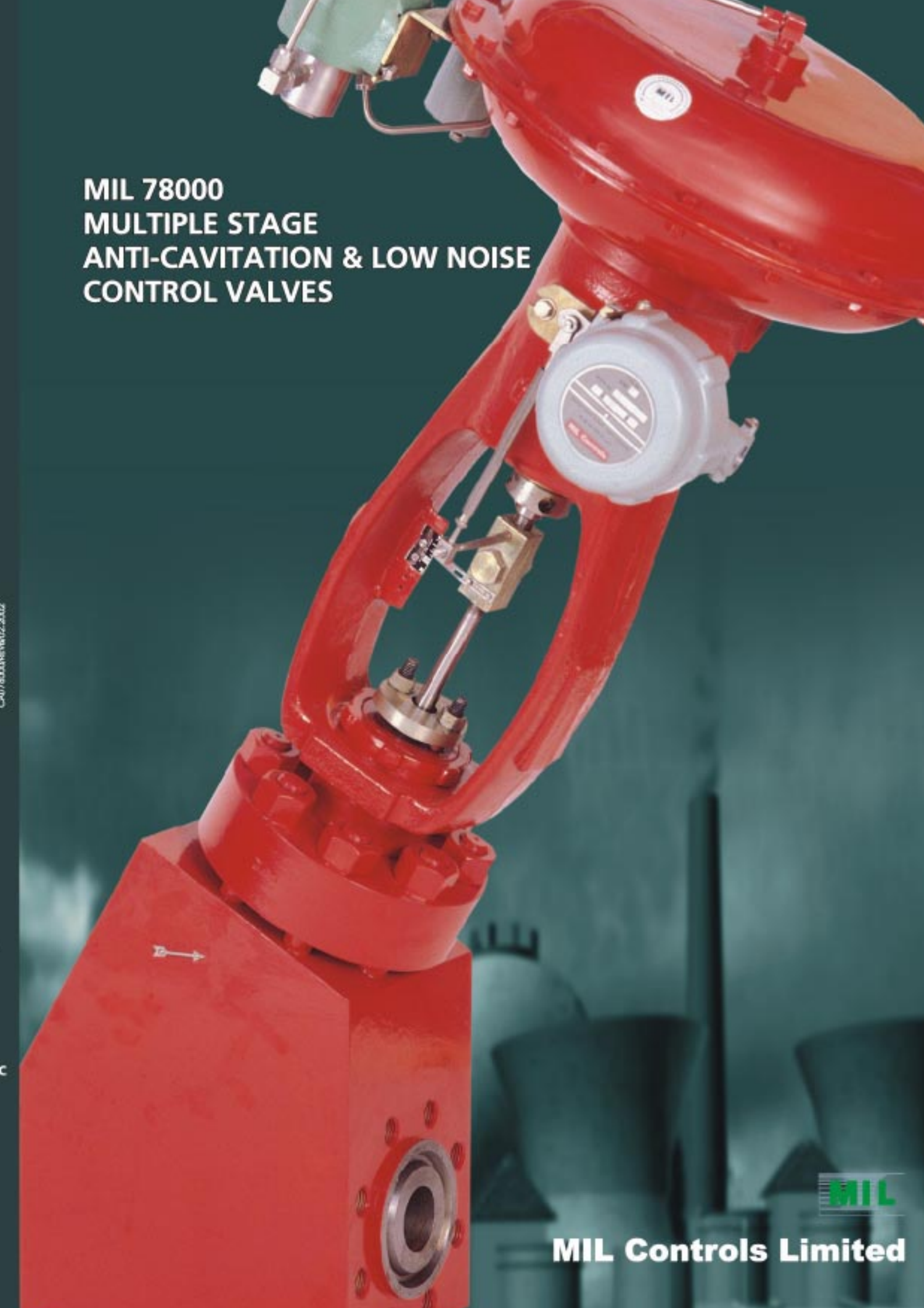


MIL 78000
MULTIPLE STAGE
ANTI-CAVITATION & LOW NOISE
CONTROL VALVES

MIL

MIL Controls Limited

COMPLETE RANGE OF MULTIPLE STAGE ANTI-CAVITATION & LOW NOISE CONTROL VALVES

With Angle body Construction - 78000
With Inline body Construction - 78100

78000 series multiple stage anti-cavitation valves provide control of high pressure fluids without erosion, vibration and high noise levels associated with conventionally designed control valves. The MIL 78000 series multi-step plug and cage design uses the principle of 'Adiabatic Flow with Friction' to reduce pressure much like pressure loss occurring in a long pipe line.

TABLE OF CONTENTS

KEY DESIGN CHARACTERISTICS

MULTIPLE-STEP AXIAL FLOW HIGH RESISTANCE TRIM

78000 design is based on the principle of multi-step high resistance axial flow. Pressure reduction occurs along the length of the plug through a series of throttling stages, designed to divide the total drop equally between the trim elements or steps (assuming incompressible flow throughout), No individual stage is ever exposed to the full pressure differential and as a result, trim life is greatly extended. In addition, the fluid takes a tortuous path. This adds resistance and therefore velocity head loss.

