SPENCE SAFETY RELIEF VALVE DESIGNER'S GUIDE

- Safety Relief Valves
- Safety Relief Valve Sizing
- Crossover Chart
- ASME Code

SPENCE

SPENCE ENGINEERING COMPANY, INC.

It is the philosophy of the
Spence Engineering Company that,
to win and be deserving of the trust of
our customers, we must be ever mindful
of and totally dedicated to quality; in
all that we do; at every level
of our operation.

ISO 9001

Certificate Number: 33694

SPENCE ENGINEERING COMPANY is a member of the Fluid Controls Institute.

SPENCE

SAFETY RELIEF VALVE DESIGNER'S GUIDE

NOTES:

SPENCE ENGINEERING COMPANY, INC.

The Spence Engineering Company was founded in 1926 by Paulsen Spence in Walden, New York. Paulsen Spence developed the original patent for the normally closed external pilot operated packless pressure regulator. This design is the basis for the products offered today. This technology offers the maximum in application and selection flexibility. Spence stands alone in their ability to produce regulators up to 12 inches in cast iron and cast steel. Their pilots are used to control pressure, temperature, differential pressure or back pressure either mechanically or with a pneumatic pilot.

Spence Engineering is a widely recognized leader in the steam regulator and flow control field. Spence regulators are used extensively for heating systems in buildings, institutions and district heating systems as well as major industrial plants.

In 1984, Spence Engineering was acquired by Watts Industries. The company continued to grow and develop new fluid control and steam specialty products. A new line of pneumatic control valves was introduced in 1986. In 1989, a range of self contained temperature regulators was added to the line to meet the demand for an economical temperature regulator.

1990 was an active year, with Spence becoming certified by the ASME for the assembly and setting of safety relief valves manufactured by their sister Watts company in Canada. Spence was also instrumental in the acquisition and management of the Nicholson Steam Trap Company. In 1994, Nicholson was integrated into the Spence Plant.

Spence continued it's product development program with the introduction of variable orifice steam traps and pressure operated condensate pumps. In 1996, Watts moved the manufacturing responsibility for safety valves to the Spence Engineering plant in Walden, New York. Spence is now an ASME certified manufacturer of bronze and iron safety relief valves.

Watts Industries, Inc. split in 1999 and Spence Engineering Company became a division of the newly formed corporation, Circor International.

Spence Engineering continues to focus their attention on providing single source steam specialty products for regulating and control of steam and fluids for the institutional and industrial marketplace. Their growth efforts are to expand the already comprehensive product capabilities to reach new developing markets.

For more information on Spence Engineering Co., visit our website at www.spenceengineering.com or reach us via e-mail at sales@spenceengineering.com

SPENCE Spence Engineering Company, Inc.

A division of CIRCOR International, Inc.

THE SPENCE ADVANTAGE IS SERVICE

LOCAL TECHNICAL SUPPORT

Spence Engineering has a network of technically trained Representatives around the world. These Representatives can direct you to local inventory of our products for fast, fast service. They can also help you in the selection and sizing of Regulators, Pilots, Desuperheaters and Noise Suppression Products.

TECHNICAL TRAINING

We offer a regular schedule of workshops covering various technical issues in our state of the art Valve Technology Training Center. We can also schedule customized training sessions to suit your particular needs.

ENGINEERING SEMINARS. These seminars provide the engineer with the skills of regulator selection and sizing.

DISTRIBUTOR SEMINARS. This seminar will provide you with all the information you need to serve your customers.

MAINTENANCE SEMINARS. Maintenance personnel will receive hands-on training in selection, installation, operation, maintenance and troubleshooting.

INTERNATIONAL SALES

Spence is well equipped to provide product to our customers around the world. We regularly ship our products to all parts of the world. Our experienced international sales group can meet the transport and documentation requirements of our international customers with ease. Our network of International Technical Sales Representatives will also be able to provide you with product from local inventory.

ENGINEERED SOLUTIONS

Spence offers a very comprehensive line of specialty options to enhance and optimize valve performance. We can tailor custom solutions for your most unique process applications. Call us for solutions.

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READY TO START?

The best way to make a selection is to contact your local Spence Engineering Technical Sales Representative. Our network of factory trained Representatives will offer you a choice of solutions for your application utilizing our Computer Valve Sizing Program. For the name and number of your local Spence Representative, call our Hotline at 1-800-398-2493 or visit our website at www.spenceengineering.com.

VALVES

DESIGN

EXCERPTS FROM ASME CODE

SPENCE SAFETY VALVE SELECTION CHART

Valve Series	Inlet Sizes inches (mm)	Min/Max* Set Pressures PSIG (barg)	Min/Max* Temperatures °F (°C)	Connections		Fluid					O_2 Cleaning	ASME Section+	PED†	Page
				Threaded	Flanged	Steam	Air	Gas	Liquid	Vacuum				
10	3/4 - 3 (20 - 80)	5 - 15 (.3 - 1)	-10 to 250 (-29 to 121)	X		X						IV		36
15C/15LC	3/4 - 3 (20 - 80)	5 - 15 (.3 - 1)	-20 to 400 (-29 to 204)	X			X	X				None		38
15A/15LA	3/4 - 3 (20 - 80)	5 - 15 (.3 - 1)	-20 to 400 (-29 to 204)	X			X	X				None		38
15V/15LV	3/4 - 3 (20 - 80)	5 - 30 in HG (169.3 - 1015.9 mbarg)	-20 to 400 (-29 to 204)	X						X		None		40
31/33 Bronze	1/2 - 2-1/2 (15 - 65)	5 - 250 (.3 - 17.2)	-20 to 406 (-29 to 208)	X		X						I	†	10
32 Bronze	1/2 - 2-1/2 (15 - 65)	5 - 300 (.3 - 20.7)	-20 to 422 (-29 to 216)	X		X						I	†	10
41/43 Bronze	1/2 - 2-1/2 (15 - 65)	5 - 250 (.3 - 17.2)	-20 to 406 (-29 to 208)	X		X						VIII	†	10
42 Bronze	1/2 - 2-1/2 (15 - 65)	5 - 300 (.3 - 20.7)	-20 to 422 (-29 to 216)	X		X						VIII	†	10
41A/43A Bronze	1/2 - 2-1/2 (15 - 65)	5 - 250 (.3 - 17.2)	-20 to 406 (-29 to 208)	X			X					VIII	†	10
42A Bronze	1/2 - 2-1/2 (15 - 65)	5 - 300 (.3 - 20.7)	-20 to 422 (-29 to 216)	X			X					VIII	†	10
41AA Bronze	1/2 - 3/4 (15 - 20)	5 - 250 (.3 - 17.2)	-20 to 406 (-29 to 208)	X			X	X				VIII	†	10
42AA Bronze	1/2 - 3/4 (15 - 20)	5 - 300 (.3 - 20.7)	-20 to 422 (-29 to 216)	X			X	X				VIII	†	10
41AT/43AT Bronze	1/2 - 2 (15 - 50)	5 - 250 (.3 - 17.2)	-20 to 406 (-29 to 208)	X			X					VIII	†	10
42AT Bronze	1/2 - 2 (15 - 50)	5 - 300 (.3 - 20.7)	-20 to 422 (-29 to 216)	X			X					VIII	†	10
31/32 Cast Iron	1-1/2 - 6 (40 - 150)	5 - 250 (.3 - 17.2)	-20 to 406 (-29 to 208)	X	X	X						I		18
41/42 Cast Iron	1-1/2 - 6 (40 - 150)	5 - 250 (.3 - 17.2)	-20 to 406 (-29 to 208)	X	X	X						VIII		18
41A/42A Cast Iron	1-1/2 - 6 (40 - 150)	5 - 250 (.3 - 17.2)	-20 to 406 (-29 to 208)	X	X		X					VIII		18
810/812/814/816	1/2 - 1-1/2 (15 - 40)	5 - 250 (.3 - 17.2) 10 to 30 in HG (338.6 to 1015.9 mbarg)	-20 to 406 (-29 to 208)	X		X	X	X	X	X		VIII	†	24
820/822/824/826	1/2 - 1-1/2 (15 - 40)	5 - 900 * (.3 - 62.0) 10 to 30 in HG (338.6 to 1015.9 mbarg)	-20 to 422 (-29 to 216)	X		X	X	X	X	X		VIII	†	24
860/862/864/866	1/2 - 1-1/2 (15 - 40) 10 to 30 in HG	5 - 900 * (.3 - 62.0) (338.6 to 1015.9 mbarg)	-20 to 422 (-29 to 216)	X		X	X	X	X	X		VIII	†	24
50/52	2 (50)	10 -30 (.7 - 2.1)	-20 to 225 (-29 to 107)	X			X					None		42
51/53	2 (50)	10 -30 (.7 - 2.1)	-20 to 225 (-29 to 107)	X			X					None		42
710/715 RXSO	1/2 - 2 (15 - 50)	10-400 (.7 - 27.6)	-423 - 400 (-252 - 204)	X			X	X			X	VIII	†	
760/765 RXSO-S	1/2 - 1 (15 - 25)	10-400 (.7 - 27.6)	-423 - 400 (-252 - 204)	X			X	X			X	VIII	†	
770 RSL	1/2 - 2 (15 - 50)	10-300 (.7 - 27.6)	0 - 300 (-17 - 148)	X					X		X	None		
775 RLS-S	1/2 - 2 (15 - 50)	10-300 (.7 - 27.6)	0 - 300 (-17 - 148)	X					X		X	None		

* Pressure and temperature ranges may vary, depending upon valve size, material, etc. Please consult the appropriate product catalog for specific data.

+ ASME does not certify valves below 15 PSIG.

† Consult Factory for PED availability.

SPENCE/KUNKLE COMPETITIVE CROSSOVER CHART

WHY CHOOSE SPENCE SAFETY AND RELIEF VALVES?

1) Spence Engineering sets and tests all valves in accordance with the applicable ASME code and API 527. Most competitive valves do not meet API 527, leading to premature simmering and leakage causing system problems and premature valve failure.
2) Spence Engineering Safety and Relief Valves are designed and manufactured with a more rugged body/bonnet design than most competitive valves. This exceptionally rugged design withstands excessive piping strains that often lead to valve failure.

6000 Series

KUNKLE	SPENCE
Model 6010 Side Outlet with bronze/brass trim[1]	
6010DC	__DCA
6010DD	__DDA
6010ED	__EDA
6010EE	__EEA
6010FE	__FEA
6010FF	__FFA
6010GF	__GFA
6010GG	__GGA
6010HG	__HGA
6010HH	__HHA
6010JH	__JHA
6010JJ	__JJA
Model 6021 Same as Model 6010 with Teflon disc insert[2, 3]	
6021DC	__DCA
6021DD	__DDA
6021ED	__EDA
6021EE	__EEA
6021FE	__FEA
6021FF	__FFA
6021GF	__GFA
6021GG	__GGA
6021HG	__HGA
6021HH	__HHA
6021JH	__JHA
6021JJ	__JJA
Model 6030 Same as Model 6010 with SS disc and nozzle[4]	
6030DC	__DCA
6030DD	__DDA
6030ED	__EDA
6030EE	__EEA
6030FE	__FEA
6030FF	__FFA
6030GF	__GFA
6030GG	__GGA
6030HG	__HGA
6030HH	__HHA
6030JH	__JHA
6030JJ	__JJA
Model 6182 Top Outlet with bronze/brass trim	
6182DC	41ATCDE
6182ED	41ATEDE
6182FE	41ATFEE
6182GF	41ATGFE
6182HG	41ATHGE
6182JH	41ATJHE
Model 6186 Same as 6182 except maximum pressure is 150 PSIG	
6186DC	41ATCDE
6186ED	41ATEDE
6186FE	41ATFEE
6186GF	41ATGFE
6186HG	41ATHGE

6000 Series cont.

KUNKLE	SPENCE
Model 6121 Same as 6182 with Teflon disc insert[5]	
6121DC	43ATCDE
6121ED	43ATEDE
6121FE	43ATFEE
6121GF	43ATGFE
6121HG	43ATHGE
6121JH	43ATJHE
Model 6130 Same as 6182 with SS nozzle and base	
6130DC	42ATCDE
6130ED	42ATEDE
6130FE	42ATFEE
6130GF	42ATGFE
6130HG	42ATHGE
6130JH	42ATJHE

6252 Series (Formerly 252)

KUNKLE	SPENCE
Model 6252 (Formerly 252) Cast Iron with bronze/brass trim[1]	
6252AJG	__JGB
6252FJG	__JGC
6252AKH	__KHB
6252FKH	__KHC
6252FKJ	__KJC
6252FKK	__KKC
6252ALJ	__LJB
6252FLJ	__LJC
6252FLK	__LKC
6252AMK	__MKB
6252FMK	__MKC
6252KNM	__NMD
6252KPM	__PMD
6252KQP	__QPD
6252KRP	__RPD
Model 6253 (Formerly 253) Same as 6252 with SS semi nozzle and disc[4]	
6253AJG	__JGB
6253FJG	__JGC
6253AKH	__KHB
6253FKH	__KHC
6253FKJ	__KJC
6253FKK	__KKC
6253ALJ	__LJB
6253FLJ	__LJC
6253FLK	__LKC
6253AMK	__MKB
6253FMK	__MKC
6253KNM	__NMD
6253KPM	__PMD
6253KQP	__QPD
6253KRP	__RPD

