend to oppose the valve closure force provided by the actuator. As the valve plug moves away from the seat, a decreasing pressure unbalance will tend to assist the valve opening force provided by the actuator (since the valve plug position is determined by the net result of a summation of forces, this unbalance change therefore has the relative effect of opposing valve opening). If the valve is installed such that flow is in the direction of valve plug closing (flow tending to close valve) a reversal in the stem thrust provided by the pressure unbalance across the plug will occur during the stroke of the valve. In going from the open to the closed position, the pressure unbalance will first produce an increasing stem thrust tending to oppose valve closure. However, as the valve plug approaches close to the seat, this stem force will abruptly reverse. The magnitude and abruptness of this force reversal will be determined by such factors as plug shape, plug size, and pressure drop. It is extremely difficult to position and control close to the seat when the plug unbalance stem thrust tends to assist (rather than oppose) actuator force since there will be a tendency to overshoot (bathtub stopper effect).

4.3.3 Control valve flow characteristics. Normally the selection of the proper plug characteristics for particular application should be left to the judgment and experience of the valve manufacturer. Except in certain cases where the system characteristics cannot be determined before selection of the valve, control valves should always obtain the required flow characteristics by way of the plug contour or porting, rather than by the use of a characterized positioner. The four principal control characteristics are described below. The characteristics shown on figures 1, 2 and 3 are only approximate and will vary to some extent depending on size, body configuration and make of valve. Also the nomenclature for these characteristics often varies between different manufacturers.

(a) Quick - opening - C_v increases rapidly With lift and reaches a maximum value at a relatively low lift. Generally not suitable for finely controlling flow over a wide throttling range and is used primarily for on-off type control or where operating conditions do not vary over a wide range and where fast valve action is required for services such as emergency dumping. Range - ability approximately 15:1.

(b) Linear - C_v varies linearly with valve lift and therefore the percentage rate of change of C_v decreases with increasing valve lift. In other words the control sensitivity remains constant and the unit sensitivity decreases with increasing valve lift. Generally used where the pressure drop across the control valve remains relatively constant under all operating conditions. Rangeability approximately 25:1.

(c) Modified linear - Compromise between linear and equal percentage characteristics. Valve has a linear characteristics during the middle portion of the lift and a decreased control sensitivity at both the lower and upper portions. The decreased control sensitivity (i.e. relatively large stem travel required to obtain a given C_v change) is an advantage at the low end because it permits fine control at low flow rates. Used where fine control at low load and rapid response in the mid-to-upper range is required. Rangeability approximately 35:1.

(d) Equal percentage - The percentage change in C_v per increment of lift remains constant regardless of the lift. Therefore, the control sensitivity increases with increasing valve lift while the unit sensitivity remains approximately constant. Provides good control over a wide range of operating conditions. Rangeability approximately 50:1.

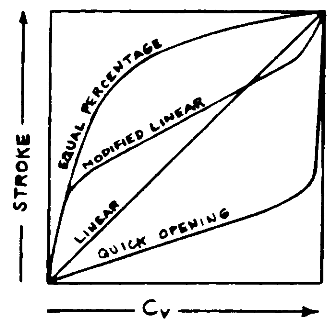

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Figure 1 - C_v versus stroke.

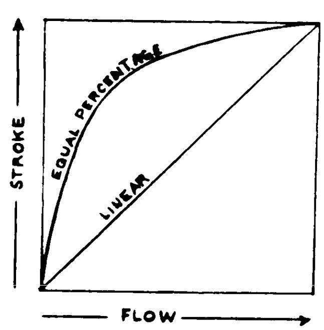

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Figure 2 - Flow versus stroke with a constant pressure drop across valve.

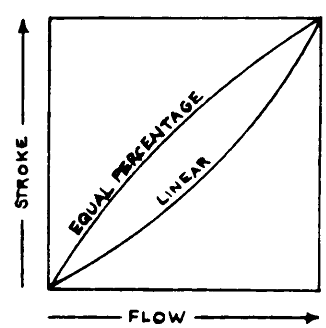

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Figure 3 - Flow versus stroke when the pressure drop across the valve decreases or varies inversely with the flow rate.

4.3.3.1 The distinction between the inherent flow characteristics of a control valve and the effective flow characteristics of a system should be noted. The piping system in which a control valve is installed will combine with the control valve characteristics to provide the effective characteristic of the system. In a system in which the pressure drop across the control valve remains relatively constant (or in other words where the major portion of the total sysstem pressure drop is taken across the control valve) , the effective flow characteristics of the system, will closely follow the inherent flow characteristics of the control valve. On the other hand, in a system where the pressure drop available across the control valve decreases or tends to vary inversely with flow (or where the major portion of the total system pressure drop is not taken across the control valve) the effective characteristics of the system will differ significantly from the inherent characteristics of the control valve. Under this condition, a valve with equal percentage characteristics will tend to provide linear control (or constant gain) in the system and a contro1 valve with linear characteristics would tend to provide quick-opening characteristics in the system (see figures 2 and 3). It is generally desirable to use a control valve characteristic for throttling service which, in combination with the remainder of the system, tends to maintain an approximately constant gain or linear characteristic in the system under all operating conditions.

4.3.4 Wherever compatible from a performance standpoint (sensitivity, speed of response, etc.) intermittent bleed pilots and other pneumatic instrumentation should be used (see 3.2.1.1 and 3.2.1.2).

4.3.5 Control valves installed on lines leading to a condenser under vacuum should be of a design such that positive pressure is maintained on the packing gland at all times to prevent the entrance of air into the condenser. Where type I control valves are used on lines leading to a condenser under vacuum, the basic body configuration should be as shown on figures 4 and 5.

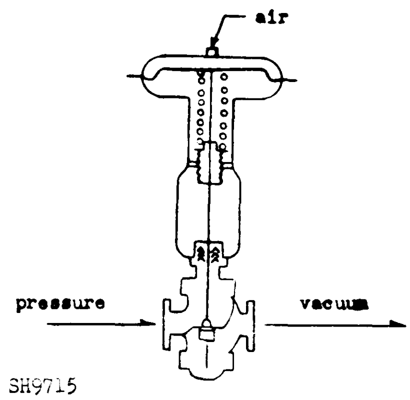


Figure 4 - Air-to-open construction.

