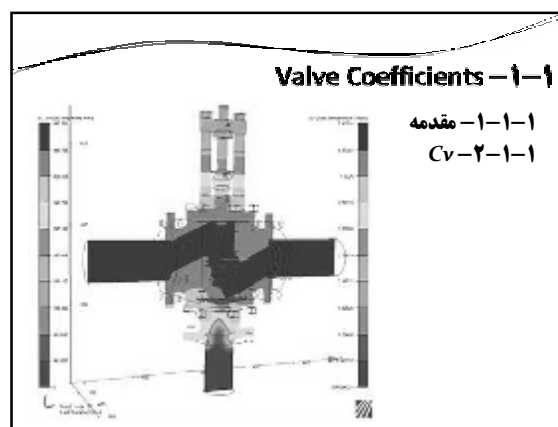
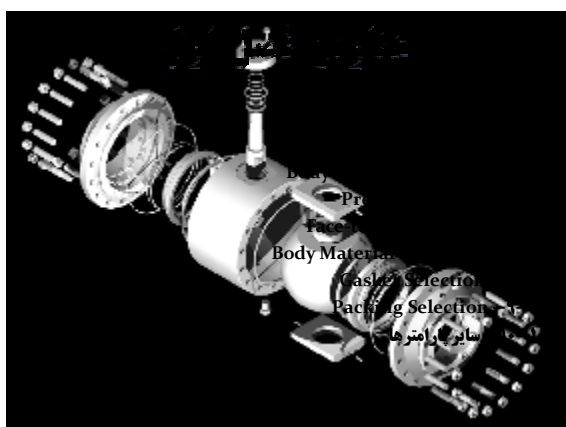
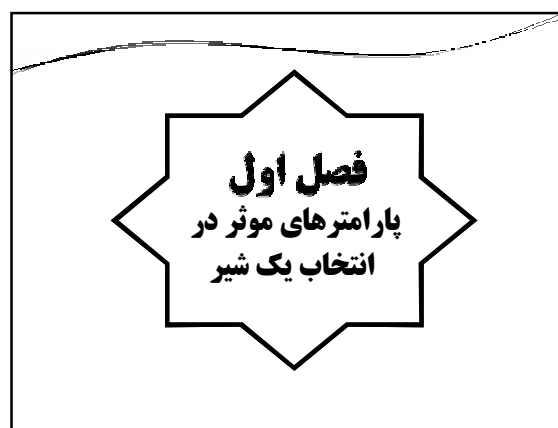
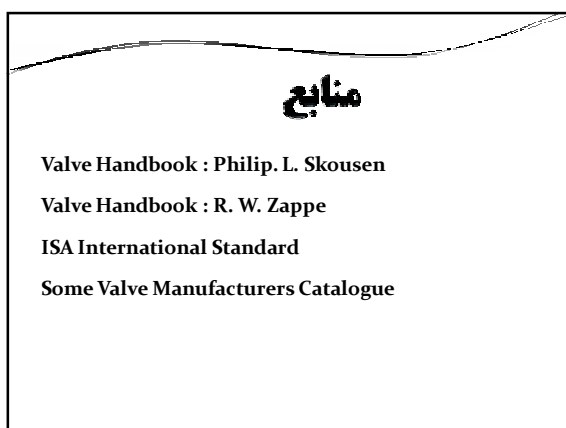
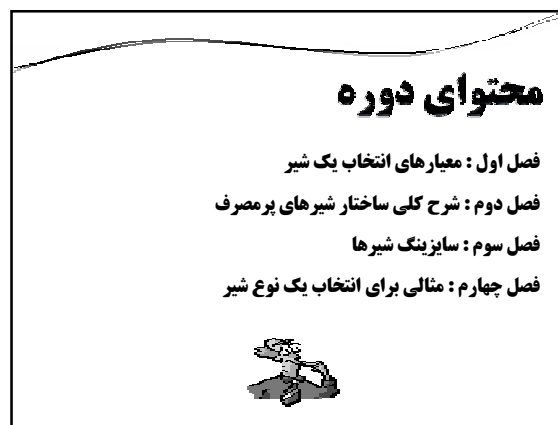




مقدمه - ۱-۱-۱

C_v is not calculated correctly → diminished performance

1. C_v is too small → valve will be undersized → process system can be starved for fluid → higher back pressures :
 - a) damage in upstream pumps or other upstream equipment
 - b) higher pressure drop across the valve, which can lead to cavitation or flashing
2. C_v is too high → oversized valve is selected → cost, size, weight are major disadvantages

Cv-۲-۱-۱

تعریف

1 C_v : 1 U.S. gallon (3.8 liters) of 60°F(16°C) water that flows through a valve with 1.0 psi (0.07 barg) of pressure drop.

$$C_v = Q \sqrt{\frac{S_g}{\Delta P}}$$

- C_v : required flow coefficient for the valve
- Q : flow rate (in gal/min)
- S_g : specific gravity of the fluid
- ΔP : pressure drop (psi)

Flow Characteristics-۲-۱

مقدمه - ۱-۲-۱

- Equal-Percentage Flow Characteristic -۲-۲-۱
- Linear Flow Characteristic -۳-۲-۱
- Quick-Open Flow Characteristic -۴-۲-۱
- Determining Installed Flow Characteristics -۵-۲-۱
- Flow Characteristic Examples -۶-۲-۱
- Choosing the Correct Flow Characteristic -۷-۲-۱
- Rangeability -۸-۲-۱

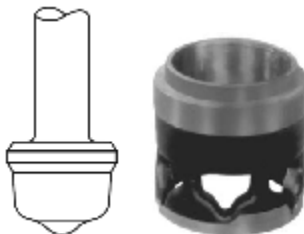
مقدمه - ۱-۲-۱

شیرهای با قابلیت تنظیم جریان (Throttling Valve)
 رابطه میان C_v و میزان باز شدن شیر
 افت فشار، دبی جریان و C_v از یکدیگر تأثیر می پذیرند

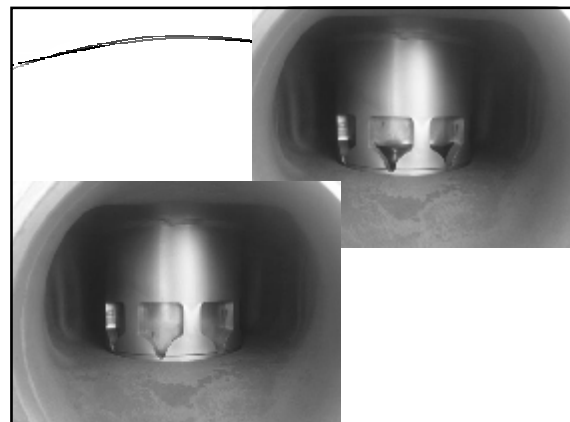


Equal-Percentage Flow Characteristic -۲-۲-۱

- در مقادیر مساوی تغییرات حرکت دیسک (Valve Travel) درصد مساوی از C_v را خواهیم داشت
- در مقایسه با انواع دیگر بیشتر مورد استفاده قرار می گیرد.

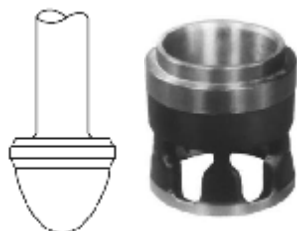


$$\frac{dC_v}{dL} = nC_v$$



Linear Flow Characteristic – ۳-۲-۱

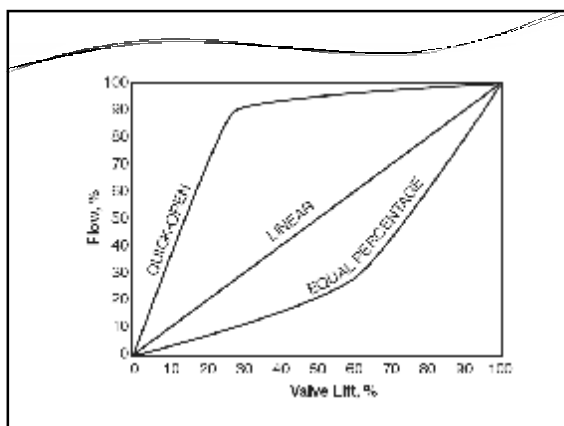
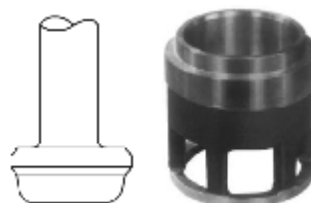
- درصد باز شدن شیر با درصد جریان عبوری برابر است؛ بدون در نظر گرفتن میزان باز بودن شیر
- کاربرد: فرایندهایی که بیشتر افت فشار خط در شیر اتفاق بیفتد



$$\frac{dQ}{dL} = k$$

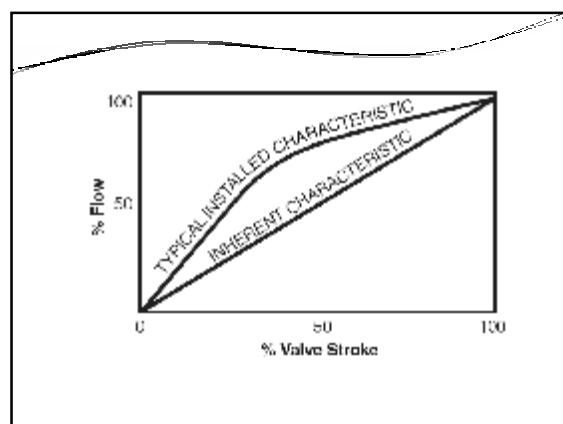
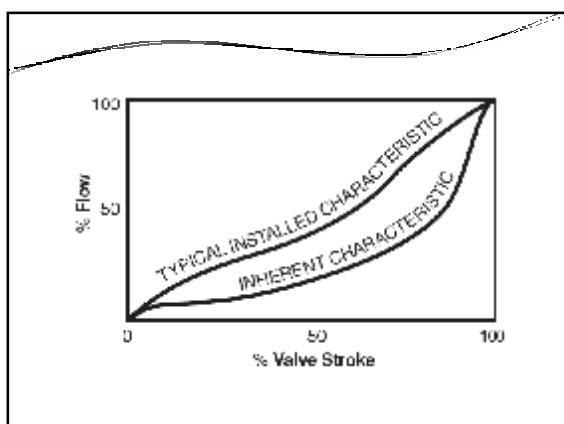
Quick-Open Flow Characteristic – ۴-۲-۱

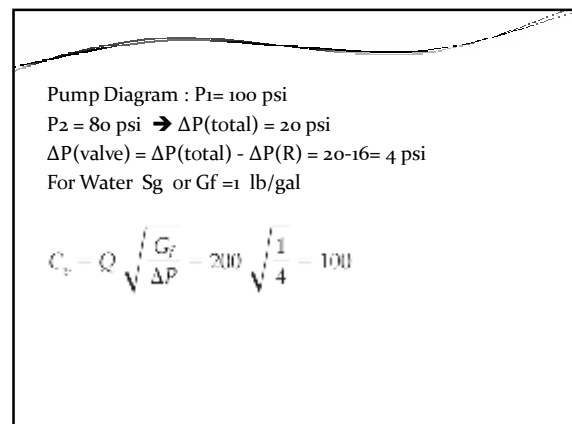
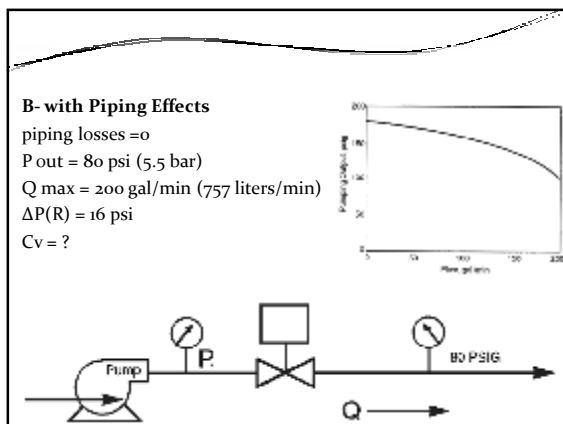
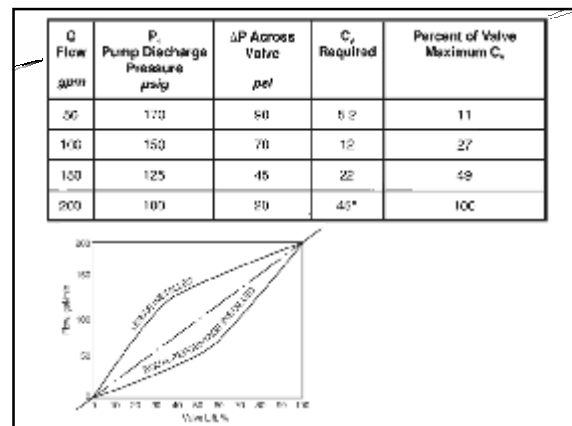
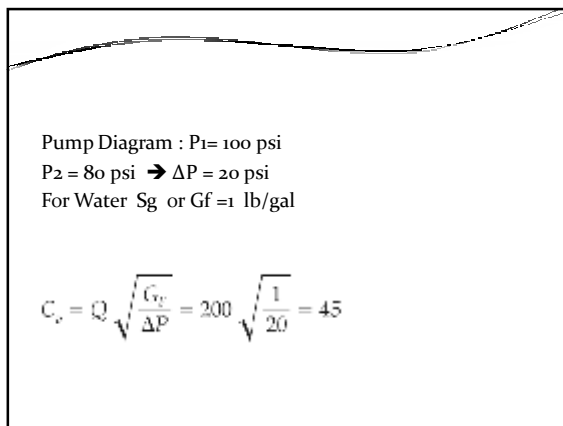
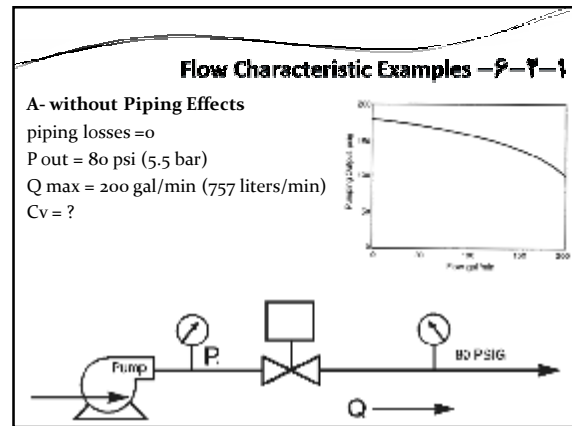
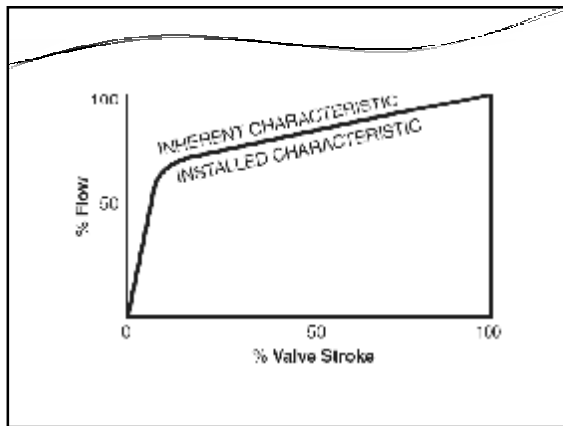
- با اندک باز شدن شیر تقریباً بیشتر دبی را از خود عبور می دهد
- کاربرد: on/off کردن سرویسهایی که دبی زیادی را در مدت زمان کوتاه از خود عبور می دهند
- خواص جریان آنها بصورت جدا و یا در خط لوله با هم برابر است

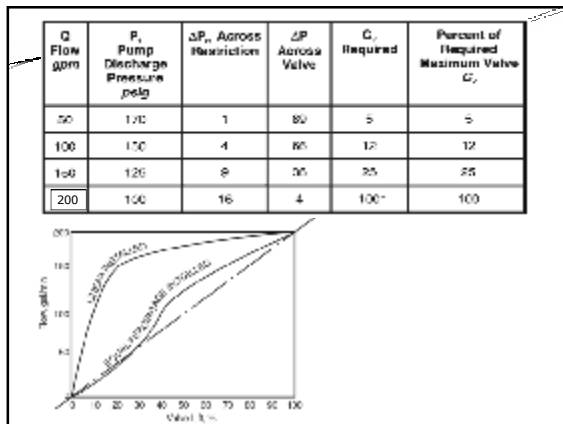


Determining Installed Flow Characteristics – ۵-۲-۱

- خواص جریان شیر پس از نصب آن در سرویس تغییر میکند
- equal-percentage characteristic → moves toward linear
- linear characteristic → moves toward quick-open
- quick-open characteristic → same before and after inst.





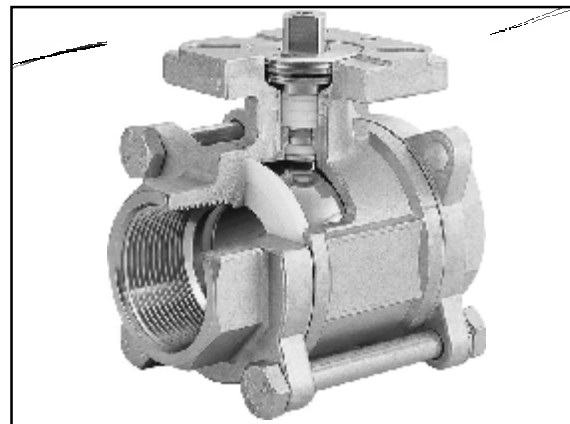


۱-۲-۲-Choosing the Correct Flow Characteristic

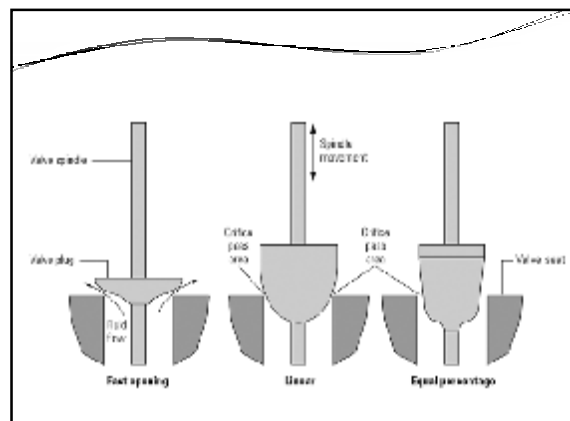
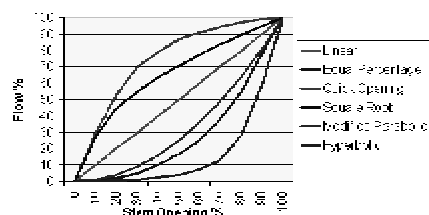
- در صورت بکارگیری شیر برای کنترل جریان (throttling)، باید از انواع linear یا equal-percentage بهره گرفت
- اگر بیشتر افت فشار در شیر حادث شود و فشار بالادست ثابت باشد، linear گزینه بهتر میباشد
- اگر پاییننگ و تجهیزات پایین دستی مقاومت قابل توجهی در مقابل جریان ایجاد کنند، equal-percentage انتخاب صحیح است
- در جریانهای دارای دبی زیاد با افت فشار کم و نیز دبی کم با افت فشار زیاد از equal-percentage استفاده می شود
- اگر بدلیل کمبود داده ها مجبور به انتخاب سایز بالاتری شدیم، equal-percentage رفتار بهتری جهت کنترل سیستم خواهد داشت

۱-۲-۳-Rangeability

- نسبت حداکثر به حداقل جریان یک شیر کنترلی که از یک کنترلر فرمان می گیرد
- ۳ عامل بر **Rangeability** موثر هستند
 - ۱- ساختار هندسی شیر
 - ۲- نشستی کانال جریان
 - ۳- محرک شیر
- شیر توپی با پورت V شکل، دارای **Rangeability** بالایی هستند
- V-notched ball valves (200:1)
- Eccentric plug valves (100:1)
- Globe valves (50:1)
- butterfly valves (20:1)
- اطلاعات بیشتر در استاندارد **ANSI / ISA S75.11**



Control Valve Flow Characteristics



Shutoff Classifications – 3-1

- *Standard: ANSI / FCI 70-2 : Six classifications of shutoff*

ANSI Class I

- does not require a test, while agreed between the user and the valve manufacturer
- also known as dust tight and can refer to metal or resilient seated valves

Shutoff Classifications – 3-1

ANSI Class II

- *Leakage : 0.5% of full open valve capacity.*
- *Test medium: Air or water @ 50 to 125 °F (10–52 °C)*
- *Test Pressure: 45 to 60 psig or max operating DP.*
- Intended for double port or balanced single port valves with a metal piston ring seal and metal to metal seats

Typical constructions:

- Low seat load: Balanced, single port, single graphite piston ring, metal seat
- High seat load: Balanced, double port, metal seats

Shutoff Classifications – 3-1

ANSI Class III

- *Leakage : 0.1% of full open valve capacity.*
- *Test medium: Air or water @ 50 to 125 °F.*
- *Test Pressure: 45 to 60 psig or max operating DP*
- Intended for double port or balanced single port valves with a metal piston ring seal and metal to metal seats

Typical constructions:

- low seat load: Balanced, double port, soft seats,
- medium seat load : Balanced, single port, single graphite piston ring, lapped metal seats

Shutoff Classifications – 3-1

ANSI Class IV

- *Leakage : 0.01% of full open valve capacity.*
- *Test medium: Air or water @ 50 to 125 °F.*
- *Test Pressure: 45 to 60 psig or max operating DP*
- Intended for single port and balanced single port valves with extra tight piston seals and metal to-metal seats

Typical constructions:

- medium seat load: Balanced, single port, multiple graphite piston rings, Teflon piston ring, lapped metal seats
- medium seat load: Unbalanced, single port, lapped metal seats
- Class IV is also known as metal to metal

Shutoff Classifications – 3-1

ANSI Class V

- *Leakage : 0.0005 cm3/min per inch of orifice diameter per psi differential*
- *Test medium: Water @ 50 to 125 °F.*
- *Test P: Max. service pressure drop across valve, not to exceed body rating*
- Intended for single port and balanced single port valves with extra tight piston seals and metal to-metal seats

Typical constructions:

- High seat load: Unbalanced, single port, lapped metal seats, soft metal seats
- Low seat load: Balanced, single port, Teflon piston rings, soft seats,

ANSI Class VI

- *The test fluid is air or nitrogen @ 50 to 125 °F.*

- Known as a soft seat classification.
- Intended for resilient seating valves.