LOW PRESSURE RECOVERY

The valve trim is designed to reduce pressure recovery (exhibits high C_f); to lessen chances of vaporization at the orifice; and consequently, eliminates cavitation for liquid service and contributes towards reduction of noise for all fluids. When the plug is in the wide-open position, the fluid velocity is nearly constant through the trim. The tortuous flow path adds significantly to the overall pressure losses. In the wide-open position, ideal conditions are approached: that is, continuous pressure drop and no appreciable recovery. At this point, the C_f is practically equal to 1. At reduced lift positions, the throttling mechanism is similar to a piping system with a number of single stage valves in series. Each stage throttles a portion of the total pressure drop with an increase in velocity and subsequent pressure recovery. Overall pressure recovery factor varies with the number of stages and please refer page 8 for the total Pressure Recovery factor (C_f) for each size.

TIGHT SHUT-OFF & SEAT PROTECTION

Protection against seat erosion is ensured by provision of ANSI/FCI 70.2 Class V seat shut-off when standard metal seats are furnished. Pressure reduction is accomplished between the multi-step plug & the liner and not across the seat ring. Thus in any severe service, seat ring damage due to high pressure drop can be ruled out.

SPECIAL SOFT SEAT DESIGN

Bubble tight leak tightness as per ANSI/FCI 70.2 Class VI can be achieved when optional soft seats are supplied. The special seat ring with sliding collar shelters the resilient insert from the high-pressure fluid, when the valve opens.

HIGH-PERFORMANCE MATERIAL IS STANDARD

78000 series high pressure valves are manufactured from solid steel forgings to assure material integrity. Castings also available as option. Without exception, the material specified as standard have been tested and selected to provide trouble free operation in services with high pressures and erosive fluids. The high performance trim material employed ensures durability of the valve for any severe application. Special trim material available for NACE and corrosive application.

HIGH ALLOWABLE PRESSURE DROPS

With balanced trim design for sizes 2" through 6", a wide range of allowable shut -off pressure drops is available with conventional spring diaphragm actuators.

VARIETY OF BODY CONFIGURATION OFFERINGS

A standard angle body and optional in-line body styles are offered to accommodate a variety of piping requirements.

SIMPLE TRIM MAINTENANCE

The multiple step trim, made from specially chosen hard material gives maximum service life and the quick change seat ring design provides ease of trim replacement.

LARGE FLOW AREA

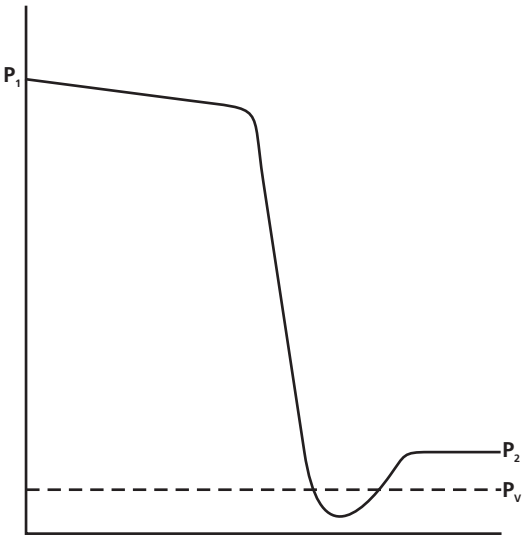
Because of their relatively large flow passages and shearing action provided by the multiple stage plug & cage designs, these valves are particularly well suited for applications involving fluids with entrained particles.

Leakage Class / Temperature Range[3]

Valve Size (Inch)	Type	Temperature Range (Deg.C)		Seat Leakage Class (As per ANSI/FCI 70.2)	
1 through 6	Unbalanced Metal Seat	-29	260	IV	V
2 through 6	Balanced Metal Seat	-29	232	IV	V
1 through 6	Soft Seat	-29	204	VI	

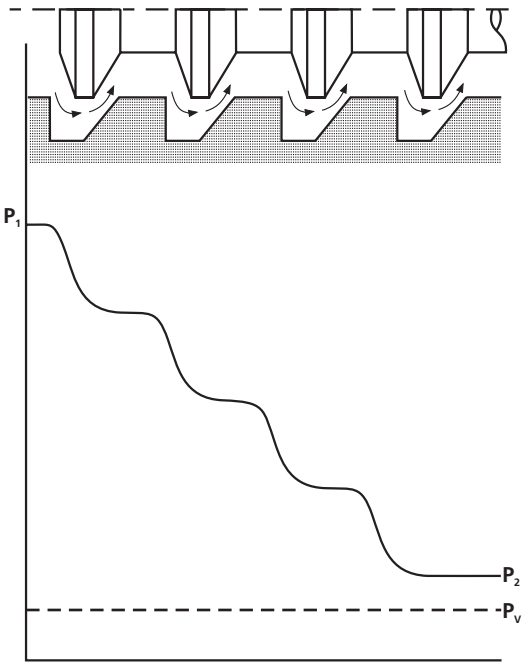
Class IV : 0.01% of maximum rated capacity at 50 psig to atmosphere
Class V : 5 x 10^{-4} ml/min of water per inch of orifice diameter per psi differential
Class VI: Bubble Tight as per ANSI/FCI 70.2