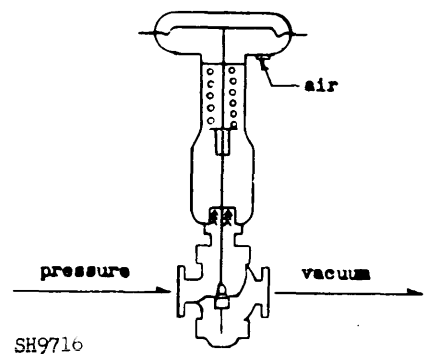


Figure 5 - Air-to-close construction.

5. INSTALLATION

5.1 General.

5.1.1 Manual by-pass valves installed around pressure regulating or control valves should permit good manual control of the downstream pressure under all operating conditions. On critical control valve applications, the manual by-pass valve should have flow characteristics which match the control valve, to permit smooth and rapid changeover.

5.1.2 Automatic regulating or control valves should always be installed at a high point in a line or system to minimize the collection of dirt or condensate in the valve.

5.1.3 Where valves handling compressible fluids are staged (installed in series), sufficient volume must be provided between valves to prevent cycling. In addition, sufficient unrestricted effective volume must be provided immediately upstream of all regulating and control valves to insure smooth and stable control under all operating conditions. Valves installed in series" require special attention to prevent interaction between valves and attendant system cycling. For the system to function properly the upstream valve must be able to keep the downstream valve supplied at all times. Since the downstream valve is nearer the demand, it will sense a change in demand sooner than the upstream valve, and when it attempts to satisfy the demand, it may momentarily starve until the upstream valve catches up. A sudden large drop in the outlet pressure of the upstream valve will cause it to over-compensate resulting in sustained system cycling. Increased piping between the two valves acts as a reservoir from which the downstream valve can draw without causing a large abrupt drop in its inlet and the resulting overcorrection on the part of the upstream valve. This reservoir should be as large as practical, and also where practical the characteristics of the two valves should be chosen so that the upstream valve acts significantly faster than the downstream valve (see 4.1.2). The need for sufficient unrestricted volume immediately upstream of all regulating and control valves (whether installed in series or not) is based on the same basic considerations. Any flow restriction immediately upstream of the valve will limit the effective "reservoir" from which the valve can draw to meet flow demands, and during transient conditions can cause abrupt fluctuations in the inlet pressure at the valve. These inlet pressure fluctuations will adversely effect the operation and stability of most valves whether of a "balanced" design or not.

5.2 Regulating valves.

5.2.1 When an external impulse connection is used on class A valves of MIL-V-17848, it should be continuously sloped and the outlet piping from the valve should be taper expanded to approximately twice the inlet pipe size, without any restrictions such as stop valves, desuperheaters, etc., between the outlet of the reducing valve and the external sensing pick-up point. Excessively long impulse lines should be avoided to minimize the possibility of instability during major load changes.

5.3 Control valves.

5.3.1 Generally a control pilot should not be located more than a maximum of 50 feet from the control valve in order to avoid excessive build-up/bleed-off time.

5.3.2 Pilots should be located so that sensing lines will not be more than approximately 10 feet in length.

5.3.3 Sensing lines must be run without horizontal leads or pockets. The leads should be given the maximum possible slope, with 20 degrees (about 4 inches per foot) the desired minimum. This is to insure that the sensing lines are either entirely free of or entirely full of condensate at all times. Installations which permit the sensing line to partially fill with condensate can result in erratic valve operation.

5.3.4 Sensing taps should not be located on bends or ells and, if possible, should be located several feet away from tees or take-offs in the main which could contribute to flow turbulence.

5.3.5 Sensing taps (or gage connections) should not be located on certain no-flow lines such as by-passes around reducing valves or on branch leads to unloading valves.

5.3.6 A pressure gage used to monitor control valve performance should take off from the sensing connection so that it indicates the pressure to which the control pilot is reacting. A pressure gage used to set the valve should be located at the point in the piping system where control is desired. Normally one gage serves both purposes since these should be the same points.

5.5.7 Where several pilots are actuated by a common pressure they should have sensing lines manifolded from a common sensing tap; to facilitate calibration a gage should utilize the same or a closely adjacent tap connection. The grouped pilots should be installed at a common elevation if differences in static head would be significant.

6. DYNAMIC RESPONSE CONSIDERATIONS

6.1 Time lags are applicable to regulating and control valve installations as follows:

(a) Valve response lag - Caused by mechanical inertia, capacity of actuating mechanism, friction etc.

(b) Capacity lag - Caused by capacity of system.
(c) Distance lag (lag between a change in valve position and the corresponding change at the point of control) - Caused by the distance between the valve and the point where control is desired.
(d) Impulse transfer lag (lag between a change at the Point of contro1 and the arrival of the signal at the valve actuator) - Caused by the distance and lags between the point where control is desired and the valve actuator.

6.1.1 While any treatment of the subject of dynamic transient response is well beyond the scope of this handbook, the following general rule can be applied to automatic control devices in a closed-loop system:

For a given control system and a given proportional band, any characteristic in the system which reduces the suddeness of changes in the controlled quantity or variable due to load changes makes the system easier to control and contributes toward stable regulation. Any lag or delay which increases the lapse of time between a change in the controlled quantity (load change) and the adjusting action of the control device, makes stable regulation (under transient conditions) more difficult.

7. PRESSURE REDUCING STATIONS

7.1 Pressure reducing stations, utilizing either regulating or control valves for automatic pressure reduction, should incorporate the following:

(a) Inlet and outlet stop valves to permit isolation, for repair and maintenance, of regulating (or control) valve and filter (or strainer).
(b) By-pass to provide manual or automatic control of outlet pressure during times when the regulating (or control) valve is isolated for repair or maintenance.
(c) Filtration equipment for particle contamination protection for regulating (or control) valve.
(d) Non-isolable overpressure protection downstream of the outlet stop valve.
(e) Pressure gages both upstream and downstream of the regulating (or control) valve.
(f) Provision for depressurization of all equipment prior to disassembly for maintenance or repair.