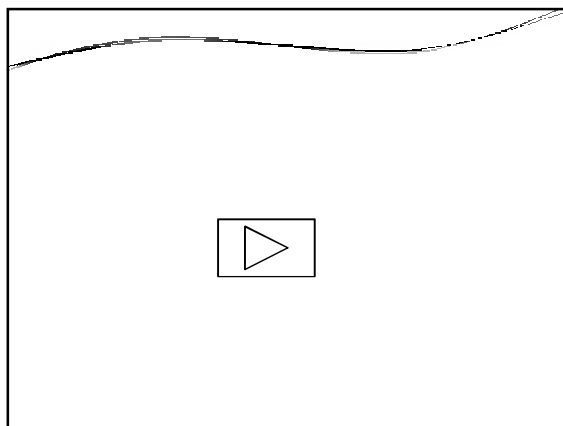
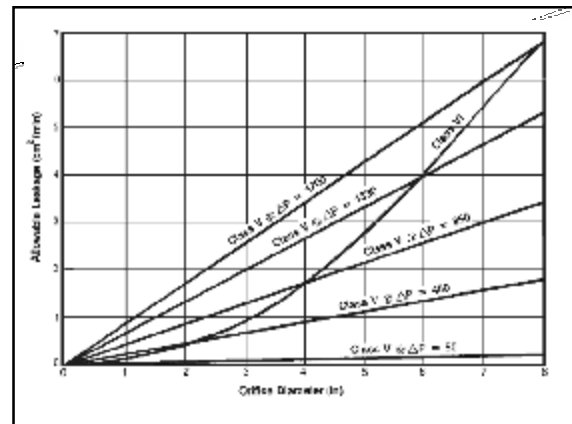
Typical constructions:

- Low load: Unbalanced, single port, soft seats



Port Diameter		Bubbles per minute	ml per minute
inches	Millimeters		
1	25	1	0.15
1 1/2	38	2	0.30
2	51	3	0.45
2 1/2	64	4	0.60
3	76	6	0.90
4	102	11	1.70
6	152	27	4.00
8	203	45	6.75
10	254	63	9
12	305	81	11.5

Body/Ends	API or ANSI or Classification	Valve Class	Required Seal Load (pounds per inch)
Steel	Class 11	1 1/2 to 4-inch DN 40 to 100	40 pounds/inch 50 psi
Steel	Class 11	4-inch and above DN 50 and above	75 pounds/inch 97 psi
Steel	150 lb Class 11	0.5 to 4-inch DN 15 to 100	100 pounds/inch 131 psi
Steel	150 lb Class 11	4-inch and above DN 150 and above	187 pounds/inch 247 psi
Steel	Class 150	1 1/2 to 4-inch DN 40 to 100	314 pounds/inch 400 psi
Steel	Class 150	4 to 10-inch DN 100 to 250	400 pounds/inch 514 psi
Steel	Class 150	0.5 to 4-inch DN 15 to 100	500 pounds/inch 637 psi
Steel	Class 150	4 to 10-inch DN 100 to 250	600 pounds/inch 764 psi
Steel	Class 150	10 to 14-inch DN 250 to 350	800 pounds/inch 1014 psi
Steel	Class 150	4-inch and above DN 50 and above	100 pounds/inch 127 psi
Steel	Class 150	0.5 to 4-inch DN 15 to 100	20 pounds/inch 25 psi
Steel	Class 150	4-inch and above DN 50 and above	100 pounds/inch 127 psi



Body End Connections—۴-۱

۱-۴-۱ مقدمه

۲-۴-۱ Threaded End Connections

۳-۴-۱ Flanged End Connections

۴-۴-۱ Welded End Connections

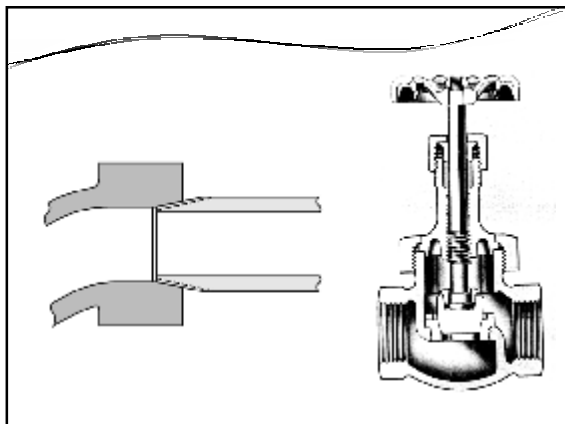
۵-۴-۱ Other End Connections

۱-۴-۱ مقدمه

- نوع و جنس انتهای شیر با پایبند معمولاً یکسان است
- معمولاً سایز ۲ اینچ و کوچکتر با انتهای SE یا SW ساخته می شوند
- سایزهای بالاتر از ۲ اینچ با انتهای FE یا BW تولید می گردند
- در سرویسهای که نشتی مشکل زیادی ایجاد نمی کند، می توان تا ۴ اینچ از نوع SE نیز استفاده نمود
- در برخی از سرویسها از شیر با دو انتهای متفاوت استفاده می شود
- در برخی موارد سایز انتهای شیر متفاوت است مانند Drain, Vent

Threaded End Connections—۲-۴-۱

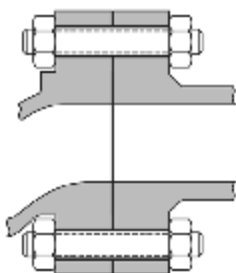
- شیرهای با انتهای رزوه ای بیشتر از نوع NPT ساخته می شود
- در سرویسهای خورنده از این نوع انتها استفاده نمی شود
- در سیستمهای اطفای حریق از NHT استفاده می شود
- GHT - معمولاً ۱/۴ اینچ هستند
- دارای حداقل قیمت است
- استاندارد: ASME B16.11 , API 5B



Flanged End Connections – ۳-۴-۱

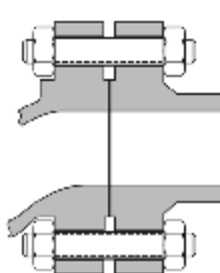
- برای شیرهای بزرگتر از ۱۲ اینچ استفاده می شود
- نصب آن از نوع رزوه ای آسان تر است
- در هر دمایی قابل بکارگیری است
- استاندارد: ASME B16.5 , B16.47
- با توجه به نوع سرویس و Pressure/Temperature Rating انتخاب می شوند
- شیر به راحتی جداکردن از سرویس خواهد بود
- در نوسانات دمایی زیاد نمی توان از آن بهره برد
- Integral flanges, separable flanges
- انواع مختلفی دارد (Facing) : FF , RF , RTJ , . . .

Flat Face (FF)

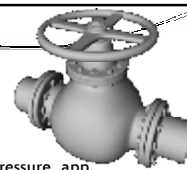


- low-pressure applications
- brass and cast-iron valves
- Face must be completely flat
- Large diameter gaskets

Raised Face (RF)

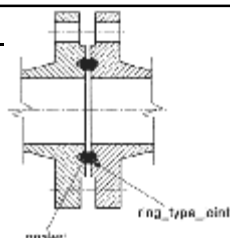


- Medium-pressure app.
- 1.6 mm for Low pressure
- 6.4 mm for high pressure
- Serrated or Smooth finish
- Pressures up to 6000 psi
- temperatures up to 1500°F
- Soft and Spiral wound Gasket



Ring-Type Joint (RTJ)

- High-pressure app.
- Face: U-shaped groove
- Pressures up to 20000 psi
- temperatures up to 1500°F
- Soft metal Gasket

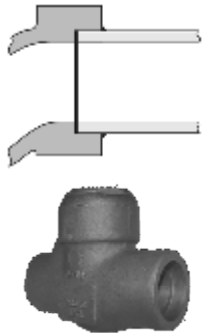


Welded End Connections – ۴-۴-۱

- برای تمام سایزها قابل استفاده است
- جایی که نیاز به نشتی صفر باشد:
- environmental, safety, sanitary, efficiency
- برای فشار و دمای بالا قابل بکارگیری است
- شیر قابل جداکردن از سرویس نخواهد بود
- انواع مختلفی دارد: SW , BW

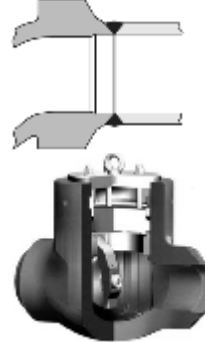


Socket weld (SW)



- High pressure fluids
- High temperature fluids
- 2 in and smaller
- Pipe mate into the valve bore
- Dimension: ASME B16.11
- Welding STD: ASME B31.1 or B31.3

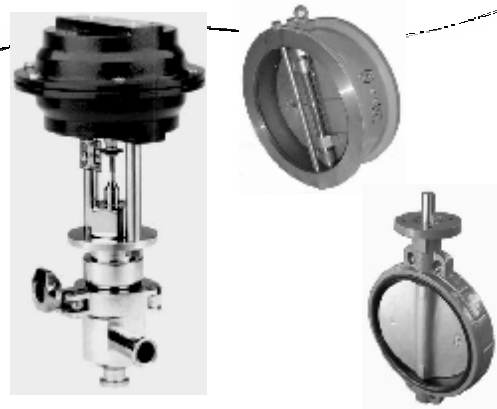
Butt weld (BW)



- High pressure fluids
- High temperature fluids
- Larger than 2 in
- Backing rings
- Dimension: ASME B16.25
- Welding STD: ASME B31.1, B31.3, B31.8

Other End Connections - Δ-Ψ-1

- Nonmetallic valves (plastic) → Male thread → External Nut
✓ vacuum service → O-ring
- PVC & CPVC → male-female socket → cement is used to fuse the two pieces together
- heat fusion → outside heating source → fuse together
- clamp coupling → fits into special grooves → allow to be disassembled for cleaning
- Wafer Ends → Rotary Valve → thermal expansion or fire → leakage → may feed the fire



Pressure Classes - Δ-1



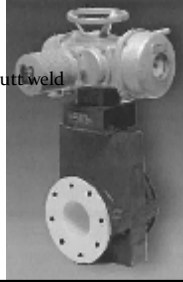
- Standard Classification - Δ-1
 Special Classification - Ψ-Δ-1
 Limited Classification - Ψ-Δ-1
 Intermediate Classification - Δ-Δ-1
 Other - ϕ-Δ-1

Rating - 1-Δ-1

- Rating: valve is designed for certain range of internal pressure
- Is not an exact working pressure
- higher pressure → thicker wall thickness
- Higher temperature → lower pressure
- pressure-temperature relationship : ANSI/ASME B16.34

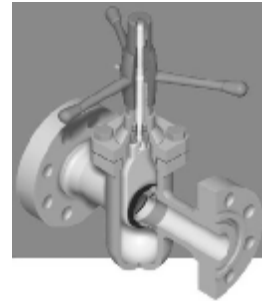
Standard Classification – Y-A-1

- ANSI Class : ANSI / ASME B16.34
- Class 150, 300, 600, 900, 1500, 2500
- Ends: Threaded, flanged, socket weld, butt weld



Special Classification – Y-A-1

- ANSI Class : ANSI / ASME B16.34
- Ends: Threaded, welded
- Special examination (NDT)
- Part 8, ASME B16.34



Limited Classification – F-A-1

- ANSI Class : ANSI / ASME B16.34
- Ends: Threaded, welded
- Size : 2 1/2 " and smaller
- Threaded ≤ Class 2500
- Socket Weld ≤ Class 4500
- Appendix V, ASME B16.34



$$P_M = \frac{7000}{7000 - (y - 0.4)P_r} P_{sp}$$

P_M = Limited Class rated working pressure for the specified material at temperature T

P_r = pressure class rating index. For all designations Class 300 through 4500, P_r is equal to the Class designation number (e.g., for Class 300, $P_r = 300$). For Class 150, $P_r = 115$. For a rating designation between Class 150 and Class 300, the interpolation shall be made using $P_r = 115$ for Class 150. The equation is not valid for P_r greater than 4500.

P_{sp} = Special Class rated working pressure for the specified material at temperature T as determined by the method of Nonmandatory Appendix B. These Special Class working pressures are tabulated in Table 2 having a designation of "Special Class." The tabulated values shall be used for establishing Limited Class ratings.

y = a material coefficient having values as listed in Table V-1

$$P_M = \frac{7000}{7000 - (y - 0.4)P_r} P_{sp}$$

Table V-1 Material Coefficient, y

Material	Applicable Temperature					
	480°C (900°F) and below (950°F)	510°C (950°F)	538°C (1000°F)	565°C (1050°F)	595°C (1100°F)	620°C (1150°F) and above
Feritic steels	0.4	0.5	0.7	0.7	0.7	0.7
Austenitic steels	0.4	0.4	0.4	0.4	0.5	0.7
Other ductile materials	0.4	0.4	0.4	0.4	0.4	0.4

Intermediate Classification – A-A-1

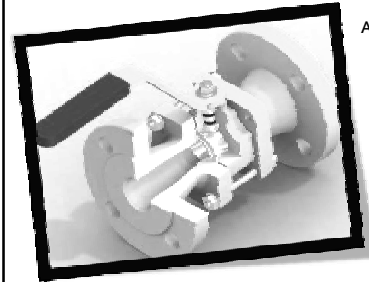
- ANSI Class : ANSI / ASME B16.34
- Ends: Threaded, welded
- Size : 2 1/2 " and smaller
- Para 6.1.4



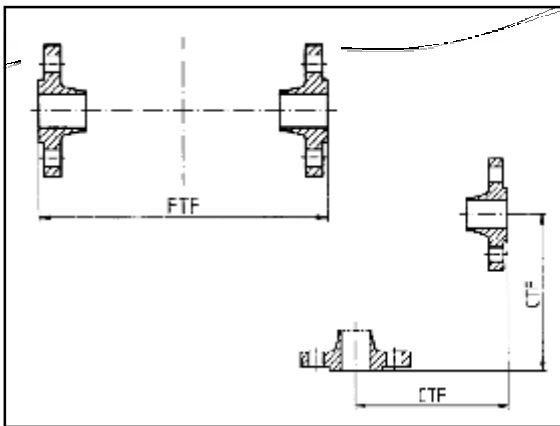
Other - 9-4-1

- API Class → API 6D → 2000, 3000(3M), 5M, 10M, 20M
- ISO → PN → 10, 20, 25, 40, 50, 100, ...
- Manufacturer :
WOG(Water, Oil, Gas)
WSP (Wet Steam Pressure)

Face-to-Face Criteria - 9-1



ASME B16.10 - 1-9-1
API 6D - 2-9-1
BSI - 3-9-1
DIN - 4-9-1



ASME B16.10 - 1-9-1

- Gate Valve
- Globe Valve
- Check Valve
- Ball Valve
- Plug Valve
- Butterfly Valve
- Class : 150, 300, 600, 900, 1500, 2500
- Size : 1/4" to 36"



API 6D - 2-9-1

- Gate
- Check
- Plug
- Ball
- Class : 150, 300, 600, 900, 1500, 2500
- Size : 2" to 36"



BSI - 3-9-1

BS 558-1 (FE)
Gate, Butterfly, Plug, Diaphragm, Globe, Check, Control
Size : DN 2000
PN : 6, 10, 16, 25, 40, 63, 100



BS 2080
Size : (1/4-42")
Class : (150 - 2500)

DIN - ۶-۶-۱

DIN 3300



Body Material Selection-۷-۱

۱-۷-۱- مقدمه

۲-۷-۱- استانداردهای انتخاب مواد



۱-۷-۱- مقدمه

- در بیشتر مواقع جنس لوله و بدنه شیر شبیه به هم هستند
- فولادهای کربنی جهت ساخت بدنه شیرها بسیار زیاد استفاده می شوند
 - سیالات غیر خورنده و بخار آب از C/S استفاده می شود
 - برای سرویسهای دایمی تا ۴۲۵ درجه سانتیگراد
 - برای سرویسهای غیر دایمی تا ۵۳۵ درجه سانتیگراد
 - قیمت مناسب تری دارد
- فولادهای استنلس نیز جهت ساخت بدنه شیرها استفاده می شوند
 - مقاومت حرارتی، مکانیکی و خوردگی بالاتری دارند
 - دماهای ۵۳۵ و بالاتر
 - قیمت گرانتر

Material	Upper Limit °F	Upper Limit °C	Lower Limit °F	Lower Limit °C
Cast Iron	410	204	-20	-28
Ductile Iron	350	176	-20	-28
Carbon Steel (Grade A53)	1100	593	-20	-28
Carbon Steel (Grade L20)	350	176	-20	-28
Carbon Alloy	350	176	-20	-28
1-1/4 Cr - 1/2 Mo (Grade WCB)	1100	593	-20	-28
3-1/2 Cr - 1/2 Mo (Grade WC6)	1100	593	-20	-28
9 Cr - 1/2 Mo (Grade 9)	1100	593	-20	-28
9 Cr - 1 Mo (Grade C12)	1100	593	-20	-28
Low Alloy (Grade CF 8)	1100	593	-20	-28
Type 304 (Grade CF8M)	1100	593	-20	-28
Type 316 (Grade CF3M)	1100	593	-20	-28
316 Ti (Grade 316Ti)	1100	593	-20	-28
Aluminum	400	204	-20	-28
Brass	400	204	-20	-28
Monel 400	1100	593	-20	-28
Monel 200	1100	593	-20	-28
Monel K500	1100	593	-20	-28
Monel 700	1100	593	-20	-28
Monel 779	1100	593	-20	-28
Monel 705	1100	593	-20	-28
Monel 706	1100	593	-20	-28
Monel 707	1100	593	-20	-28
Monel 708	1100	593	-20	-28
Monel 709	1100	593	-20	-28
Monel 710	1100	593	-20	-28
Monel 711	1100	593	-20	-28
Monel 712	1100	593	-20	-28
Monel 713	1100	593	-20	-28
Monel 714	1100	593	-20	-28
Monel 715	1100	593	-20	-28
Monel 716	1100	593	-20	-28
Monel 717	1100	593	-20	-28
Monel 718	1100	593	-20	-28
Monel 719	1100	593	-20	-28
Monel 720	1100	593	-20	-28
Monel 721	1100	593	-20	-28
Monel 722	1100	593	-20	-28
Monel 723	1100	593	-20	-28
Monel 724	1100	593	-20	-28
Monel 725	1100	593	-20	-28
Monel 726	1100	593	-20	-28
Monel 727	1100	593	-20	-28
Monel 728	1100	593	-20	-28
Monel 729	1100	593	-20	-28
Monel 730	1100	593	-20	-28
Monel 731	1100	593	-20	-28
Monel 732	1100	593	-20	-28
Monel 733	1100	593	-20	-28
Monel 734	1100	593	-20	-28
Monel 735	1100	593	-20	-28
Monel 736	1100	593	-20	-28
Monel 737	1100	593	-20	-28
Monel 738	1100	593	-20	-28
Monel 739	1100	593	-20	-28
Monel 740	1100	593	-20	-28
Monel 741	1100	593	-20	-28
Monel 742	1100	593	-20	-28
Monel 743	1100	593	-20	-28
Monel 744	1100	593	-20	-28
Monel 745	1100	593	-20	-28
Monel 746	1100	593	-20	-28
Monel 747	1100	593	-20	-28
Monel 748	1100	593	-20	-28
Monel 749	1100	593	-20	-28
Monel 750	1100	593	-20	-28
Monel 751	1100	593	-20	-28
Monel 752	1100	593	-20	-28
Monel 753	1100	593	-20	-28
Monel 754	1100	593	-20	-28
Monel 755	1100	593	-20	-28
Monel 756	1100	593	-20	-28
Monel 757	1100	593	-20	-28
Monel 758	1100	593	-20	-28
Monel 759	1100	593	-20	-28
Monel 760	1100	593	-20	-28
Monel 761	1100	593	-20	-28
Monel 762	1100	593	-20	-28
Monel 763	1100	593	-20	-28
Monel 764	1100	593	-20	-28
Monel 765	1100	593	-20	-28
Monel 766	1100	593	-20	-28
Monel 767	1100	593	-20	-28
Monel 768	1100	593	-20	-28
Monel 769	1100	593	-20	-28
Monel 770	1100	593	-20	-28
Monel 771	1100	593	-20	-28
Monel 772	1100	593	-20	-28
Monel 773	1100	593	-20	-28
Monel 774	1100	593	-20	-28
Monel 775	1100	593	-20	-28
Monel 776	1100	593	-20	-28
Monel 777	1100	593	-20	-28
Monel 778	1100	593	-20	-28
Monel 779	1100	593	-20	-28
Monel 780	1100	593	-20	-28
Monel 781	1100	593	-20	-28
Monel 782	1100	593	-20	-28
Monel 783	1100	593	-20	-28
Monel 784	1100	593	-20	-28
Monel 785	1100	593	-20	-28
Monel 786	1100	593	-20	-28
Monel 787	1100	593	-20	-28
Monel 788	1100	593	-20	-28
Monel 789	1100	593	-20	-28
Monel 790	1100	593	-20	-28
Monel 791	1100	593	-20	-28
Monel 792	1100	593	-20	-28
Monel 793	1100	593	-20	-28
Monel 794	1100	593	-20	-28
Monel 795	1100	593	-20	-28
Monel 796	1100	593	-20	-28
Monel 797	1100	593	-20	-28
Monel 798	1100	593	-20	-28
Monel 799	1100	593	-20	-28
Monel 800	1100	593	-20	-28

