Unbalanced and Pressure-balanced Trim

Unbalanced Trim Types

Valtek offers three unbalanced trim designs: 1) standard full area trim which provides maximum C_v with a removable seat ring; 2) reduced trim which provides a lower C_v in a wide variety of sizes or when larger bodies are required; and 3) integral seat trim which utilizes the seat machined into the body and an oversized plug to provide additional C_v beyond the capabilities of standard full area trim.

Mark One, Mark Two and Mark Eight valves can be converted from one unbalanced trim type to another since all seat rings and plugs within a given size and pressure class are completely interchangeable. Integral seat trim is available by changing the plug and removing the seat ring. Table 8-III lists the values for unbalanced, full trims.

NOTE: *All Mark One, Mark Two, Mark Eight, and Mark Eleven bodies are machined with integral seats, except ANSI Classes 900, 1500 and 2500.*

Pressure-balanced Trim

Some high pressure drop applications or valves with large seat diameters may require pressure-balanced trim. Pressure-balanced trim reduces the actuator thrust requirement by reducing the trim's effective off-balance area. However, with high-thrust cylinder actuators, pressure-balanced trim may not be required. Often, an over-sized cylinder actuator may be the most economical choice.

Because the pressure-balanced plug fits closely to the sleeve (or retainer), the trim should be used in relatively clean services.

As a standard, pressure-balanced trim is designed to ANSI Class II shutoff for valve sizes ½ to 3-inch and Class III shutoff for valve sizes 4-inch and larger shutoff. These specifications call for a maximum seat leakage of 0.5 and 0.1 percent (respectively) of rated valve capacity. Flow direction is normally under the plug for fail-closed applications and over the plug for fail-open applications. The sleeve area minus the stem area is designed slightly larger than the seat area, creating an off-balanced area that assists closing with flow under for fail-closed applications. The off-balance area for various valve sizes are given in Table 8-IV.

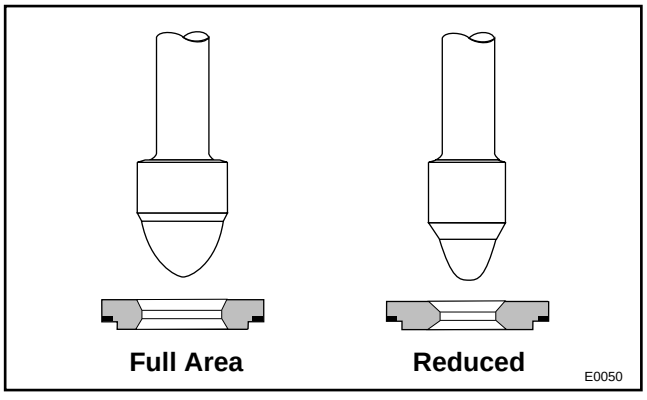

Figure 8-1: Unbalanced Trim Design

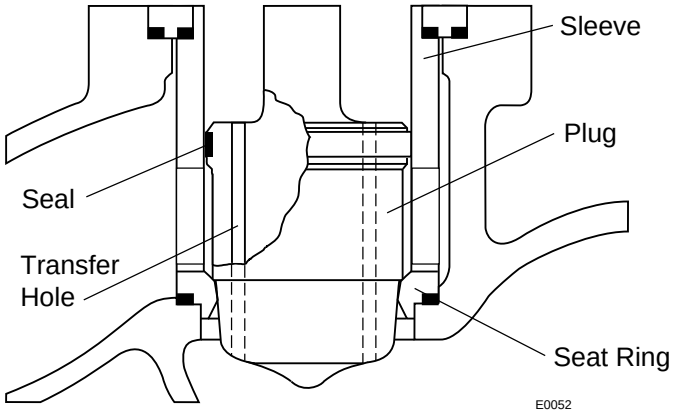

**Figure 8-2:
Typical Pressure-balanced Design**

Allowing the fluid pressure to act on both sides of the plug results in a net force equal to the pressure times the off-balance area. This balancing force is made possible by transfer holes in the plug. Leakage past the plug is prevented by a seal around the top of the plug head. Figure 8-2 shows a typical pressure-balanced design. The following list provides information about the types of plug seals available for pressure-balanced service:

Metal Seals

1. **NiResist Rings** for all sizes and pressures, and temperatures up to 800 degrees Fahrenheit. For temperatures over 600 degrees Fahrenheit, the surface of the pressure-balanced sleeve bore must be hardened. Pressure-balanced sleeves for temperatures up to 800 degrees Fahrenheit are constructed from the following materials;
   - Carbon steel with electroless nickel plating (up to 600 degrees Fahrenheit)
   - 410-416 high temperature stainless steel (up to 800 degrees Fahrenheit)
   - 316 stainless steel with Stellite overlay or (up to 1600 degrees Fahrenheit)
2. **Muskegon Multi-seal™ Rings** for temperatures from 300 to 1600 degrees Fahrenheit. When Muskegon rings are used, the bore surface of pressure-balanced sleeves must be hardened with one of the following materials:
   - 410-416 high temperature stainless steel (up to 800 degrees Fahrenheit)
   - 316 stainless steel with Stellite overlay (up to 1600 degrees Fahrenheit)

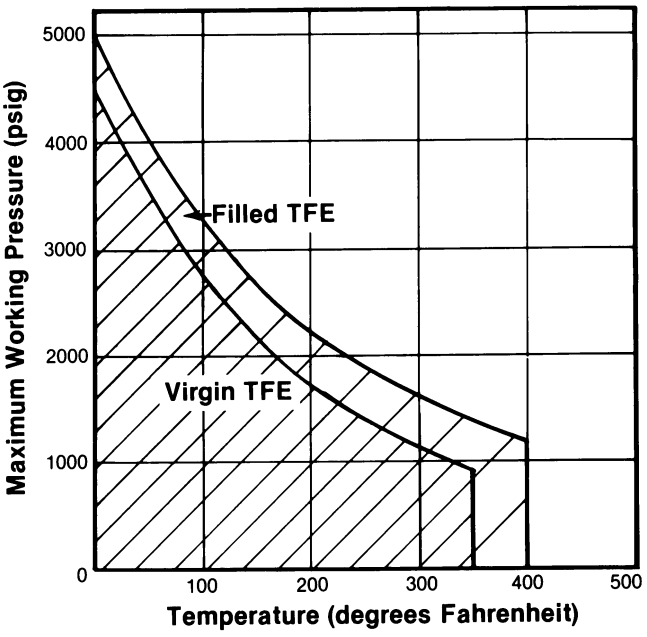

Figure 8-3: Pressure/Temperature Limitation for Teflon Seals

O-ring Seals with Backup Rings

Buna-N O-rings are standard for those applications with temperatures between -60 to 250 degrees Fahrenheit and pressures to 6000 psi. Viton O-rings can be used for higher temperatures – between -40 to 435 degrees Fahrenheit – and for pressures up to 6000 psi. Back-up rings are used in conjunction with O-rings. Special materials are available in O-rings and back-up rings for temperatures up to 500 degrees Fahrenheit.

Teflon (TFE) Seals

The maximum pressure/temperature usage for Teflon seals in pressure-balanced applications is shown in Figure 8-3:

Leakage Requirements

Table 8-I provides the class shutoff available with pressure-balanced trim and Table 8-II provides the seat loading ratings which are necessary to obtain the specified leakage rate. ANSI standard B16.104 discusses shut-off classes in section 5.