8. ILLUSTRATIONS

8.1 This section contains figures and descriptions to provide illustrations typical of the valves covered in this handbook. The following valves are illustrated:

Figure	Description
6	MIL-V-17848 class A
7	MIL-V-17848 class B
8	MIL-V-17848 class C
9	MIL-V-2961 type I
10	MIL-V-2961 type II
11	MIL-V-2961 type III
12	MIL-v-2042
13	MIL-v-18030 type I
14	MIL-V-18030 type II
15	MIL-v-18030 type III
16	MIL-V-18030 type IV

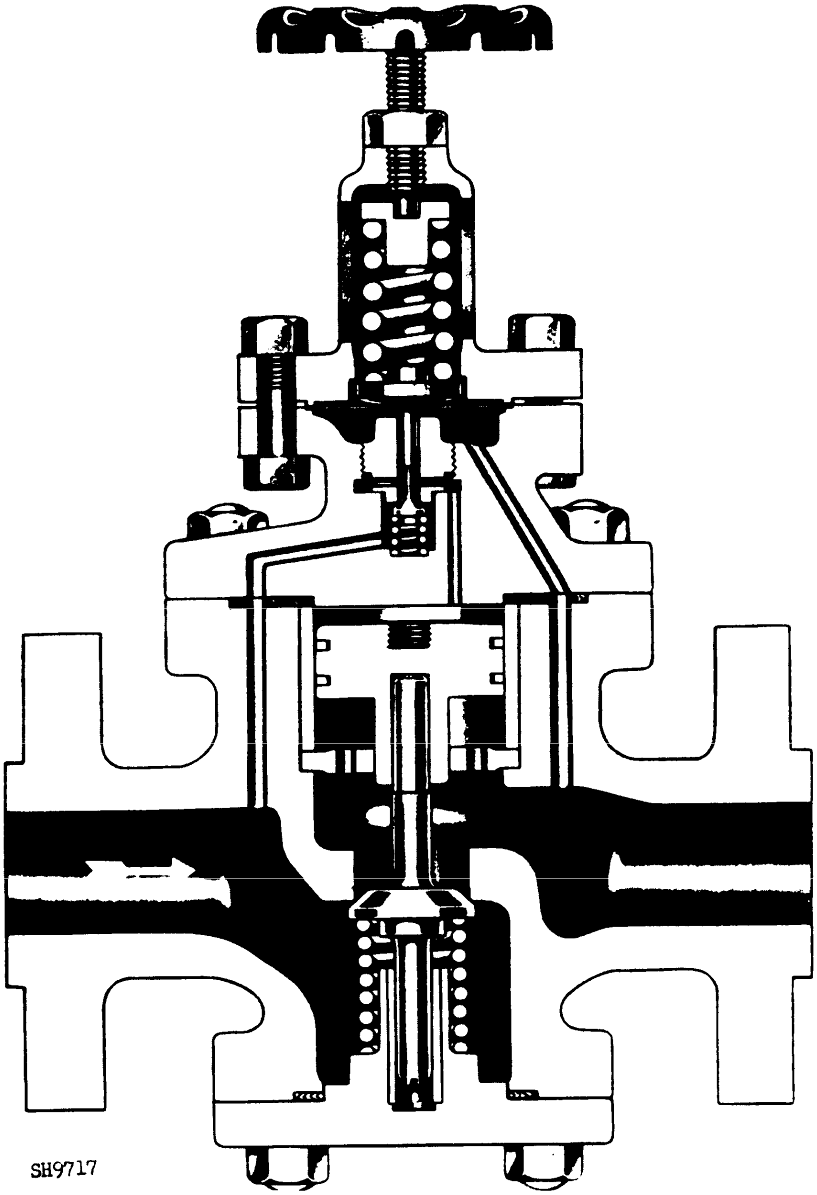


Figure 6 - MIL-V-17848, class A (internal pilot operated)

In this design the actual control of the valve is accomplished by a small pilot assembly located in the valve above the main valve and operating piston. The downstream pressure feedback is sensed by the spring loaded pilot diaphragm to position the pilot valve. The position of the pilot valve determines the amount of upstream steam which is fed onto the top of the piston and thereby controls the position of the main valve. Since there is also a direct downstream pressure feedback under the piston, the main valve assembly acts at any instant of time like a simple fixed gas dome loaded regulator. Therefore the piston anticipates any load change before the control pilot can respond and the valve has much faster response characteristics than normally associated with pilot operated valves.