۲-۷-۱- استانداردهای انتخاب مواد

- ANSI / ASME B16.34
- ASTM



Gasket Selection-A-۱

۱-۸-۱- مقدمه

Flat Gaskets -۲-۸-۱

Spiral-Wound Gaskets -۳-۸-۱

Metal O-Ring Gaskets -۴-۸-۱

Metal C-Ring Gaskets -۵-۸-۱

Metal Spring-Energized Rings -۶-۸-۱

Metal U-Ring Gaskets -۷-۸-۱

۸-۸-۱- استاندارد انتخاب



۱-۱-۱ مقدمه

- گسکت باید نرم تر از قطعات آب بند شونده باشد
- جنس آن بستگی به دما، فشار و خواص سیال دارد
- معمولاً یکبار مصرف هستند
- میتوانند فلزی یا غیر فلزی باشد
- میزان آب بندی آن به نیروی وارد شده بستگی دارد؛
 - نوع گسکت
 - میزان جابجایی قطعات
 - ضخامت گسکت
 - جنس گسکت
 - عمق شیار
- فشردن بیش از حد گسکت باعث لهیدگی آن و بروز نشتی می گردد
- در برخی شیرها میزان فشردگی گسکت با ارتفاع پله ها کنترل می شود

Types of Gasket

- Flat gaskets
- Spiral-wound gaskets
- Metal O-ring gaskets
- Metal C-ring gaskets
- Metal spring-energized gaskets
- Metal U-ring gaskets



۱-۲-۱ Flat Gaskets

- ساده و ارزان قیمت
- بدلیل انعطاف پذیری، برای آب بندی سطوح ناصاف فلزی مناسب است
- برای سرویسهای معمولی (دما و فشار) بکار می رود
- جنس:

- Chlorotrifluoroethylene (CTFE)
- polytetrafluoroethylene (PTFE)
- Soft metals: aluminum, copper, silver, soft iron, lead, brass
- Nickel → 1400°F
- Monel → 1500°F
- Inconel → 2000°F

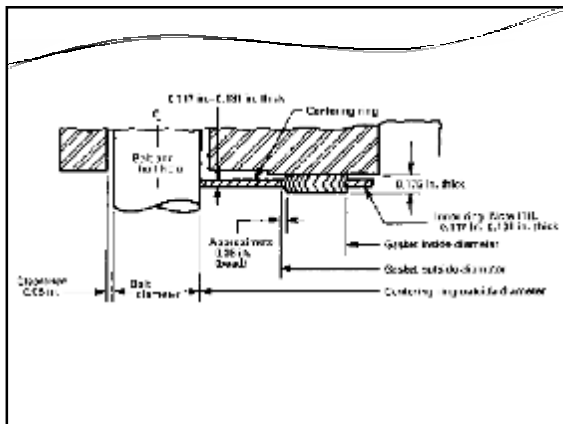


۱-۳-۱ Spiral-Wound Gaskets

- تقریباً همه منظوره است
- قیمت متوسط
- بین ورقه های فلزی، فیلر غیر فلزی قرار دارد
- یکبار مصرف هستند
- فیلر: asbestos, PTFE, graphite, mica, ceramic paper
- جنس نوار:

304, 315, 316, 347, or 321 stainless steels, carbon steel
Monel, nickel, Titanium, Alloy 20, Inconel, Hastelloy B,
Hastelloy C-276, phosphor bronze, copper, gold, Platinum





Metal Q-Ring Gaskets — ۴ — A — ۱

- اورینگ فلزی
- سطح مقطع دایره ای یا غیر دایره ای
- گرانتر از گسکت تخت و اسپیرال
- مناسب سرویسهای با دما و فشار بالا
- آب بندی در هر دو جهت
- آب بندی در مقابل سطوح ناهموار
- یکبار مصرف

Metal C-Ring Gaskets — ۵ — A — ۱

- self-energizing
- more expensive than most gaskets
- low seating loads and high spring-back
- used for low-vacuum or low-pressure systems

Metal Spring-Energized Rings — ۶ — A — ۱

- Similar to metal C-ring gaskets
- include metal springs inside C-ring gaskets
- Expensive
- Application : when the service conditions vary widely
- allows the gasket to expand or contract during changes in temperature or pressure, while maintaining the seal

Metal U-Ring Gaskets — ۷ — A — ۱

- Use where reliability is an important consideration
- For high-pressure (up to 12,000 psi)
- For high-temperature (up to 1600°F)

Type	Gasket Material	Maximum Temperature (°F)	Minimum Temperature (°F)	Maximum Pressure (psia/bar)
Ru	Vulcan PTFE	300/275	-200/-190	5000 - 1000 psi / 415 - 70 bar
Ru	Fluorinated PTFE	500/250	-200/-190	8000 - 990 psi / 415 - 35 bar
Ru	CTFE	220/25	-428/-250	6000 - 500 psi / 415 - 35 bar
Hd	PEP	400/200	-40/-250	8000 - 500 psi / 415 - 35 bar
Spinel-wound	Al ₂ O ₃	1220/315	-40/-50	6250 psi / 420 bar
Spinel-wound	304 SS/Al ₂ O ₃ bezel	750/400	-40/-50	6250 psi / 420 bar
Spinel-wound	316 SS/Al ₂ O ₃ bezel	1020/400	-40/-50	6250 psi / 420 bar
Spinel-wound	316 SS/PTFE	210/170	-20/-180	5000 - 500 psi / 415 - 35 bar
Spinel-wound	316 SS/Graphite	1650/400	113/150	8000 psi / 420 bar
Helbow U-ring	Inconel 2-750	1650/400	20/-50	15,000 psi / 1035 bar

Packing Selection - 1-1-1

40000-1-1-1

Packing Configurations - 2-1-1

Packing-Material Considerations - 3-1-1

Polytetrafluoroethylene Packing - 4-1-1

Asbestos and Asbestos-Free Packings - 5-1-1

Graphite Packing - 6-1-1

Perfluoroelastomer Packing - 7-1-1

Limits for Packing Temperature and Pressure - 8-1-1

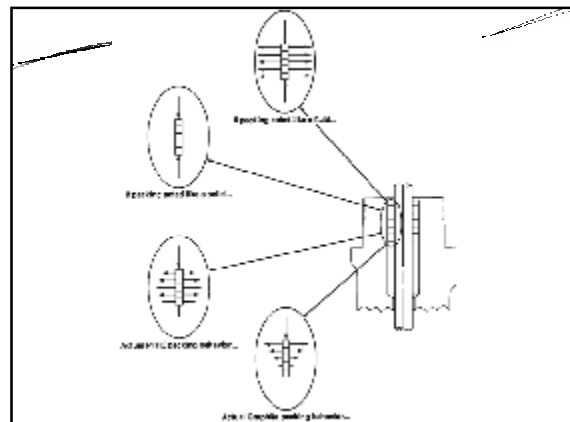
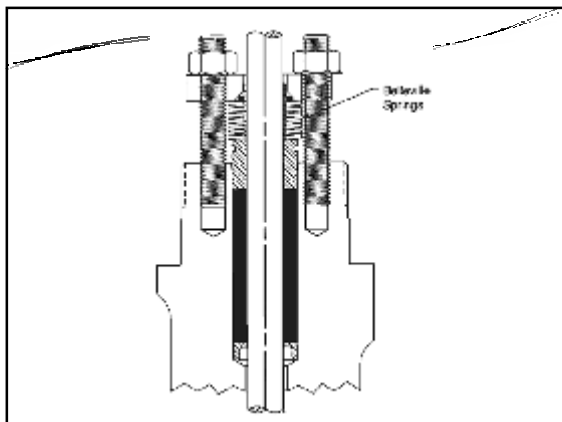
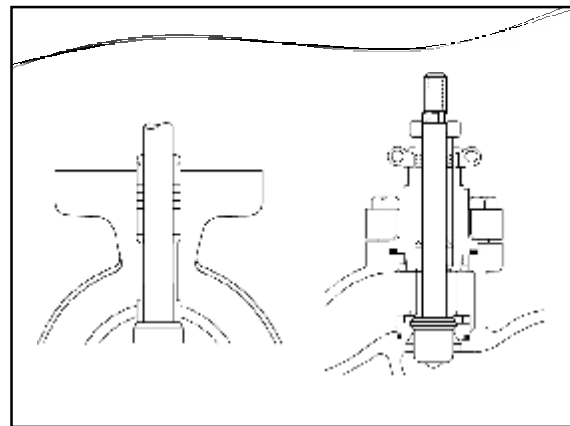
Packing Lubricants - 9-1-1

40000-1-1-1

- *Preformed packing* : V-ring
- *Square packing* : square-shaped ring
- *Braided packing* : woven strands of elastomeric materials
- Packing for rotary valves & linear valves.
- *Live loading* → compensate *packing consolidation* → wear, cold flow, plastic deformation, extrusion

40000-1-1-1

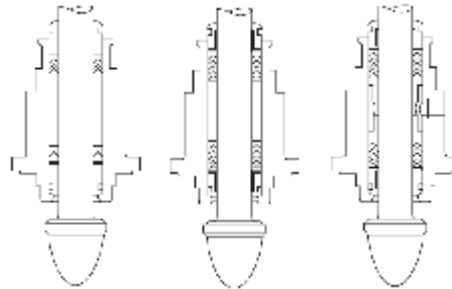
- Ideally: Max radial load → in middle of the packing set
- Soft packing materials → Max radial load → for Ex. PTFE
- harder packing → maximum radial force → Near the Gland
- Stems are polished between 8 and 4 μin
- bonnet walls polished between 32 and 16 μin
- Small & such rotary valves → misalign the stem → leaking



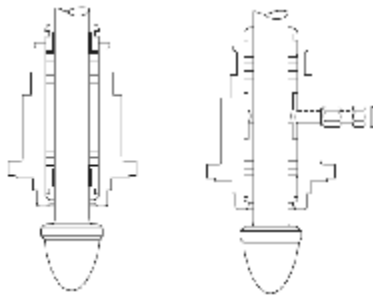
Packing Configurations – 7-4-1

- standard and twin configurations
- V-shaped → excellent self-adjusting seal → Min stem friction
- Square → twin packing configuration → lubrication
- Graphite → lubrication → soft and pliable
- braided packing
 - high-temperature → solid graphite are abrasive → high stem friction
 - two solid rings → not adequately seal → braided complete the seal
 - One braided ring → bottom wiper →
- lantern ring
 - leak to freely circulate
 - Warner for lower packing leakage → retightening the gland
 - Lubrication the packing box
 - Liquid packing injection

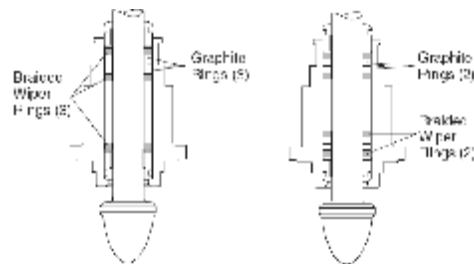
V-shaped packing



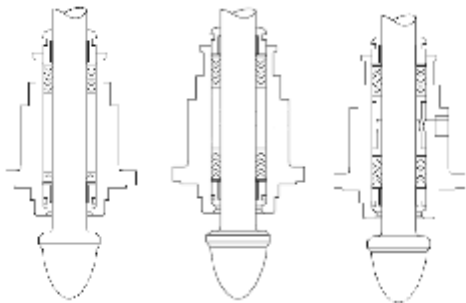
Square packing



Standard & Twin graphite packing configuration



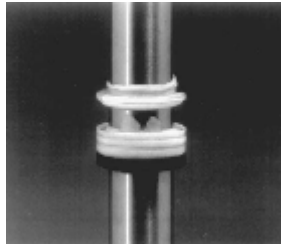
vacuum service packing configuration



Packing-Material Considerations – 7-4-1

- variety of valve applications → wide range of temperature, fluid medium
- graphite → good for high temp. → but with high friction
- Ideal packing material
 - operates within the temperature and pressure ranges
 - creates minimal stem friction
 - Holds a seal with very little material
 - withstands extrusion
- backing ring: a close tolerance ring → harder, less pliable → fit between packing ring , packing box wall , stem

Packing extruded between stem and gland bushing



Poly tetra fluoro ethylene Packing – P-1-1

- Virgin PTFE packing → common and inexpensive → V-ring
- Elasticity, V-ring → little compression, long-lasting seal
- Smooth surfaces → smooth stroking → min. break-out force
- Very little friction → wear is not a concern
- Can be used in a number of general services
- Available in a braided packing
- Limited temperature range
- Thermal expansion=10 times of steel → weak in thermal cycling → packing loss, shorter life, extrusion → **Live Loading**
- Not suitable for nuclear valves → radiation deteriorate it quickly
- RPTFE: more rigidity → less elasticity → greater sealing force
- Combine Virgin PTFE and RPTFE,

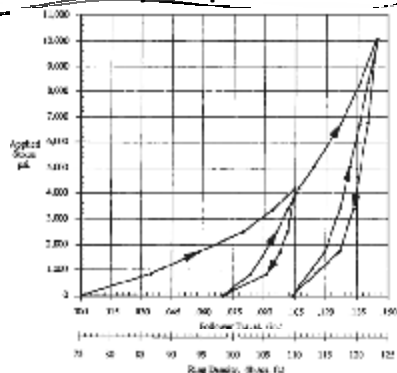
Asbestos and Asbestos-Free Packings – A-1-1

- effective high-temperature packing with good sealability
- hook-shaped fibers → accumulate into the lungs → respiratory illnesses → *asbestos-free packing (AFP)*
- Substitutes : ceramic fiber for high-temperature

Graphite Packing – G-1-1

- Graphite(carbon-based packings): Good substitute for asbestos
- can be produced either in **die-formed** rings or **braided** rings
- Die-formed
 - Graphite ribbon → wound and compressed in a die
 - Density → 1440 to 1600 kg/m³ (90 to 100 lb/ft³)
 - Formation pressure → less than gland (or service)compress
- **Braided graphite**
 - winding small strands of graphite together
 - Is quite pliable
 - forms to the stem → min stem friction
 - Anti-extrusion ring on both sides
 - grab the stem → not transfer load to die-formed → high friction, leakage
 - Has tendency to break down **when** compression exceeds 4000 psi

density-compression stress



Graphite Packing . . .



- Graphite advantages
 - Remains stable through wide range of thermal cycles (thermal expansion)
 - does not extrude during thermal cycling
 - does not lose a seal during thermal cycling
 - is fire-safe → excellent for chemical and petroleum refining industries
 - Good for nuclear service
 - used with a wide range of process fluids (except for strong oxidizers)

Graphite Packing ...

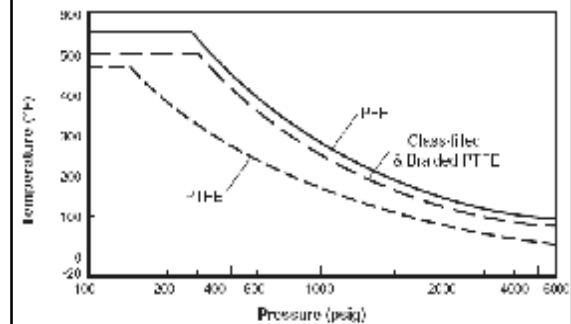
- Graphite disadvantages
 - when fully compressed → has a tendency to stick to the stem → jerky valve motion → premature wear of Stem
 - Rotary valve stem contact face is constant with packing → faster wear
 - High compression → stem galling → packing damage → leakage
 - Is fragile → can be broken easily by mishandling (over compression)
 - accurate torque wrench → preventing overcompress the packing
 - smaller diameter stems → may misalign → create a leak path

Perfluoro elastomer Packing –V–9–1

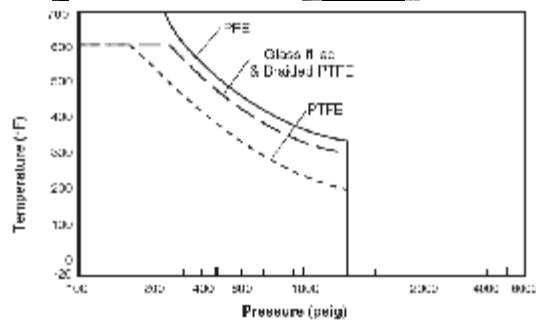
- Recently developed packing
- PFE has a better temperature range than PTFE
- Resists chemical attack
- PFE's only drawback is its cost → very expensive

Temperature and Pressure Limits for Packing –A–9–1

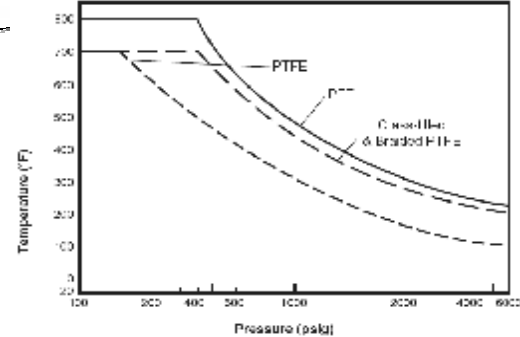
- packing material → affected by fluid's temp. and pressure
- temperature increase → softer packing → become more fluid → extrude out of the packing box
- High pressures also can cause extrusion
- combination of high temp. & pressure → accelerate extrusion
- extended bonnets → temperature limit is always higher



Standard bonnets



Extended bonnets (ANSI Classes 150, 300, and 600)



Extended bonnets (ANSI Classes 900, 1500 and 2500)

Packing Lubricants – 1-1-1

- Packing box → lantern ring → injection of lubricant → minimize stem friction
- Effective lubricants
 - reduces stem friction without increasing the packing box leakage
 - lubricant should not react with the process fluid
 - lubricant should not attract dirt or other particulate matter
 - must maintain its characteristics during severe temperatures
- silicone grease
 - temperatures up to 500°F (260°C)

- ## Packing Lubricants ...
- Lubrication limitations
 - not recommended for oxygen service
 - not recommended for flammable services → petroleum based lubricant could **react** with the fluid
 - In high compression → injection of lubricant may be difficult
 - if injection not impossible → packing box need to disassemble

Packing Lubricants . . .