Table 8-I: Shutoff Capabilities of Pressure-balanced Trim

Metal Seats

NiResist rings	(.5 to 3-inch)	Class II
	(4-inch and above)	Class III
Muskegon rings	(.5 to 4-inch)	Class III
Muskegon rings	(6-inch and above)	Class IV
TFE Seals	Up to 10% of Class IV	
O-Ring seal	Class V	

Soft Seats

TFE Seals	Up to 1% of Class IV
O-Ring Seal	Class VI

Table 8-II: Seat Loading Rates to Obtain Specified Leakage Class

Class IV

Metal Seats*	.5 to 4-inch	50 lbs/linear inch
	6-inch and above	75 lbs/linear inch
Soft Seats	All sizes	50 lbs/linear inch

Class V

Metal Seats*	.5 to 4-inch	250 lbs/linear inch
	6-inch and above	400 lbs/linear inch
Soft Seats	All sizes	50 lbs/linear inch

Class VI

Soft Seats	.5 to 4-inch	50 lbs/linear inch
	6-inch and above	100 lbs/linear inch

* When hardened trim is used, add 100 lbs / linear inch to the listed loading rates.

Table 8-III: Unblanced Trim – Full Area

Valve Size (inches)	Rating Class	Full Area Trim Size*	Seat Area (sq. in.)	Stem Area (sq. in.)	Std. Act. Size**	Stroke (inches)
1/2	150-600	.50	.196	.248	25	.75
3/4	150-2500	.72	.405	.248	25	.75
1	150-600	.81	.518	.248	25	.75
1	900-1500	.81	.518	.248	25	.75
1	2500	.72	.405	.248	25	.75
1 1/2	150-600	1.25	1.23	.601	25	1.00
1 1/2	900-1500	1.25	1.23	.601	50	1.00
1 1/2	2500	1.00	.785	.601	50	.75
2	150-600	1.62	2.07	.601	25	1.50
2	900-1500	1.62	2.07	.601	50	1.50
2	2500	1.25	1.23	.601	50	1.00
3	150-600	2.62	5.41	.99	50	2.00
3	900-1500	2.62	5.41	1.77	100	2.00
3	2500	2.00	3.14	.99	100	1.50
4	150-600	3.50	9.62	.99	50	2.50
4	900-1500	3.50	9.62	1.77	100	2.50
4	2500	2.62	5.41	1.77	100	2.00
6	150	5.00	19.63	.99	50	3.00
6	300-1500	5.00	19.63	3.14	100	3.00
6	2500	4.00	12.57	3.14	100	3.00
8	150	6.25	30.68	1.77	100	4.00
8	300-600	6.25	30.68	3.14	100	4.00
8	900-1500	6.25	30.68	4.91	100	4.00
8	2500	5.00	19.63	4.91	100	3.00
10	150	8.75	60.13	3.14	100	4.00
10	300-600	8.75	60.13	4.91	100	4.00
10	900-1500	8.00	50.27	7.07	100	4.00
10	2500	6.25	30.68	7.07	100	4.00
12	150	9.50	70.88	3.14	100	4.00
12	300-600	9.50	70.88	7.07	100	4.00
12	900-2500	8.00	50.27	7.07	100	4.00
14	150	11.00	95.03	7.07	100	4.00
14	300-600	11.00	95.03	7.07	100	4.00

*This data does not always apply to ChannelStream or MegaStream trim.
**Minimum standard actuator size. Oversized actuators may be required for large pressure drops.

Flow Direction

Unbalanced trim design generally requires that the direction of flow should assist the motion of failure, for example, flow-over for fail-closed and flow-under for fail-open. The force required to fail-open or closed is a function of the off-balanced area. This area is equal to the seat area in fail-open applications and the seat area minus the stem area in fail-closed applications. Values for unbalanced, or standard, full trim are listed in Table 8-III.