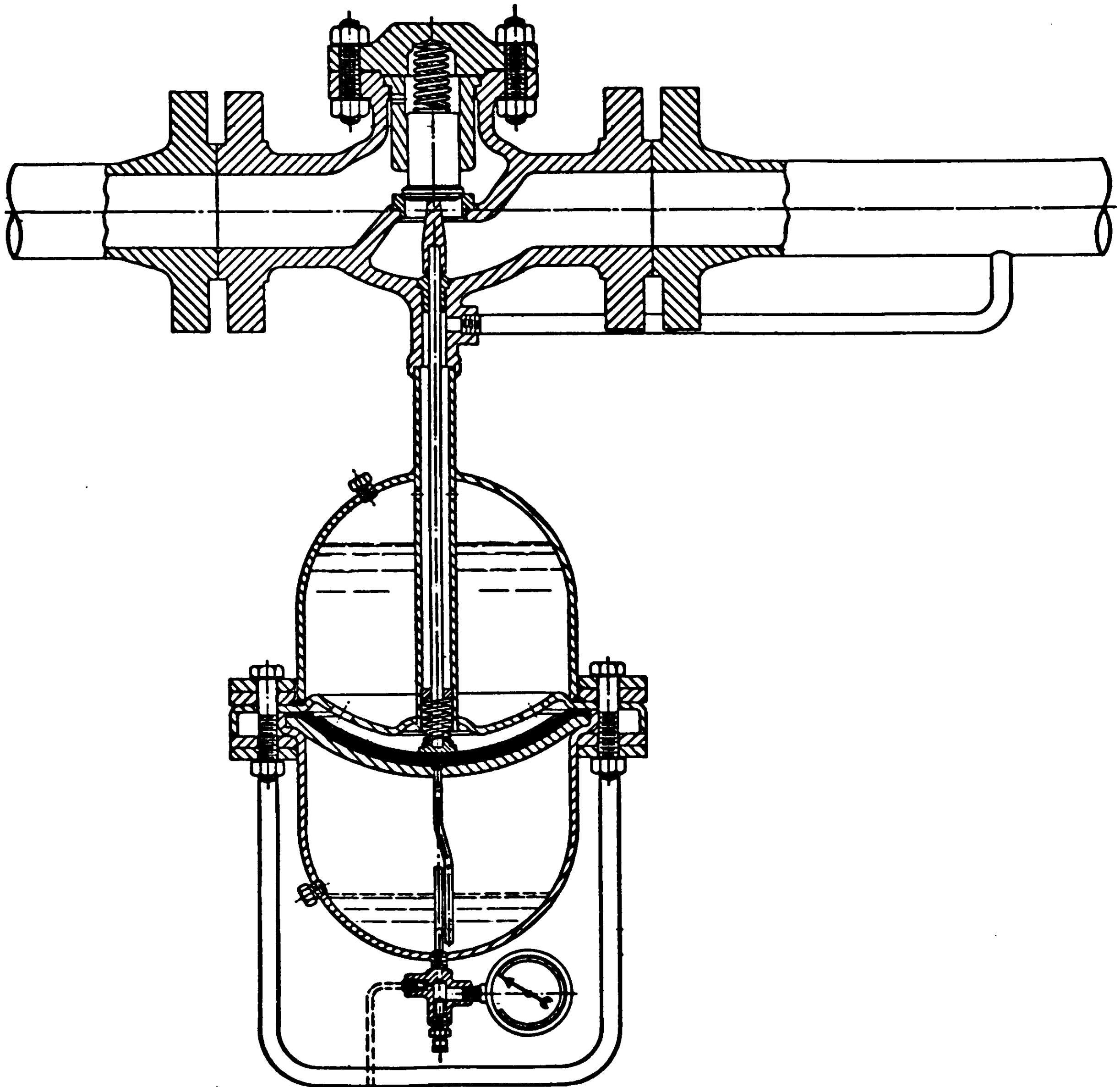


Figure 7 - MIL-V-17848, class B (inverted, gas loaded, glycerine sealed)

In this design the downstream pressure is sensed by an air (or other inert gas) loaded rubber diaphragm located below the main valve body. The downstream pressure feedback is conducted to the top of the diagragm, which is protected by a water seal, and compared with the air load to directly position the main throttling valve. The bottom surface of the diaphragm is protected with a glycerine seal. This design provides a wide range of set pressure adjustment because of the air spring loading.

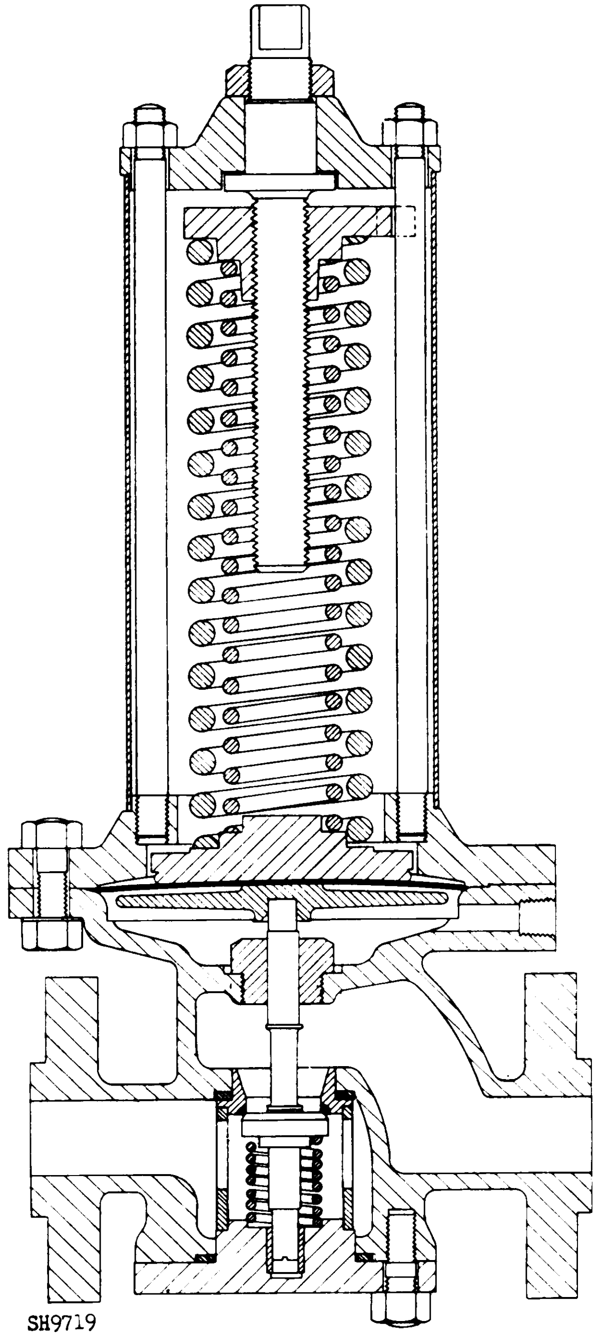
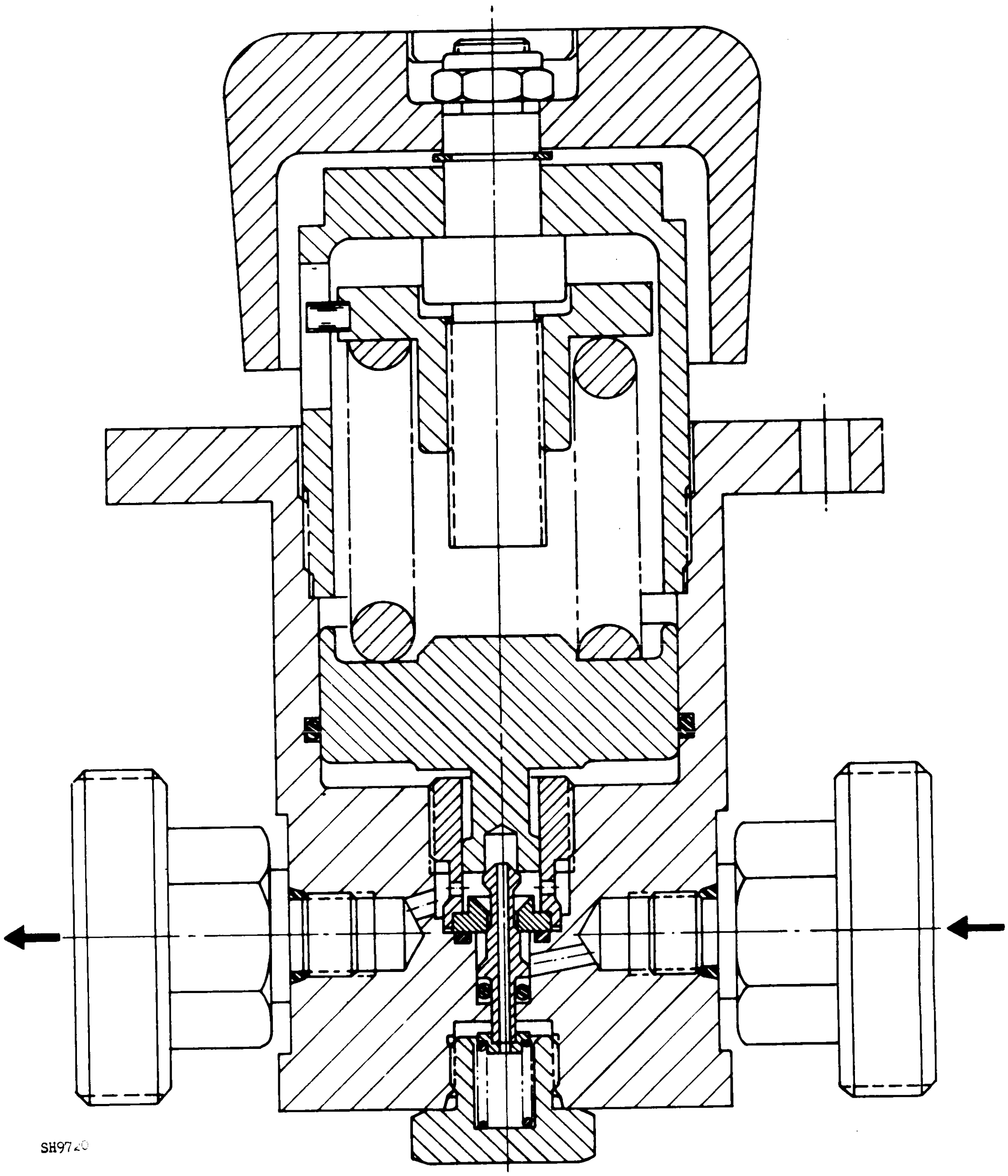