(3) : Special Designs available for applications outside the given temperature range, consult MIL

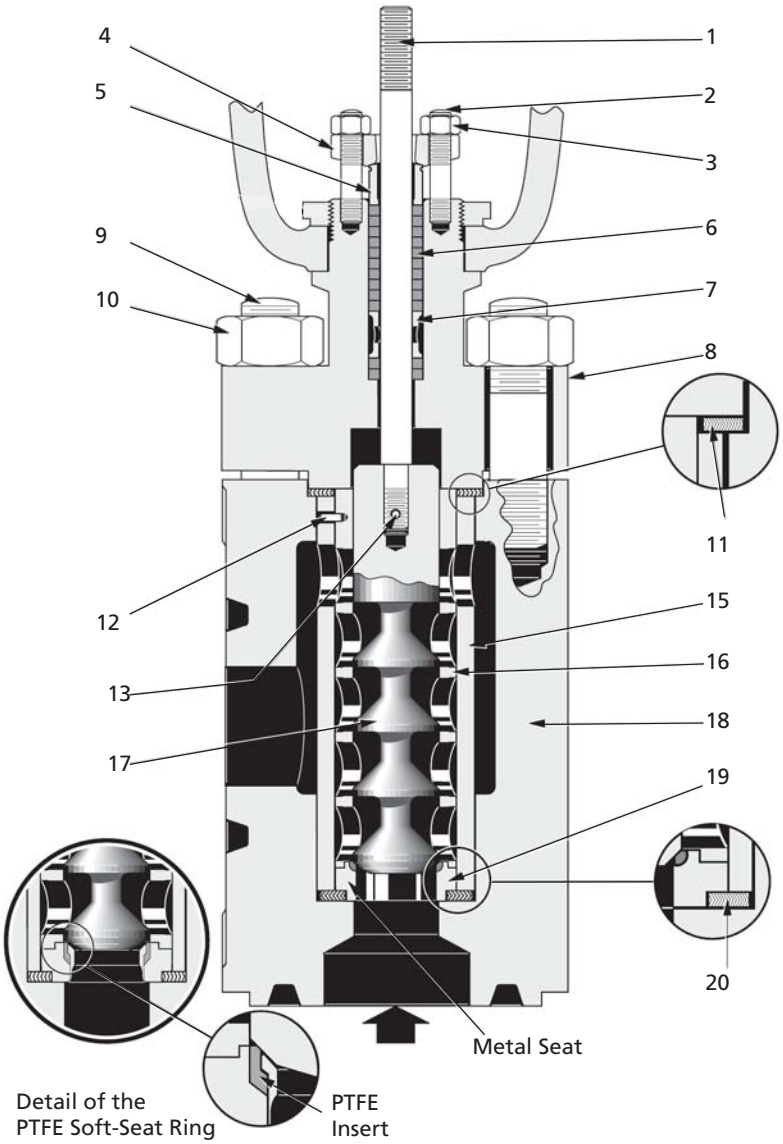


PRESSURE DROP DIAGRAM OF A CONVENTIONAL VALVE IN CAVITATING SERVICE

(Pressure drops below the vapour pressure at the vena-contracta and then recovers, resulting in cavitation.