- silicone grease
 - temperatures up to 500°F (260°C)
 - may oxidize at temperatures higher than 500°F
- Turning the screw on the lubricator , forces the lubricant into the packing box
- Graphite → easily absorb lubricant → pliable → improving the sealability

- | Packing Material | Volume Range (cubic feet) | Standard Length (feet) | Extended Length (feet) |
|----------------------|--|--|--|
| PTL | 50 to 100
1000 to 15000
15000 to 25000 | -20 to 4500' F
-30 to 2200' F
-20 to 4500' F
-20 to 4500' F | -150 to 5500' F
-100 to 2100' F
-150 to 5500' F
-100 to 5500' F |
| Bulked PTL | 50 to 100
1000 to 15000
15000 to 25000 | -20 to 4500' F
-30 to 2200' F
-20 to 4500' F | -150 to 5500' F
-100 to 2100' F
-150 to 5500' F |
| Chopped PTL | 50 to 100
1000 to 15000
15000 to 25000 | -20 to 4500' F
-30 to 2200' F
-20 to 4500' F | -150 to 5500' F
-100 to 2100' F
-150 to 5500' F |
| Subsided PTL Packing | 50 to 100
1000 to 15000
15000 to 25000 | -20 to 4500' F
-30 to 2200' F
-20 to 4500' F | -150 to 5500' F
-100 to 2100' F
-150 to 5500' F |
| Perforated | 50 to 100
1000 to 15000
15000 to 25000 | -20 to 4500' F
-30 to 2200' F
-20 to 4500' F | -150 to 5500' F
-100 to 2100' F
-150 to 5500' F |
| PTL | 50 to 100
1000 to 15000
15000 to 25000 | -20 to 4500' F
-30 to 2200' F
-20 to 4500' F | -150 to 5500' F
-100 to 2100' F
-150 to 5500' F |
| PTL (non-compressed) | 50 to 100
1000 to 15000
15000 to 25000 | -20 to 4500' F
-30 to 2200' F
-20 to 4500' F | -150 to 5500' F
-100 to 2100' F
-150 to 5500' F |

۱-۵-۱- مایه پارامترها

- ۱-۱۰-۱- فاز سیال در جریان
- ۲-۱۰-۱- فشار ، دما و جنس
- ۳-۱۰-۱- وظیفه شیر در شبکه
- ۴-۱۰-۱- میزان خوردگی سروس
- ۵-۱۰-۱- خواص جریان
- ۶-۱۰-۱- شکل کانال جریان
- ۷-۱۰-۱- نوع Pattern
- ۸-۱۰-۱- نوع انتهای شیر
- ۹-۱۰-۱- محدودیت در نصب
- ۱۰-۱۰-۱- محدودیت در باز و بست
- ۱۱-۱۰-۱- سرعت باز و بست
- ۱۲-۱۰-۱- نوع ساختار بدنه
- ۱۳-۱۰-۱- روشی ساخت قطعات
- ۱۴-۱۰-۱- نوع عملکرد
- ۱۵-۱۰-۱- سایر

- ۱-۱-۱ فاز سیال در جریان

۱-۱-۱-۱ گاز

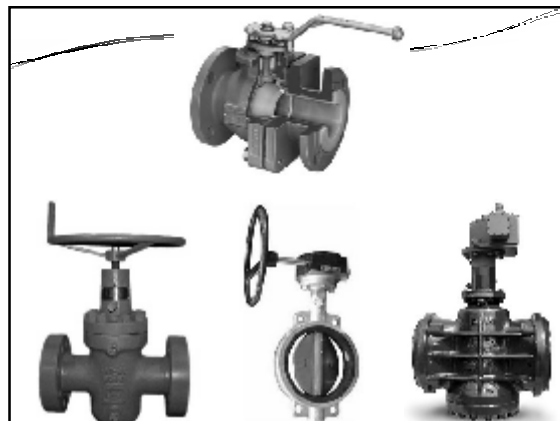
۱-۱-۱-۲ مایع

۱-۱-۱-۳ دوفازی

۱-۱-۱-۱- جریانات گازی

- ☐ کیفیت آب بندی بالا
- ☐ Soft Seat
- ☐ دارای Bleed باشند (در صورت داشتن Cavity)
- ☐ Fire Safe بودن در صورت اشتعال زایی
- ☐ مقاوم در مقابل نوسانات دمایی
- ☐ قابلیت باز و بست سریع
- ☐ سیستم آب بندی ثانویه
- ☐ عمر بهره برداری بالا

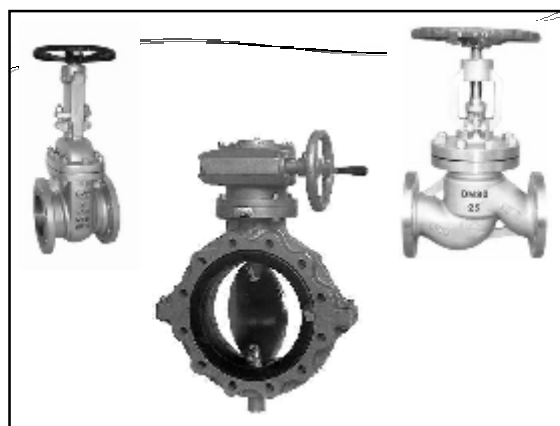
Ball Plug (Conduit Gate) Butterfly



۱-۱-۱-۲- جریانات حالت مایع

- ☐ کیفیت آب بندی متوسط
- ☐ Soft or Metal Seat
- ☐ وجود Drain در صورت نیاز
- ☐ مقاوم در مقابل نوسانات دمایی

Gate Globe Butterfly (Ball, Plug)



۱-۱-۱-۳- جریانات دوفازی

- ۱-۱-۱-۳-۱- مایع + گاز
- ۱-۱-۱-۳-۲- مایع + جامد



۱-۱-۱-۳-۱- حالت مایع + گاز

- ☐ کیفیت آب بندی بالا
- ☐ Soft or Metal Seat
- ☐ وجود Vent, Drain
- ☐ Fire Safe بودن در صورت اشتعال زایی
- ☐ مقاوم در مقابل نوسانات دمایی
- ☐ قابلیت باز و بست سریع
- ☐ سیستم آب بندی ثانویه

Ball Plug Gate Globe Butterfly

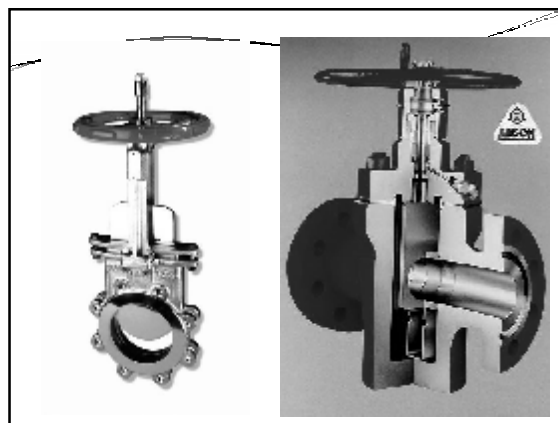
۱-۱-۱-۲- حالت مایع + جامد

- ☐ نداشتن Cavity و یا عدم راهیابی سیال به آن
- ☐ سطوح آب بندی انعطاف پذیر و یا برنده ذرات جامد
- ☐ عملکرد به نسبت قویتر
- ☐ کیفیت آب بندی متوسط
- ☐ باید دارای Drain باشد

Knife, Cond. Gate

Globe

Butterfly



١-٢-٤-٥ - فشا، دما و جنس

۱-۱۰-۲-۱- فشار و دما معلوم، جنس مجهول

۱-۱۰-۲-۲-فشار و جنس معلوم، دما مجهول

تذکر: فشار، پارامتری است که در فرایند انتخاب شیرآلات حتماً باید مشخص باشد.

پس حالت "دما و جنس معلوم، فشار مجهول" جوابی نخواهد داشت.

١-٢-١-١-١ - فساد و دوا معلوم، جنس مجهول

Figure 2.1.1. Reference Temperature, T_{ref} , and Maximum

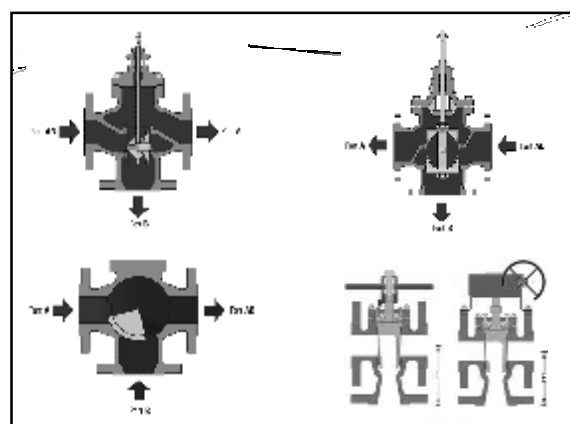
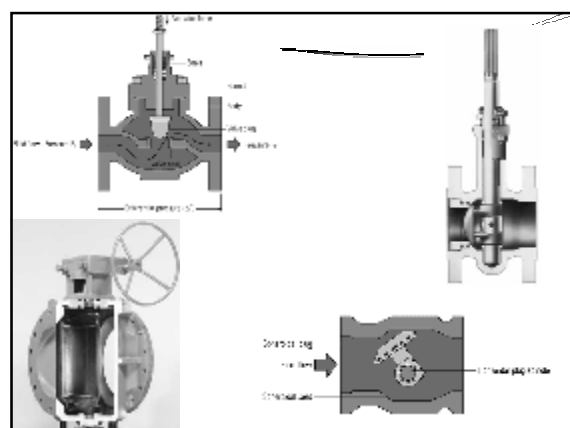
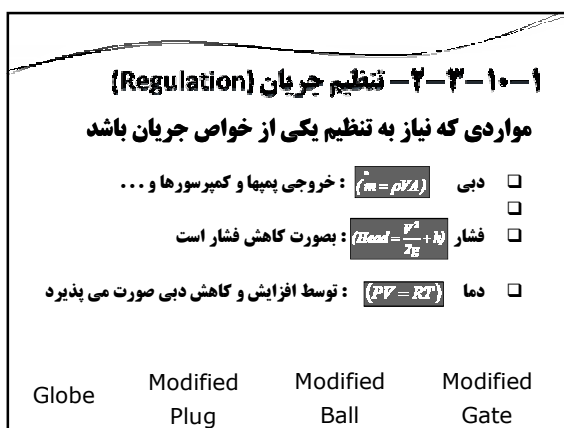
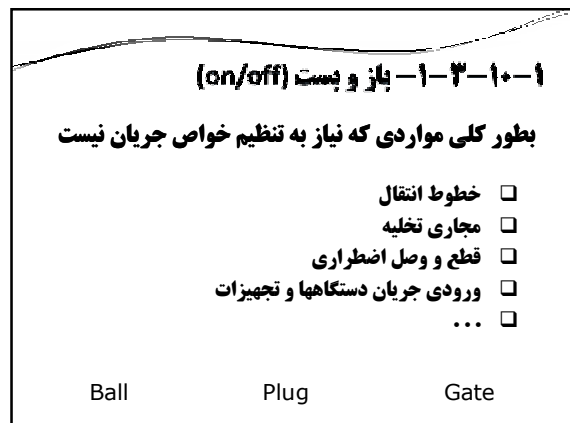
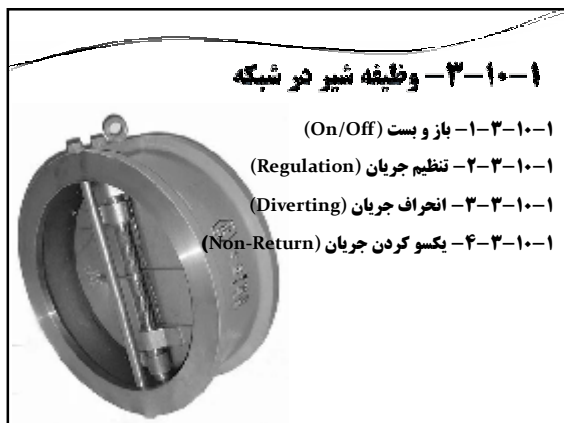
T_{ref} (°C)	T_{ref} (°F)	T_{ref} (°C)	T_{ref} (°F)
0.0	32.0	100.0	212.0
10.0	50.0	150.0	302.0
20.0	68.0	200.0	392.0
30.0	86.0	250.0	482.0
40.0	104.0	300.0	572.0
50.0	122.0	350.0	662.0
60.0	140.0	400.0	752.0
70.0	158.0	450.0	842.0
80.0	176.0	500.0	932.0
90.0	194.0	550.0	1022.0
100.0	212.0	600.0	1112.0
110.0	230.0	650.0	1202.0
120.0	248.0	700.0	1292.0
130.0	266.0	750.0	1382.0
140.0	284.0	800.0	1472.0
150.0	302.0	850.0	1562.0
160.0	320.0	900.0	1652.0
170.0	338.0	950.0	1742.0
180.0	356.0	1000.0	1832.0
190.0	374.0	1050.0	1922.0
200.0	392.0	1100.0	2012.0
210.0	410.0	1150.0	2102.0
220.0	428.0	1200.0	2192.0
230.0	446.0	1250.0	2282.0
240.0	464.0	1300.0	2372.0
250.0	482.0	1350.0	2462.0
260.0	500.0	1400.0	2552.0
270.0	518.0	1450.0	2642.0
280.0	536.0	1500.0	2732.0
290.0	554.0	1550.0	2822.0
300.0	572.0	1600.0	2912.0
310.0	590.0	1650.0	3002.0
320.0	608.0	1700.0	3092.0
330.0	626.0	1750.0	3182.0
340.0	644.0	1800.0	3272.0
350.0	662.0	1850.0	3362.0
360.0	680.0	1900.0	3452.0
370.0	698.0	1950.0	3542.0
380.0	716.0	2000.0	3632.0
390.0	734.0	2050.0	3722.0
400.0	752.0	2100.0	3812.0
410.0	770.0	2150.0	3902.0
420.0	788.0	2200.0	3992.0
430.0	806.0	2250.0	4082.0
440.0	824.0	2300.0	4172.0
450.0	842.0	2350.0	4262.0
460.0	860.0	2400.0	4352.0
470.0	878.0	2450.0	4442.0
480.0	896.0	2500.0	4532.0
490.0	914.0	2550.0	4622.0
500.0	932.0	2600.0	4712.0
510.0	950.0	2650.0	4802.0
520.0	968.0	2700.0	4892.0
530.0	986.0	2750.0	4982.0
540.0	1004.0	2800.0	5072.0
550.0	1022.0	2850.0	5162.0
560.0	1040.0	2900.0	5252.0
570.0	1058.0	2950.0	5342.0
580.0	1076.0	3000.0	5432.0
590.0	1094.0	3050.0	5522.0
600.0	1112.0	3100.0	5612.0
610.0	1130.0	3150.0	5702.0
620.0	1148.0	3200.0	5792.0
630.0	1166.0	3250.0	5882.0
640.0	1184.0	3300.0	5972.0
650.0	1202.0	3350.0	6062.0
660.0	1220.0	3400.0	6152.0
670.0	1238.0	3450.0	6242.0
680.0	1256.0	3500.0	6332.0
690.0	1274.0	3550.0	6422.0
700.0	1292.0	3600.0	6512.0
710.0	1310.0	3650.0	6602.0
720.0	1328.0	3700.0	6692.0
730.0	1346.0	3750.0	6782.0
740.0	1364.0	3800.0	6872.0

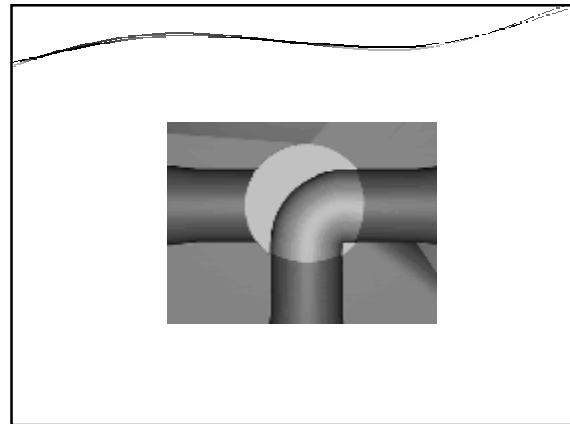
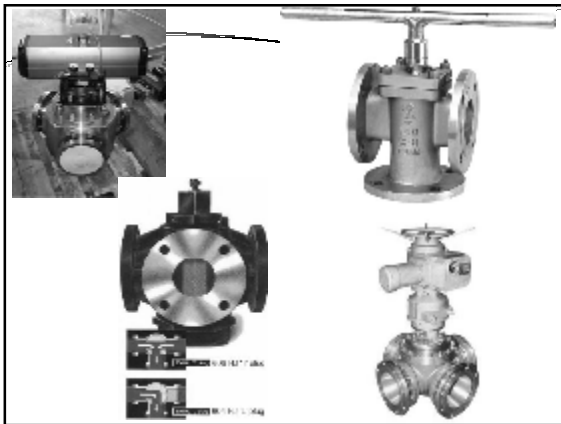
~~۱-۲-۳-۴-۵-۶-۷-۸-۹-۱۰-۱۱-۱۲-۱۳-۱۴-۱۵-۱۶-۱۷-۱۸-۱۹-۲۰-۲۱-۲۲-۲۳-۲۴-۲۵-۲۶-۲۷-۲۸-۲۹-۳۰-۳۱-۳۲-۳۳-۳۴-۳۵-۳۶-۳۷-۳۸-۳۹-۴۰-۴۱-۴۲-۴۳-۴۴-۴۵-۴۶-۴۷-۴۸-۴۹-۵۰-۵۱-۵۲-۵۳-۵۴-۵۵-۵۶-۵۷-۵۸-۵۹-۶۰-۶۱-۶۲-۶۳-۶۴-۶۵-۶۶-۶۷-۶۸-۶۹-۷۰-۷۱-۷۲-۷۳-۷۴-۷۵-۷۶-۷۷-۷۸-۷۹-۸۰-۸۱-۸۲-۸۳-۸۴-۸۵-۸۶-۸۷-۸۸-۸۹-۹۰-۹۱-۹۲-۹۳-۹۴-۹۵-۹۶-۹۷-۹۸-۹۹-۱۰۰~~

[illegible]

دما و جنس معلوم ، فشار مچہول

[illegible]

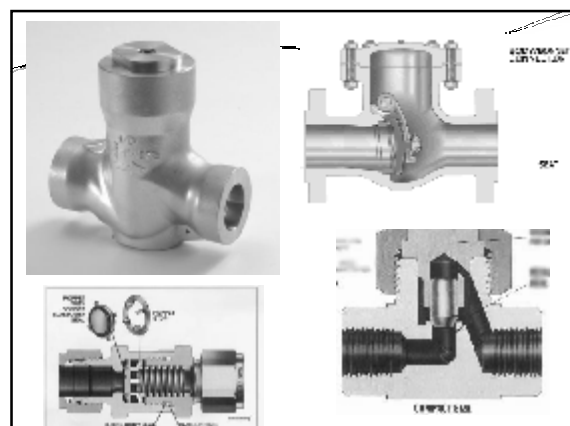




۱-۳-۴- یکسو کردن جریان (Non-Return) Check Valve
جلوگیری از جریان برگشتی - انواع Check Valve

- ☐ خروجی Rotary Machines
- ☐ خروجی تاسیسات
- ☐ خطوطی که دارای اختلاف ارتفاع هستند
- ☐ پایین دست تجهیزات اندازه گیری دقیق
- ☐ جلوگیری از مخلوط شدن چند جریان
- ☐ خروجی تلمبه خانه ها و ایستگاههای افزایش فشار

Swing Lift Axial



۱-۴-۱- میزان خوردگی سرویس

- ۱-۴-۱-۱ - خوردگی های معمولی
- ۲-۴-۱-۱ - خوردگی های متوسط
- ۳-۴-۱-۱ - خوردگی های بالا

۱-۴-۱- خوردگی های معمولی

- ☐ مواد انتخابی مناسب و متروتن نه سرامیک
- ☐ گزینش صحیح نوع شیر
- ☐ عمر بهره برداری مناسب

۱-۱۰-۴-۳- خوردگی های بالا



- ☐ مواد انتخابی مناسب
- ☐ گزینش صحیح نوع شیر
- ☐ عمر بهره برداری مناسب
- ☐ میزان تعمیر پذیری روی خط
- ☐ انتخاب صحیح انتهای شیر
- ☐ میزان فراوانی



۱-۱۰-۴-۲- خوردگی های متوسط

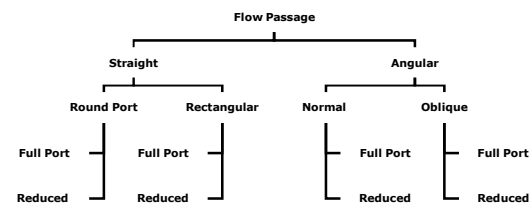


- ☐ مواد انتخابی مناسب و مقرون به صرفه
- ☐ گزینش صحیح نوع شیر
- ☐ عمر بهره برداری مناسب
- ☐ میزان تعمیر پذیری روی خط
- ☐ انتخاب صحیح انتهای شیر

۱-۱۰-۶-۱- شکل کانال جریان

تعریف :

قسمتی از بدنه ، درپوش و مجرایند که در حالت باز یا سیال جریان در تماس هستند .

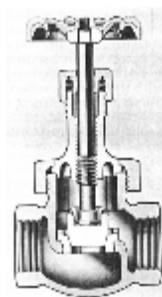


۱-۱۰-۵- خواص جریان

- Pressure Drop
- Flow Capacity
- Actual Pressure Drop
- Choked Pressure Drop
- Allowable Pressure Drop
- Cavitation Incipient and Advanced
- Flashing Issues
- Liquid Pressure-Recovery Factor
- Liquid Critical-Pressure Ratio Factor
- Choked Flow
- Velocity
- ...