Figure 8 - MIL-V-17848, class C (direct spring loaded)

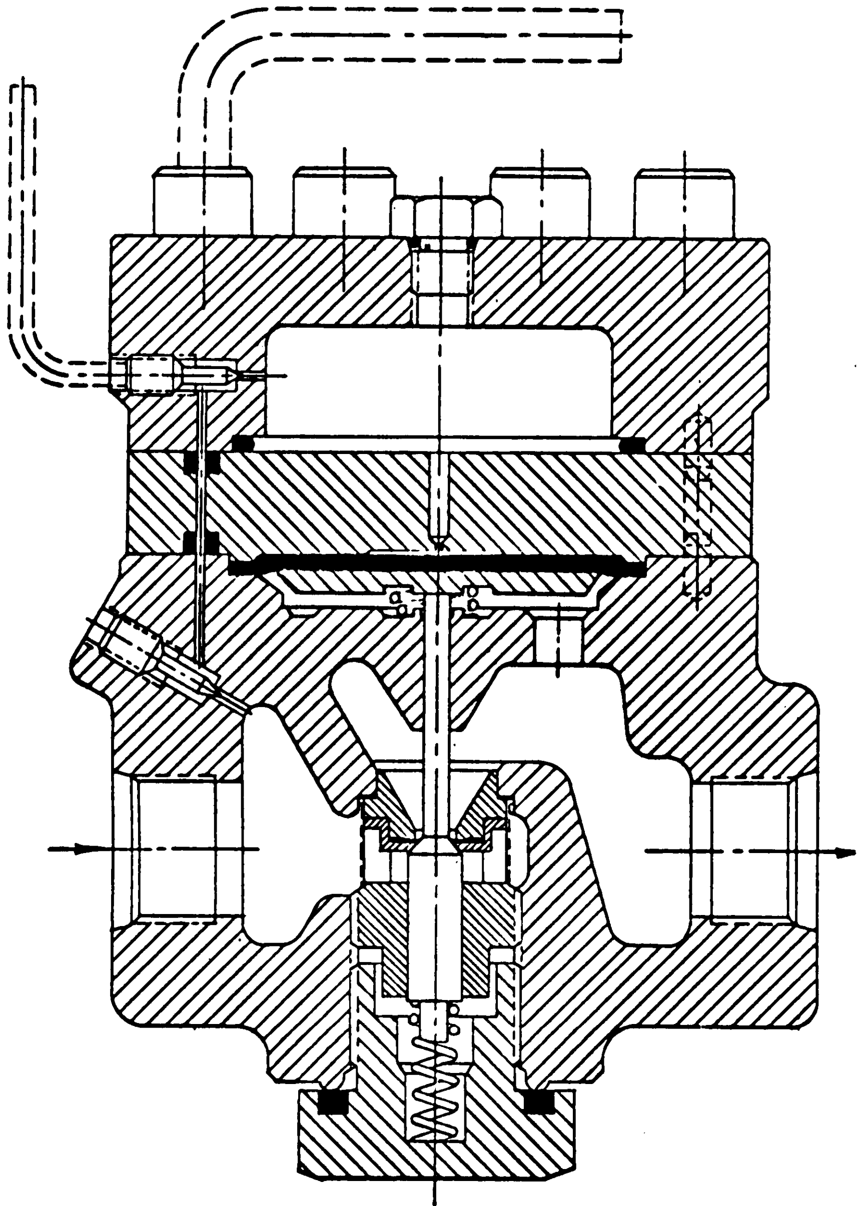
In this design the down stream pressure is sensed by a spring loaded diaphragm and compared with the spring load to directly position the main throttling valve. The diaphragm is metallic and therefore is not protected from the line steam. this design is normally limited to relatively low capacity and/or low reduced pressure applications because of the large springs that would be required to maintain accurate control at high flow and/or high reduced pressure. The valve illustrated incorporates quick change trim.



SH9720

Figure 9 - MIL-V-2961, type I (direct spring loaded)

In this design the downstream pressure issensed by a spring loaded piston and compared with the spring load to directly position the main throttling valve. This design is normally limited to relatively low capacity and/or low reduced pressure applications because of the large springs that would be required to maintain accurate control at high flow and/or high reduced pressure.



SH9721

Figure 10 - MIL-V-2961, type II (gas dome loaded).

In this design the downstream pressure is sensed by an air loaded diaphragm and compared with the air load to directly position the main throttling valve. The air load is established by a fixed quantity of gas which is bled into the dome from the upstream side and locked in with a series of needle valves. The valve illustrated incorporates an orifice plate to separate the dome into upper and lower chambers. The lower chamber, which is in direct contact with the diaphragm, is much smaller than the upper chamber and this arrangement provides a dampening characteristic to insure stable control, particularly at low flow rates. This design provides a wide range of set pressure adjustments because of the air spring loading.