900 Series

KUNKLE	SPENCE
Model 910 Full nozzle with Carbon Steel body and bonnet with SS Trim See Model 911 for equal SS conversion	
Model 911 Full nozzle with all SS contruction	
Plain Cap	
911BDCM01	860NDCA
911BEDM01	860NEDA
911BFEM01	860NFEA
911BGFM01	860NGFA
911BHGM01	860NHGA
Open Lever	
911BDCM03	860EDCA
911BEDM03	860EEDA
911BFEM03	860EFEA
911BGFM03	860EGFA
911BHGM03	860EHGA
Packed Lever	
911BDCM06	860PDCA
911BEDM06	860PEDA
911BFEM06	860PFEA
911BGFM06	860PGFA
911BHGM06	860PHGA
Model 912 Full nozzle with SS disc and bronze base	
Plain Cap	
912BDCM12	810NDCA
912BEDM01	810NEDA
912BFEM01	810NFEA
912BGFM01	810NGFA
912BHGM01	810NHGA
Open Lever	
912BDCM14	810EDCA
912BEDM03	810EEDA
912BFEM03	810EFEA
912BGFM03	810EGFA
912BHGM03	810EHGA
Packed Lever	
912BDCM17	810PDCA
912BEDM06	810PEDA
912BFEM06	810PFEA
912BGFM06	810PGFA
912BHGM06	810PHGA
Model 913 Same as 912 with 316SS base and disc holder	
Plain Cap	
913BDCM12	820NDCA
913BEDM01	820NEDA
913BFEM01	820NFEA
913BGFM01	820NGFA
913BHGM01	820NHGA
Open Lever	
913BDCM14	820EDCA
913BEDM03	820EEDA
913BFEM03	820EFEA
913BGFM03	820EGFA
913BHGM03	820EHGA
Packed Lever	
913BDCM17	820PDCA
913BEDM06	820PEDA
913BFEM06	820PFEA
913BGFM06	820PGFA
913BHGM06	820PHGA

900 Series cont.

KUNKLE	SPENCE
Model 916 Same as 910 with soft seat See Model 917 for equal SS conversion	
Model 917 Same as 911 with soft seat[6, 9]	
Plain Cap	
917BDC_01	86__NDCA
917BED_01	86__NEDA
917BFE_01	86__NFEA
917BGF_01	86__NGFA
917BHG_01	86__NHGA
Open Lever	
917BDC_03	86__EDCA
917BED_03	86__EEDA
917BFE_03	86__EFEA
917BGF_03	86__EGFA
917BHG_03	86__EHGA
Packed Lever	
917BDC_06	86__PDCA
917BED_06	86__PEDA
917BFE_06	86__PFEA
917BGF_06	86__PGFA
917BHG_06	86__PHGA
Model 918 Same as 912 with soft seat[6, 7]	
Plain Cap	
918BDC_12	81__NDCA
918BED_01	81__NEDA
918BFE_01	81__NFEA
918BGF_01	81__NGFA
918BHG_01	81__NHGA
Open Lever	
918BDC_14	81__EDCA
918BED_03	81__EEDA
918BFE_03	81__EFEA
918BGF_03	81__EGFA
918BHG_03	81__EHGA
Packed Lever	
918BDC_17	81__PDCA
918BED_06	81__PEDA
918BFE_06	81__PFEA
918BGF_06	81__PGFA
918BHG_06	81__PHGA
Model 919 Same as 913 with soft seat[6, 8]	
Plain Cap	
919BDC_12	82__DCA
919BED_01	82__NEDA
919BFE_01	82__NFEA
919BGF_01	82__NGFA
919BHG_01	82__NHGA
Open Lever	
919BDC_14	82__EDCA
919BED_03	82__EEDA
919BFE_03	82__EFEA
919BGF_03	82__EGFA
919BHG_03	82__EHGA
Packed Lever	
919BDC_17	82__PDCA
919BED_06	82__PEDA
919BFE_06	82__PFEA
919BGF_06	82__PGFA
919BHG_06	82__PHGA

930 Series

KUNKLE	SPENCE
Model 930 Cast Iron for ASME Sec. IV Service[10]	
0930-H01	0010ZHA
0930-J01	0010ZJA
0930-K01	0010ZKA

300 Series

KUNKLE	SPENCE
Model 300 Cryogenic	
363	*710E Bronze
363C	*710N
389C	*760N (SS)

20 Series

KUNKLE	SPENCE
Model 20 Bronze with plain cap for Liquid	
0020-C01	810NDCA
0020-D01	810NEDA
0020-E01	810NFEA
0020-F01	810NGFA
0020-G01	810NHGA
Model 20P Same as model 20 with packed lever	
020P-C01	810PDCA
020P-D01	810PEDA
020P-E01	810PFEA

20 Series cont.

KUNKLE	SPENCE
020P-F01	810PGFA
020P-G01	810PHGA

299 Series

KUNKLE	SPENCE
Model 299 Drip Pan Elbows	
299-D	DPE-D
299-E	DPE-E
299-F	DPE-F
299-G	DPE-G
299-H	DPE-H
299-J	DPE-J
299-K	DPE-K
299-M	DPE-M
299-P	DPE-P
299-Q	DPE-Q

215V Series

KUNKLE	SPENCE
Model 215V Cast Iron for Vacuum Service[10]	
215V-H01	015VZHA
215V-J01	015VZJA
215V-K01	015VZKA

337 Series

KUNKLE	SPENCE
Model 337 Cast Iron with pull ring[10]	
0337-H01	015CZHA
0337-J01	015CZJA
0337-K01	015CZKA

[1] Choose SPENCE model 0031, 0041 or 041A depending on Choice of ASME code Setting *See page 10*

[2] Choose SPENCE model 0033, 0043 or 043A depending on Choice of ASME code Setting *See page 10*

[3] SPENCE models 0033 and 0043 have EPDM and model 043A has Viton disc insert

[4] Choose SPENCE model 0032, 0042 or 042A depending on Choice of ASME code Setting *See page 10*

[5] SPENCE model has Viton disc insert

[6] Kunkle Soft Seat (o-ring) choices - B (Buna N), E (EPR), S (Silicone), V (Viton) or N(Neoprene)

[7] Choose SPENCE model 812 (EPDM), 814 (Viton) or 816 (TFE/25% Glass) o-ring

[8] Choose SPENCE model 822 (EPDM), 824 (Viton) or 826 (TFE/25% Glass) o-ring

[9] SPENCE model 862 (EPDM), 864 (Viton) or 866 (TFE/25% Glass) o-ring

[10] Spence model is 2 x 2-1/2 connections - for vacuum service, outlet connection gets connected to vacuum side

* Pressure limited

This crossover chart is to be used as a guideline ONLY. All applications should be reviewed in the product catalog or by the factory.
All valve data should be reviewed before final selection (physical dimensions, capacity requirements, materials, inlet/outlet connections, etc.)
Neither Spence Engineering nor it's agents assume any responsibility for the selection and/or cross reference of any product.
Spence Engineering does not guarantee that this information is accurate and/or up to date, therefore it should be used only as a guide.

VALVES

VALVES

FIGURE 31 / 41
BRONZE SERIES

SIZES 1/2" – 21/2"
PRESSURES to 300 PSIG at 422°F

FIGURE 31 BRONZE SERIES

- **Meets ASME Section I & VIII Code for Steam, Air & Non-hazardous Gas Service**
- **"V" or "UV" National Board Certified**
- **Dual Ring Control** See page 12
- **Rugged Cast Unitized Bonnet**
- **SS Spring Supplied as Standard**
- **Full Nozzle**
- **Soft Seat Design Available** See page 12
- **Open Lever Assembly**

Application Data

- Steam Boilers
- Pressure Reducing Stations
- Unfired Steam Pressure Vessels & Lines
- Accumulators, Sterilizers, Steam Cleaners
- Air compressors, Cookers, Receivers
- Pneumatic Systems
- OEM Equipment

Valve Ratings *See Capacity Charts beginning on page 14*

Model	Pressure PSIG (bar)	Temperature °F (°C)
0031/0041/041A/41AT/41AA	10 to 250 (.7 to 17.2)	-20 to 406 (-29 to 208)
0032/0042/042A/42AT/42AA	10 to 300 (.7 to 20.7)	-20 to 422 (-29 to 216)
0033/0043/043A/43AT	10 to 250 (.7 to 17.2)	-20 to 406 (-29 to 208)

Applicable Codes

- ASME Section I "V" for Steam
- ASME Section VIII "UV" for Steam/Air/Gas
- API 527
- Canadian Registration # 0G0591.9C
- PED (Consult Factory)

Options

- Top Outlet Discharge
- BSP Connections
- Soft Seated Valves
- Plain Cap (on selected models)
- Test Reports Available

Models

- 0031 - ASME Section I Steam, Bronze Trim
- 0041 - ASME Section VIII Steam, Bronze Trim
- 041A - ASME Section VIII Air, Bronze Trim
- 41AT - Top Outlet on 041A
- 41AA - Plain Cap on 041A (D orifice only)
- 0032 - SS Base & Disc on 0031
- 0042 - SS Base & Disc on 0041
- 042A - SS Base & Disc on 041A
- 42AT - SS Base & Disc on 41AT
- 42AA - SS Base & Disc on 41AA (D orifice only)
- 0033 - EPDM Soft Seat on 0031
- 0043 - EPDM Soft Seat on 0041
- 043A - Viton Soft Seat on 041A
- 43AT - Viton Soft Seat on 41AT

CODE SELECTION CHART

Model				Orifice	Inlet Size	Connec- tions	–	Set Pressure		
0	0	4	1	D	C	A	-	0	4	0
1	2	3	4	5	6	7		8	9	10

Model - Position 1, 2, 3 & 4
- 0031 = ASME Section I Steam, Bronze Trim
- 0041 = ASME Section VIII Steam, Bronze Trim
- 041A = ASME Section VIII Air, Bronze Trim
- 41AT = Top Outlet on 041A
- 41AA = Plain Cap on 041A (D orifice only)
- 0032 = SS Base & Disc on 0031
- 0042 = SS Base & Disc on 0041
- 042A = SS Base & Disc on 041A
- 42AT = SS Base & Disc on 41AT
- 42AA = SS Base & Disc on 41AA
- 0033 = EPDM Soft Seat on 0031
- 0043 = EPDM Soft Seat on 0041
- 043A = Viton Soft Seat on 041A
- 43AT = Viton Soft Seat on 41AT

Orifice - Position 5
- D
- E
- F
- G
- H
- J

Inlet Size - Position 6
- C = ½
- D = ¾
- E = 1
- F = 1¼
- G = 1½
- H = 2
- J = 2½

Connections - Position 7
- A = MPT x FPT
- E = MPT x Top
- F = MBSP x FBSP
- Z = Other

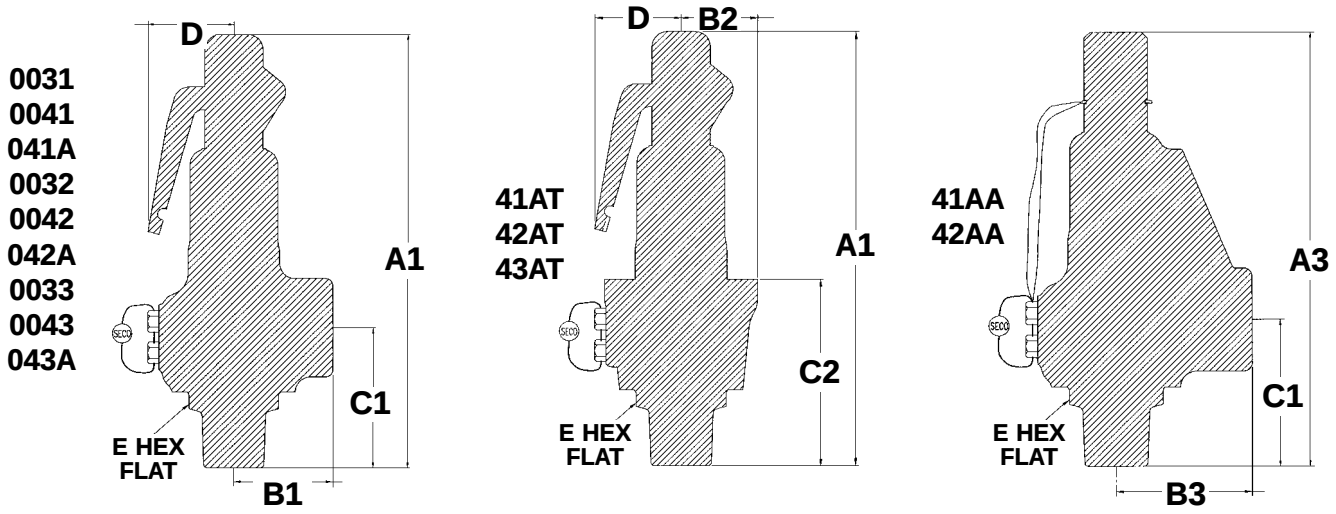
Set Pressure - Position 8, 9 & 10
- __ __ __ = Actual Setting
- LAS - Loosely Assembled†

†Spence Certified Assemblers Only (use 0031, 0032, 0033, 41AT, 42AT, 43AT, 41AA or 42AA only)

FIGURE 31 / 41
BRONZE SERIES

SPECIFICATION

The valve shall meet the ASME Section I or VIII Code for steam, air and gas services. It shall be “V” or “UV” National Board Certified. The valve shall have dual blowdown ring to allow better adjustment of the pop and blowdown. The valve shall consist of a unitized bonnet design guaranteeing proper guiding and making the valve extremely dependable in terms of pop action, seat tightness and repeatability.The valve shall be top guided and shall have a full nozzle for optimum flow performance. The valve shall have a stainless steel spring for better corrosion and yield strength. The valve shall meet the API 527 leakage standard requiring bubble tight shutoff up to 90% of set pressure.