Table 8-IV: Pressure-balanced Trim – Full Area

Valve Size (inches)	Rating Class	Full Area Trim Size*	Seat Area (sq.in.)	Stem Area (sq.in.)	Sleeve Area (sq.in.)	Off-balance Area (sq.in.) to close	Off-balance Area (sq.in.) to open	Standard Actuator SIze**	Stroke (inches)
2	600	1.62	2.07	.248	2.58	.26	.51	25	1
2	1500	1.62	2.07	.248	2.41	.09	.34	25	1
2	2500	1.25	1.23	.248	1.55	.07	.32	25	1
3	600	2.62	5.41	.601	6.77	.76	1.36	50	1.5
3	1500	2.62	5.41	.601	6.49	.48	1.08	100	2
3	2500	2.00	3.14	.601	3.86	.12	.72	100	1.5
4	600	3.50	9.62	.601	11.41	1.19	1.79	50	2
4	1500	3.50	9.62	.994	11.41	.80	1.79	100	2
4	2500	2.62	5.41	.994	6.77	.37	1.36	100	2
6	150	5.00	19.63	.994	22.69	2.06	3.06	50	2.5
6	600	5.00	19.63	1.77	23.76	2.36	4.13	100	2.5
6	1500	5.00	19.63	1.77	22.69	1.29	3.06	100	2.5
6	2500	4.00	12.57	1.77	15.03	.69	2.46	100	2.5
8	600	6.25	30.68	1.77	35.78	3.33	5.10	100	3
8	1500	6.25	30.68	3.14	35.78	1.96	5.10	100	4
8	2500	5.00	19.63	3.14	23.76	.99	4.13	100	4
10	600	8.00	50.27	3.14	58.36	4.95	8.09	100	3
10	1500	8.00	50.27	4.91	58.36	3.18	8.09	100	4
10	2500	6.25	30.68	4.91	37.12	1.53	6.44	100	4
12	600	9.50	70.88	4.91	78.54	6.73	11.64	100	4
12	1500	9.50	70.88	4.91	79.53	3.74	8.65	100	4
12	2500	8.00	50.27	4.91	56.75	1.57	6.48	100	4
14	150	11.00	95.03	4.91	108.43	8.49	13.40	100	4
14	600	11.00	95.03	7.07	106.05	3.95	11.02	100	4
14	1500	11.00	95.03	7.07	103.87	1.77	8.84	100	4
16	600	12.75	127.68	7.07	148.49	13.74	20.81	100	4
16	1500	12.75	127.68	7.07	140.61	5.86	12.93	100	4

*This data does not always apply to ChannelStream or MegaStream trim.
**Minimum standard actuator size. Oversized actuators may be required for large pressure drops.

Flow Direction

Pressure-balanced trim design generally requires that the direction of flow be opposite to standard (unbalanced) trim to oppose the motion of failure--for example, flow-over for fail-open and flow-under for fail-closed. The force required to fail-open or closed is a function of the off-balanced area. This area is equal to the sleeve area minus the stem and seat area in fail-closed applications. When flowing under the seat, the net off-balanced area pushes downward to assist closure. For fail-open applications, the off-balanced area is equal to the sleeve area minus the seat area, thus there is an upward force with flow over the seat to assist failing open. Values for full area, first and second reduction are listed in Tables 8-IV, 8-V and 8-VI.