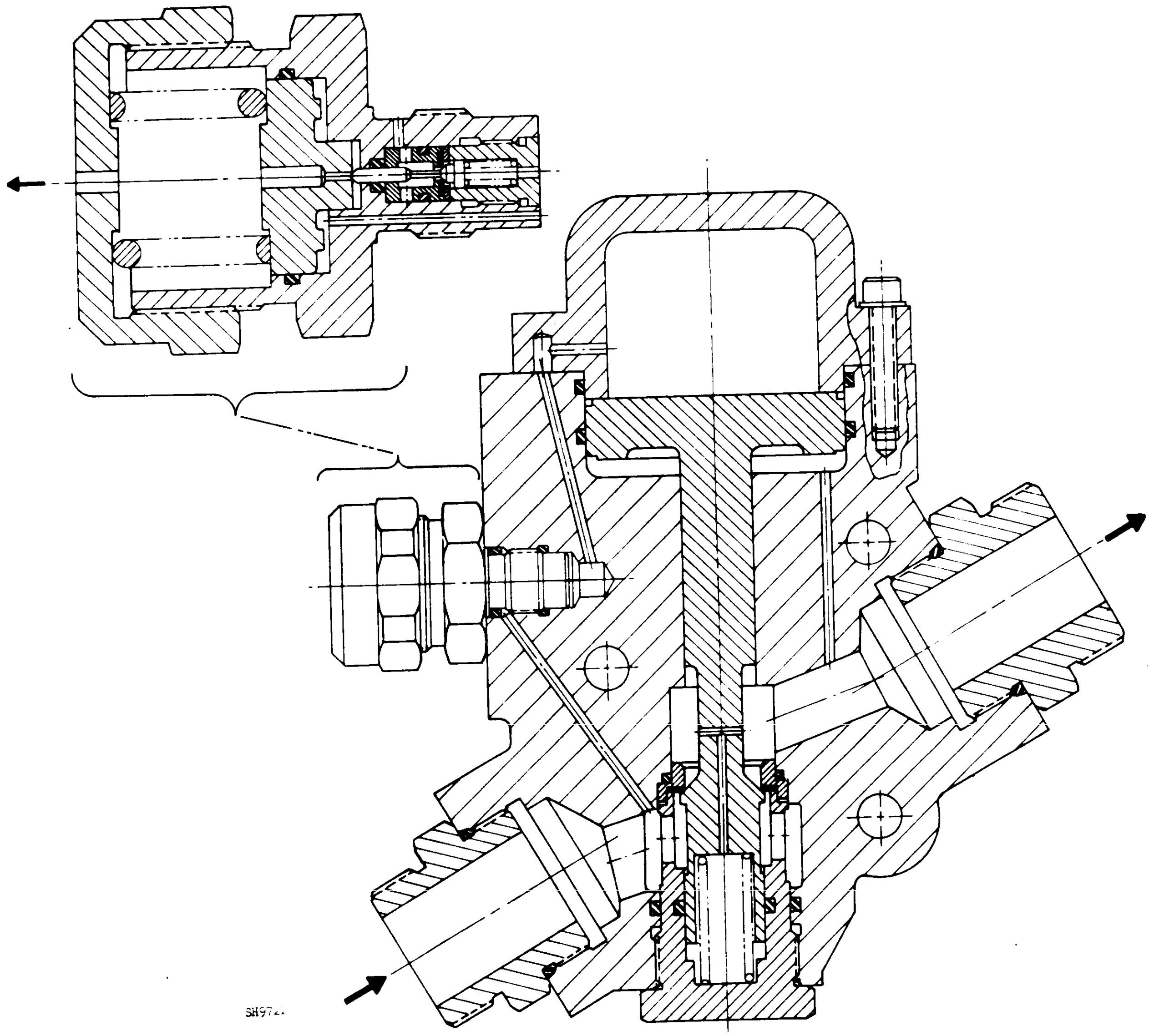


Figure 11 - MIL-V-2961, type III (gas dome loaded, pilot referenced).

This design is a refinement of the basic gas dome loaded valve where a small spring loaded pilot valve senses dome pressure and is used to maintain the gas charge in the dome at a constant pressure regardless of valve stroke or changes in the dome gas temperature. This construction can therefore maintain greater accuracy than a basic dome loaded valve under conditions of large flow and\or temperature variations."