78000 PLUG AT FULL OPEN POSITION
(Continuous pressure drop & no appreciable recovery)

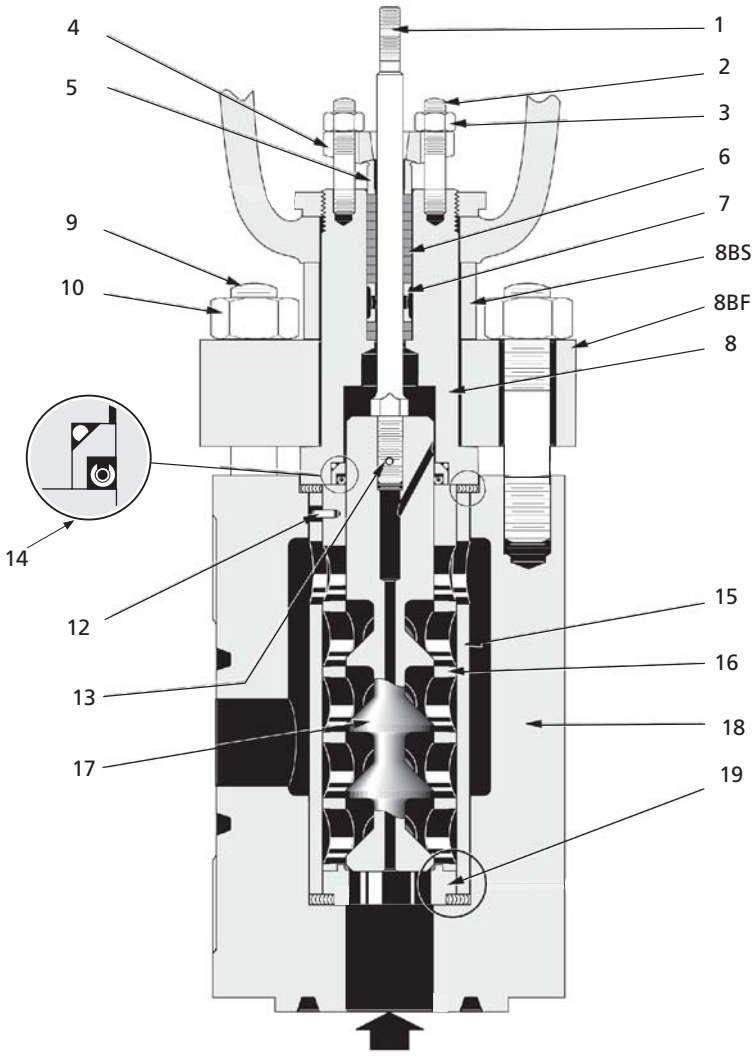


78000 SERIES UNBALANCED PLUG CONSTRUCTION

Material of construction [4]

Drawing Ref. No.	Part Name	Standard Material	
1	Valve Plug Stem	St. Steel 17.4 PH ASTM A 564 Gr 630, Cond H 1075	
2	Packing Flange Stud	Alloy Steel ASTM A 193 Gr. B7	
3	Packing Flange Nut	St. Steel ASTM A 194 Gr. 8	
4	Packing Flange	Carbon Steel ASTM A 105	
5	Packing Follower	St. Steel ASTM A 479 Ty 304	
6	Gland Packing	<180°C	PTFE
		>180°C	GRAPHITE
7	Packing Spacer/Lantern Ring	St. Steel ASTM A 479 Ty 304	
8,18	Bonnet, Body	Carbon Steel ASTM A 105	
		Alloy Steel ASTM A 182 Gr. F11 / F22	
		Stainless Steel ASTM A 182 Gr. F316	
8BS	Bonnet Spacer [5]	Carbon Steel ASTM A 106 Gr. B	
8BF	Bonnet Flange [5]	Carbon Steel ASTM A 105	
9	Body Stud	Alloy Steel ASTM A 193 Gr. B7	
10	Body Nut	Alloy Steel ASTM A 194 Gr 2H	
11	Body Gasket	SS 304 + Asbestos or Graphite (spiral wound)	
12,13	Roll Pin, Plug Pin	ASTM A 276 Ty. 420 (Roll Pin), SS 316 (Plug Pin)	
14	Balancing Seal Set [6]	< 232°C	Spring energised Carbon Filled PTFE
15	Spacer	St. Steel 17.4 PH ASTM A 564 Gr 630, Cond H 1075	
16	Liner	St. Steel 17.4 PH ASTM A 564 Gr 630, Cond H 1075	
17	Plug	St. Steel 440 C ASTM A 276 Ty 440C, Hardened	
19	Seat Ring	St. Steel ASTM A 479 Ty 316+ Stellite No. 6 or PTFE	
20	Seat Ring Gasket	SS 304 + Asbestos or Graphite (spiral wound)	

(4): For other material consult MIL
(5): Refer page 6, For sizes 2" through 6" only
(6): Refer page 6, For balanced construction only, sizes 2" through 6"



78000 SERIES BALANCED PLUG CONSTRUCTION

Optional Material for Corrosive Service [4]

Drawing Ref. No.	Part Name	Standard Material	
1	Valve Plug Stem	Inconel X 750 ASTM A 461 (HRC 35 max.)	
2	Packing Flange Stud	Alloy Steel ASTM A 193 Gr. B7	
3	Packing Flange Nut	St. Steel ASTM A 194 Gr. 8	
4	Packing Flange	Carbon Steel ASTM A 105	
5	Packing Follower	St. Steel ASTM A 479 Ty 304	
6	Gland Packing	<180°C	PTFE
		>180°C	GRAPHITE
7	Packing Spacer/Lantern Ring	St. Steel ASTM A 479 Ty 304	
8,18	Bonnet, Body	Carbon Steel ASTM A 105 Stainless Steel ASTM A 182 Gr. F316 (HRC 22 max.)	
8BS	Bonnet Spacer [5]	Carbon Steel ASTM A 106 Gr. B	
8BF	Bonnet Flange [5]	Carbon Steel ASTM A 105	
9	Body Stud	Alloy Steel ASTM A 193 Gr. B7	
10	Body Nut	Alloy Steel ASTM A 194 Gr 2H	
11	Body Gasket	SS 304 + Asbestos or Graphite (spiral wound)	
12,13	Roll Pin, Plug Pin	ASTM A 479 Ty 316	
14	Balancing Seal Set [6]	<232°C	Spring energised Carbon filled PTFE
15	Spacer	Ferralium 255, ASTM A 351 Gr. CD4MCU or Monel K500 or Inconel X 750 (HRC 35 max.)	
16	Liner	Ferralium 255, ASTM A 351 Gr. CD4MCU or Monel K500 or Inconel X 750 (HRC 35 max.)	
17	Plug	Nitronic 60, ASTM A479 Type S21800 with Hard facing on seat area or Nitronic 50, ASTM A479 Type XM19 with HF on seat & guide area (HRC 35 max.)	
19	Seat Ring	St. Steel ASTM A 479 Ty 316+ Stellite No. 6 or PTFE	
20	Seat Ring Gasket	SS 304 + Asbestos or Graphite (spiral wound)	