۱-۱۰-۶-۱- مستقیم یا تحت زاویه

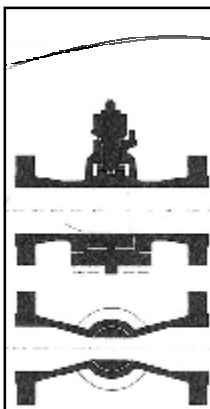
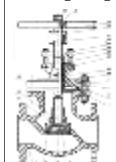
- ☐ زاویه بین راستای ورودی و خروجی شیر
- ☐ میزان آشفتنی جریان
- ☐ ایجاد سر و صدا
- ☐ افت هد جریان

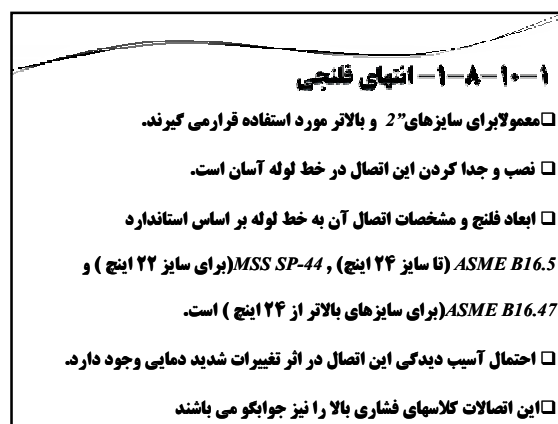
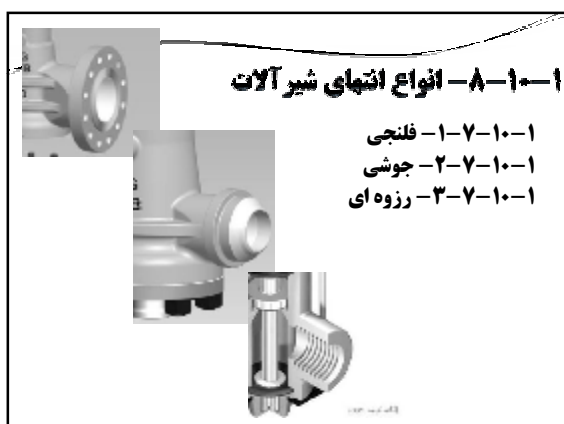
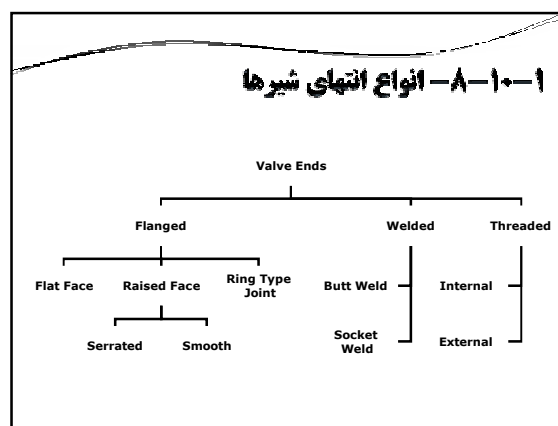
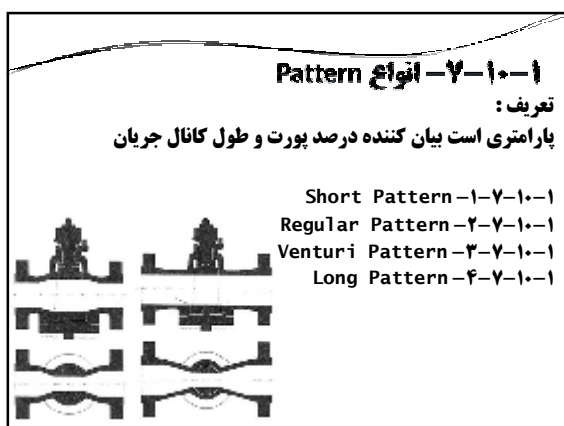


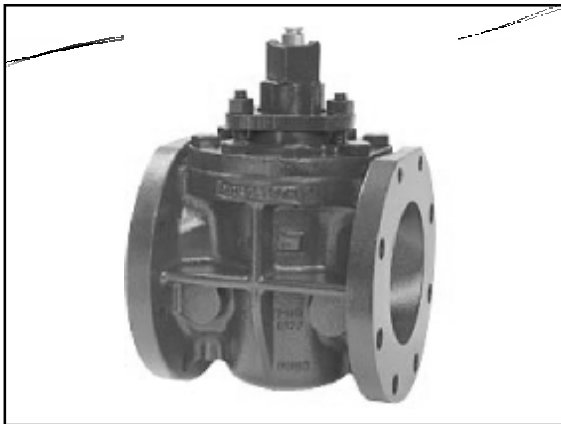
۱-۱۰-۶-۱- شکل کانال جریان

- ۱-۱۰-۶-۱- مستقیم یا تحت زاویه
- ۲-۱۰-۶-۱- سطح مقطع گرد یا چهار گوش
- ۳-۱۰-۶-۱- پورت کامل یا کاهنده

نکته : شکل کانال جریان با شکل خارجی شیر تفاوت دارد





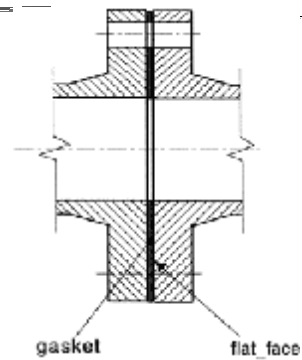


دسته بندی اتصالات فلنجی

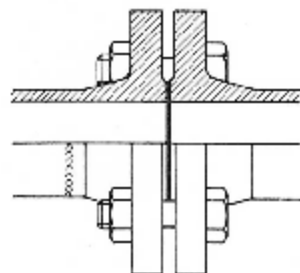
- ❑ Flat face
- ❑ Raised face
- ❑ Ring Type Joint
- ❑ Others
 - Tongue & Groove
 - Male & Female

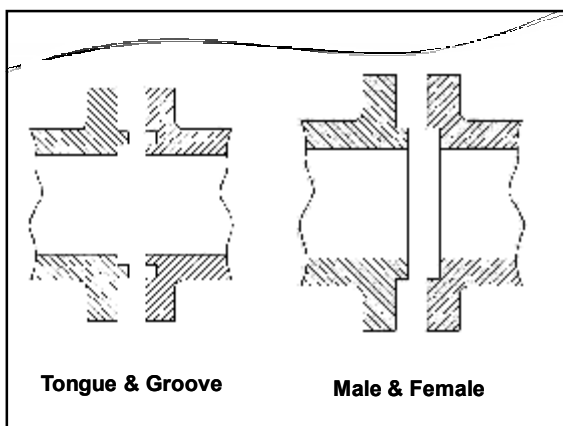
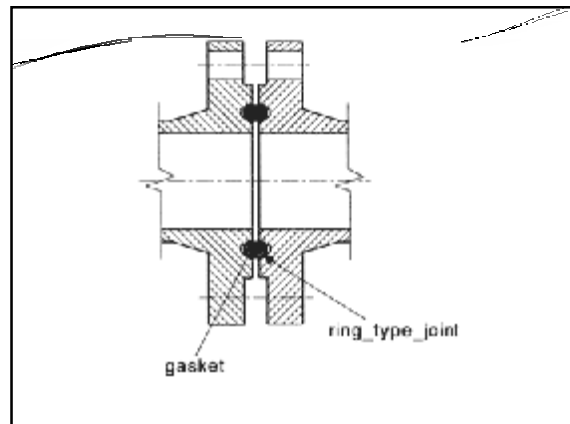
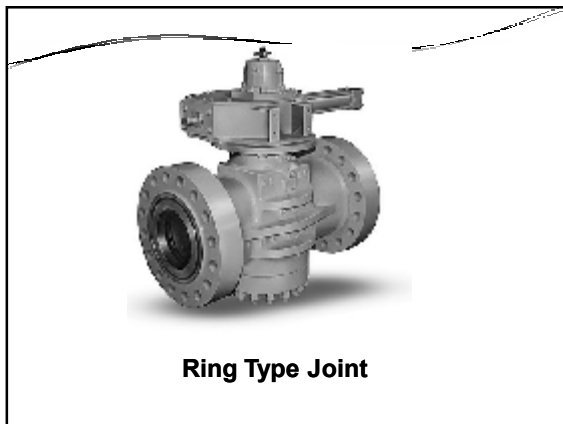


Flat Face



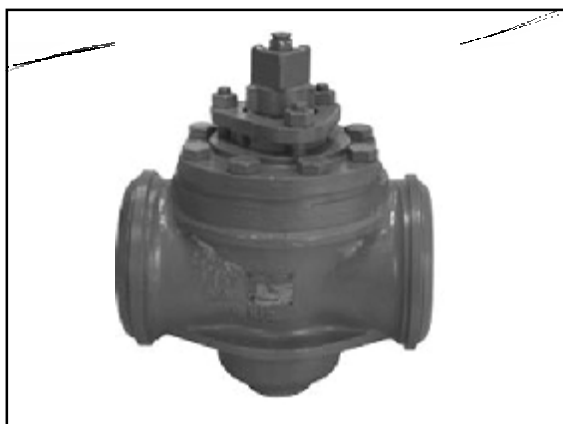
Raised Face





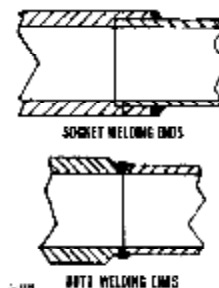
۱-۱-۸-۲- انتهای جوشی

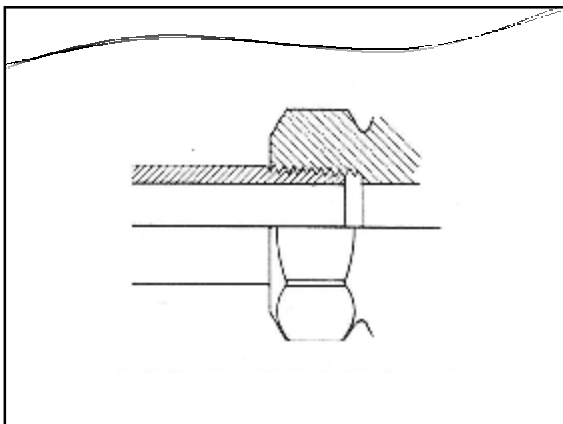
- معمولاً برای سائزهای "1 و بالاتر مورد استفاده قرار می گیرند.
- این اتصالات با ایجاد یک ساختار یکپارچه در خط لوله سبب ایجاد یک آب بندی مناسب و بدون نیاز به تعمیر و نگهداری می شوند.
- روش اتصال این شیرها به خط لوله بر مبنای استاندارد *ASME B31.1* و *ASME B31.8* می باشد.
- از این نوع اتصال می توان در سرویسهای فشار بالا و نیز دمای بالا استفاده کرد.



دسته بندی اتصالات جوشی

- ☐ *Butt Weld*
- ☐ *Socket Weld*

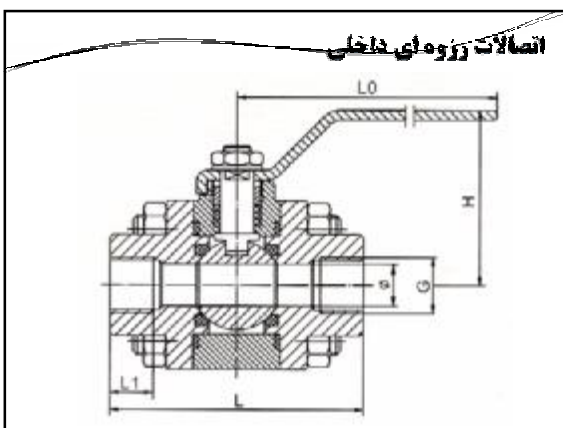




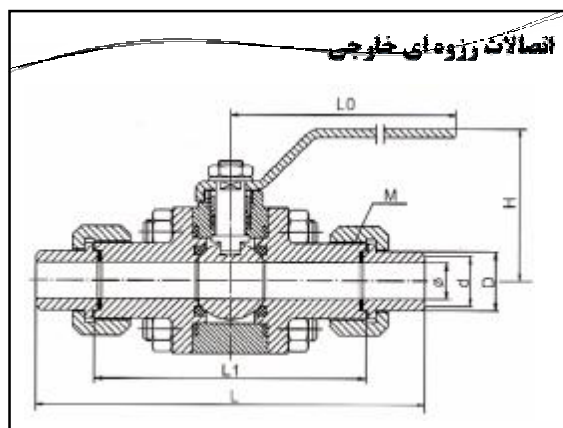
دسته بندی اتصالات رزوه ای

□ اتصالات رزوه ای داخلی

□ اتصالات رزوه ای خارجی



اتصالات رزوه ای داخلی



اتصالات رزوه ای خارجی

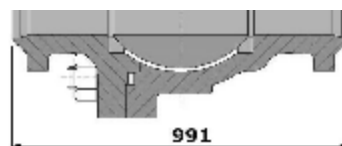
۱-۱۰-۹- محدودیت در نصب

- ۱-۱۰-۹-۱ طول شیر
- ۲-۱۰-۹-۲ استاندارد اتصال انتهایی
- ۳-۱۰-۹-۳ ضخامت لبه انتهایی جوشی
- ۴-۱۰-۹-۴ محدودیت در باز و بست

۱-۱۰-۹-۱ طول شیر

□ مطابق کدام استاندارد است

- API 6D
- ASME B16.10
- BS 2080
- BS EN 558-1
- DIN
- OTHERS



۱-۹-۲-۲- استاندارد اتصال انتهایی

FLANGE :

- ☐ ASME
- ☐ API
- ☐ BSI
- ☐ DIN
- ☐ GOST
- ☐ OTHERS

Butt Weld :

- ☐ ASME
- ☐ BSI
- ☐ DIN
- ☐ OTHERS

Threade :

- ☐ ASME
- ☐ API
- ☐ BSI
- ☐ DIN
- ☐ OTHERS



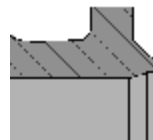
۱-۹-۳- ضخامت لبه انتهایی جوشی

□ ضخامت لبه جوشی = ضخامت لوله

□ PIPE SCHEDULE : بیانگر ضخامت دیواره لوله است

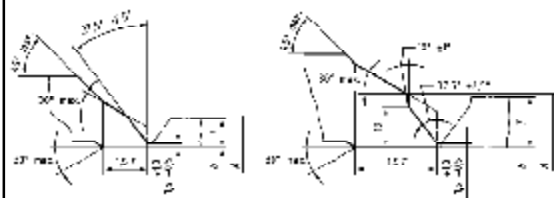
□ انواع تقسیم بندی SCH :

- STD , XS , XXS
- 10, 20, 30, ...



۱-۹-۳-۱- ضخامت لبه انتهایی جوشی (ادامه)

❖ استانداردهای مورد نیاز : ASME B16.25, ASME B36.10, API 5L, ...



1) ASME B16.25, ASME B36.10, API 5L, ...

A = nominal outside diameter of pipe and steel
S = nominal inside diameter of pipe
T = nominal wall thickness of pipe

۱-۹-۱- محدودیت در باز و بست

□ در ارتفاع

□ شبکه بسیار شلوغ

□ کنار دیوار یا مانع بزرگ

□ داخل حوضچه کوچک

□ زیر زمین (دفنی)



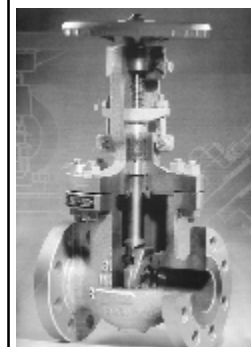
۱-۹-۱۱- سرعت باز و بست

□ سرعت بالا : شیرهای ربع گرد

BALL PLUG BUTTERFLY

□ سرعت پایین : شیرهای RISING STEM

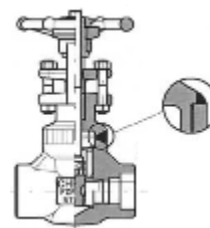
GATE GLOBE PISTON



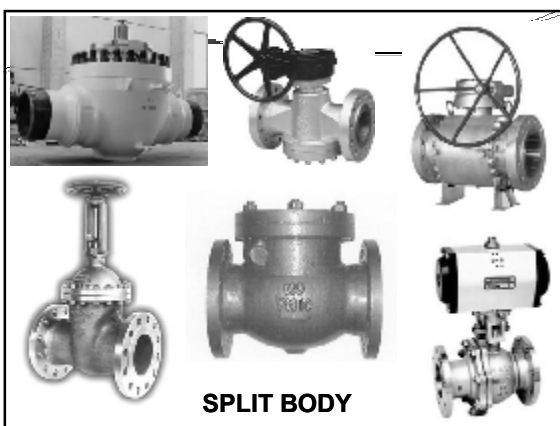
۱-۱۰-۱۲- نوع ساختار بدنه

❑ RIDGID
- FULLY WELDED BODY

❑ SPLIT BODY
- ONE PIECE
- TWO PIECES
- THREE PIECES
- OTHERS



FULLY WELDED BODY



SPLIT BODY

۱-۱۰-۱۳- روش ساخت قطعات

❑ ریخته گری

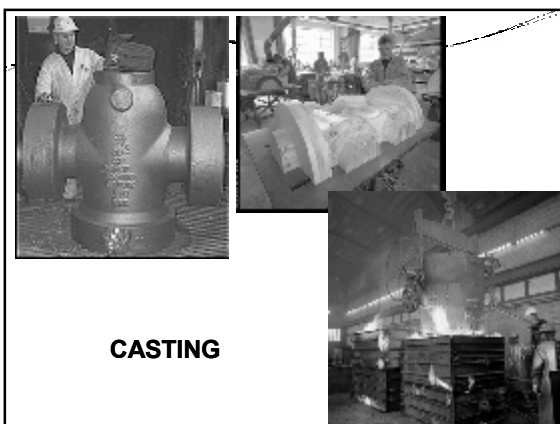
- ریخته گری ماسه ای
- ریخته گری دقیق
- ...

❑ فورج

- ضربه ای
- فرمینگ

❑ تراشکاری

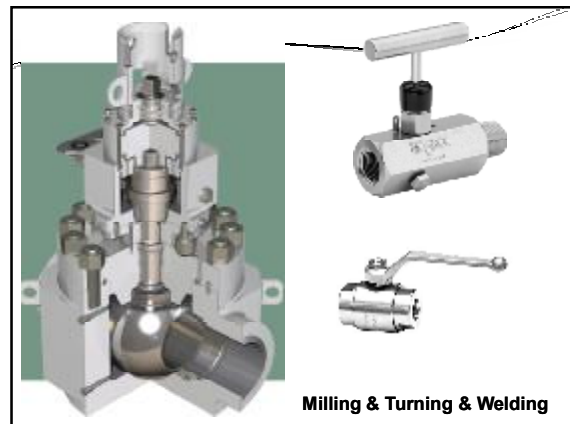
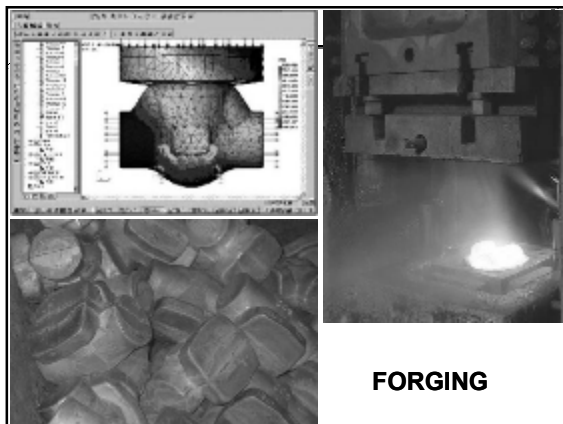
- TURNING
- MILLING
- ...



CASTING



FORGING



۱-۱۰-۱۴- نوع عملگر

❖ ۱-۱۰-۱۴-۱- آچار (Wrench)

❖ ۱-۱۰-۱۴-۲- گیر بکس (Gearbox)

❖ ۱-۱۰-۱۴-۳- عملگر (Actuator)

۱-۱۰-۱۴-۱- آچار (Wrench)

❖ حداکثر نیروی وارده نباید از 360 N بیشتر شود

❖ طول آن نباید از ۲ برابر طول شیر بیشتر شود

Plug & Ball Valve	
class	size
150	≤ 8 in
300	≤ 6 in
600	≤ 4 in



۱-۱۰-۱۴-۲- گیر بکس (Gearbox)

❖ حداکثر نیروی وارده نباید از 360 N بیشتر شود

❖ قطر فرمان آن نباید از طول شیر و یا یک متر بیشتر شود

❖ ممکن است دارای مکانیزم محدودکننده گشتاور باشد

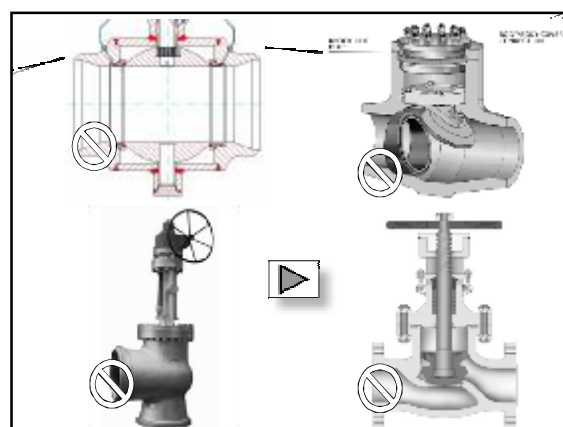
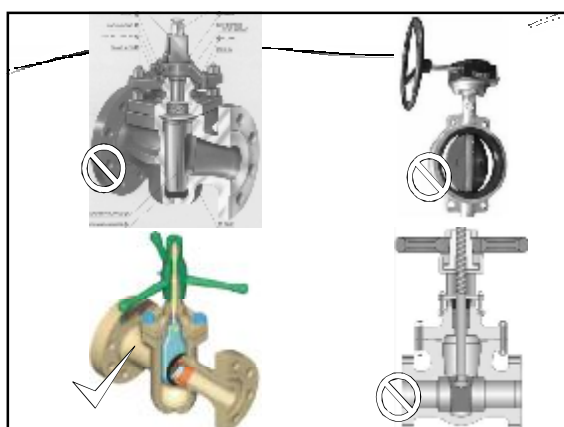
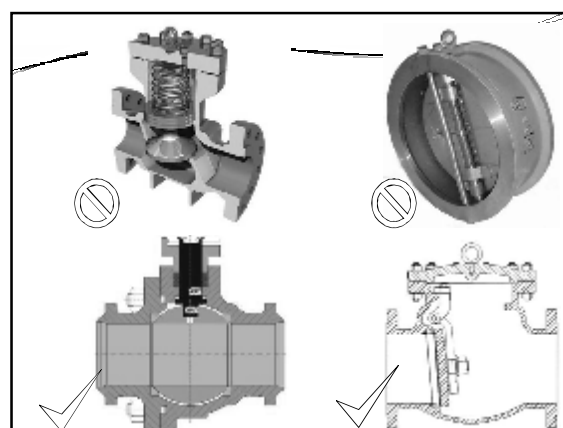
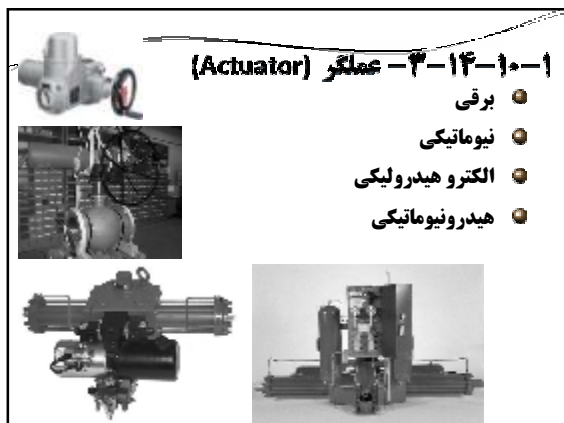
Plug & Ball Valve	
class	size
150	≥ 8 in
300	≥ 6 in
600	≥ 4 in

حداکثر گشتاور گیربکس

3.30. The max gear box output torque shall be :

- Greater or equal to 1.2 the max break out torque of the ball valve at the max shut off pressure.
- Greater or equal to 1.5 the max break out torque of the plug and hose/cable valve at the max shut off pressure.