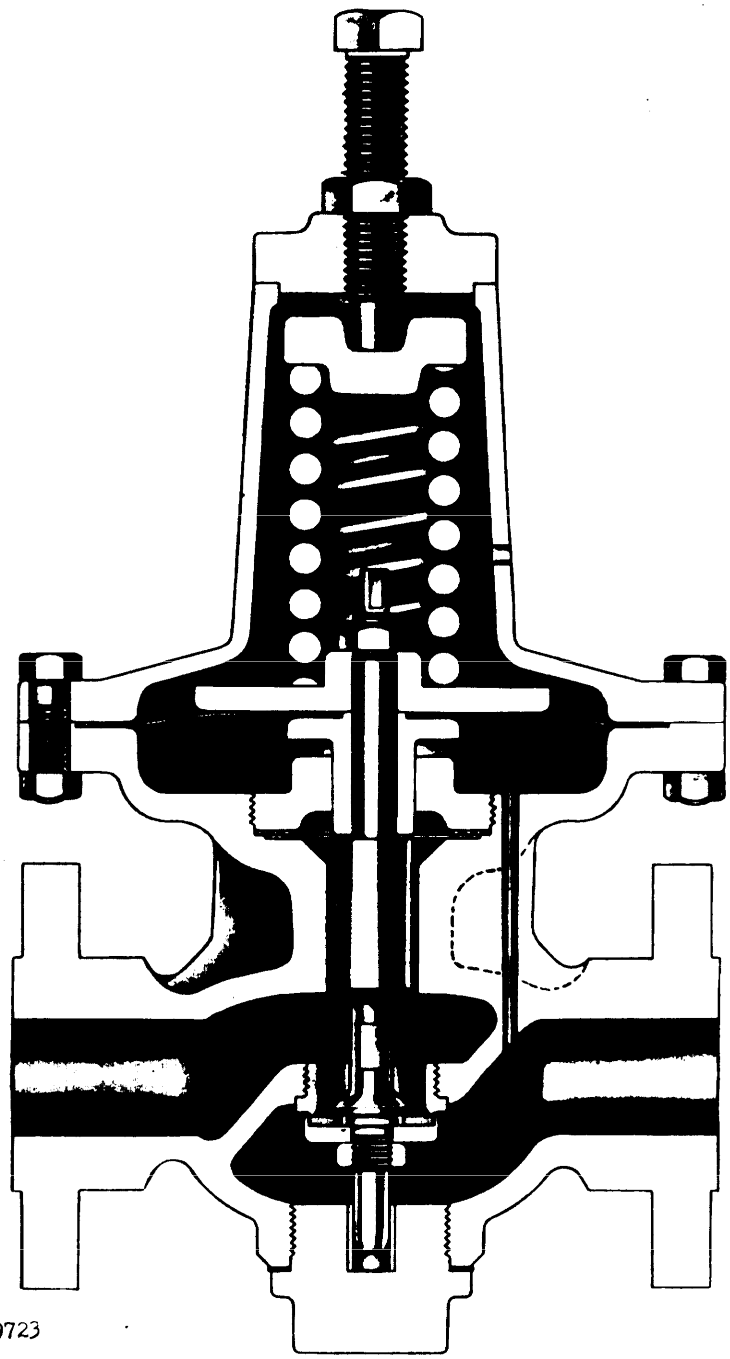


Figure 12 - MIL-V-2042

In this design the downstream pressure is sensed by a spring loaded diaphragm and compared with the spring load to directly position the main throttling valve. The main valve or poppet is balanced (by means of the dynamic stem seal) to minimize the effects of upstream pressure variations on regulation accuracy.

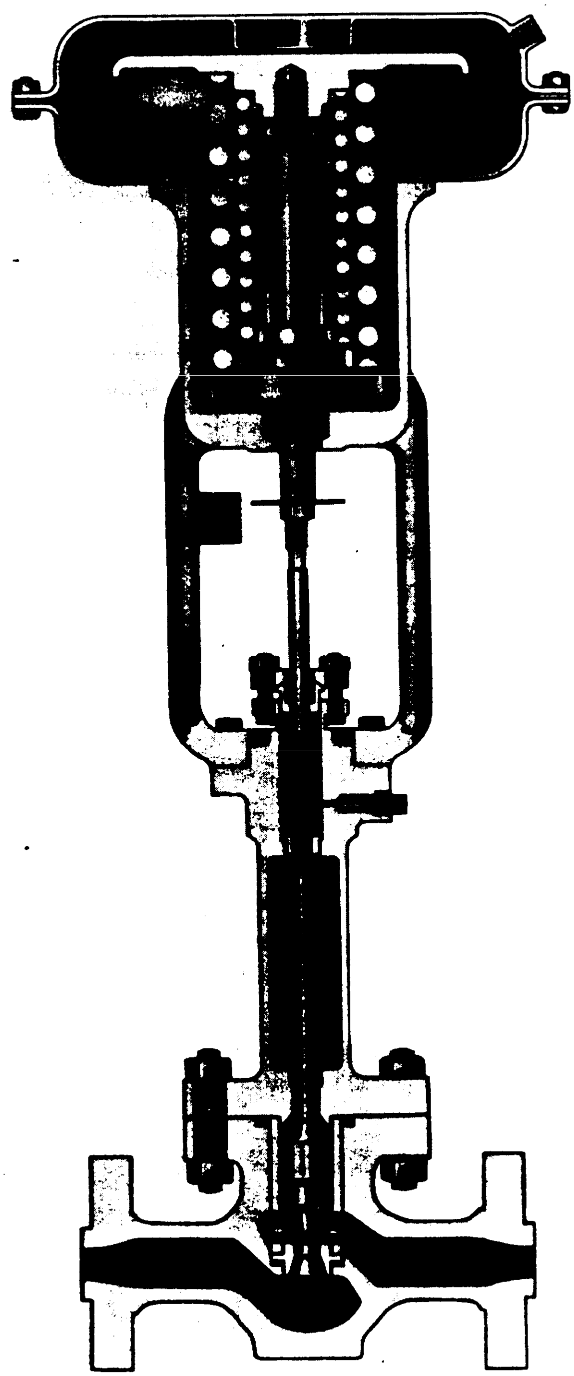


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Figure 13 - MIL-V-18030, type I (single-seated, unbalanced)

The valve illustrated incorporates quick change cage trim.

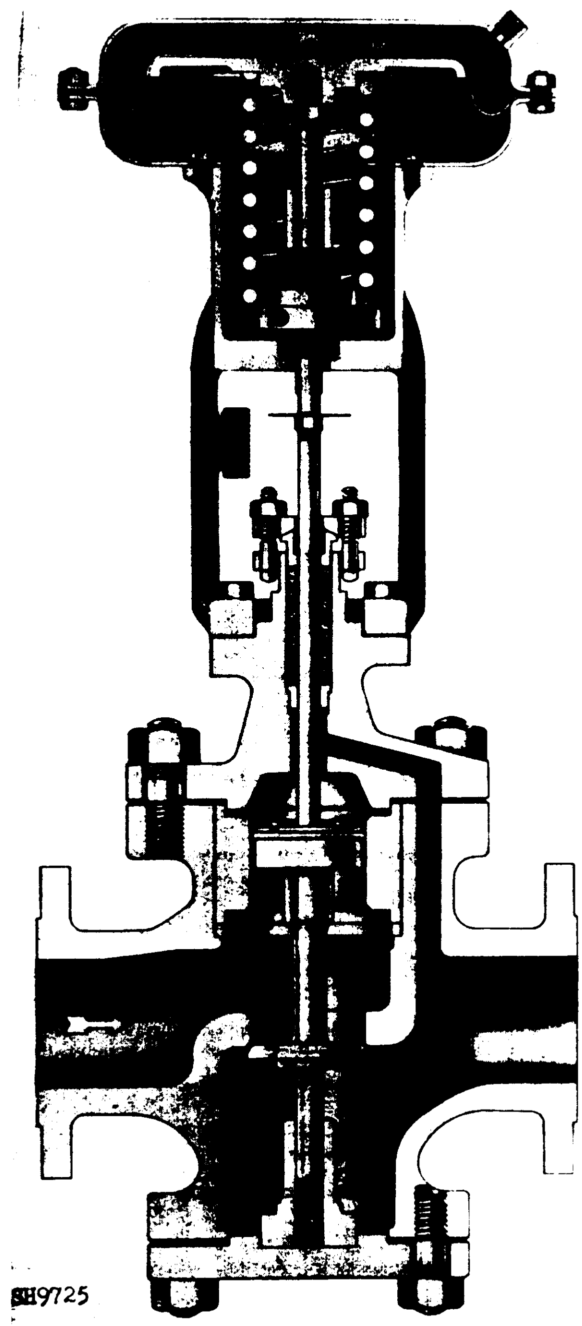

Figure 14 - MIL-V-18030 type II (single-seated, direct piston balanced)

In this design a piston is used to partially balance out pressure forces across the main valve plug.