Table 8-V: Pressure-balanced Trim – First Reduction

Valve Size	Rating	Trim Size	Seat Area	Stem Diameter	Stem Area	Sleeve Diameter	Sleeve Area	OBA* to close	OBA* to open
2	600	1.25	1.23	.56	.26	1.44	1.62	.15	.39
2	1500	1.25	1.23	.56	.25	1.44	1.62	.15	.39
2	2500	1.00	.79	.56	.25	1.19	1.11	.07	.32
3	600	2.00	3.14	.88	.61	2.31	4.20	.46	1.06
3	1500	2.00	3.14	.88	.61	2.25	3.98	.23	.83
3	2500	1.25	1.23	.88	.61	1.56	1.92	.09	.69
4	600	2.62	5.41	.88	.61	2.88	6.49	.48	1.08
4	1500	2.62	5.41	1.12	.99	2.94	6.77	.37	1.36
4	2500	2.00	3.14	1.12	.99	2.34	4.32	.18	1.17
6	150	4.00	12.57	1.12	.99	4.38	15.03	1.47	2.47
6	600	4.00	12.57	1.50	1.77	4.50	15.90	1.57	3.34
6	1500	4.00	12.57	1.50	1.77	4.38	15.03	.70	2.47
6	2500	3.00	7.07	1.50	1.77	3.44	9.28	.44	2.21
8	600	5.00	19.63	1.50	1.77	5.50	23.76	2.36	4.12
8	1500	5.00	19.63	2.00	3.14	5.50	23.76	.98	4.12
8	2500	4.00	12.57	2.00	3.14	4.56	16.35	.64	3.78
10	600	6.25	30.68	2.00	3.14	6.88	37.12	3.30	6.44
10	1500	6.25	30.68	2.50	4.91	6.88	37.12	1.53	6.44
10	2500	5.00	19.63	2.50	4.91	5.69	25.41	.86	5.77
12	600	7.38	42.78	2.50	4.91	8.12	51.85	4.22	9.13
12	1500	7.38	42.78	2.50	4.91	8.00	50.27	2.62	7.55
12	2500	6.25	30.68	2.50	4.91	6.81	36.45	.86	5.77
14	150	8.00	50.27	2.50	4.91	8.75	60.13	4.96	9.87
14	600	8.00	50.27	3.00	7.07	8.88	61.86	4.53	11.60
14	1500	8.00	50.27	3.00	7.07	8.75	60.13	2.80	9.87
16	600	10.00	78.54	3.00	7.07	11.00	95.03	9.42	16.49
16	1500	10.00	78.54	3.00	7.07	10.75	90.76	5.15	12.22

* off balance area

Table 8-VI: Pressure-balanced Trim – Second Reduction

Valve Size	Rating	Trim Size	Seat Area	Stem Diameter	Stem Area	Sleeve Diameter	Sleeve Area	OBA* to close	OBA* to open
2	600	1.00	.79	.56	.25	1.22	1.17	.14	.38
2	1500	1.00	.79	.56	.25	1.19	1.11	.07	.32
2	2500	.81	.52	.56	.25	1.00	.79	.02	.27
3	600	1.25	1.23	.88	.61	1.62	2.07	.25	.85
3	1500	1.25	1.23	.88	.61	1.56	1.92	.09	.69
3	2500	1.00	.79	.88	.61	1.38	1.48	.10	.70
4	600	2.00	3.14	.88	.61	2.31	4.20	.46	1.06
4	1500	2.00	3.14	1.12	.99	2.34	.43	.18	1.17
4	2500	1.50	1.77	1.12	.99	1.91	2.85	.09	1.09
6	150	3.00	7.07	1.12	.99	3.38	8.95	.88	1.88
6	600	3.00	7.07	1.50	1.77	3.50	9.62	.79	2.55
6	1500	3.00	7.07	1.50	1.77	3.44	9.28	.44	2.21
6	2500	2.25	3.98	1.50	1.77	2.75	5.94	.20	1.96
8	600	4.00	12.57	1.50	1.77	4.50	15.90	1.57	3.34
8	1500	4.00	12.57	2.00	3.14	4.56	16.35	.64	3.78
8	2500	3.00	7.07	2.00	3.14	3.69	10.68	.47	3.61
10	600	5.00	19.63	2.00	3.14	5.63	24.85	2.07	5.22
10	1500	5.00	19.63	2.50	4.91	5.75	25.97	1.42	6.33
10	2500	4.00	12.57	2.50	4.91	4.81	18.19	.71	5.62
12	600	6.00	28.27	2.50	4.91	6.81	36.45	3.26	8.17
12	1500	6.00	28.27	2.50	4.91	6.63	24.47	1.29	6.20
12	2500	5.00	19.63	2.50	4.91	5.69	25.40	.86	5.77
14	150	6.25	30.68	2.50	4.91	7.00	38.48	2.90	7.80
14	600	6.25	30.68	3.00	7.07	7.13	39.87	2.12	9.19
14	1500	6.25	30.68	3.00	7.07	7.00	38.48	.74	7.80
16	600	7.75	47.17	3.00	7.07	8.75	60.13	5.89	12.96
16	1500	7.75	47.17	3.00	7.00	8.75	56.75	2.50	9.57

*off balance area