عناوين فصل سوم

مقدمه - ۱-۳

Valve-Sizing Nomenclature - ۲-۳

Body Sizing of Liquid-Service Control Valves - ۳-۳

Control Valves Body Sizing of Gas-Service - ۴-۳

مقدمه - ۱-۳

The Importance of Correct Valve Sizing - ۱-۱-۳

Valve-Sizing Criteria for Manual Valves - ۲-۱-۳

Valve-Sizing Criteria for Check Valves - ۳-۱-۳

Valve-Sizing Criteria for Throttling Valves - ۴-۱-۳

The Importance of Correct Valve Sizing - ۱-۱-۳

- valve sizing is based on the standard thermodynamic laws
- these laws is affected by :
 - function of the valve
 - Type of service
 - severity of service
- sizing → throttling valves
- On/off valve :
 - sized smaller → flow will be restricted → pressure drop → less flow
 - sized larger → expensive costs (valve, piping)

The Importance of Correct Valve Sizing - ۱-۱-۳

- throttling valve :
 - sized smaller → maximum flow will be limited → inhibit the function of system
 - sized larger → expensive costs (valve, piping) & entire flow passes in first half of stroke
- Because of safety factors → throttling valves are oversized

Valve-Sizing Criteria for Manual Valves - ۲-۱-۳

- Valve basic function : pass full flow while the valve is open
- valve size → size of piping → which sized by system engineer
- Manufacturers → sizing charts → Q for min , max valve size
- Usually : manual-valve sizing → full bore or reduced bore
- Check : valve for full flow or to take a slight pressure drop ?
- full bore :
 - services with Slurries
 - services with particulates
 - Passing pig
 - For high velocities
 - Low erosion

Valve-Sizing Criteria for Manual Valves – ٢ – ١ – ٣

- **Reduced bore :**
 - services without Slurries & contaminant
 - no pigability
 - For low velocity services
- **manual-valve sizing :**
 - Max , Min temperatures (T)
 - Max , Min pressures (P)
 - Max , Min Flow rates (Q)
 - Max , Min Specific volume (ρ)



Valve-Sizing Criteria for Check Valves – ٢ – ١ – ٣

- sufficient pressure drop
- Min. flow exist for open
- **Example :** pump fails
- **Low pressure drop (<1 psi)** → Disk will float back and forth
→ wear of moving parts → short life of the valve
- **Higher pressure drop (>10 psi)** → erosion of Disk



Continue...

- **Cracking pressure :**
 - min. pressure required to open the check valve
 - is a fixed number depending on style & size of the check valve
 - can vary from 0.1 to 0.5 psi
 - **Is a little concern** unless the pressures is low or P. drop is less than 1 psi
 - Is important if the valve is installed in a vertical line
 - Smaller lines have higher cracking pressures than larger
- check valves are sized for minimum flow

Continue...

- For wide range of flow: check valves are sized for min. flow
- manufacturer's sizing charts → for the min. flow → if valve size equivalent to or greater than pipeline size → pipeline size should be used
- **Example :**
Manu. Chart → Min Flow → Valve Size=4" , Pipe Size=3" → Valve size=3
- **oversize check valve** → more expensive → more cost of project

Continue...

- If valve for min. flow < Pipe size → reducers use with valve
- High flow rates → increase frequency of vortices and currents
→ increase the pressure drop , valve wear
- Insufficient flow → cause the valve to FLUTTER
- Flow must overcome :
gravity, weight of Disk, spring force, line orientation
- the maximum liquid flow velocity = 3.4 m/s
- The minimum liquid flow velocity = 1.8 to 2.1 m/s
- some designs (such as double-disk) velocity = 0.9 m/s

Valve-Sizing Criteria for Throttling Valves – ٢ – ١ – ٣

- size of the valve body
- body style
- Material → can accommodate process conditions
- correct pressure rating
- Proper installed flow characteristic
- Standard for flow capacity : ANSI/ISA S75.01

Continue...

- For correct sizing, following conditions are needed

- Upstream pressure
- Max. And min. Temperatures
- Type of process fluid
- Max. Flow rate
- Average flow rate
- Min. Flow rate
- Vapor pressure
- Pipeline size, schedule, and material
- Max., Average, and min. Pressure drop
- Specific gravity of the fluid
- Critical pressure



Valve-Sizing Nomenclature – ۲-۲

Pressures Upstream and Downstream – ۱-۲-۲
 Pressure Drop – ۲-۲-۲
 Flow Capacity – ۲-۲-۲
 Actual Pressure Drop – ۴-۲-۲
 Choked Pressure Drop – ۵-۲-۲
 Allowable Pressure Drop – ۶-۲-۲
 Incipient and Advanced Cavitation – ۷-۲-۲
 Flashing Issues – ۸-۲-۲
 Liquid Pressure-Recovery Factor – ۹-۲-۲
 Liquid Critical-Pressure Ratio Factor – ۱۰-۲-۲
 Choked Flow – ۱۱-۲-۲
 Velocity – ۱۲-۲-۲
 Reynolds-Number Factor – ۱۳-۲-۲
 Piping-Geometry Factor – ۱۴-۲-۲
 Expansion Factor – ۱۵-۲-۲
 Ratio of Specific Heats Factor – ۱۶-۲-۲
 Terminal Pressure-Drop Ratio – ۱۷-۲-۲
 Compressibility Factor – ۱۸-۲-۲



Upstream and Downstream Pressures – ۱-۲-۲

- Upstream pressure: The pressure reading before the valve
- Downstream pressure: The pressure reading taken after the valve
- Upstream pressure $\neq$ Downstream pressure



Pressure Drop – ۲-۲-۲

- Pressure drop (or the pressure differential):
 Difference between the upstream and downstream pressures

The greater the
pressure drop



The greater the flow
through the valve

Flow Capacity – ۲-۲-۲

Cv

- The most commonly applied sizing coefficient
- One U.S. gallon of 60°F water that flows through a valve with 1.0 psi of pressure drop.
- When calculated properly → determines the correct trim size

$$C_v = Q \sqrt{\frac{S_g}{\Delta P}}$$

C_v = required flow coefficient for the valve
 Q = flow rate (in gal/min)
 S_g = specific gravity of the fluid
 ΔP = pressure drop (psi)

Actual Pressure Drop – ۴-۲-۲

- Difference between the inlet and outlet the valve
- If actual pressure drop < choked pressure drops → actual pressure drop is used in Cv equation



Choked Pressure Drop — Δ—Ψ—Ψ

- Pressure drop is increased → flow should increase
- At *choked flow*: further increases in the pressure drop → will not change the valve's flow rate
- In choked condition
 - Liquids: flow rate will reach a max. with existence of Cavitation
 - Gases: sonic velocity

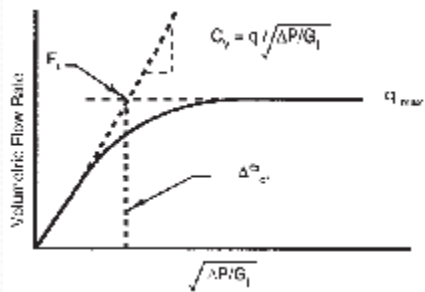
$$C_v = \frac{Q}{\frac{\Delta P}{S_g}} \Rightarrow C_v = \text{Const} \Rightarrow Q \propto \sqrt{\Delta P}$$

$$\Delta P = P_1 - P_2$$

$$P_1 = \text{Const} \Rightarrow P_2 \downarrow \Rightarrow Q \uparrow$$

Choked Pressure Drop — Δ—Ψ—Ψ

- theoretical point of choked flow :
 - intersecting the linear lines of the C_v and the max. flow rate (Q_{max}).
- Point of intersection = liquid pressure-recovery factor (F_L)
- For liquids, F_L can lead to calculating ΔP_{choked}
- For gases, X_T is used to describe the ΔP_{choked}
- STD : ANSI/ISA S75.01



Allowable Pressure Drop — Δ—Ψ—Ψ

ΔP_a

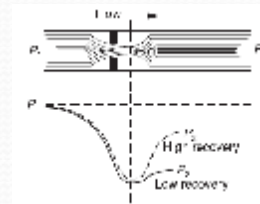
- smaller of the actual pressure drop or the choked pressure drop
- Lead to determination of the correct C_v
- Liquid → calculating $C_v \Rightarrow \Delta P_a$ should be checked :
 - if the inlet pressure P_1 is fairly close to the vapor pressure
 - if the outlet pressure P_2 is fairly close to the vapor pressure
 - if the actual pressure drop is fairly large when compared to P_1
- ΔP_a should be compare with the actual pressure drop

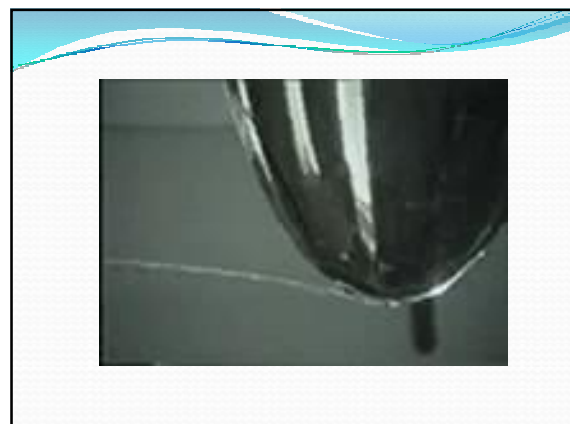
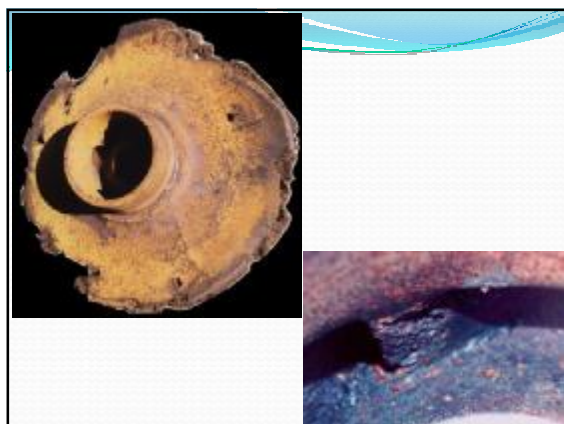
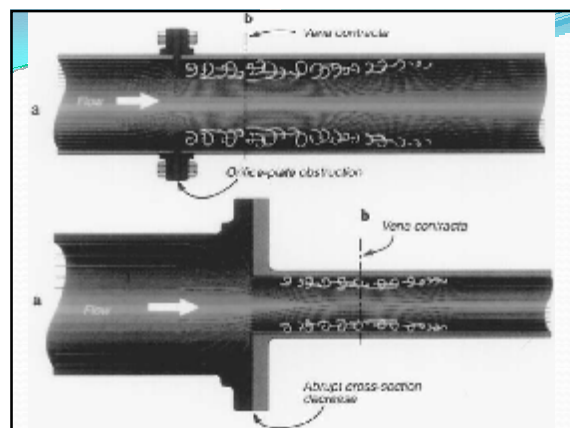
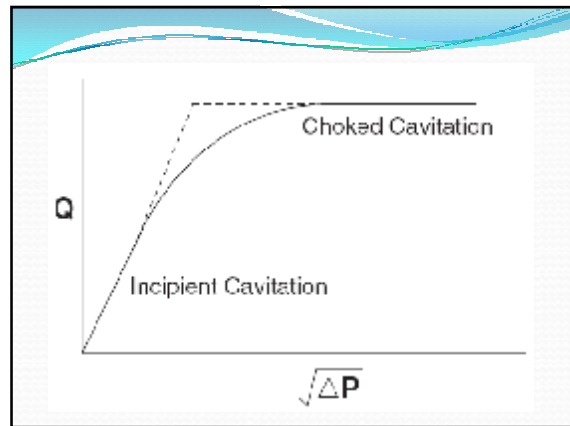
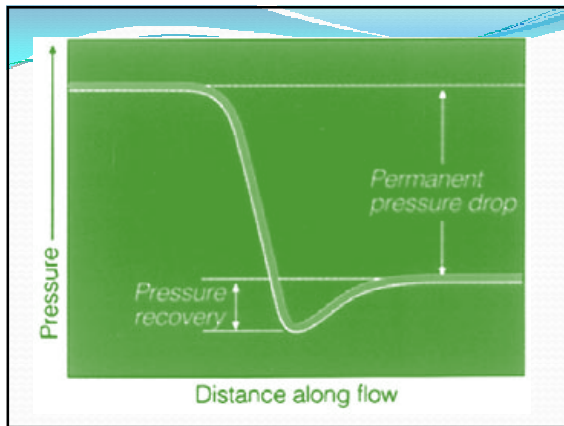
Incipient and Advanced Cavitation — Ψ—Ψ—Ψ

- Liquid service → in narrowest point → velocity increase → pressure decreases → If $P < P_{vapor}$ → vapor bubbles forms → in larger area → pressure increases → vapor bubbles collapse
- This two step-process called **Cavitation**
- erosion of metal surfaces
- *incipient Cavitation* : point where vapor bubbles begin to form
- *advanced Cavitation* : where Cavitation is at its max. level
- In advanced Cavitation, the flow is choked and cannot increase

Incipient and Advanced Cavitation — Ψ—Ψ—Ψ

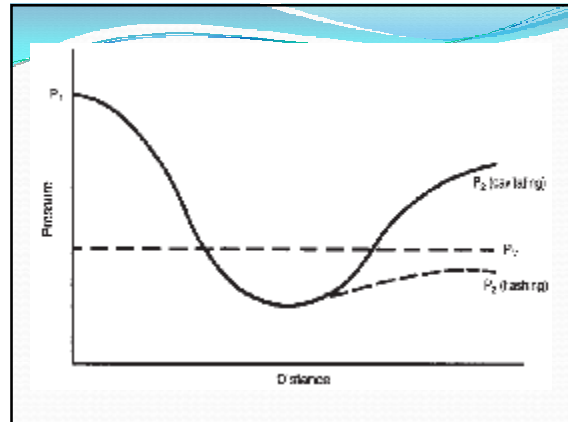
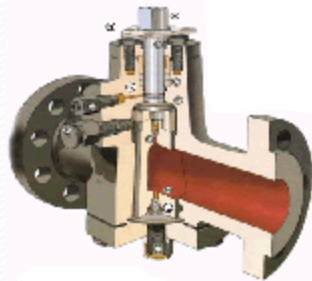
- and affects the flow capacity & function of the valve
- The point where advanced Cavitation occurs can be predicted
- ΔP must be determined, using the liquid Cavitation factor F_i





Flashing Issues – ۱-۲-۳

- P_2 does not recover above the vapor pressure $\rightarrow$ vapor bubbles remain in the fluid $\rightarrow$ creating a mixture of liquid and gas
- Problems :
 - higher velocities
 - erosion of valve components



Plug damaged by flashing



Liquid Pressure-Recovery Factor – ۹-۲-۳

F_L

- critical element in liquid sizing
- Predicts the effect the geometry of a valve's body on max. capacity
- Predict pressure recovery , between vena contracta & body outlet
- Can vary depending on the internal design of the valve
- Rotary valves, allow for a high recovery of the fluid following the vena contracta
- Especially ball and butterfly valves
- Globe valves have better F_L
- Globe valves: *able to handle severe services when compared to rotary valves*

Liquid Critical-Pressure Ratio Factor – ۱۰-۲-۳

F_F

- is important to liquid sizing
- it predicts the theoretical pressure at the vena contracta
- When the max. pressure drop occurs across the valve
- Or in the choked pressure drop



Choked Flow – 11-2-2

- In liquid services, Cavitation or flashing → expands the specific volume
- Volume increases at a faster rate than the flow increased (due to the pressure differential)
- Then ,valve cannot pass any additional flow, even in lower P₂
- For Gas & Vapor services, choked flow occurs when the velocity achieves sonic levels (Mach 1 or greater)
- Occurs at any point in the valve body or downstream piping

Choked Flow – 11-2-2

- Mass and energy LAW : $P + \frac{1}{2} \rho V^2 + \rho g h = \text{Const}$
if pressure decreases in the valve, velocity increases inversely
- If pressure lowers → specific volume of the fluid increases → sonic velocity is achieved
- velocity limitation : Mach 1 for gases and 12.7 m/s for liquids
- Thus, flow rate is limited for sonic velocity through the vena contracta or downstream piping

Velocity – 12-2-2

V

- smaller valve sizes are better equipped to handle higher velocities than larger-sized
- But actual size , vary according to the valve style
- For liquid services, max. velocity at the valve outlet is 12.7 m/s
- gas services velocity are generally restricted to Mach 1.0
- In Cavitation or flashing → higher velocity associated with the liquid-gas mixture → max. velocity restricted to 127 m/s

Velocity – 12-2-2

- Exceptions for liquids :
 - If temperatures are close to saturation point : $V < 7.6 \text{ m/s}$
 - Valve with full flow rate with min. P Drop : $V < 7.6 \text{ m/s}$
 - Valve with P Drop falls below the vapor P, advanced cavitation : $V < 7.6 \text{ m/s}$



Reynolds-Number Factor – 13-2-2

F_R

- Non-turbulent flow → Laminar flow (Oils) → High viscosity , Lower velocities , Low flow capacity
- F_R is used to correct the Cv equation for these flow
- if the viscosity is fairly low → F_R is insignificant



Piping-Geometry Factor – 14-2-2

F_P

- C_v → affected by nonstandard piping configurations
- Example : use of increasers or reducers
- C_v must be corrected , using the F_P
- C_v testing : with straight piping , line & valve size are Same
- use of larger or smaller piping size & proximity of elbows → can decrease these C_v → must be considered during sizing



Expansion Factor – 15-2-2

Y

- gas service :
 - Flow moves from the upstream to the vena contracta
 - the *specific weight* of the fluid varies
 - *Y* is used to compensate this effects
- *Y* is important for :
 - Takes into account the changes in the cross-sectional area of the vena contracta
 - And the pressure drop changes in that region

Ratio of Specific Heats Factor – 16-2-2

F_K

- *C_v* equation for gases is based upon air → some adjustment must be made for other gases
- *F_K* is used to adjust the *C_v* equation for Gases



Terminal Pressure-Drop Ratio – 17-2-2

X_T

- gas service :
 - Valve choked point → predicted by *X_T*
 - Similar in many respects to the *F_L*
- *X_T* is affected by :
 - Geometry of the valve's body
 - Varies according to valve style
 - Valve size



Compressibility Factor – 18-2-2

Z

- Gas services :
 - Are Compressible
 - Change in temp. & pressure → density varies → *Z* takes into account the compressibility in *C_v* equation



Body Sizing of Liquid-Service Control Valves – 2-2

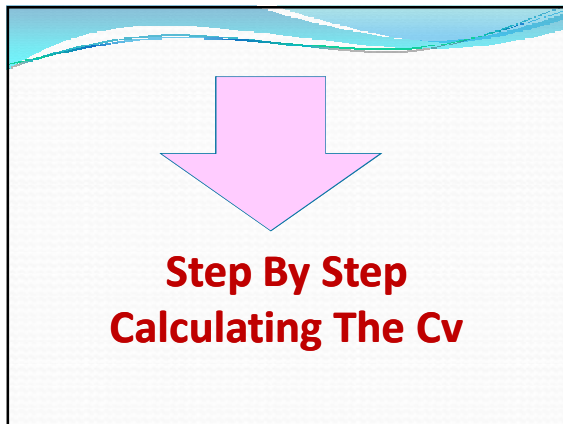
- Basic Liquid Sizing Equation – 1-2-2
- Actual-Pressure-Drop Calculation – 2-2-2
- Choked Flow, Cavitation, and Flashing Determination – 3-2-2
- Specific-Gravity Determination – 4-2-2
- Approximate-Flow-Coefficient Calculation – 5-2-2
- Approximate Body Size Selection – 6-2-2
- Reynolds-Number-Factor Calculation – 7-2-2
- Flow-Coefficient Recalculation – 8-2-2
- Piping-Geometry-Factor Calculation – 9-2-2
- Final-Flow-Coefficient Calculation – 10-2-2
- Valve Exit-Velocity Calculation – 11-2-2
- Trim-Size Selection – 12-2-2
- Flashing-Velocity Calculation – 13-2-2
- Percentage of Flashing Calculation – 14-2-2
- Liquid Sizing Examples – 15-2-2

Basic Liquid Sizing Equation – 1-2-2

- for most liquid applications → using actual pressure drop
- For non-laminar liquids :

$$C_v = \frac{Q}{F_p} \sqrt{\frac{S_g}{\Delta P_e}}$$

where *C_v* = valve-sizing coefficient
F_p = piping geometry function
Q = flow rate (gal/min)
S_g = specific gravity (at flowing temperature)
 ΔP_e = allowable pressure drop across the valve (psi)



Actual-Pressure-Drop Calculation – ۳-۳-۳

- $\Delta P \rightarrow$ Before determining the allowable pressure drop
- $\Delta P = P_1 - P_2$

Choked Flow, Cavitation, and Flashing Determination – ۳-۳-۳

a) The choked flow point

$$\Delta P_{choked} = F_L^2 (P_1 - F_F P_v)$$

where ΔP_{choked} = choked pressure drop
 F_L = liquid pressure-recovery factor
 F_F = liquid critical-pressure-ratio factor
 P_v = vapor pressure of the liquid (at inlet temperature, psia)

- **Liquid Critical Pressure Ratio**

$$F_F = 0.96 - 0.28 \sqrt{\frac{P_v}{P_c}}$$

P_c = critical pressure of the liquid (psia)

If $\Delta P_{choked} < \Delta P \rightarrow \Delta P_a = \Delta P_{choked}$ in the Cv Equation

F_L is usually provided by the manufacturer

Valve Style	Flow Direction	Trim Area	F_L
Linear globe	Over seat	Full area	0.85
	Over seat	Reduced area	0.80
	Under seat	Full area	0.90
	Under seat	Reduced area	0.90
Butterfly	60° open	Full area	0.76
	90° open	Full area	0.56
Ball	60° open	Full area	0.78
	90° open	Full area	0.66

*Courtesy of Valtek International.
 *Note: All values provided are full open.