DIMENSIONS* inches (mm) **AND WEIGHTS** pounds (kg)

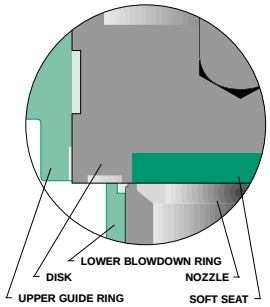
Model	Inlet	Orifice	Outlet[2]	A1	A3	B1	B2	B3	C1	C2	D[1]	E	Weight
****DCA	½ MPT (15)	D	¾ FPT (20)	6 9/16 (166.7)	6¼ (158.8)	1⅜ (34.9)	1 1/16 (27.0)	1⅞ (47.6)	2¼ (57.2)	2⅞ (73.0)	1⅜ (34.9)	1⅛ (28.6)	2 (0.91)
****DDA	¾ MPT (20)	D	¾ FPT (20)	6 9/16 (166.7)	6¼ (158.8)	1⅜ (34.9)	—	1⅞ (47.6)	2¼ (57.2)	—	1⅜ (34.9)	1¼ (31.8)	2¼ (1.02)
****EDA	¾ MPT (20)	E	1 FPT (25)	7⅛ (181.0)	—	1⅝ (41.3)	1¼ (31.8)	—	2 5/16 (58.7)	3⅛ (79.4)	1⅜ (34.9)	1¼ (31.8)	2½ (1.13)
****EEA	1 MPT (25)	E	1 FPT (25)	7⅛ (181.0)	—	1⅝ (41.3)	—	—	2 5/16 (58.7)	—	1⅜ (34.9)	1½ (38.1)	2¾ (1.25)
****FEA	1 MPT (25)	F	1¼ FPT (32)	9 (228.6)	—	1⅞ (47.6)	1 7/16 (36.5)	—	2 13/16 (71.4)	3½ (88.9)	1 11/16 (42.9)	1½ (38.1)	4 (1.81)
****FFA	1¼ MPT (32)	F	1¼ FPT (32)	9 (228.6)	—	1⅞ (47.6)	—	—	2 13/16 (71.4)	—	1 11/16 (42.9)	1¾ (44.5)	4¼ (1.93)
****GFA	1¼ MPT (32)	G	1½ FPT (40)	9 11/16 (246.1)	—	2⅛ (54.0)	1 11/16 (42.9)	—	3 (76.2)	3¾	1 11/16 (42.9)	1⅞ (47.6)	7 (3.18)
****GGA	1½ MPT (40)	G	1½ FPT (40)	9 11/16 (246.1)	—	2⅛ (54.0)	—	—	3 (76.2)	—	1 11/16 (42.9)	2 1/16 (52.4)	7¼ (3.29)
****HGA	1½ MPT (40)	H	2 FPT (50)	12⅛ (308.0)	—	2 9/16 (65.1)	2 1/16 (52.4)	—	3½ (88.9)	4 1/16 (119.1)	2¾ (69.9)	2¼ (57.2)	13½ (6.12)
****HHA	2 MPT (50)	H	2 FPT (50)	12⅛ (308.0)	—	2 9/16 (65.1)	—	—	3½ (88.9)	—	2¾ (69.9)	2 9/16 (65.1)	13¾ (6.24)
****JHA	2 MPT (50)	J	2½ FPT (65)	13 5/16 (338.1)	—	3⅛ (79.4)	2½ (63.5)	—	3¾ (95.3)	5 (127.0)	2¾ (69.9)	2¾ (69.9)	17½ (7.94)
****JJA	2½ MPT (65)	J	2½ FPT (65)	13 5/16 (338.1)	—	3⅛ (79.4)	—	—	3¾ (95.3)	—	2¾ (69.9)	3 (76.2)	17¾ (8.05)

*Accurate to ±1/8".
**** Use appropriate Model Number.

[1] Add 50% to D Dimension when lever is pulled out to manually operate valve.
[2] Outlet connections do not apply for **AT top outlet valve.

FIGURE 31 / 41 BRONZE SERIES SOFT SEATS

Safety Valves with metal seats will start to leak at 90% of set pressure. A Spence Safety Valve equipped with a soft seat seals on both the metal and soft seats (see illustration). As a result, it will not begin to leak until system pressure reaches 95% of set pressure, minimizing system energy loss.



The o-rings in standard soft seat safety valves tend to blow out during discharge. Spence Soft Seat Safety Valves utilize a flat soft seat insert in the disc assembly of the valve that stays in place during operation, thus providing hassle-free operation.

There are many troublesome applications where using a Spence Soft Seat Safety Valve can reduce costly downtime and repair costs. Consider a Spence Soft Seat Safety Valve for:

- Operating very close to set pressure
- Heavy vibration
- Hard-to-hold fluids
- Occasional foreign particles
- Icing problems
- Pipe strain due to excessive discharge

SERVICE RECOMMENDATIONS*

EPDM Soft Seat

WET - -20 to 422°F (-29 to 216°C)
DRY - -20 to 250°F (-29 to 121°C)

Acetone
Acetylene Gas
Beer
Bleach Liquor
Brake Fluid
Calcium Chloride
Carbon Monoxide
Carbonic Acid
Citric Acid
Denatured Alcohol
Ethylene Diamine
Freon 22
Hydrazine
Lindol Hydraulic Fluid
Lye
Methanol
Methyl Alcohol
Methyl Butyl Ketone
Nitrogen
STEAM
Sulfur Hexafluoride
WATER

Viton Soft Seat

-20 to 400°F (-29 to 204°C)

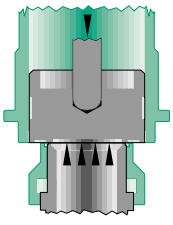
AIR
Benzoic Acid
Benzul Alcohol
Butane
Butyl Alcohol
Carbon Disulfide
Carbon Tetrachloride
Castor Oil
Chlorine
Chromic Acid
Corn Oil
Crude Oil
Diesel Oil
Dowtherm A
Ethane
Ethyl Alcohol
Ethyl Chloride
Ethylene
Ethylene Glycol
Fuel Oil
Gasoline
Glucose
Glycerin
Helium
Hydraulic Oil
Hydrogen Gas
Iodine
Kerosene
Linseed Oil
Methane
Mineral Oils
Natural Gas
Petroleum Oil
Propane
Propyl Alcohol
Propylene
Sulfur Dioxide
Turpentine

*These recommendations should be used as a guide only. It is the sole responsibility of the user to select suitable materials.

FIGURE 31 BRONZE SERIES DUAL RING CONTROL

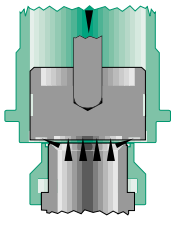
Safety Valves are pressure relief devices actuated by inlet static pressure and characterized by rapid opening or “pop” action. The difference between Safety Valves from different manufacturers is how well they do this.

Spence Figure 31 Safety Valves have Dual Ring Control which allows for finer adjustment of the “popping” action and length of “blowdown”. This allows exceptional flow efficiency and maximum lifting force while minimizing system energy loss.



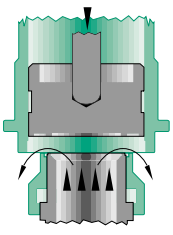
CLOSED

System pressure is pushing upward against the disk which is held closed by the downward force of the spring against the spindle.



OPENING

When system pressure rises above the set pressure of the spring, the disc begins to lift. This simmer/warn stage allows system pressure to enter the “huddling chamber” where it acts on a larger, secondary area of the disc. This magnified force causes the valve to “pop” open.



OPEN

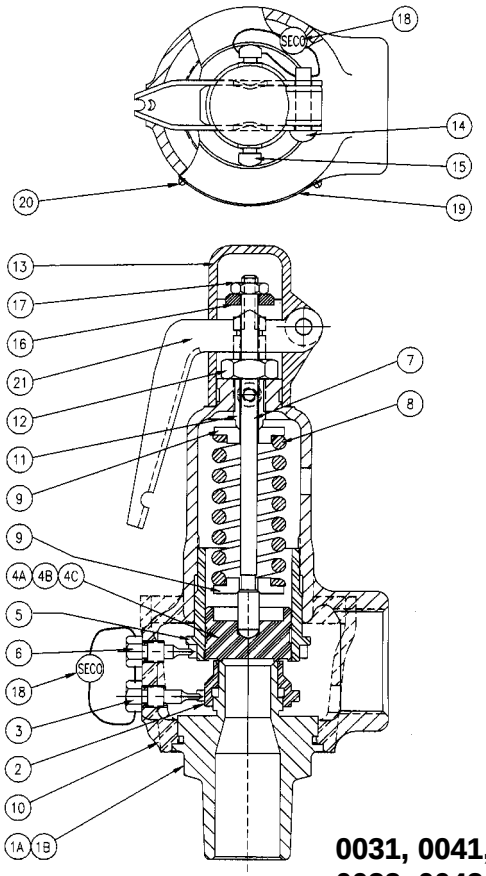
As pressure increases, the disc continues to lift until fully open. When pressure is reduced to a level below the set point of the valve, the spring force against the spindle will snap shut the disc.

FIGURE 31 / 41
BRONZE SERIES

Materials of Construction

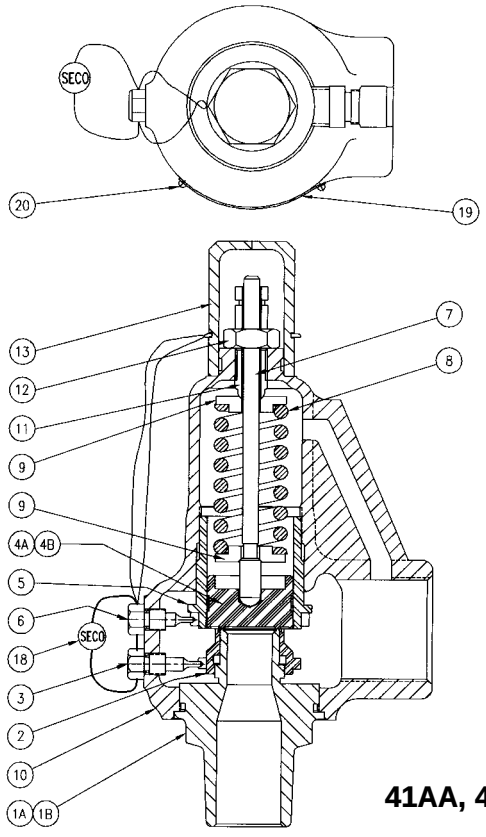
Ref	Part Name	Material
1A	Base/Nozzle - Bronze	Brass or Brz ASTM B283 or ASME SB62
1B	Base/Nozzle - SST	316 SST ASTM A276
2	Base Ring	Brass or Brz ASTM B283 or ASTM B62
3	Nozzle Ring Set Screw	Brass ASTM B16
4A	Disc - Bronze Metal	Brass or Brz ASTM B16 or ASTM B62
4B	Disc - SST Metal	316 SST ASTM A276
4C	Disc Assembly - Soft	Brass or Brz - EPDM/Viton
5	Guide Ring	Brass or Brz B283 or B584
6	Guide Ring Set Screw	Brass ASTM B16
7	Spindle	Steel ASTM A108
8	Spring	302 SST/17-7 SST
9	Spring Washer	Steel ASTM A108
10	Bonnet†	Cast Brz ASME SB62
11	Adjusting Bolt	Brass ASTM B16
12	Adjusting Bolt Locknut	Steel (Plated) SAE J995 GRD 2
13	Lifting Cap	Zinc Alloy
14	Lifting Cap Pin	Steel
15	Lifting Cap Lockscrew	Plated Steel
16	Spindle Nut	Steel ASTM
17	Spindle Nut Locknut	Plated Steel
18	Seal and Wire	Lead and SST
19	Nameplate	SST
20	Drive Screw	SST
21	Lever	Steel (Plated)

†41AT, 42AT, 43AT denoted by dotted line.