(4): For other material consult MIL, Certification to NACE MR01-75, Latest revision available
(5): Refer page 6, For sizes 2" through 6" only
(6): Refer page 6, For balanced construction only, sizes 2" through 6"

Flow Coefficients - Rated Cv, Critical Flow Factor - Cf

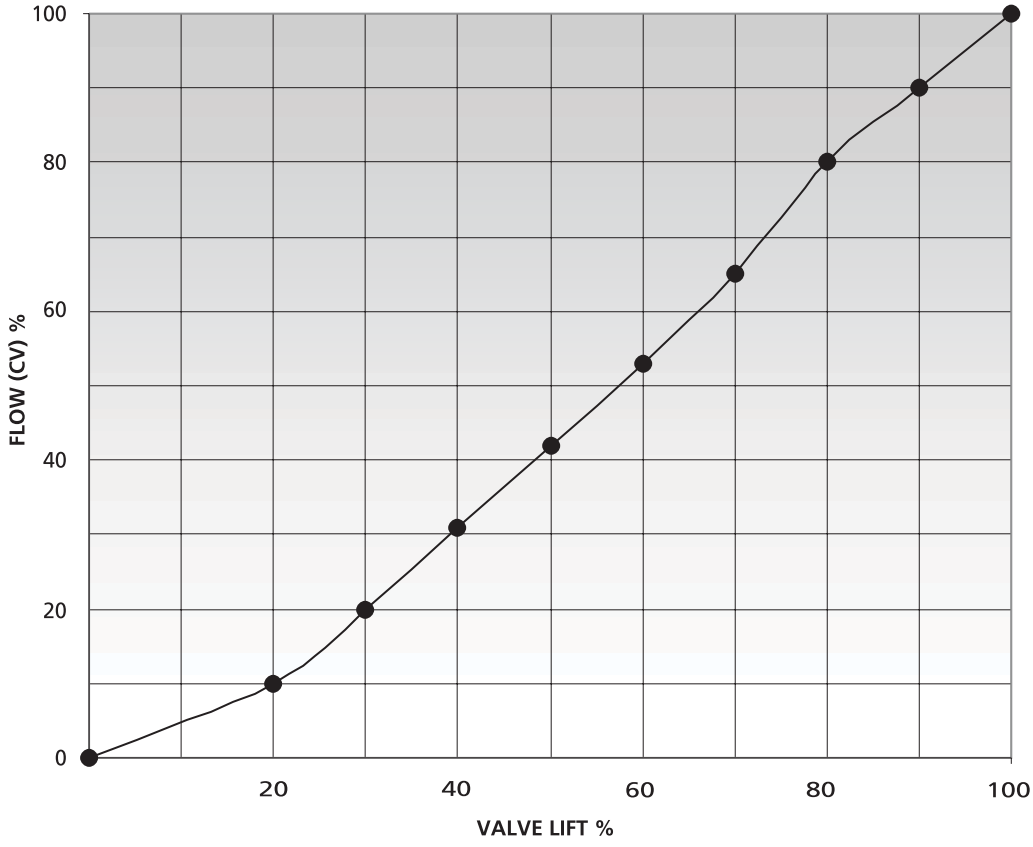
Valve Size & Rating	Orifice Dia (Inch)	Travel (Inch)	Trim Type								Minimum Operable Cv
			Liquid						Gas or Steam		
			A		B		B+				
			Cf	Cv	Cf	Cv	Cf	Cv	Cf	Cv	
1"≤2500#	0.500	0.125	0.998	0.1, 0.3	0.992	0.6	0.985	0.9, 1.1	0.970	0.75	0.03
1.5"≤2500#	1.00	0.25	0.997	1.2	0.991	2.4	0.982	3.6, 4.5	0.970	3.5	0.06
2"≤2500#	1.875	0.50	0.997	4	0.991	8	0.982	12, 15	0.970	13	0.12
3"≤2500#	3.250	0.88	0.997	15	0.988	30	0.978	40, 55, 70*	0.970	40	0.61
4"≤2500#	3.250	0.88	0.997	15	0.988	30	0.978	40, 55, 70*	0.970	40	0.61
6"≤600#	3.250	0.88	-	-	-	-	0.978	70, 110	0.970	60	1.5
6"≥900#	3.250	0.88	0.997	15	0.988	30	0.978	55	0.970	40	0.61

** Cv-70 with cast body upto ANSI Class 600#*

Trim Characteristic

78000 series valves have an inherent Mod. Linear characteristic, integrating the clearance flow concept over 10% of the initial valve travel to avoid high pressure drops in the seating area and throttling at low lifts. The 10 to 100% of the travel ensures precise control.