Liquid	Critical Pressure psia/psf
Acetone	1636.1/112.8
Acrylonitrile	2127.0/148.8
Ammonia	713.0/49.0
Benzene	551.0/38.0
Carbon Dioxide	1272.0/73.8
Carbon Monoxide	567.0/39.0
Chlorine	1117.0/77.0
Chloroform	517.0/35.7
Chlorobenzene	2185.0/148.8
Cyclohexane	250.0/16.5
Ethylene	360.0/24.8
Ethyl alcohol	410.0/28.0
Helium	2282.0/158.0
Hydrogen	1316.0/90.0
Hydrogen Fluoride	1215.0/83.0
Isobutane	520.0/35.5
Isopentane	500.0/34.0
Kerosene	360.0/24.8
Methane	567.0/39.0
Nitrogen	482.0/33.0
Nitrobenzene	125.0/8.5
Octane	230.0/15.5
Phenol	500.0/34.0
Propane	510.0/34.5
Propylene	570.0/39.0
Trichloroethylene	514.0/34.0
Trichlorofluoromethane	540.0/37.0
Trichloromethane	540.0/37.0
Trichloroethylene	514.0/34.0
Water	3208.0/212.0

**PC : Critical Pressures for
Common Process Fluids**

b) The Cavitation

$$\Delta P_{cavitation} = F_c^2 (P_1 - P_v)$$

F_c = liquid cavitation factor

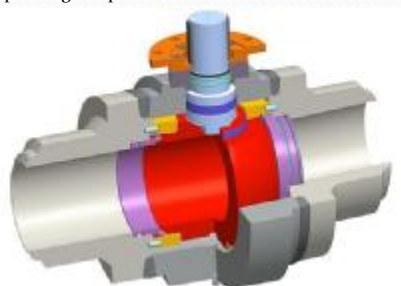
advanced cavitation $\rightarrow$

Valve Style	Flow Direction	Trim Area	F_c
Linear globe	Over seat	Full area	0.75
	Over seat	Reduced area	0.72
	Under seat	Full area	0.81
	Under seat	Reduced area	0.81
Butterfly	60° open	Full area	0.65
	90° open	Full area	0.49
Ball	60° open	Full area	0.65
	90° open	Full area	0.44

Specific-Gravity Determination — ୧-୩-୩

S_g

- Operating temperature → Reference table



Approximate-Flow-Coefficient Calculation — ୧-୩-୩

- Determining the calculated C_v
- Assumption : $F_P = 1.0$
- high viscosity, low velocity, or low flow → F_R can be ignored

$$C_v = \frac{Q}{F_P} \sqrt{\frac{S_g}{\Delta P_e}}$$


Approximate Body Size Selection — ୧-୩-୩

- manufacturer's C_v tables → smallest-sized body near the calculated C_v

Typical manufacturer's C_v data. (Courtesy of Valtek International)

Valve Size (inches)	Pressure Drop (psi)										Valve Size (inches)	Pressure Drop (psi)									
	100	200	300	400	500	600	700	800	900	1000		100	200	300	400	500	600	700	800	900	1000
1/2	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50	1/2	1.25	1.50	1.75	2.00	2.25	2.50	2.75	3.00	3.25	3.50
3/4	1.50	1.80	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	3/4	1.50	1.80	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20
1	1.80	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	1	1.80	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50
1 1/2	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.80	1 1/2	2.10	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.80
2	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10	2	2.40	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10
2 1/2	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	2 1/2	2.70	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40
3	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	3	3.00	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70
3 1/2	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00	3 1/2	3.30	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00
4	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00	6.30	4	3.60	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00	6.30
4 1/2	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00	6.30	6.60	4 1/2	3.90	4.20	4.50	4.80	5.10	5.40	5.70	6.00	6.30	6.60
5	4.20	4.50	4.80	5.10	5.40	5.70	6.00	6.30	6.60	6.90	5	4.20	4.50	4.80	5.10	5.40	5.70	6.00	6.30	6.60	6.90
5 1/2	4.50	4.80	5.10	5.40	5.70	6.00	6.30	6.60	6.90	7.20	5 1/2	4.50	4.80	5.10	5.40	5.70	6.00	6.30	6.60	6.90	7.20
6	4.80	5.10	5.40	5.70	6.00	6.30	6.60	6.90	7.20	7.50	6	4.80	5.10	5.40	5.70	6.00	6.30	6.60	6.90	7.20	7.50
6 1/2	5.10	5.40	5.70	6.00	6.30	6.60	6.90	7.20	7.50	7.80	6 1/2	5.10	5.40	5.70	6.00	6.30	6.60	6.90	7.20	7.50	7.80
7	5.40	5.70	6.00	6.30	6.60	6.90	7.20	7.50	7.80	8.10	7	5.40	5.70	6.00	6.30	6.60	6.90	7.20	7.50	7.80	8.10
7 1/2	5.70	6.00	6.30	6.60	6.90	7.20	7.50	7.80	8.10	8.40	7 1/2	5.70	6.00	6.30	6.60	6.90	7.20	7.50	7.80	8.10	8.40
8	6.00	6.30	6.60	6.90	7.20	7.50	7.80	8.10	8.40	8.70	8	6.00	6.30	6.60	6.90	7.20	7.50	7.80	8.10	8.40	8.70
8 1/2	6.30	6.60	6.90	7.20	7.50	7.80	8.10	8.40	8.70	9.00	8 1/2	6.30	6.60	6.90	7.20	7.50	7.80	8.10	8.40	8.70	9.00
9	6.60	6.90	7.20	7.50	7.80	8.10	8.40	8.70	9.00	9.30	9	6.60	6.90	7.20	7.50	7.80	8.10	8.40	8.70	9.00	9.30
9 1/2	6.90	7.20	7.50	7.80	8.10	8.40	8.70	9.00	9.30	9.60	9 1/2	6.90	7.20	7.50	7.80	8.10	8.40	8.70	9.00	9.30	9.60
10	7.20	7.50	7.80	8.10	8.40	8.70	9.00	9.30	9.60	9.90	10	7.20	7.50	7.80	8.10	8.40	8.70	9.00	9.30	9.60	9.90
10 1/2	7.50	7.80	8.10	8.40	8.70	9.00	9.30	9.60	9.90	10.20	10 1/2	7.50	7.80	8.10	8.40	8.70	9.00	9.30	9.60	9.90	10.20
11	7.80	8.10	8.40	8.70	9.00	9.30	9.60	9.90	10.20	10.50	11	7.80	8.10	8.40	8.70	9.00	9.30	9.60	9.90	10.20	10.50
11 1/2	8.10	8.40	8.70	9.00	9.30	9.60	9.90	10.20	10.50	10.80	11 1/2	8.10	8.40	8.70	9.00	9.30	9.60	9.90	10.20	10.50	10.80
12	8.40	8.70	9.00	9.30	9.60	9.90	10.20	10.50	10.80	11.10	12	8.40	8.70	9.00	9.30	9.60	9.90	10.20	10.50	10.80	11.10
12 1/2	8.70	9.00	9.30	9.60	9.90	10.20	10.50	10.80	11.10	11.40	12 1/2	8.70	9.00	9.30	9.60	9.90	10.20	10.50	10.80	11.10	11.40
13	9.00	9.30	9.60	9.90	10.20	10.50	10.80	11.10	11.40	11.70	13	9.00	9.30	9.60	9.90	10.20	10.50	10.80	11.10	11.40	11.70
13 1/2	9.30	9.60	9.90	10.20	10.50	10.80	11.10	11.40	11.70	12.00	13 1/2	9.30	9.60	9.90	10.20	10.50	10.80	11.10	11.40	11.70	12.00
14	9.60	9.90	10.20	10.50	10.80	11.10	11.40	11.70	12.00	12.30	14	9.60	9.90	10.20	10.50	10.80	11.10	11.40	11.70	12.00	12.30
14 1/2	9.90	10.20	10.50	10.80	11.10	11.40	11.70	12.00	12.30	12.60	14 1/2	9.90	10.20	10.50	10.80	11.10	11.40	11.70	12.00	12.30	12.60
15	10.20	10.50	10.80	11.10	11.40	11.70	12.00	12.30	12.60	12.90	15	10.20	10.50	10.80	11.10	11.40	11.70	12.00	12.30	12.60	12.90
15 1/2	10.50	10.80	11.10	11.40	11.70	12.00	12.30	12.60	12.90	13.20	15 1/2	10.50	10.80	11.10	11.40	11.70	12.00	12.30	12.60	12.90	13.20
16	10.80	11.10	11.40	11.70	12.00	12.30	12.60	12.90	13.20	13.50	16	10.80	11.10	11.40	11.70	12.00	12.30	12.60	12.90	13.20	13.50
16 1/2	11.10	11.40	11.70	12.00	12.30	12.60	12.90	13.20	13.50	13.80	16 1/2	11.10	11.40	11.70	12.00	12.30	12.60	12.90	13.20	13.50	13.80
17	11.40	11.70	12.00	12.30	12.60	12.90	13.20	13.50	13.80	14.10	17	11.40	11.70	12.00	12.30	12.60	12.90	13.20	13.50	13.80	14.10
17 1/2	11.70	12.00	12.30	12.60	12.90	13.20	13.50	13.80	14.10	14.40	17 1/2	11.70	12.00	12.30	12.60	12.90	13.20	13.50	13.80	14.10	14.40
18	12.00	12.30	12.60	12.90	13.20	13.50	13.80	14.10	14.40	14.70	18	12.00	12.30	12.60	12.90	13.20	13.50	13.80	14.10	14.40	14.70
18 1/2	12.30	12.60	12.90	13.20	13.50	13.80	14.10	14.40	14.70	15.00	18 1/2	12.30	12.60	12.90	13.20	13.50	13.80	14.10	14.40	14.70	15.00
19	12.60	12.90	13.20	13.50	13.80	14.10	14.40	14.70	15.00	15.30	19	12.60	12.90	13.20	13.50	13.80	14.10	14.40	14.70	15.00	15.30
19 1/2	12.90	13.20	13.50	13.80	14.10	14.40	14.70	15.00	15.30	15.60	19 1/2	12.90	13.20	13.50	13.80	14.10	14.40	14.70	15.00	15.30	15.60
20	13.20	13.50	13.80	14.10	14.40	14.70	15.00	15.30	15.60	15.90	20	13.20	13.50	13.80	14.10	14.40	14.70	15.00	15.30	15.60	15.90
20 1/2	13.50	13.80	14.10	14.40	14.70	15.00	15.30	15.60	15.90	16.20	20 1/2	13.50	13.80	14.10	14.40	14.70	15.00	15.30	15.60	15.90	16.20
21	13.80	14.10	14.40	14.70	15.00	15.30	15.60	15.90	16.20	16.50	21	13.80	14.10	14.40	14.70	15.00	15.30	15.60	15.90	16.20	16.50
21 1/2	14.10	14.40	14.70	15.00	15.30	15.60	15.90	16.20	16.50	16.80	21 1/2	14.10	14.40	14.70	15.00	15.30	15.60	15.90	16.20	16.50	16.80
22	14.40	14.70	15.00	15.30	15.60	15.90	16.20	16.50	16.80	17.10	22	14.40	14.70	15.00	15.30	15.60	15.90	16.20	16.50	16.80	17.10
22 1/2	14.70	15.00	15.30	15.60	15.90	16.20	16.50	16.80	17.10	17.40	22 1/2	14.70	15.00	15.30	15.60	15.90	16.20	16.50	16.80	17.10	17.40
23	15.00	15.30	15.60	15.90	16.20	16.50	16.80	17.10	17.40	17.70	23	15.00	15.30	15.60	15.90	16.20	16.50	16.80	17.10	17.40	17.70
23 1/2	15.30	15.60	15.90	16.20	16.50	16.80	17.10	17.40	17.70	18.00	23 1/2	15.30	15.60	15.90	16.20	16.50	16.80	17.10	17.40	17.70	18.00
24	15.60	15.90	16.20	16.50	16.80	17.10	17.40	17.70	18.00	18.30	24	15.60	15.90	16.20	16.50	16.80	17.10	17.40	17.70	18.00	18.30
24 1/2	15.90	16.20	16.50	16.80	17.10	17.40	17.70	18.00	18.30	18.60	24 1/2	15.90	16.20	16.50	16.80	17.10	17.40	17.70	18.00	18.30	18.60
25	16.20	16.50	16.80	17.10	17.40	17.70	18.00	18.30	18.60	18.90	25	16.20	16.50	16.80	17.10	17.40	17.70	18.00	18.30	18.60	18.90
25 1/2	16.50	16.80	17.10	17.40	17.70	18.00	18.30	18.60	18.90	19.20	25 1/2	16.50	16.80	17.10	17.40	17.70	18.00	18.30	18.60	18.90	19.20
26	16.80	17.10	17.40	17.70	18.00	18.30	18.60	18.90	19.20	19.50	26	16.80	17.10	17.40	17.70	18.00	18.30	18.60	18.90	19.20	19.50
26 1/2	17.10	17.40	17.70	18.00	18.30	18.60	1														

Valve Recovery Coefficient and Incipient Cavitation Factors

Valve Type	Flow Direction	Y-Valve	F	F ₁	Y ₁	F ₂
Globe	Open Flow	1.00	0.55	0.75	1.0	1.0
	Open Flow	Reduced Area	0.12	0.75	0.75	1.0
	Back Flow	Full Flow	0.42	0.75	0.75	1.0
	Back Flow	Reduced Area	0.42	0.75	0.75	1.0
Ball or Plug	Full Open	Full	0.58	0.58	58	75
	Full Open	Full	0.58	0.45	26	75
Diaphragm	Full Open	Full	0.55	0.55	55	1.0
	Full Open	Full	0.55	0.44	36	1.0
Butterfly	Open	Full	0.45	0.45	45	0.25
Liquid Control	Open	Full	0.12	0.12	12	0.25
	Open	Reduced Area	0.12	0.12	12	0.25
	Open	Reduced Area	0.12	0.12	12	0.25

Source: Hydraulic Institute

Flow-Coefficient Recalculation — 1-3-3

- If $Fr < 0.48 \rightarrow$ Flow is laminar $\rightarrow C_v = C_{vs} = \frac{1}{F_s} \left(\frac{Q_{vs}}{N_s \Delta P} \right)^{0.667}$
- If $Fr > 0.98 \rightarrow$ Flow is turbulent $\rightarrow$ Assuming $Fr = 1.0 \rightarrow$
 $Fr = 1.0 \rightarrow C_s = \frac{Q}{F_s \sqrt{\Delta P_s}}$
- If $0.48 < Fr < 0.98 \rightarrow$ flow is in Transitional Stage $\rightarrow$
 $C_s = \frac{Q}{F_s \sqrt{\Delta P}}$

Piping-Geometry-Factor Calculation — 1-3-3

F_P

- inside diameter of the piping $\rightarrow$ required to determine F_P
- If the pipe size not known $\rightarrow$ Sec. 6-3-3 (Manufacturer Chart)
- maximum effective pressure drop $= \Delta P_{choked}$
- maximum effective pressure drop $\rightarrow$ can be affected by the use of **increasers** and **reducers**



F_P: For Valves with Reducers and Increases on Both Ends

C _v / d ²	d / D				
	0.50	0.60	0.70	0.80	0.90
4	0.99	0.99	1.00	1.00	1.00
6	0.98	0.99	0.99	1.00	1.00
8	0.97	0.98	0.99	0.99	1.00
10	0.96	0.97	0.98	0.99	1.00
12	0.94	0.96	0.97	0.98	1.00
14	0.92	0.94	0.96	0.98	0.99
16	0.90	0.92	0.95	0.97	0.99
18	0.87	0.90	0.94	0.97	0.99
20	0.85	0.89	0.92	0.96	0.99
25	0.79	0.84	0.89	0.94	0.98
30	0.73	0.79	0.85	0.91	0.97
35	0.68	0.74	0.81	0.89	0.96
40	0.63	0.69	0.77	0.86	0.95

F_P: For Valves with Reducers and Increases on Outlet Only

C _v / d ²	d / D				
	0.50	0.60	0.70	0.80	0.90
4	1.00	1.00	1.00	1.00	1.00
6	1.01	1.01	1.01	1.01	1.01
8	1.01	1.02	1.02	1.02	1.01
10	1.02	1.03	1.03	1.03	1.02
12	1.03	1.04	1.04	1.04	1.03
14	1.04	1.05	1.06	1.05	1.04
16	1.06	1.07	1.08	1.07	1.05
18	1.08	1.10	1.11	1.10	1.06
20	1.10	1.12	1.12	1.12	1.08
25	1.17	1.22	1.24	1.22	1.13
30	1.27	1.37	1.42	1.37	1.20
35	1.44	1.63	1.79	1.65	1.32
40	1.75	2.41	3.14	2.41	1.50

F_P: With Reducers or Increases on Both Inlet and Outlet of Valve

C _v / d ²	0.50 d/D	0.60 d/D	0.70 d/D	0.80 d/D	0.90 d/D
4	0.99	0.99	1.00	1.00	1.00
6	0.98	0.98	0.99	1.00	1.00
8	0.97	0.98	0.99	1.00	1.00
10	0.96	0.97	0.98	1.00	1.00
12	0.94	0.96	0.97	0.99	1.00
14	0.92	0.94	0.96	0.98	0.99
16	0.90	0.92	0.95	0.97	0.99
18	0.87	0.90	0.94	0.97	0.99
20	0.85	0.89	0.92	0.96	0.99
25	0.79	0.84	0.89	0.94	0.98
30	0.73	0.79	0.85	0.91	0.97
35	0.68	0.74	0.81	0.89	0.96
40	0.63	0.69	0.77	0.86	0.95

F_P : With Reducer or Inceaser on Outlet of Valve

C_v at	1.00 d/D	0.80 d/D	0.70 d/D	0.60 d/D	0.50 d/D
4	1.00	1.00	1.00	1.00	1.00
8	1.01	1.01	1.01	1.01	1.01
15	1.01	1.01	1.01	1.01	1.01
20	1.02	1.02	1.02	1.02	1.02
25	1.02	1.02	1.02	1.02	1.02
30	1.03	1.03	1.03	1.03	1.03
40	1.04	1.04	1.04	1.04	1.04
50	1.05	1.05	1.05	1.05	1.05
60	1.06	1.06	1.06	1.06	1.06
70	1.07	1.07	1.07	1.07	1.07
80	1.08	1.08	1.08	1.08	1.08
90	1.09	1.09	1.09	1.09	1.09
100	1.10	1.10	1.10	1.10	1.10
125	1.12	1.12	1.12	1.12	1.12
150	1.14	1.14	1.14	1.14	1.14
175	1.16	1.16	1.16	1.16	1.16
200	1.18	1.18	1.18	1.18	1.18
250	1.22	1.22	1.22	1.22	1.22
300	1.26	1.26	1.26	1.26	1.26
350	1.30	1.30	1.30	1.30	1.30
400	1.34	1.34	1.34	1.34	1.34
450	1.38	1.38	1.38	1.38	1.38
500	1.42	1.42	1.42	1.42	1.42
550	1.46	1.46	1.46	1.46	1.46
600	1.50	1.50	1.50	1.50	1.50

Final-Flow-Coefficient Calculation – 1-3-3

- After F_P is determined → it should be applied to the liquid C_v equation (Sec. 1-3-3)

The final C_v calculated

Valve Exit-Velocity Calculation – 11-3-3

- Velocities in liquids generally < 50 ft/s (15.2 m/s)
- It may vary according to the size of the valve
- Smaller valves can handle higher velocities
- the exit velocities from the valve →

$$V = \frac{0.321 Q}{A_v}$$

V = velocity (ft/s)

A_v = flow area of valve body port (square inches)



- If $V >$ acceptable velocity → larger valve size → for Low erosion
- If larger size chosen → F_P will change → New C_v must calculate

Valve Exit-Velocity Calculation – 11-3-3

?

Velocity in the pipe: $V_P = V_v A_v / A_P$

V_P : velocity in pipe,

A_v : valve outlet area.

V_v : velocity in valve outlet,

A_P : pipe area.