0031, 0041, 041A
0032, 0042, 042A
0033, 0043, 043A
41AT, 42AT, 43AT

Ref	Part Name	Material
1A	Base/Nozzle - Bronze	Brass ASTM B283
1B	Base/Nozzle - SST	316 SST ASTM A276
2	Base Ring	Brass ASTM B283
3	Nozzle Ring Set Screw	Brass ASTM B16
4A	Disc - Bronze Metal	Brass ASTM B16
4B	Disc - SST Metal	316 SST ASTM A276
5	Guide Ring	Brass B283
6	Guide Ring Set Screw	Brass ASTM B16
7	Spindle	Steel ASTM A108
8	Spring	302 SST/17-7 SST
9	Spring Washer	Steel ASTM A108
10	Bonnet	Cast Brz ASME SB62
11	Adjusting Bolt	Brass ASTM B16
12	Adjusting Bolt Locknut	Steel (Plated) SAE J995 GRD 2
13	Cap	Brass ASTM B16
18	Seal and Wire	Lead and SST
19	Nameplate	SST
20	Drive Screw	SST



41AA, 42AA

SATURATED STEAM CAPACITY CHART

BRONZE MODELS 31, 32, 33

ASME Section I V" 90% rated at 3% Overpressure LBS/HR (KGS/HR)
Flow Coefficient = .9 x .975 = .878

LBS/HR

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479	J 1.391
10 *	143	255	400	654	1023	1678
15	170	303	475	776	1213	1991
20	197	351	550	899	1405	2305
25	224	398	625	1021	1596	2619
30	250	446	700	1144	1788	2933
35	277	494	774	1266	1979	3247
40	304	542	849	1388	2171	3561
45	331	589	924	1511	2362	3875
50	358	637	999	1633	2553	4189
55	385	685	1074	1756	2745	4503
60	411	733	1149	1878	2936	4817
65	438	780	1224	2001	3128	5131
70	466	829	1300	2126	3323	5451
75	493	878	1377	2252	3520	5774
80	521	928	1455	2378	3717	6098
85	548	977	1532	2504	3914	6421
90	576	1026	1609	2630	4111	6745
95	604	1075	1686	2756	4308	7068
100	631	1124	1763	2882	4506	7392
105	659	1174	1840	3008	4703	7715
110	687	1223	1917	3134	4900	8038
115	714	1272	1995	3261	5097	8362
120	742	1321	2072	3387	5294	8685
125	769	1370	2149	3513	5491	9009
130	797	1420	2226	3639	5688	9332
135	825	1469	2303	3765	5886	9655
140	852	1518	2380	3891	6083	9979
145	880	1567	2457	4017	6280	10302
150	908	1616	2535	4143	6477	10626
155	935	1666	2612	4269	6674	10949
160	963	1715	2689	4396	6871	11273
165	990	1764	2766	4522	7068	11596
170	1018	1813	2843	4648	7266	11919
175	1046	1862	2920	4774	7463	12243
180	1073	1912	2997	4900	7660	12566
185	1101	1961	3075	5026	7857	12890
190	1128	2010	3152	5152	8054	13213
195	1156	2059	3229	5178	8251	13537
200	1184	2108	3306	5404	8448	13860
205	1211	2158	3383	5531	8646	14183
210	1239	2207	3460	5657	8843	14509
215	1267	2256	3538	5783	9040	14830
220	1294	2305	3615	5909	9237	15154
225	1322	2354	3692	6035	9434	15477
230	1349	2404	3769	6161	9631	15800
235	1377	2453	3846	6287	9829	16124
240	1405	2502	3923	6413	10026	16447
245	1432	2551	4000	6540	10223	16771
250	1460	2600	4078	6666	10420	17094
255	1488	2650	4155	6792	10617	17418
260	1515	2699	4232	6918	10814	17741
265	1543	2748	4309	7044	11011	18064
270	1570	2797	4386	7470	11209	18388
275	1598	2846	4463	7296	11406	18711
280	1626	2896	4540	7422	11603	19035
285	1653	2945	4618	7548	11800	19358
290	1681	2994	4695	7675	11997	19682
295	1709	3043	4772	7801	12194	20005
300	1736	3092	4849	7927	12391	20328
1.0	6	10	15	25	39	65

KGS/HR

Set Pressure Barg	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47	J 8.974
0.4*	55	97	153	250	391	641
0.6*	62	110	173	282	441	723
0.8*	69	123	192	314	491	806
1*	76	135	212	346	542	889
1.2	83	148	232	379	592	971
1.4	90	160	251	411	642	1054
1.6	97	173	271	443	693	1136
1.8	104	185	291	475	743	1219
2	111	198	310	508	793	1302
2.2	118	211	330	540	844	1384
2.4	125	223	350	572	894	1467
2.6	132	236	370	604	944	1549
2.8	139	248	389	636	995	1632
3	146	261	409	669	1045	1715
3.2	153	273	429	701	1095	1797
3.4	161	286	448	733	1146	1880
3.6	168	299	468	765	1196	1962
3.8	175	311	488	797	1247	2045
4	182	324	507	830	1297	2128
4.2	189	336	527	862	1347	2210
4.4	196	349	547	894	1398	2293
4.6	203	361	567	926	1448	2375
4.8	210	374	587	959	1500	2460
5	217	387	607	993	1552	2545
5.2	225	400	627	1026	1603	2631
5.4	232	413	648	1059	1655	2716
5.6	239	426	668	1092	1707	2801
5.8	246	439	688	1125	1759	2886
6	254	452	709	1158	1811	2971
6.5	272	484	759	1241	1941	3184
7	290	517	810	1324	2070	3396
7.5	308	549	861	1407	2200	3609
8	326	581	912	1490	2329	3822
8.5	345	614	962	1573	2459	4034
9	363	646	1013	1656	2589	4247
9.5	381	678	1064	1739	2718	4460
10	399	711	1114	1822	2848	4672
10.5	417	743	1165	1905	2978	4885
11	435	775	1216	1988	3107	5098
11.5	454	808	1267	2071	3237	5310
12	472	840	1317	2154	3367	5523
12.5	490	873	1368	2237	3496	5736
13	508	905	1419	2319	3626	5948
13.5	526	937	1470	2402	3756	6161
14	544	970	1520	2485	3885	6374
14.5	563	1002	1571	2568	4015	6586
15	581	1034	1622	2651	4144	6799
15.5	599	1067	1673	2734	4274	7012
16	617	1099	1723	2817	4404	7224
16.5	635	1131	1774	2900	4533	7437
17	653	1164	1825	2983	4663	7650
17.5	672	1196	1875	3066	4793	7862
18	690	1228	1926	3149	4922	8075
18.5	708	1261	1977	3232	5052	8288
19	726	1293	2028	3315	5182	8500
19.5	744	1325	2078	3398	5311	8713
20	762	1358	2129	3481	5441	8926
20.5	780	1390	2180	3563	5571	9139
21	799	1423	2231	3646	5700	9351
21.5	817	1455	2281	3729	5830	9564
0.1	3.6	6.4	10.1	16.6	25.9	42.5

* Pressure settings below 15 PSIG (1.034 barg) are non code.

SATURATED STEAM CAPACITY CHART

BRONZE MODELS 41, 42, 43

ASME Section VIII "UV" 90% rated at 10% Overpressure LBS/HR (KGS/HR)
Flow Coefficient = .9 x .975 = .878

LBS/HR

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479	J 1.391
10 *	149	265	416	679	1062	1742
15	176	313	491	802	1254	2057
20	203	361	566	925	1445	2371
25	229	409	641	1047	1637	2686
30	256	456	716	1170	1829	3000
35	286	509	798	1305	2040	3346
40	315	562	881	1440	2251	3692
45	345	614	963	1575	2461	4038
50	374	667	1046	1709	2672	4384
55	404	720	1128	1844	2883	4730
60	434	772	1211	1979	3094	5076
65	463	825	1293	2114	3305	5422
70	493	877	1376	2249	3516	5768
75	522	930	1458	2384	3727	6114
80	552	983	1541	2519	3937	6460
85	581	1035	1623	2654	4148	6805
90	611	1088	1706	2789	4359	7151
95	640	1140	1788	2923	4570	7497
100	670	1193	1871	3058	4781	7843
105	699	1246	1953	3193	4992	8189
110	729	1298	2036	3328	5203	8535
115	758	1351	2118	3463	5414	8881
120	788	1404	2201	3598	5624	9227
125	818	1456	2283	3733	5835	9573
130	847	1509	2366	3868	6046	9919
135	877	1561	2448	4003	6257	10265
140	906	1614	2531	4137	6468	10611
145	936	1667	2614	4272	6679	10957
150	965	1719	2696	4407	6890	11303
155	995	1772	2779	4542	7100	11648
160	1024	1825	2861	4677	7311	11994
165	1054	1877	2944	4812	7522	12340
170	1083	1930	3026	4947	7733	12686
175	1113	1982	3109	5082	7944	13032
180	1143	2035	3191	5217	8155	13378
185	1172	2088	3274	5352	8366	13724
190	1202	2140	3356	5486	8577	14070
195	1231	2193	3439	5621	8787	14416
200	1261	2246	3521	5756	8998	14762
205	1290	2298	3604	5891	9209	15108
210	1320	2351	3686	6026	9420	15454
215	1349	2403	3769	6161	9631	15800
220	1379	2456	3851	6296	9842	16146
225	1408	2509	3934	6431	10053	16492
230	1438	2561	4016	6566	10263	16837
235	1468	2614	4099	6700	10474	17183
240	1497	2667	4181	6835	10685	17529
245	1527	2719	4264	6970	10896	17875
250	1556	2772	4346	7105	11107	18221
255	1586	2824	4429	7240	11318	18567
260	1615	2877	4511	7375	11529	18913
265	1645	2930	4594	7510	11740	19259
270	1674	2982	4676	7645	11950	19605
275	1704	3035	4759	7780	12161	19951
280	1733	3088	4841	7914	12372	20297
285	1763	3140	4924	8049	12583	20643
290	1793	3193	5007	8184	12794	20989
295	1822	3245	5089	8319	13005	21335
300	1852	3298	5172	8454	13216	21681
1.0	6.0	10.5	16.5	27.0	42.2	69

* Pressure settings below 15 PSIG (1.034 barg) are non code.

KGS/HR

Set Pressure Barg	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47	J 8.974
0.4*	57	102	160	261	409	670
0.6*	64	115	180	294	459	753
0.8*	71	127	199	326	509	836
1*	78	140	219	358	560	918
1.2	86	152	239	390	610	1001
1.4	93	165	259	423	661	1084
1.6	100	177	278	455	711	1167
1.8	107	190	298	487	762	1249
2	114	203	318	519	812	1332
2.2	121	216	339	554	866	1420
2.4	129	230	360	589	921	1511
2.6	137	244	382	625	977	1602
2.8	145	258	404	660	1032	1693
3	152	271	426	696	1088	1784
3.2	160	285	447	731	1143	1875
3.4	168	299	469	767	1199	1966
3.6	176	313	491	802	1254	2057
3.8	183	327	512	838	1309	2148
4	191	341	534	873	1365	2239
4.2	199	354	556	909	1420	2330
4.4	207	368	578	944	1476	2421
4.6	215	382	599	980	1531	2512
4.8	222	396	621	1015	1587	2603
5	230	410	643	1051	1642	2694
5.2	238	424	664	1086	1698	2785
5.4	246	438	686	1122	1753	2876
5.6	253	451	708	1157	1809	2967
5.8	261	465	729	1192	1864	3058
6	269	479	751	1228	1920	3149
6.2	277	493	773	1263	1975	3240
6.4	284	507	795	1299	2031	3331
6.6	292	521	816	1334	2086	3422
7	308	548	860	1405	2197	3604
7.5	327	583	914	1494	2336	3832
8	347	617	968	1583	2474	4059
8.5	366	652	1022	1671	2613	4287
9	386	687	1077	1760	2752	4514
9.5	405	721	1131	1849	2890	4742
10	424	756	1185	1938	3029	4969
10.5	444	790	1240	2026	3168	5196
11	463	825	1294	2115	3306	5424
11.5	483	860	1348	2204	3445	5651
12	502	894	1402	2292	3584	5879
12.5	522	929	1457	2381	3722	6106
13	541	964	1511	2470	3861	6334
13.5	560	998	1565	2559	4000	6561
14	580	1033	1619	2647	4138	6789
14.5	599	1067	1674	2736	4277	7016
15	619	1102	1728	2825	4416	7244
15.5	638	1137	1782	2913	4554	7471
16	658	1171	1836	3002	4693	7699
16.5	677	1206	1891	3091	4832	7926
17	696	1240	1945	3179	4970	8154
17.5	716	1275	1999	3268	5109	8381
18	735	1310	2053	3357	5248	8609
18.5	755	1344	2108	3446	5386	8836
19	774	1379	2162	3534	5525	9064
19.5	794	1413	2216	3623	5664	9291
20	813	1448	2271	3712	5802	9519
20.5	832	1483	2325	3800	5941	9746
0.1	3.9	6.9	10.9	17.7	27.7	45.5

AIR CAPACITY CHART

BRONZE MODELS 41A, 42A, 43A, 41AT, 42AT, 43AT, 41AA, 42AA

ASME Section VIII "UV" 90% rated at 10% Overpressure SCFM (M^3/HR)
Flow Coefficient = .9 x .975 = .878