VALVE CAPACITY AS A FUNCTION OF PLUG LIFT (EXPRESSED AS PERCENTAGE OF CV)



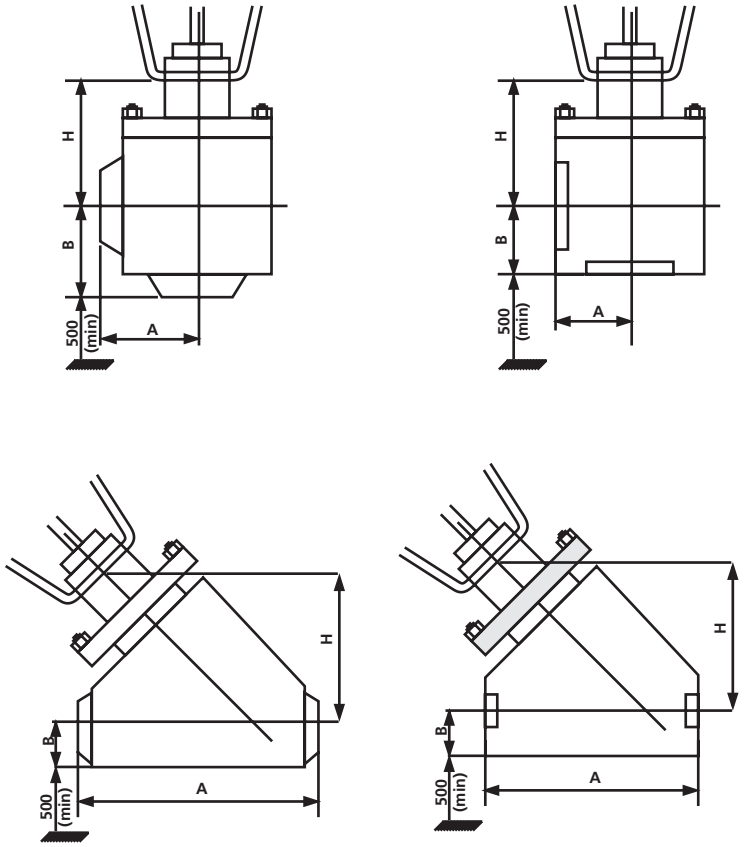
Actuator Selection for 78000 series unbalanced valves

Valve Size	Max. Rating ANSI	Stroke (inch)	Act. Size	Air to Close (37)				Air to Open (38)		
				Spring Range Psig	Supply Press. Psig	Shut off Pressure Kg/cm^2		Spring Range Psig	Shut off Pressure Kg/cm^2	
						V	VI		V	VI
1	2500	0.125	13	6-10	25	210	210	12-16	210	210
				6-10	30	420	420	18-22	420	420
1.5	2500	0.25	15	6-12	30	210	210	14-20	175	175
				6-12	50	420	420	24-30	316	316
2	2500	0.5	15	6-16	40	70	70	16-25	35	35
				6-16	60	140	140	23-33	60	60
3	2500	0.88	18	3-15	30	28	28	15-25	17	14
				3-15	60	70	63	18-30	28	21
4	2500	0.88	18	3-15	30	28	28	15-25	17	14
				3-15	60	70	63	18-30	28	21
6	2500	0.88	18	3-15	30	28	28	15-25	17	14
				3-15	60	70	63	18-30	28	21

Actuator Selection for 78000 series balanced valves

Valve Size	Max. Rating ANSI	Stroke (inch)	Act. Size	Air to Close (37)				Air to Open (38)		
				Spring Range Psig	Supply Press. Psig	Shut off Pressure Kg/cm^2		Spring Range Psig	Shut off Pressure Kg/cm^2	
						V	VI		V	VI
2	2500	0.5	15	6-16	35	210	210	16-25	210	210
				6-16	45	420	420	23-33	386	344
3	2500	0.88	18	3-15	50	210	210	15-25	140	77
				3-15	60	420	330	18-29	228	109
4	2500	0.88	18	3-15	50	210	210	15-25	140	77
				3-15	60	420	330	18-29	228	109
6	2500	0.88	18	3-15	50	210	210	15-25	140	77
				3-15	60	420	330	18-29	228	109

Dimensions (mm)



Approximate dimensions of 78000 series Forged Valves, 2500#ANSI

All dimensions in mm

VALVE SIZE (inch)	ANGLE VALVE						INLINE VALVE		
	BUTT WELD			SOCKET WELD			BUTT & SOCKET WELD		
	A	B	H	A	B	H	A	B	H
1	95	104	179	65	101.5	179	220	58	183
1.5	119	119	217	80	117	217	300	51	223
2	165	178	283	100	163	283	394	71	259
3	225	235	375	150	216	375	394	71	259
4X2	165	178	283	-	-	-	430	71	298
4X3	220	226	336	-	-	-	610	108	417
6X3	205	271	376	-	-	-	575	91	427