A_v : Valve Port Areas

Valve Size (Inches)	Valve Outlet Area, A _v (Square Inches)						
	Class 150	Class 300	Class 600	Class 900	Class 1500	Class 2500	Class 4500
1/2	0.30	0.30	0.30	0.30	0.30	0.30	0.30
3/4	0.44	0.44	0.44	0.44	0.44	0.44	0.44
1	0.70	0.70	0.70	0.70	0.61	0.44	0.32
1 1/2	1.37	1.37	1.37	1.22	.50	0.20	0.12
2	2.14	2.14	2.14	2.22	2.70	1.77	1.21
2 1/2	3.07	3.07	3.07	3.21	3.94	3.34	2.79
3	4.07	4.07	4.07	4.22	5.29	4.87	4.29
4	6.30	6.30	6.30	6.47	8.73	8.27	7.49
6	12.57	12.57	12.57	12.84	17.49	16.77	15.49
8	21.24	21.24	21.24	21.61	29.77	28.77	27.07
10	30.90	30.90	30.90	31.37	43.67	42.27	40.27
12	41.61	41.61	41.61	42.17	59.17	57.27	54.77
14	53.36	53.36	53.36	53.97	76.27	73.97	70.97
16	66.05	66.05	66.05	66.77	95.97	93.27	89.27
18	79.68	79.68	79.68	80.47	118.77	115.57	110.77
20	94.25	94.25	94.25	95.17	144.77	141.07	135.27
24	137.84	137.84	137.84	139.17	219.77	215.27	208.27
30	212.40	212.40	212.40	214.17	344.77	339.27	330.27
36	287.96	287.96	287.96	290.17	470.77	464.27	454.27
42	363.52	363.52	363.52	366.17	596.77	589.27	578.27
48	439.08	439.08	439.08	442.17	722.77	714.27	702.27
54	514.64	514.64	514.64	518.17	848.77	839.27	826.27
60	590.20	590.20	590.20	594.17	974.77	964.27	950.27
66	665.76	665.76	665.76	670.17	1100.77	1089.27	1074.27
72	741.32	741.32	741.32	746.17	1226.77	1214.27	1198.27
78	816.88	816.88	816.88	822.17	1352.77	1339.27	1322.27
84	892.44	892.44	892.44	898.17	1478.77	1464.27	1446.27
90	967.99	967.99	967.99	974.17	1604.77	1589.27	1570.27
96	1043.55	1043.55	1043.55	1050.17	1730.77	1714.27	1694.27
102	1119.11	1119.11	1119.11	1126.17	1856.77	1839.27	1818.27
108	1194.67	1194.67	1194.67	1202.17	1982.77	1964.27	1942.27
114	1270.23	1270.23	1270.23	1278.17	2108.77	2089.27	2066.27
120	1345.79	1345.79	1345.79	1354.17	2234.77	2214.27	2190.27
126	1421.35	1421.35	1421.35	1430.17	2360.77	2339.27	2314.27
132	1496.91	1496.91	1496.91	1506.17	2486.77	2464.27	2438.27
138	1572.47	1572.47	1572.47	1582.17	2612.77	2589.27	2562.27
144	1648.03	1648.03	1648.03	1658.17	2738.77	2714.27	2686.27
150	1723.59	1723.59	1723.59	1734.17	2864.77	2839.27	2810.27
156	1799.15	1799.15	1799.15	1810.17	2990.77	2964.27	2934.27
162	1874.71	1874.71	1874.71	1886.17	3116.77	3089.27	3058.27
168	1950.27	1950.27	1950.27	1962.17	3242.77	3214.27	3182.27
174	2025.83	2025.83	2025.83	2038.17	3368.77	3339.27	3306.27
180	2101.39	2101.39	2101.39	2114.17	3494.77	3464.27	3430.27
186	2176.95	2176.95	2176.95	2190.17	3620.77	3589.27	3554.27
192	2252.51	2252.51	2252.51	2266.17	3746.77	3714.27	3678.27
198	2328.07	2328.07	2328.07	2342.17	3872.77	3839.27	3802.27
204	2403.63	2403.63	2403.63	2418.17	3998.77	3964.27	3926.27
210	2479.19	2479.19	2479.19	2494.17	4124.77	4089.27	4050.27
216	2554.75	2554.75	2554.75	2570.17	4250.77	4214.27	4174.27
222	2630.31	2630.31	2630.31	2646.17	4376.77	4339.27	4298.27
228	2705.87	2705.87	2705.87	2722.17	4502.77	4464.27	4422.27
234	2781.43	2781.43	2781.43	2798.17	4628.77	4589.27	4544.27
240	2856.99	2856.99	2856.99	2874.17	4754.77	4714.27	4668.27
246	2932.55	2932.55	2932.55	2950.17	4880.77	4839.27	4792.27
252	3008.11	3008.11	3008.11	3026.17	5006.77	4964.27	4916.27
258	3083.67	3083.67	3083.67	3102.17	5132.77	5089.27	5040.27
264	3159.23	3159.23	3159.23	3178.17	5258.77	5214.27	5164.27
270	3234.79	3234.79	3234.79	3254.17	5384.77	5339.27	5288.27
276	3310.35	3310.35	3310.35	3330.17	5510.77	5464.27	5412.27
282	3385.91	3385.91	3385.91	3406.17	5636.77	5589.27	5534.27
288	3461.47	3461.47	3461.47	3482.17	5762.77	5714.27	5658.27
294	3537.03	3537.03	3537.03	3558.17	5888.77	5839.27	5782.27
300	3612.59	3612.59	3612.59	3634.17	6014.77	5964.27	5906.27
306	3688.15	3688.15	3688.15	3710.17	6140.77	6089.27	6030.27
312	3763.71	3763.71	3763.71	3786.17	6266.77	6214.27	6152.27
318	3839.27	3839.27	3839.27	3862.17	6392.77	6339.27	6276.27
324	3914.83	3914.83	3914.83	3938.17	6518.77	6464.27	6398.27
330	3990.39	3990.39	3990.39	4014.17	6644.77	6589.27	6518.27
336	4065.95	4065.95	4065.95	4090.17	6770.77	6714.27	6640.27
342	4141.51	4141.51	4141.51	4166.17	6896.77	6839.27	6762.27
348	4217.07	4217.07	4217.07	4242.17	7022.77	6964.27	6884.27
354	4292.63	4292.63	4292.63	4318.17	7148.77	7089.27	6998.27
360	4368.19	4368.19	4368.19	4394.17	7274.77	7214.27	7118.27
366	4443.75	4443.75	4443.75	4470.17	7400.77	7339.27	7238.27
372	4519.31	4519.31	4519.31	4546.17	7526.77	7464.27	7358.27
378	4594.87	4594.87	4594.87	4622.17	7652.77	7589.27	7476.27
384	4670.43	4670.43	4670.43	4698.17	7778.77	7714.27	7594.27
390	4745.99	4745.99	4745.99	4774.17	7904.77	7839.27	7712.27
396	4821.55	4821.55	4821.55	4850.17	8030.77	7964.27	7830.27
402	4897.11	4897.11	4897.11	4926.17	8156.77	8089.27	7948.27
408	4972.67	4972.67	4972.67	5002.17	8282.77	8214.27	8066.27
414	5048.23	5048.23	5048.23	5078.17	8408.77	8339.27	8182.27
420	5123.79	5123.79	5123.79	5154.17	8534.77	8464.27	8298.27
426	5199.35	5199.35	5199.35	5230.17	8660.77	8589.27	8412.27
432	5274.91	5274.91	5274.91	5306.17	8786.77	8714.27	8526.27
438	5350.47	5350.47	5350.47	5382.17	8912.77	8839.27	8640.27
444	5426.03	5426.03	5426.03	5458.17	9038.77	8964.27	8754.27
450	5501.59	5501.59	5501.59	5534.17	9164.77	9089.27	8868.27
456	5577.15	5577.15	5577.15	5610.17	9290.77	9214.27	8982.27
462	5652.71	5652.71	5652.71	5686.17	9416.77	9339.27	9096.27
468	5728.27	5728.27	5728.27	5762.17	9542.77	9464.27	9210.27
474	5803.83	5803.83	5803.83	5838.17	9668.77	9589.27	9324.27
480	5879.39	5879.39	5879.39	5914.17	9794.77	9714.27	9438.27
486	5954.95	5954.95	5954.95	5990.17	9920.77	9839.27	9552.27
492	6030.51	6030.51	6030.51	6066.17	10046.77	9964.27	9666.27
498	6106.07	6106.07	6106.07	6142.17	10172.77	10089.27	9780.27
504	6181.63	6181.63	6181.63	6218.17	10298.77	10214.27	9894.27
510	6257.19	6257.19	6257.19	6294.17	10424.77	10339.27	10008.27
516	6332.75	6332.75	6332.75	6370.17	10550.77	10464.27	10122.27
522	6408.31	6408.31	6408.31	6446.17	10676.77	10589.27	10236.27
528	6483.87	6483.87	6483.87	6522.17	10802.77	10714.27	10350.27
534	6559.43	6559.43	6559.43	6598.17	10928.77	10839.27	10464.27
540	6634.99	6634.99	6634.99	6674.17	11054.77	10964.27	10578.27
546	6710.55	6710.55	6710.55	6750.17	11180.77	11089.27	10692.27
552	6786.11	6786.11	6786.11	6826.17	11306.77	11214.27	10806.27
558	6861.67	6861.67	6861.67	6902.17	11432.77	11339.27	10920.27
564	6937.23	6937.23	6937.23	6978.17	11558.77	11464.27	11034.27
570	7012.79	7012.79	7012.79	7054.17	11684.77	11589.27	11148.27
576	7088.35	7088.35	7088.35	7130.17	11810.77	11714.27	11262.27
582	7163.91	7163.91	7163.91	7206.17	11936.77	11839.27	11376.27
588	7239.47	7239.47	7239.47	7282.17	12062.77	11964.27	11490.27
594	7315.03	7315.03	7315.03	7358.17	12188.77	12089.27	11604.27
600	7390.59	7390.59	7390.59	7434.17	12314.77	12214.27	11718.27
606	7466.15	7466.15	7466.15	7510.17	12440.77	12339.27	11832.27
612	7541.71	7541.71	7541.71	7586.17	12566.77	12464.27	11946.27
618	7617.27	7617.27	7617.27	7662.17	12692.77	12589.27	12060.27
624	7692.83	7692.83	7692.83	7738.17	12818.77	12714.27	12174.27
630	7768.39	7768.39	7768.39	7814.17	12944.77	12839.27	12288.27
636	7843.95	7843.95	7843.95	7890.17	13070.77	12964.27	12402.27
642	7919.51	7919.51	7919.51	7966.17	13196.77	13089.27	12516.27
648	7995.07	7995.07	7995.07	8042.17	13322.77	13214.27	12630.27
654	8070.63	8070.63	8070.63	8118.17	13448.77	13339.27	12744.27
660	8146.19	8146.19	8146.19	8194.17	13574.77	13464.27	12858.27
666	8221.75	8221.75	8221.75	8270.17	13700.77	13589.27	12972.27
672	8297.31	8297.31	8297.31	8346.17	13826.77	13714.27	13086.27
678	8372.87	8372.87	8372.87	8422.17	13952.77	13839.27	13200.27
684	8448.43	8448.43	8448.43	8498.17	14078.77	13964.27	13314.27
690	8523.99	8523.99	8523.99	8574.17	14204.77	14089.27	13428.27
696	8599.55	8599.55	8599.55	8650.17	14330.77	14214.27	13542.27
702	8675.11	8675.11	8675.11	8726.17	14456.77	14339.27	13656.27
708	8750.67	8750.67	8750.				

Smaller trim numbers

↓

Smaller diameter

↓

Smaller Cv

↓

Smaller Body size



Flashing-Velocity Calculation – 13-3-3

- In flashing → liquid-gas mixture, in downstream → increased velocity → difficult control situations
- Valve damage & wear → special trims or hardened materials
- Flashing applications velocity < 500 ft/s (152 m/s)

Flashing-Velocity Calculation – 13-3-3

- Velocity for mass flow rate (w) :

$$V = \frac{0.040}{A_v} w \left[\left(1 - \frac{x}{100\%} \right) V_{f2} + \frac{x}{100\%} V_{g2} \right]$$

- Velocity for volume flow rate (Q) :

$$V = \frac{20}{A_v} Q \left[\left(1 - \frac{x}{100\%} \right) V_{f2} + \frac{x}{100\%} V_{g2} \right]$$

V = velocity (ft/s)
 w = liquid flow rate (lb/h)
 V_{f2} = saturated liquid specific volume (ft³/lb at outlet pressure)
 V_{g2} = saturated vapor specific volume (ft³/lb at outlet pressure)
 x = percentage of liquid mass flashed to vapor (Sec. 7.3.14)

Percentage of Flashing Calculation – 13-3-3

- percentage of the liquid → flashing into gas
- Users should have access to steam tables → Listing of enthalpies and specific volumes

$$x = \left(\frac{h_{f1} - h_{f2}}{h_{fg2}} \right) \times 100\%$$

h_{f1} = enthalpy of saturated liquid at inlet temperature
 h_{f2} = enthalpy of saturated liquid at outlet pressure
 h_{fg2} = enthalpy of evaporation at outlet pressure

Liquid Sizing Examples – 14-3-3

Liquid	Water
Critical pressure P_c	3206.2 psia
Temperature	230°F
Upstream pressure P_1	314.7 psia
Downstream pressure P_2	104.7 psia
Flow rate Q	500 gal/min
Vapor pressure P_v	30 psia
Specific gravity S_g	0.91
Kinematic viscosity ν	0.014 cS
Pipeline size	4 in (ANSI Class 600)
Valve	Globe, flow to open
Flow characteristic	Equal percentage

Body Sizing of Gas-Service Control Valves – 4-3

Basic Gas Sizing Equations – 1-4-3

Choked-Flow Determination – 2-4-3

Expansion-Factor Calculation – 3-4-3

Compressibility-Factor Determination – 4-4-3

Flow-Coefficient Calculation – 5-4-3

Approximate Body-Size Selection – 6-4-3

Piping-Geometry-Factor Calculation – 7-4-3

Final-Flow-Coefficient Calculation – 8-4-3

Valve Exit Mach-Number Calculation – 9-4-3

Trim-Size Selection – 10-4-3

Gas Sizing Examples – 11-4-3

Basic Gas Sizing Equations – 1-ƒ-3

- difference between **Liquid** , **Gas** sizing → compressibility
- Compressibility :
 - Gas tends to expand
 - When pressure drop occurs
 - In vena contracta of the valve
 - It lowers the specific weight of Gas
 - Correction factor : expansion factor **Y**
- Depending on the given **service conditions** , one of the bellow equations is used :



$$w = 63.3 F_p C_v Y \sqrt{x P_1 \gamma_1} \quad Q = 1360 F_p C_v P_1 Y \sqrt{\frac{x}{G_s T_1 Z}}$$

$$w = 19.3 F_p C_v P_1 Y \sqrt{\frac{x M_w}{T_1 Z}} \quad Q = 7320 F_p C_v P_1 Y \sqrt{\frac{x}{M_w T_1 Z}}$$

w = gas flow rate (lb/h)
 F_p = piping-geometry factor
 C_v = valve sizing coefficient
 Y = expansion factor
 x = pressure-drop ratio
 γ_1 = specific weight at inlet service conditions (lb/ft³)
 Q = gas flow (scfh)
 G_s = specific gravity or gas relative to air at standard conditions
 T_1 = absolute upstream pressure ("R = "F + 460)
 Z = compressibility factor
 M_w = molecular weight
 P_1 = upstream absolute pressure (psia)

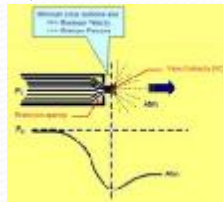
Choked-Flow Determination – 2-ƒ-2

X_T : Terminal pressure-drop ratio (Tables)

F_K : Ratio of specific heats factor

K : Ratio of specific heats (Tables)

$$F_K = \frac{k}{140} \quad x = \frac{\Delta P_d}{P_1}$$



if $X < F_K X_T \rightarrow$ choked flow is not occurring

if $X \geq F_K X_T \rightarrow$ the flow is choked $\rightarrow$ let $X = F_K X_T \rightarrow$ Equation

X_T : terminal pressure-drop ratio

Valve Style	Flow Direction	Trim Area	X_T
Linear globe	Over seat	Full area	0.70
	Over seat	Reduced area	0.70
	Under seat	Full area	0.75
	Under seat	Reduced area	0.75
Butterfly	60° open	Full area	0.36
	90° open	Full area	0.26
Ball	60° open	Full area	0.51
	90° open	Full area	0.50

Physical Data for Common Gas Services

Gas	Molecular Weight (lb/lb-mole)	Critical Temperature (°F)	Critical Pressure (psia)	Specific Heat Ratio (k)
Air	28.97	-333	660.0	1.40
Ammonia	17.03	-280	608.1	1.31
Argon	39.95	-248	705.4	1.67
Carbon Dioxide	44.01	-110	1070.8	1.28
Chlorine	70.91	-34	680.8	1.40
Fluorine	38.00	-150	580.0	1.30
Hydrogen	2.02	-423	12.8	1.41
Helium	4.00	-452	2.26	1.66
Hydrocarbon	12.01	-162	667.0	1.31
Hydrogen Sulfide	34.08	-107	859.7	1.30
Isobutane	58.12	-11	460.0	1.10
Propane	44.10	-42	667.0	1.10
Steam	18.02	374	218.0	1.33

Expansion-Factor Calculation – 2-ƒ-3

- Because of the compressibility of gases $\rightarrow$
 Y must be determine and use in equation
- For choked flow $Y=2/3$ (?)

$$Y = 1 - \frac{x}{3 F_K Y_T}$$



Compressibility-Factor Determination – $f-f-Z$

Z

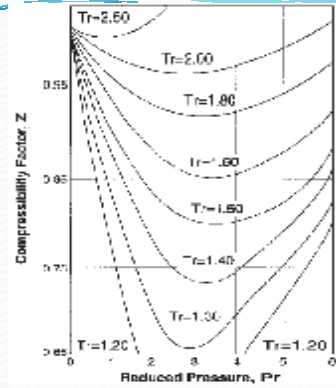
$P_r, T_r \rightarrow \text{Diagram} \rightarrow Z$

P_r : reduced pressure = P_1/P_c

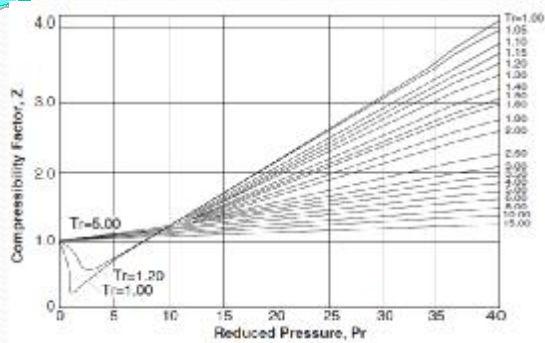
T_r : reduced temperature = T_1/T_c



Compressibility factors, reduced pressures 0 to 6.



Compressibility factors, reduced pressures 0 to 40.



Flow-Coefficient Calculation – $\Delta-f-Z$

- In this point $\rightarrow$ preliminary $C_v \rightarrow$ calculate by above Equations
- Assumption: $F_P=1.0$



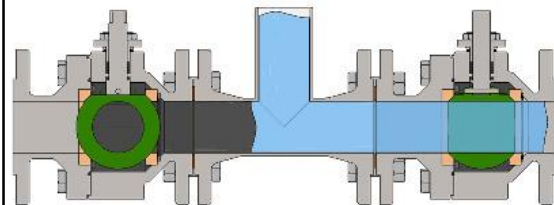
Approximate Body-Size Selection – $\phi-f-Z$

- manufacturer's C_v tables $\rightarrow$ smallest sized body related to Calculate preliminary C_v



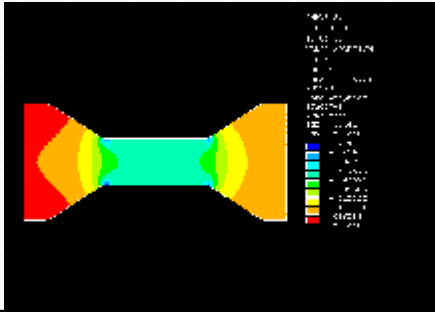
Piping-Geometry-Factor Calculation – $\gamma-f-Z$

- pipeline size not determined $\rightarrow$ use size in sec. 6-4-3
- $F_P \rightarrow$ Tables in Sec. 9-3-3



Final-Flow-Coefficient Calculation – 8-4-2

- With F_p & one of 4 Equations → calculate final C_v
- Usually, final C_v will be close to preliminary C_v



Valve Exit Mach-Number Calculation – 9-4-2

- C_v , Size are known → the exit velocity must be calculate (in Mach)
- velocities in gas services :

$$M_{gas} = \frac{Q_g}{5574 A_v \sqrt{\frac{kT}{M_w}}}$$

$$M_{gas} = \frac{Q_g}{1036 A_v \sqrt{\frac{kT}{G_g}}}$$

M_{gas} = Mach number for gas service
 Q_g = actual flow rate (cfh instead of scfh)
 A_v = applicable flow area of body port (square inches) from Table 7.9
 k = ratio of specific heats
 T = absolute temperature (°R or °F + 460)
 M_w = molecular weight
 G_g = specific gravity at standard conditions relative to air



- velocities for **Air** services :

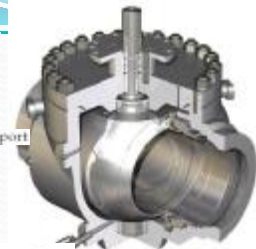
$$M_{air} = \frac{Q_a}{1225 A_v \sqrt{T}}$$

Q_a = actual volume flow rate (cfh)
 A_v = applicable flow area of body port

- velocities for **STEAM**:

$$M_{steam} = \frac{W}{1514 A_v \sqrt{T}}$$

W = mass flow rate (lb/hr)
 v = specific volume at flow conditions (ft³/lb)



- If exit velocity > Mach-0.5 → turbulent flow → vibration, noise
- If velocity exceeds the Mach-0.5 → larger valve body will need
- If noise is occurring, anti-noise trim is used → $V < \text{Mach } 0.33$

Trim-Size Selection – 10-4-2

- Manufacturers tables :

- manufacturers provide tables
- flow direction
- body-pressure rating
- Flow characteristic
- size of the valve seat (full or reduced)
- length of stroke
- percentages of opening



- Depending on valve style → trim number → predetermined flow area obtain → flow will calc. According to the $C_v \max$.

Gas Sizing Examples – 11-4-2

Gas	Natural gas
Temperature	63°F
Upstream pressure P_1	1314.7 psia
Downstream pressure P_2	99.7 psia
Flow rate Q_1	2,000,000 scfh
Critical pressure P_c	672.9 psia
Critical temperature T_c	342.8°F
Molecular weight M_w	16.04
Ratio k of specific heats	1.31
Pipe line size	Unspecified (ANSI Class 600)
Valve	Globe, flow-to-open
Flow characteristic	Linear