SCFM

Set Pressure PSIG	Orifice Area in^2 D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479	J 1.391
10 *	53	94	148	242	378	620
15	63	111	175	285	446	732
20	72	128	201	329	514	844
25	82	145	228	373	583	956
30	91	162	255	416	651	1068
35	102	181	284	464	726	1191
40	112	200	313	512	801	1314
45	123	219	343	560	876	1437
50	133	237	372	608	951	1560
55	144	256	402	656	1026	1684
60	154	275	431	704	1101	1807
65	165	294	460	753	1176	1930
70	175	312	490	801	1251	2053
75	186	331	519	849	1326	2176
80	196	350	548	897	1402	2299
85	207	368	578	945	1477	2422
90	217	387	607	993	1552	2545
95	228	406	637	1041	1627	2669
100	238	425	666	1089	1702	2792
105	249	443	695	1137	1777	2915
110	259	462	725	1185	1852	3038
115	270	481	754	1233	1927	3161
120	280	500	783	1281	2002	3284
125	291	518	813	1329	2077	3407
130	302	537	842	1377	2152	3531
135	312	556	872	1425	2227	3654
140	323	575	901	1473	2302	3777
145	333	593	930	1521	2377	3900
150	344	612	960	1569	2452	4023
155	354	631	989	1617	2527	4146
160	365	649	1018	1665	2602	4269
165	375	668	1048	1713	2677	4392
170	386	687	1077	1761	2753	4516
175	396	706	1106	1809	2828	4639
180	407	724	1136	1857	2903	4762
185	417	743	1165	1905	2978	4885
190	428	762	1195	1953	3053	5008
195	438	781	1224	2001	3128	5131
200	449	799	1253	2049	3203	5254
205	459	818	1283	2097	3278	5378
210	470	837	1312	2145	3353	5501
215	480	855	1341	2193	3428	5624
220	491	874	1371	2241	3503	5747
225	501	893	1400	2289	3578	5870
230	512	912	1430	2337	3653	5993
235	522	930	1459	2385	3728	6116
240	533	949	1488	2433	3803	6239
245	543	968	1518	2481	3878	6363
250	554	987	1547	2529	3953	6486
255	564	1005	1576	2577	4028	6609
260	575	1024	1606	2625	4104	6732
265	585	1043	1635	2673	4179	6855
270	596	1062	1665	2721	4254	6978
275	606	1080	1694	2769	4329	7101
280	617	1099	1723	2817	4404	7224
285	628	1118	1753	2865	4479	7348
290	638	1136	1782	2913	4554	7471
295	649	1155	1811	2961	4629	7594
300	659	1174	1841	3009	4704	7717
1.0	2.2	3.6	6.0	9.6	15.0	24.6

* Pressure settings below 15 PSIG (1.034 barg) are non code.

M^3/HR

Set Pressure Barg	Orifice Area cm^2 D .766	E 1.365	F 2.141	G 3.499	H 5.47	J 8.974
0.4*	76	136	213	349	545	894
0.6*	86	153	240	392	612	1004
0.8*	95	170	266	435	679	1114
1*	105	186	292	478	747	1225
1.2	114	203	318	521	814	1335
1.4	123	220	345	564	881	1445
1.6	133	237	371	607	948	1556
1.8	142	253	397	650	1016	1666
2	152	270	424	693	1083	1776
2.2	162	288	452	738	1154	1894
2.4	172	307	481	786	1228	2015
2.6	182	325	510	833	1302	2137
2.8	193	343	539	880	1376	2258
3	203	362	568	928	1450	2379
3.2	214	380	596	975	1524	2501
3.4	224	399	625	1022	1598	2622
3.6	234	417	654	1070	1672	2743
3.8	245	436	683	1117	1746	2865
4	255	454	712	1164	1820	2986
4.2	265	473	741	1212	1894	3107
4.4	276	491	770	1259	1968	3229
4.6	286	510	799	1306	2042	3350
4.8	296	528	828	1354	2116	3471
5	307	547	857	1401	2190	3593
5.2	317	565	886	1448	2264	3714
5.4	328	583	915	1496	2338	3835
5.6	338	602	944	1543	2412	3957
5.8	348	620	973	1590	2486	4078
6	359	639	1002	1637	2560	4199
6.2	369	657	1031	1685	2634	4321
6.4	379	676	1060	1732	2708	4442
6.6	390	694	1088	1779	2782	4563
7	410	731	1146	1874	2930	4806
7.5	436	777	1219	1992	3114	5109
8	462	823	1291	2111	3299	5413
8.5	488	870	1363	2229	3484	5716
9	514	916	1436	2347	3669	6019
9.5	540	962	1508	2465	3854	6323
10	566	1008	1581	2584	4039	6626
10.5	592	1054	1653	2702	4224	6929
11	618	1100	1725	2820	4409	7233
11.5	644	1146	1798	2939	4594	7536
12	670	1193	1870	3057	4779	7839
12.5	695	1239	1942	3175	4964	8143
13	721	1285	2015	3293	5148	8446
13.5	747	1331	2087	3412	5333	8749
14	773	1377	2159	3530	5518	9053
14.5	799	1423	2232	3648	5703	9356
15	825	1469	2304	3767	5888	9659
15.5	851	1516	2376	3885	6073	9963
16	877	1562	2449	4003	6258	10266
16.5	903	1608	2521	4121	6443	10570
17	929	1654	2594	4240	6628	10873
17.5	955	1700	2666	4358	6813	11176
18	980	1746	2738	4476	6998	11480
18.5	1006	1792	2811	4595	7182	11783
19	1032	1839	2883	4713	7367	12086
19.5	1058	1885	2955	4831	7552	12390
20	1084	1931	3028	4949	7737	12693
20.5	1110	1977	3100	5068	7922	12996
0.1	5.2	9.2	14.5	23.6	37	60.7

NOTES:

FIGURE 31 / 41
CAST IRON SERIES

SIZES 1½" – 6"
PRESSURES to 250 PSIG at 406°F

- **Meets ASME Section I & VIII Code for Steam, Air & Non-hazardous Gas Service**
- **"V" or "UV" National Board Certified**
- **Dual Ring Control** See page 12
- **Heavy Duty Construction**
- **Flanged or Threaded Connections**
- **SS Trim Design Available**
- **Heavy Duty Open Lever Assembly**

FIGURE 31 CAST IRON SERIES

Options
- SS Trim
- BSP Connections
- Test Reports Available

Application Data
- Steam Boilers
- Pressure Reducing Stations
- Unfired Steam Pressure Vessels & Lines
- Air compressors, Cookers, Receivers
- Pneumatic Systems
- OEM Equipment

Models
- 0031 - ASME Section I Steam, Bronze Trim
- 0041 - ASME Section VIII Steam, Bronze Trim
- 041A - ASME Section VIII Air, Bronze Trim
- 0032 - SS Base & Disc on 0031
- 0042 - SS Base & Disc on 0041
- 042A - SS Base & Disc on 041A

Valve Ratings *See Capacity Charts beginning on page 21*

Model	Pressure PSIG (bar)	Temperature °F (°C)
All	10 to 250 (.7 to 17.2)	-20 to 406 (-29 to 208)

Applicable Codes
- ASME Section I "V" for Steam
- ASME Section VIII "UV" for Steam/Air/Gas
- API 527
- Canadian Registration # 0G0591.9C

CODE SELECTION CHART

Model				Orifice	Inlet Size	Connec- tions	–	Set Pressure		
0	4	1	A	K	H	C	-	1	0	0
1	2	3	4	5	6	7		8	9	10

Model -
Position 1, 2, 3 & 4
0031 = ASME Section I Steam, Bronze Trim
0041 = ASME Section VIII Steam, Bronze Trim
041A = ASME Section VIII Air, Bronze Trim
0032 = SS Base & Disc on 0031
0042 = SS Base & Disc on 0041
042A = SS Base & Disc on 041A

Orifice -
Position 5
J
K
L
M
N
P
Q
R

Inlet Size -
Position 6
G = 1½
H = 2
J = 2½
K = 3
M = 4
P = 6

Connections -
Position 7
B = FPT x FPT
C = 250# x FPT
D = 250# x 125#
Z = Other

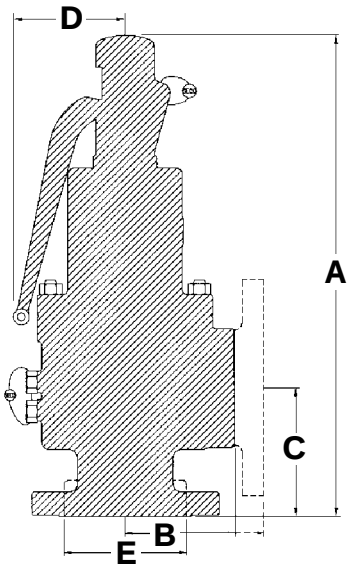
Set Pressure -
Position 8, 9 & 10
__ __ __ = Actual Setting
LAS - Loosely Assembled†

†Spence Certified Assemblers Only (use 0031or 0032 only)

FIGURE 31 / 41
CAST IRON SERIES

SPECIFICATION

The valve shall meet the ASME Section I or VIII Code for steam, air and gas services. It shall be “V” or “UV” National Board Certified. The valve shall have dual blowdown ring to allow better adjustment of the pop and blowdown. The valve shall be top guided and shall have a semi nozzle for optimum flow performance. The valve shall have an open lever assembly. The valve shall meet the API 527 leakage standard requiring bubble tight shutoff up to 90% of set pressure.



0031, 0041, 041A
0032, 0042, 042A

DIMENSIONS* inches (mm) **AND WEIGHTS** pounds (kg)

Model	Inlet	Orifice	Outlet	A	B	C	D[1]	E	Weight
****JGB	1½" FPT (40)	J	2½" FPT (65)	15⅛ (384.2)	3½ (88.9)	4¼ (108)	3 (76.2)	3¼ (82.6)	29 (13.2)
****JGC	1½" 250# (40)	J	2½" FPT (65)	15⅛ (384.2)	3½ (88.9)	4¼ (108)	3 (76.2)	—	36 (16.3)
****JHC	2" 250# (50)	J	3" FPT (80)	15¾ (400.1)	4 (101.6)	45/8 (117.5)	3½ (88.9)	—	42 (19.1)
****KHB	2" FPT (50)	K	3" FPT (80)	15¾ (400.1)	4 (101.6)	4⅝ (117.5)	3½ (88.9)	3⅝ (92.1)	36 (16.3)
****KHC	2" 250# (50)	K	3" FPT (80)	15¾ (400.1)	4 (101.6)	4⅝ (117.5)	3½ (88.9)	—	42 (19.1)
****KJC	2½" 250# (65)	K	3" FPT (80)	15¾ (400.1)	4 (101.6)	4¾ (120.7)	3½ (88.9)	—	45 (20.4)
****LJB	2½" FPT (65)	L	4" FPT (100)	23 [2] (584.2)	5⅛ (130.2)	5½ (139.7)	6 (152.4)	4½ (114.3)	97 (44.0)
****LJC	2½" 250# (65)	L	4" FPT (100)	23 [2] (584.2)	5⅛ (130.2)	5½ (139.7)	6 (152.4)	—	105 (47.6)
****KKC	3" 250# (80)	K	3" FPT (80)	15¾ (400.1)	4 (101.6)	5 (127)	3½ (88.9)	—	48 (21.8)
****LKC	3" 250# (80)	L	4" FPT (100)	23 [2] (584.2)	5⅛ (130.2)	5½ (139.7)	6 (152.4)	—	107 (48.5)
****MKB	3" FPT (80)	M	4" FPT (100)	23⅛ [2] (587.4)	5⅛ (130.2)	55/8 (142.9)	6 (152.4)	4½ (114.3)	99 (44.9)
****MKC	3" 250# (80)	M	4" FPT (100)	23 [2] (584.2)	5⅛ (130.2)	5½ (139.7)	6 (152.4)	—	107 (48.5)
****NMD	4" 250# (100)	N	6" 125# (150)	29½ [2] (749.3)	7¼ (184.2)	6¾ (171.5)	6 (152.4)	—	215 (97.5)
****PMD	4" 250# (100)	P	6" 125# (150)	29½ [2] (749.3)	7¼ (184.2)	6¾ (171.5)	6 (152.4)	—	215 (97.5)
****QPD [2]	6" 250# (150)	Q	8" 125# (200)	39½ [2] (1003.3)	10 (254)	9¼ (235)	10½ (266.7)	—	605 (274.4)
****RPD [2]	6" 250# (150)	R	8" 125# (200)	39½ [2] (1003.3)	10 (254)	9¼ (235)	10½ (266.7)	—	605 (274.4)

*Accurate to ±1/8".
**** Use appropriate Model Number.

[1] Add 50% to D Dimension when lever is pulled out to manually operate valve.
[2] Dimensions are current as of printing, consult factory for updated dimensions as they may change.