Face to Face dimension tolerance ± 2mm

Specification Data

Checklist below contains the necessary data to specify the basic 78000 series control valve. The page reference will guide you to the appropriate sections when a selection is to be made. For accessories and special options, consult your MIL representative

Body	Type		Angle ☐		Inline ☐
	Size		Refer Page 8		
	Rating		Refer Page 8		
	Connection		Flanged ☐	Butt-Weld ☐	Socket-Weld ☐
	Material		Refer Page 5,7		
Bonnet	Type		Standard ☐		With Bellow Seal ☐
	Packing		Refer Page 5,7		
	Lubricator		Yes ☐		No ☐
Trim	Type		A(Liquid) ☐		B(Liquid) ☐
			B+(Liquid)☐		Gas or Steam ☐
			Special ☐		
	Liner&Spacer	Material	Refer Page 5,7		
	Plug	Type	Unbalanced ☐		Balanced ☐
		Guiding	Liner		
		Material	Refer Page 5,7		
	Seat Ring	Type	Clamped		
		Material	Refer Page 5,7		
Flow Direction			Flow to Open		
Leakage Class(ANSI/FCI 70.2)			IV ☐	V ☐	VI ☐
Actuator	Type		Pneumatic Spring Diaphragm ☐		Electrical ☐
			Piston Cylinder ☐		Manual ☐
	Action		Air to Open ☐		Air to Close ☐
	Air Failure		Close ☐	Open ☐	Stayput ☐
	Actuator Size		Refer Page 9		
	Actuator Spring Range		Refer Page 9		
Hand Wheel			Yes ☐	No ☐	
Model Number			Refer Page 2		
Accessories & Special Requirements					

Application Data

Checklist below provides a convenient means for listing all the process data required to properly size your 78000 series control valve.

FLUID PHASE	Liquid ☐ Gas ☐ Steam ☐ Two-Phase ☐		
Required Parameters	Liquid	Gas	Steam
Flow Rate (Start-up/Min/Nor/Max)	✓	✓	✓
Inlet Press. (Start-up/Min/Nor/Max)	✓	✓	✓
Outlet Press. Start-up/Min/Nor/Max)	✓	✓	✓
Shut-off Pressure	✓	✓	✓
Temperature	✓	✓	✓
Specific Gravity or Density or Mol. Wt.	✓	✓	
Vapour Pressure	✓		
Critical Pressure	✓		
Viscosity	✓		
Compressibility Factor		✓	
Specific Heat Ratio		✓	
Inlet & Outlet Pipe Size/Schedule	✓	✓	✓

Other useful information

Maximum working pressure for standard material (as per ASME B 16.34 - 1996)

Working Temp		Max. Working Pressure in Kg. /cm^2											
^{0}F	^{0}C	ANSI 150#		ANSI 300#		ANSI 600#		ANSI 900#		ANSI 1500#		ANSI 2500#	
		WCC	WC6	WCC	WC6	WCC	WC6	WCC	WC6	WCC	WC6	WCC	WC6
100	38	20	20	53	53	105	105	158	158	264	264	440	440
200	93	18	18	53	53	105	105	158	158	264	264	440	440
300	149	16	16	51	51	102	102	154	152	256	254	427	427
400	204	14	14	50	49	99	97	149	146	248	244	414	414
500	260	12	12	47	47	94	94	140	140	234	234	390	390
600	316	10	10	43	43	85	85	128	128	213	213	354	354
650	343	9	9	41	41	83	83	124	124	207	207	345	345
700	371	8	8	40	40	80	80	120	120	200	200	333	333
750	399	7	7	36	37	71	75	106	112	177	187	295	312
800	427	6	6	29	36	58	71	87	107	145	179	241	297
850	454	5	5	19	34	38	69	57	103	94	171	157	263
900	482	4	4	12	32	24	63	36	95	60	158	101	187
950	510	2	2	7	23	14	45	22	67	36	112	60	127
1000	537	1	1	4	15	7	30	11	46	18	76	30	30

Working Temp		Max. Working Pressure in Kg./ cm^2											
^{0}F	^{0}C	ANSI 150#		ANSI 300#		ANSI 600#		ANSI 900#		ANSI 1500#		ANSI 2500#	
		WC9	CF8M	WC9	CF8M	WC9	CF8M	WC9	CF8M	WC9	CF8M	WC9	CF8M
100	38	20	19	53	51	105	101	158	152	264	253	440	422
200	93	18	17	53	44	105	87	158	131	264	218	440	363
300	149	16	15	51	39	102	79	154	118	256	197	427	328
400	204	14	14	50	36	99	72	149	108	248	181	414	301
500	260	12	12	47	34	94	67	140	101	234	168	390	280
600	316	10	10	43	32	85	63	128	95	213	159	354	264
650	343	9	9	41	31	83	63	124	94	207	156	345	260
700	371	8	8	40	30	80	61	120	92	200	153	333	255
750	399	7	7	37	30	75	60	112	90	187	150	312	250
800	427	6	6	36	30	71	59	107	89	179	148	297	248
850	454	5	5	34	30	69	59	103	88	171	147	286	245
900	482	4	4	32	29	63	58	95	88	158	146	263	243
950	510	2	2	26	27	53	55	79	82	133	136	221	226
1000	537	1	1	18	25	37	49	55	74	92	123	153	205
1050	565	1	1	12	24	25	48	37	72	62	121	102	201