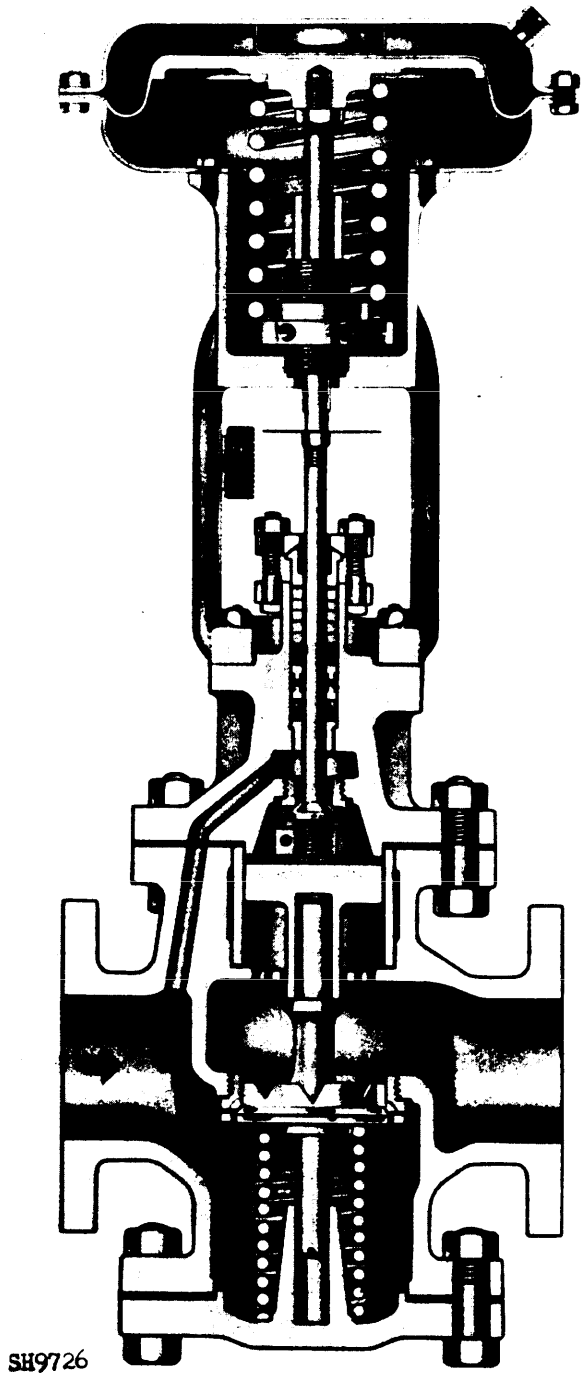

Figure 15 - MIL-V-18030, type III (single-seated, piston balanced incorporating an equalizing valve)

In this design balancing pressure across the piston is shut off when the actuator goes to the full close position in order to provide tight shutoff.

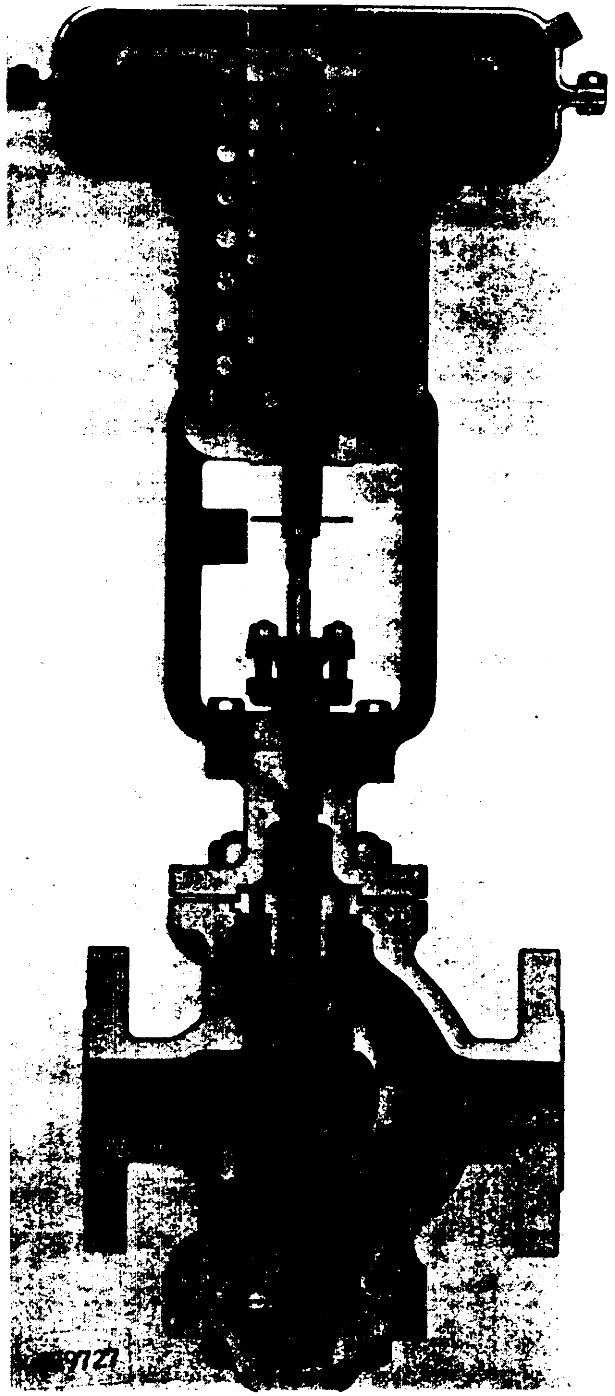

Figure 16 - MIL-V-18030, type IV (double-seated, semi-balanced)

In this design, double seated construction provides partial pressure balance and also provides greater capacity for a given stroke. Pressure balancing is only partial because the valve plugs must be of different size to permit assembly and disassembly.