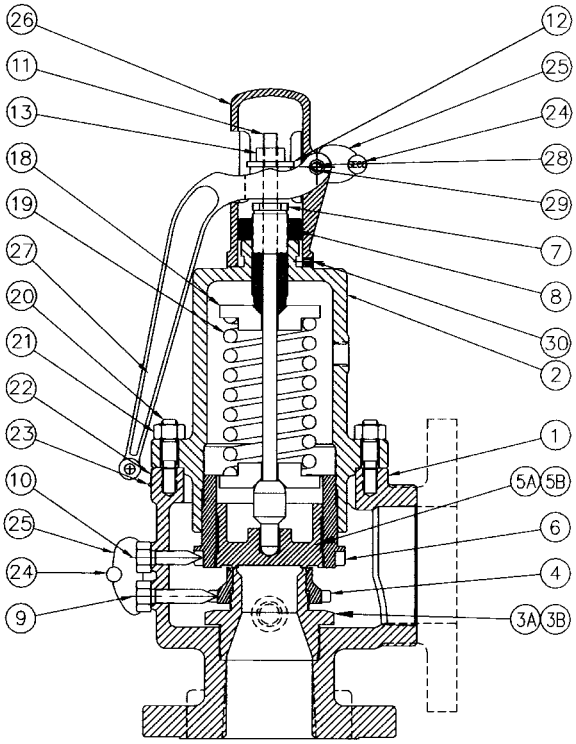
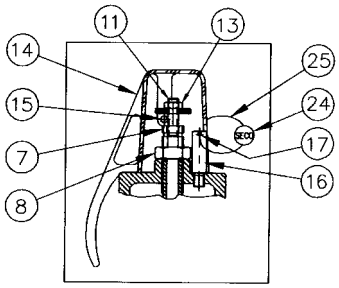


FIGURE 31 CAST IRON SERIES



CAP & LEVER CONFIGURATION FOR J & K ORIFICES

FIGURE 31 / 41
CAST IRON SERIES

MATERIALS OF CONSTRUCTION

Ref	Part Name	Material
1	Body	Cast Iron ASTM A126-B
2	Bonnet	Cast Iron ASTM A126-B
3A	Nozzle - Bronze	Brass or Bronze ASTM B16 or B62
3B	Nozzle - SST	SST ASME SA351, CF8M or ASME SA479, S31600
4	Nozzle Ring	Bronze ASTM B584-C84400
5A	Disc - Bronze	Brass or Bronze ASTM B16 or B62
5B	Disc - SST	SST ASTM A479, S31600
6	Guide Ring	ASTM B584-C84400
7	Adjusting Bolt	Brass ASTM B16
8	Adjusting Bolt Locknut	Steel, Zinc Plated
9	Nozzle Ring Set Screw	Brass ASTM B16
10	Guide Ring Set Screw	Brass ASTM B16
11	Spindle	Steel ASTM A108 Grade 1212
12	Spindle Nut	Steel ASTM A108 Grade 1212
13	Spindle Nut Locknut	Steel, Zinc Plated
14	Lifting Cap	Zinc Alloy Zamac #3
15	Lifting Cap Pins	Steel, Zinc Plated AISI 1020
16	Pivot Post	Steel AISI 1020
17	Post Pin	Steel, Zinc Plated AISI 1070
18	Spring Washer	Steel AISI 1212
19	Spring	Steel Zinc Plated
20	Stud	Steel, Chrome-Moly ASTM A193 B7
21	Stud Nut	Steel, Chrome-Moly ASTM A194 2H
22	Nameplate	SST AISI 304
23	Nameplate Screws	SST Commercial 18-8
24	Lead Seal	Lead
25	Seal Wire	SST AISI 304
26	Lifting Cap	Cast Iron A126-B*
27	Lifting Lever	Cast Iron ASTM A126-B
28	Clevis Pin	Steel, Zinc Plated
29	Cotter Pin	Steel
30	Liftcap Lockscrew	Steel

*Ductile Iron for 4" and above.

ASTM A395 Grade 60-40-18

SATURATED STEAM CAPACITY CHART

CAST IRON MODELS 31 & 32

ASME Section I "V" 90% rated at 3% Overpressure LBS/HR (KGS/HR)

Flow Coefficient = .9 x .975 = .878

LBS/HR

Set Pressure PSIG	Orifice Area, in² J 1.391	K 1.892	L 2.935	M 3.715	N 4.468	P 6.564	Q 11.365	R 16.475
10 *	1465	2281	3538	4478	5386	7912	13700	19860
15	1991	2708	4200	5318	6394	9394	16265	23579
20	2305	3135	4863	6157	7403	10876	18831	27298
25	2619	3562	5526	6996	8412	12358	21396	31017
30	2983	3989	6188	7835	9420	13839	23962	34736
35	3247	4416	6851	8674	10429	15321	26527	38455
40	3561	4843	7513	9512	11437	16803	29093	42174
45	3875	5270	8176	10351	12446	18285	31658	45893
50	4189	5697	8838	11190	13455	19766	34224	49612
55	4503	6125	9501	12029	14463	21248	36789	53331
60	4817	6552	10163	12868	15472	22730	39355	57050
65	5131	6979	10826	13707	16480	24212	41920	60769
70	5451	7414	11502	14562	17509	25723	44537	64562
75	5774	7854	12184	15426	18548	27249	47180	68393
80	6098	8294	12866	16290	19587	28775	49822	72223
85	6421	8734	13549	17154	20626	30302	52464	76054
90	6745	9174	14231	18018	21665	31828	55107	79884
95	7068	9614	14914	18882	22703	33354	57749	83715
100	7392	10054	15596	19746	23742	34880	60392	87546
105	7715	10494	16279	20610	24781	36406	63034	91376
110	8038	10934	16961	21474	25820	37932	65677	95207
115	8362	11374	17643	22338	26859	39459	68319	99037
120	8685	11813	18326	23202	27898	40985	70962	102868
125	9009	12253	19008	24066	28937	42511	73604	106699
130	9332	12693	19691	24930	29975	44037	76247	110529
135	9655	13133	20373	25794	31014	45563	78889	114360
140	9979	13573	21055	26658	32053	47090	81532	118190
145	10302	14013	21738	27522	33092	48616	84174	122021
150	10626	14453	22420	28386	34131	50142	86817	125851
155	10949	14893	23103	29250	35170	51668	89459	129682
160	11273	15333	23785	30114	36208	53194	92101	133513
165	11596	15773	24468	30978	37247	54721	94744	137343
170	11919	16212	25150	31842	38286	56247	97386	141174
175	12243	16652	25832	32706	39325	57773	100029	145004
180	12566	17092	26515	33570	40364	59299	102671	148835
185	12890	17532	27197	34434	41403	60825	105314	152666
190	13213	17972	27880	35298	42442	62351	107956	156496
195	13537	18412	28562	36162	43480	63878	110599	160327
200	13860	18852	29244	37026	44519	65404	113241	164157
205	14183	19292	29927	37890	45558	66930	115884	167988
210	14507	19732	30609	38754	46597	68456	118526	171818
215	14830	20172	31292	39618	47636	69982	121169	175649
220	15154	20612	31974	40482	48675	71509	123811	179480
225	15477	21051	32656	41346	49714	73035	126453	183310
230	15800	21491	33339	42210	50752	74561	129096	187141
235	16124	21931	34021	43074	51791	76087	131738	190971
240	16447	22371	34704	43938	52830	77613	134381	194802
245	16771	22811	35386	44802	53869	79140	137023	198633
250	17094	23251	36069	45666	54908	80666	139666	202463
1.0	64.6	88.0	136.4	172.8	207.8	305.2	528.4	766.0

* Pressure settings below 15 PSIG (1.034 barg) are non code.

KGS/HR

Set Pressure Barg	Orifice Area, cm² J 8.97	K 12.21	L 18.94	M 23.97	N 28.83	P 42.35	Q 73.32	R 106.29
0.4*	641	872	1352	1712	2059	3025	5237	7591
0.6*	724	984	1527	1932	2324	3414	5912	8570
0.8*	806	1097	1701	2153	2589	3804	6587	9548
1*	889	1209	1875	2374	2855	4194	7262	10527
1.2	971	1321	2050	2594	3120	4584	7937	11505
1.4	1054	1434	2224	2815	3385	4974	8611	12483
1.6	1137	1546	2398	3036	3651	5363	9286	13462
1.8	1219	1658	2573	3256	3916	5753	9961	14440
2	1302	1771	2747	3477	4182	6143	10636	15419
2.2	1384	1883	2921	3697	4447	6533	11311	16397
2.4	1467	1995	3095	3918	4712	6923	11986	17376
2.6	1550	2108	3270	4139	4978	7313	12661	18354
2.8	1632	2220	3444	4359	5243	7702	13336	19332
3	1715	2333	3618	4580	5508	8092	14011	20311
3.2	1797	2445	3793	4801	5774	8482	14686	21289
3.4	1880	2557	3967	5021	6039	8872	15361	22268
3.6	1963	2670	4141	5242	6304	9262	16036	23246
3.8	2045	2782	4316	5462	6570	9652	16711	24225
4	2128	2894	4490	5683	6835	10041	17386	25203
4.2	2211	3007	4664	5904	7100	10431	18061	26181
4.4	2293	3119	4838	6124	7366	10821	18736	27160
4.6	2376	3231	5013	6345	7631	11211	19411	28139
4.8	2461	3347	5192	6572	7904	11613	20106	29146
5	2546	3463	5372	6800	8178	12014	20801	30154
5.2	2631	3579	5551	7027	8451	12416	21497	31162
5.4	2716	3694	5731	7254	8724	12817	22192	32170
5.6	2801	3810	5911	7481	8998	13219	22887	33177
6	2971	4042	6270	7936	9544	14022	24277	35193
6.5	3184	4331	6718	8504	10228	15025	26015	37713
7	3397	4620	7167	9072	10911	16029	27753	40232
7.5	3610	4910	7616	9640	11594	17033	29491	42751
8	3822	5199	8065	10208	12277	18037	31229	45271
8.5	4035	5488	8514	10776	12961	19041	32967	47790
9	4248	5778	8963	11345	13644	20045	34705	50310
9.5	4460	6067	9411	11913	14327	21048	36443	52829
10	4673	6356	9860	12481	15010	22052	38181	55349
10.5	4886	6646	10309	13049	15694	23056	39919	57868
11	5099	6935	10758	13617	16377	24060	41657	60388
11.5	5311	7224	11207	14185	17060	25064	43395	62907
12	5524	7514	11656	14753	17744	26067	45133	65426
12.5	5737	7803	12104	15321	18427	27071	46871	67946
13	5949	8092	12553	15889	19110	28075	48609	70465
13.5	6162	8382	13002	16458	19793	29079	50347	72985
14	6375	8671	13451	17026	20477	30083	52085	75504
14.5	6588	8960	13900	17594	21160	31086	53823	78024
15	6800	9250	14349	18162	21843	32090	55561	80543
15.5	7013	9539	14798	18730	22526	33094	57299	83063
16	7226	9828	15246	19298	23210	34098	59037	85582
16.5	7438	10118	15695	19866	23893	35102	60775	88102
17	7651	10407	16144	20434	24576	36105	62513	90621
0.1	42.5	57.9	89.8	113.6	136.6	200.8	347.6	503.9

SATURATED STEAM CAPACITY CHART

CAST IRON MODELS 41 & 42

ASME Section VIII "UV" 90% rated at 10% Overpressure LBS/HR (KGS/HR)

Flow Coefficient = .9 x .975 = .878

LBS/HR

Set Pressure PSIG	Orifice Area, in² J 1.391	K 1.892	L 2.935	M 3.715	N 4.468	P 6.564	Q 11.365	R 16.475
10 *	1742	2251	3676	4653	5596	8221	14235	20635
15	2057	2798	4340	5494	6606	9706	16804	24360
20	2371	3225	5003	6335	7617	11190	19374	28085
25	2686	3653	5667	7175	8627	12674	21943	31809
30	3000	4081	6330	8015	9637	14158	24513	35534
35	3346	4551	7060	8939	10748	15790	27339	39631
40	3692	5022	7790	9863	11859	17422	30165	43729
45	4038	5492	8520	10787	12970	19055	32992	47826
50	4384	5963	9250	11711	14081	20687	35818	51923
55	4730	6433	9980	12636	15193	22320	38645	56020
60	5076	6904	10710	13560	16304	23952	41471	60117
65	5422	7374	11440	14484	17415	25585	44297	64215
70	5768	7845	12170	15408	18526	27217	47124	68312
75	6114	8316	12900	16332	19637	28849	49950	72409
80	6460	8786	13630	17256	20748	30482	52777	76506
85	6805	9257	14359	18180	21860	32114	55603	80604
90	7151	9727	15089	19105	22971	33747	58429	84701
95	7497	10198	15819	20029	24082	35379	61256	88798
100	7843	10668	16549	20953	25193	37012	64082	92895
105	8189	11139	17279	21877	26304	38644	66909	96992
110	8538	11609	18009	22801	27415	40276	69735	101090
115	8881	12080	18739	23725	28527	41909	72561	105187
120	9227	12550	19469	24649	29638	43541	75388	109284
125	9573	13021	20199	25574	30749	45174	78214	113381
130	9919	13491	20929	26498	31860	46806	81041	117479
135	10265	13962	21659	27422	32971	46438	83867	121576
140	10611	14432	22388	28346	34082	50071	86693	125673
145	10957	14903	23118	29270	35194	51703	89520	129770
150	11303	15373	23848	30194	36305	53336	92346	133868
155	11648	15844	24578	31118	37416	54968	95173	137965
160	11994	16314	25308	32043	38527	56601	97999	142062
165	12340	16785	26038	32967	39638	58233	100825	146159
170	12686	17256	26768	33891	40749	59865	103652	150256
175	13032	17726	27498	34815	41861	61498	106478	154354
180	13378	18197	28228	35739	42972	63130	109305	158451
185	13724	18667	28958	36663	44083	64763	112131	162548
190	14070	19138	29688	37587	45194	66395	114957	166645
195	14416	19608	30418	38512	46305	68028	117784	170743
200	14762	20079	31147	39436	47416	69660	120610	174840
205	15108	20549	31877	40360	48527	71292	123437	178937
210	15454	21020	32607	41284	49639	72925	126263	183034
215	15800	21490	33337	42208	50750	74557	129089	187131
220	16146	21961	34067	43132	51861	76190	131916	191229
225	16492	22431	34797	44057	52972	77822	134742	195326
230	16837	22902	35527	44981	54083	79455	137569	199423
235	17183	23372	36257	45905	55194	81087	140395	205320
240	17529	23843	36987	46829	56306	82719	143221	207618
245	17875	24313	37717	47753	57417	84352	146048	211715
250	18221	24784	38447	48677	58528	85984	148874	215812
1.0	69.2	94.0	146.0	184.8	222.2	326.4	565.2	819.4

* Pressure settings below 15 PSIG (1.034 barg) are non code.