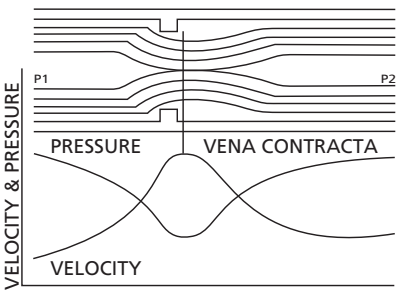
FUNDAMENTAL DEFINITIONS

FLOW COEFFICIENT (Cv): Cv, which is universally accepted as a yardstick of control valve capacity is defined as the number of US gallons per minute of water at 60F that will pass through a given flow restriction with a pressure drop of 1 psi. For example, a control valve, which has a maximum Cv of 16, has an effective full port area which allows flow of 16 gallons per minute of water with 1 psi pressure drop.

CRITICAL FLOW FACTOR (Cf): Cf is a dimensionless expression of the pressure recovery ratio in a control valve. As the fluid flows through a valve orifice, there is a marked increase in velocity. Increase in velocity is accompanied by a decrease in pressure. Velocity reaches a maximum and pressure it's minimum at the smallest cross-sectional flow stream area downstream of the orifice (vena contracta). Downstream to the vena contracta, the fluid decelerates and consequently the pressure recovers, hence the term pressure recovery.

$$Cf = \sqrt{\frac{P1 - P2}{P1 - Pvc}}$$

P1: Valve Upstream Pressure
P2: Downstream Pressure
Pvc: Vena Contracta Pressure

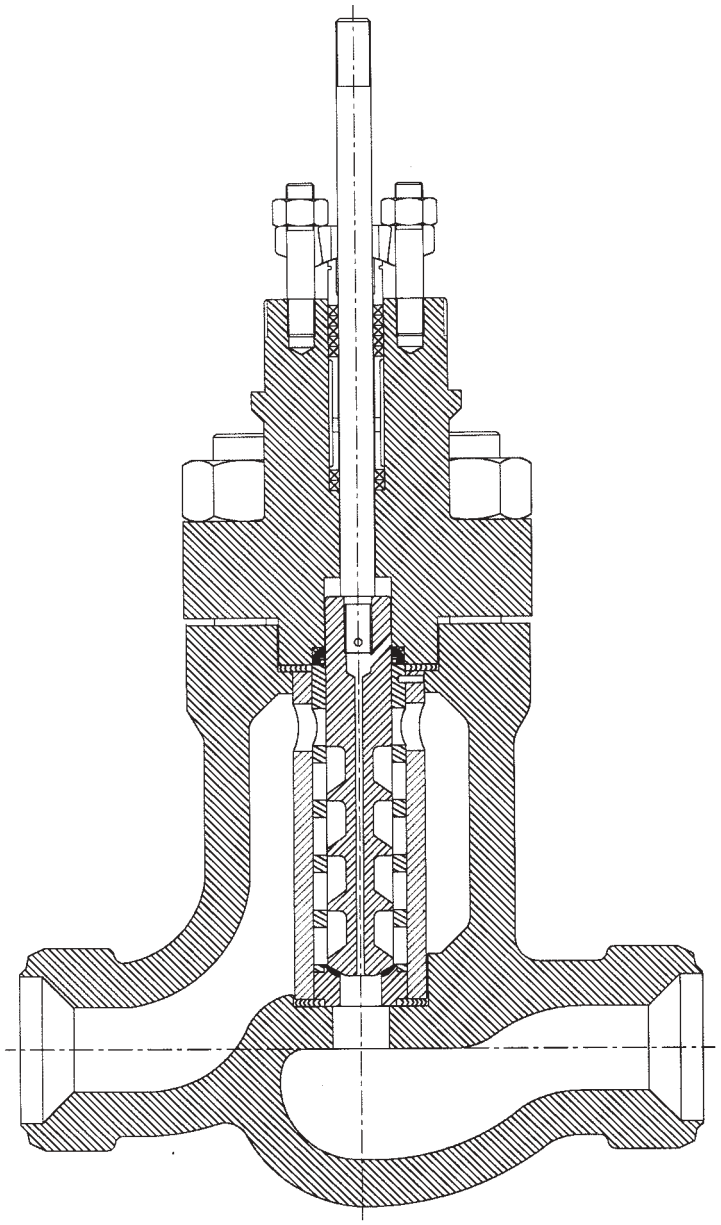


Optional Design

AVAILABLE SIZES / RATINGS

2"	600#	Inline
2"	1500#	Inline
4" x 2"	600#	Inline
4" x 2"	2500#	Inline
4" x 3"	2500#	Inline

6" x 3"	600#	Inline
6" x 3"	2500#	Inline
4" x 2"	600#	Angle
6" x 3"	600#	Angle



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