KGS/HR

Set Pressure Barg	Orifice Area, cm² J 8.97	K 12.21	L 18.94	M 23.97	N 28.83	P 42.35	Q 73.32	R 106.29
0.4*	670	912	1414	1790	2153	3163	5477	7939
0.6*	753	1024	1589	2011	2419	3554	6153	8919
0.8*	836	1137	1763	2232	2685	3944	6829	9899
1*	918	1249	1938	2453	2950	4334	7504	10879
1.2	1001	1362	2113	2674	3216	4725	8180	11858
1.4	1084	1474	2287	2895	3482	5115	8856	12838
1.6	1167	1587	2462	3116	3747	5505	9532	13818
1.8	1249	1699	2636	3337	4013	5896	10208	14798
2	1332	1812	2811	3558	4279	6286	10884	15777
2.2	1420	1932	2997	3793	4562	6702	11604	16821
2.4	1511	2056	3189	4036	4854	7131	12347	17899
2.6	1602	2179	3381	4279	5146	7561	13091	18977
2.8	1693	2303	3573	4522	5439	7990	13834	20055
3	1784	2427	3765	4765	5731	8420	14578	21132
3.2	1875	2551	3957	5008	6023	8849	15321	22210
3.4	1966	2674	4149	5251	6316	9278	16065	23288
3.6	2057	2798	4341	5494	6608	9708	16808	24365
3.8	2148	2922	4533	5737	6900	10137	17552	25443
4	2239	3046	4725	5980	7192	10567	18295	26521
4.2	2330	3169	4917	6223	7485	10996	19038	27599
4.4	2421	3293	5109	6466	7777	11425	19782	28676
4.6	2512	3417	5301	6709	8069	11855	20525	29754
4.8	2603	3541	5493	6952	8362	12284	21269	30832
5	2694	3665	5685	7195	8654	12713	22012	31910
5.2	2785	3788	5877	7438	8946	13143	22756	32987
5.4	2876	3912	6069	7681	9238	13572	23499	34065
5.6	2967	4036	6261	7924	9531	14002	24243	35143
6	3149	4283	6645	8410	10115	14860	25730	37298
6.5	3377	4593	7125	9018	10846	15934	27588	39993
7	3604	4902	7605	9626	11577	17007	29447	42687
7.5	3832	5212	8085	10233	12307	18081	31305	45381
8	4059	5521	8565	10841	13038	19154	33164	48075
8.5	4287	5830	9045	11448	13769	20228	35023	50770
9	4514	6140	9525	12056	14499	21301	36881	53464
9.5	4742	6449	10005	12663	15230	22375	38740	56158
10	4969	6759	10485	13271	15961	23448	40599	58853
10.5	5196	7068	10965	13878	16691	24522	42457	61547
11	5424	7378	11445	14486	17422	25595	44316	64241
11.5	5651	7687	11925	15094	18153	26669	46174	66936
12	5879	7996	12404	15701	18884	27742	48033	69630
12.5	6106	8306	12884	16309	19614	28816	49892	72324
13	6334	8615	13364	16916	20345	29889	51750	75019
13.5	6561	8925	13844	17524	21076	30963	53609	77713
14	6789	9234	14324	18131	21806	32036	55468	80407
14.5	7016	9543	14804	18739	22537	33110	57326	83102
15	7244	9853	15284	19346	23268	34183	59185	85796
15.5	7471	10162	15764	19954	23998	35256	61044	88490
16	7699	10472	16244	20562	24729	36330	62902	91185
16.5	7926	10781	16724	21169	25460	37403	64761	93879
17	8154	11091	17204	21777	26191	38477	66619	96573
0.1	45.5	61.9	96	121.5	146.1	214.7	371.7	538.9

AIR CAPACITY CHART

CAST IRON MODELS 41A & 42A

ASME Section VIII "UV" 90% rated at 10% Overpressure SCFM (M^3/HR)
Flow Coefficient = .9 x .975 = .878

SCFM

Set Pressure PSIG	Orifice Area, in^2							
	J	K	L	M	N	P	Q	R
	1.391	1.892	2.935	3.715	4.468	6.564	11.365	16.475
10 *	620	843	1308	1656	1992	2926	5067	7345
15	732	996	1545	1956	2351	3455	5981	8671
20	844	1148	1781	2255	2711	3983	6896	9996
25	956	1300	2017	2554	3071	4511	7810	11322
30	1068	1453	2253	2853	3430	5039	8725	12648
35	1191	1620	2513	3182	3826	5620	9731	14106
40	1314	1787	2773	3511	4221	6201	10737	15565
45	1437	1955	3033	3840	4617	6782	11743	17023
50	1560	2122	3292	4169	5012	7363	12749	18482
55	1684	2290	3552	4498	5408	7945	13755	19940
60	1807	2457	3812	4826	5803	8526	14761	21398
65	1930	2625	4072	5155	6199	9107	15767	22857
70	2053	2792	4332	5484	6594	9688	16773	24315
75	2176	2960	4592	5813	6990	10269	17779	25773
80	2299	3127	4851	6142	7385	10850	18785	27232
85	2422	3295	5111	6471	7781	11431	19791	28690
90	2545	3462	5371	6800	8176	12012	20797	30149
95	2669	3630	5631	7129	8572	12593	21804	31607
100	2792	3797	5891	7458	8967	13174	22810	33065
105	2915	3965	6150	7787	9363	13755	23816	34524
110	3038	4132	6410	8116	9758	14336	24822	35982
115	3161	4300	6670	8445	10154	14917	25828	37440
120	3284	4467	6930	8774	10549	15498	26834	38899
125	3407	4635	7190	9103	10945	16079	27840	40357
130	3581	4802	7449	9432	11340	16660	28846	41816
135	3654	4970	7709	9761	11736	17241	29852	43274
140	3777	5137	7969	10090	12131	17822	30858	44732
145	3900	5305	8229	10418	12527	18403	31864	46191
150	4023	5472	8489	10747	12922	18984	32870	47649
155	4146	5640	8748	11076	13318	19565	33876	49107
160	4269	5807	9008	11405	13713	20147	34882	50566
165	4392	5974	9268	11734	14109	20728	35888	52024
170	4516	6142	9528	12063	14504	21309	36894	53483
175	4639	6309	9788	12392	14900	21890	37900	54941
180	4762	6477	10047	12721	15295	22471	38906	56399
185	4885	6644	10307	13050	15691	23052	39912	57858
190	5008	6812	10567	13379	16086	23633	40918	59316
195	5131	6979	10827	13708	16482	24214	41924	60774
200	5254	7147	11087	14037	16877	24795	42930	62233
205	5378	7314	11346	14366	17273	25376	43936	63691
210	5501	7482	11606	14695	17668	25957	44942	65150
215	5624	7649	11866	15024	18064	26538	45948	66608
220	5747	7817	12126	15353	18459	27119	46954	68066
225	5870	7984	12386	15682	18855	27700	47960	69525
230	5993	8152	12646	16010	19251	28281	48966	70983
235	6116	8319	12905	16339	19646	28862	49972	72441
240	6239	8487	13165	16668	20042	29443	50979	73900
245	6363	8654	13425	16997	20437	30024	51985	75358
250	6486	8822	13685	17326	20833	30605	52991	76817
1.0	24.6	33.6	52.0	65.8	79.2	116.2	201.2	291.8

* Pressure settings below 15 PSIG (1.034 barg) are non code.

M^3/HR

Set Pressure Barg	Orifice Area, cm^2							
	J	K	L	M	N	P	Q	R
	8.97	12.21	18.94	23.97	28.83	42.35	73.32	106.29
0.4*	894	1216	1886	2387	2871	4218	7303	10587
0.6*	1004	1366	2119	2682	3225	4739	8205	11893
0.8*	1114	1516	2352	2976	3580	5259	9106	13200
1*	1225	1666	2584	3271	3934	5780	10007	14506
1.2	1335	1816	2817	3566	4288	6300	10908	15813
1.4	1445	1966	3050	3860	4643	6821	11810	17119
1.6	1556	2116	3283	4155	4997	7341	12711	18426
1.8	1666	2266	3515	4450	5351	7862	13612	19732
2	1776	2416	3748	4744	5706	8382	14513	21039
2.2	1894	2576	3996	5058	6083	8937	15474	22431
2.4	2015	2741	4252	5382	6473	9510	16465	23868
2.6	2137	2906	4508	5706	6863	10082	17456	25305
2.8	2258	3071	4764	6030	7252	10655	18448	26742
3	2379	3236	5020	6354	7642	11227	19439	28179
3.2	2501	3401	5276	6678	8032	11800	20430	29617
3.4	2622	3566	5532	7002	8422	12372	21422	31054
3.6	2743	3731	5788	7326	8811	12945	22413	32491
3.8	2865	3896	6044	7651	9201	13518	23405	33928
4	2986	4061	6300	7975	9591	14090	24396	35365
4.2	3107	4226	6556	8299	9981	14663	25387	36802
4.4	3229	4391	6812	8623	10370	15235	26379	38239
4.6	3350	4556	7068	8947	10760	15808	27370	39676
4.8	3471	4722	7324	9271	11150	16381	28361	41114
5	3593	4887	7580	9595	11540	16953	29353	42551
5.2	3714	5052	7836	9919	11929	17526	30344	43988
5.4	3835	5217	8092	10243	12319	18098	31336	45425
5.6	3957	5382	8348	10567	12709	18671	32327	46862
6	4199	5712	8860	11215	13488	19816	34310	49736
6.5	4503	6124	9501	12025	14463	21247	36788	53329
7	4806	6537	10141	12836	15437	22679	39267	56922
7.5	5109	6950	10781	13646	16412	24110	41745	60515
8	5413	7362	11421	14456	17386	25542	44224	64108
8.5	5716	7775	12061	15266	18360	26973	46702	67700
9	6019	8187	12701	16076	19335	28405	49180	71293
9.5	6323	8600	13341	16886	20309	29836	51659	74886
10	6626	9013	13981	17696	21283	31268	54137	78479
10.5	6929	9425	14621	18507	22258	32699	56616	82072
11	7233	9838	15261	19317	23232	34131	59094	85665
11.5	7536	10250	15901	20127	24206	35562	61573	89257
12	7839	10663	16541	20937	25181	36994	64051	92850
12.5	8143	11076	17181	21747	26155	38425	66530	96443
13	8446	11488	17821	22557	27130	39856	69008	100036
13.5	8749	11901	18461	23368	28104	41288	71486	103629
14	9053	12313	19101	24178	29078	42719	73965	107221
14.5	9356	12726	19741	24988	30053	44151	76443	110814
15	9659	13139	20381	25798	31027	45582	78922	114407
15.5	9963	13551	21022	26608	32001	47014	81400	118000
16	10266	13964	21662	27418	32976	48445	83879	121593
16.5	10570	14376	22302	28228	33950	49877	86357	125186
17	10873	14789	22942	29039	34925	51308	88836	128778
0.1	60.7	82.5	128	162	194.9	286.3	495.7	718.6

FIGURE 800 SAFETY RELIEF VALVE

FIGURE 800 SERIES

SIZES ½" – 1½"
PRESSURES to 900 PSIG at 422°F

- **Meets ASME VIII Code for Liquid, Steam, Air & Gas Service**
- **"UV" National Board Certified**
- **Short Blowdown**
- **No Ring Adjustments Required**
- **Unitized Bonnet Design**
- **All SS Internals/SS Springs**
- **Pivoting Disc Design**
- **Full Nozzle**
- **Soft Seat Design Available**
- **Wide Variety of Options**

Application Data

- Liquid Filled Pressure Vessels & Systems
- Steam/air/gas Pressure Vessels & Systems
- Low temperature cryogenic systems
- Pumps, Tanks & Hydraulic Systems
- Pressure Reducing Stations
- Vacuum Systems
- OEM Equipment

Applicable Codes

- ASME Section VIII "UV" for Liquid/Steam/Air/Gas
- API 527
- Canadian Registration # 0G0591.9C
- PED (Consult Factory)

Options

- Screwed, Plain & Packed Caps
- BSP Connections
- Vacuum Service (Non-code)
- EPDM, Viton & TFE/25% Glass Soft Seats
- Low Temperature Cryogenic Service Trim*
- Test Reports Available

Models

- 810 - Bronze Bonnet & Base, SS Disc
- 812 - EPDM Seat on 810
- 814 - Viton Seat on 810
- 816 - TFE/25% Glass Seat on 810
- 820 - Bronze Bonnet, SS Base & Disc
- 822 - EPDM Seat on 820
- 824 - Viton Seat on 820
- 826 - TFE/25% Glass Seat on 820
- 860 - 316 SS Bonnet, Base & Disc
- 862 - EPDM Seat on 860
- 864 - Viton Seat on 860
- 866 - TFE/25% Glass Seat on 860

VALVE RATINGS *See Capacity Charts beginning on page 28*

Model	Temperature* °F (°C)	Pressure PSIG (bar)		
		D,E Orifices	F,G Orifices	H Orifice
810/812	-20-406 (-28.9-207.8)	5-250 (0.34-17.24)		
814/816	-20-400 (-28.9-204.4)			
820[1]	-20-422 (-28.9-216.7)	5-900 (0.34-62.06)	5-600 (0.34-41.37)	5-500 (0.34-34.48)
822[1]/824[2]/826[2]	-20-400 (-28.9-204.4)			
860	-20-800 (-28.9-427)			
862/864/866	-20-400 (-28.9-204.4)			

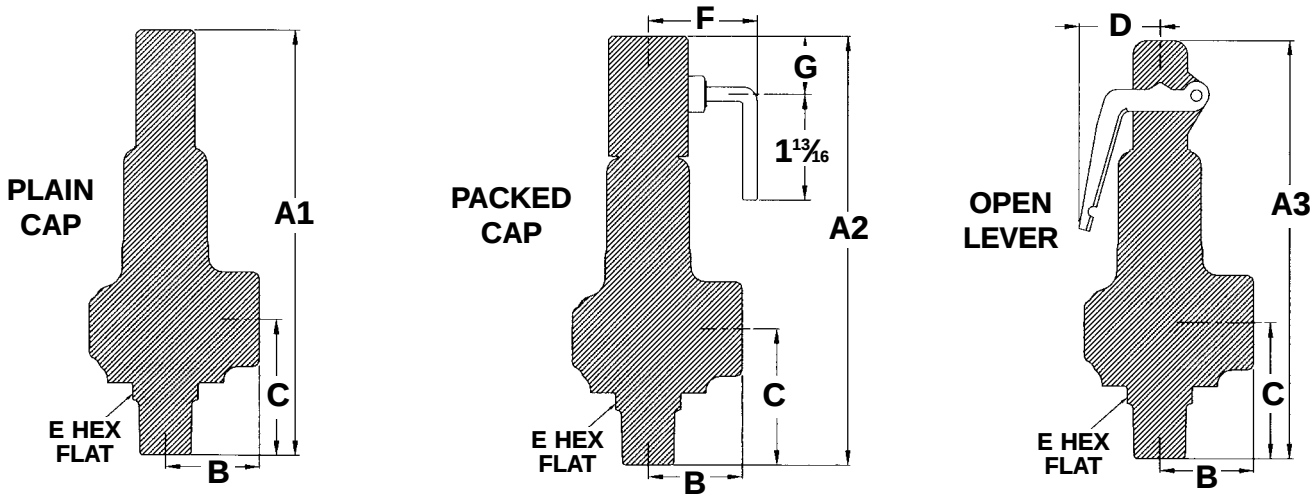
Maximum Backpressure (Plain/Packed Cap) - 50 PSIG (3.45 barg)
Vacuum Pressure Range - 10 to 30" HG (3.38.64 to 1015.92 mbarg)

[1] Maximum pressure for steam is 300 PSIG (20.67 barg).
[2] Maximum pressure for steam is 250 PSIG (17.4 barg).

FIGURE 800 SERIES

SPECIFICATION

The valve shall meet the ASME Section VIII code for liquid, steam, air and gas services. It shall be "UV" National Board Certified. It shall have non-adjustable blowdown that shall be less than 10% for steam, air or gas and less than 20% for liquid. The valve shall consist of a unitized bonnet design guaranteeing proper guiding and making the valve extremely dependable in terms of pop action, seat tightness and repeatability. The disc shall have a pivoting design which optimizes the seating performance. The valve shall have a full nozzle for optimum flow performance. Internal trim (excepting the base) shall be stainless steel. The valve shall meet the API 527 leakage standard requiring bubble tight shutoff up to 90% of set pressure.



DIMENSIONS* inches (mm) **AND WEIGHTS** pounds (kg)

Model	Inlet	Orifice	Outlet	A1	A2	A3	B	C	D(1)	E	F	G	Weight
8**+DCA	½ (15)	D	1 (25)	7⅜ (18.73)	7⅜ (18.73)	7⅛ (18.10)	1⅜ (3.49)	2¼ (5.72)	1 13/32 (3.57)	1⅛ (2.86)	1 15/16 (4.92)	½ (1.27)	2.50 (1.13)
8**+EDA	¾ (20)	E	1¼ (32)	8⅞ (22.54)	8⅞ (22.54)	8¾ (22.23)	1⅝ (4.13)	2 5/16 (5.87)	1 13/32 (3.57)	1¼ (3.18)	1 15/16 (4.92)	1 1/16 (2.70)	4.50 (2.04)
8**+FEA	1 (25)	F	1½ (40)	9⅞ (25.08)	9⅞ (25.08)	9¾ (24.77)	1⅞ (4.76)	2 13/16 (7.14)	2¼ (5.72)	1½ (3.81)	1 15/16 (4.92)	1 1/16 (2.70)	7.00 (3.18)
8**+GFA	1¼ (32)	G	2 (50)	12 (30.48)	12 (30.48)	11⅞ (30.16)	2⅛ (5.40)	3 (7.62)	2¼ (5.72)	1⅞ (4.76)	2⅛ (5.40)	1¾ (4.45)	11.50 (5.22)
8**+HGA	1½ (40)	H	2½ (65)	13⅜ (33.97)	13⅜ (33.97)	13¼ (33.66)	2 9/16 (6.51)	3½ (8.89)	3 (7.62)	2½ (6.35)	2⅛ (5.40)	1¾ (4.45)	17.00 (7.71)

*Accurate to ±1/8". **Use appropriate model number. (1) Add 50% to D Dimension when lever is pulled out to manually operate valve.
+Use appropriate Cap Letter

CODE SELECTION CHART

Model			Cap	Orifice	Inlet Size	Connections	Service		Set Pressure		
8	1	0	N	D	C	A	- A		0	2	5
1	2	3	4	5	6	7	8		9	10	11

Model -
Position 1, 2 & 3
- 810 = Bronze Bonnet & Base, SS Disc
- 812 = EPDM Seat on 810
- 814 = Viton Seat on 810
- 816 = TFE/25% Glass Seat on 810
- 820 = Bronze Bonnet, SS Base & Disc
- 822 = EPDM Seat on 820
- 824 = Viton Seat on 820
- 826 = TFE/25% Glass Seat on 820
- 860 = 316 SS Bonnet, Base & Disc
- 862 = EPDM Seat on 860
- 864 = Viton Seat on 860
- 866 = Teflon Seat on 860

Cap -
Position 4
- N = Plain Cap
- E = Open Lever
- P = Packed Cap

Orifice -
Position 5
- D
- E
- F
- G
- H

Inlet Size -
Position 6
- C = ½
- D = ¾
- E = 1
- F = 1¼
- G = 1½

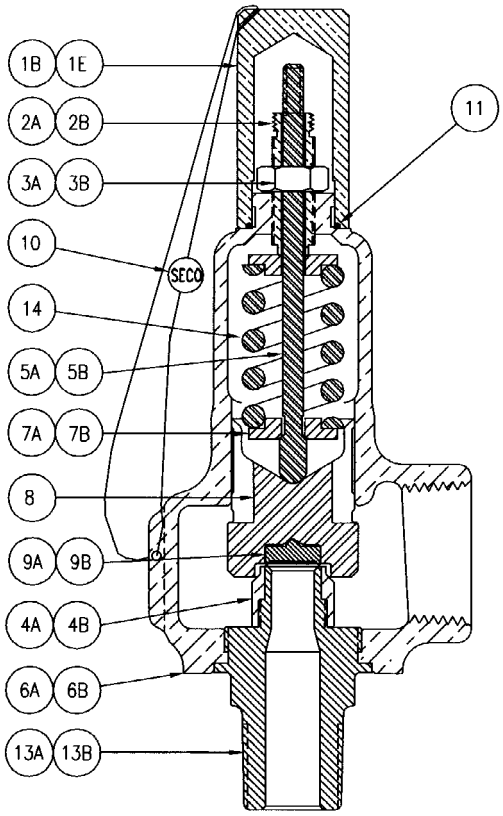
Connections -
Position 7
- A = MPT x FTP
- F = MBSP x FBSP
- Z = Other

Service -
Position 8
- A = Air/Gas Sect. VIII
- M = Steam Non-code
- N = Air/Gas Non-code
- P = Liquid Non-code
- T = Steam Sect. VIII
- V = Vacuum
- W = Liquid Sect. VIII
- G = *Loosely Assembled Gas*†
- X = *Loosely Assembled Liquid*†
- Z = Other

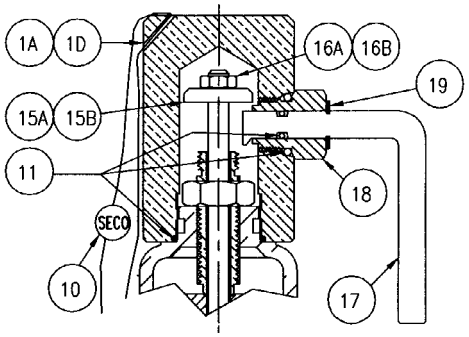
Set Pressure -
Position 9, 10 & 11
__ __ __ = Actual Setting
LAS - Loosely Assembled†

† Spence Certified Assemblers Only

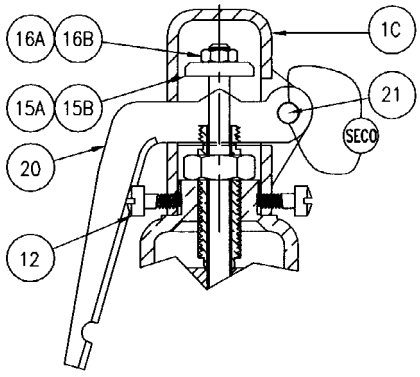
FIGURE 800 SERIES



PLAIN CAP VALVE



PACKED CAP OPTION



OPEN LEVER OPTION

MATERIALS OF CONSTRUCTION

Ref	Part Name	Material
1A	Cap - Packed	Brass ASTM B16
1B	Cap - Plain	Brass ASTM B16
1C	Cap - Open Lever	Zinc Alloy
1D	Cap - Packed (860 Series)	316 SST ASTM A276
1E	Cap - Plain (860 Series)	316 SST ASTM A276
2A	Adjusting Bolt	Brass ASTM B16
2B	Adjusting Bolt (860 Series)	316 SST ASTM A276
3A	Adjusting Bolt Locknut	303 SST ASTM A582
3B	Adjusting Bolt Locknut (860 Series)	316 SST ASTM A276
4A	Base Ring (Liquid Only)	Brass ASTM B16
4B	Base Ring (Liquid Only - Series 860)	316 SST ASTM A276
5A	Spindle	304 SST ASTM A479
5B	Spindle (860 Series)	316 SST ASTM A276
6A	Bonnet	Bronze ASME SB62
6B	Bonnet	316 SST ASTM A351 CF8M
7A	Spring Washer	303 SST ASTM A582
7B	Spring Washer (860 Series)	316 SST ASTM A276
8	Disc Holder - Metal/Soft[1]	316 SST ASTM A351 CF8M
9A	Disc - Metal	316 SST ASTM A276
9B	Disc Assembly - Soft	316SST - EPDM/Viton/TFE
10	Seal and Wire	Lead and SST
11	O-rings, various[3]	Buna-N/TFE
12	Lock Screw	Plated Steel
13A	Base[2]	Brass/Brz, ASTM B283/ASME SB62
13B	Base[2] (820 & 860 Series)	316 SST ASTM A276
14	Spring	316 SST or 302 SST or 17-7 SST
15A	Spindle Nut	Steel
15B	Spindle Nut (860 Series)	316 SST ASTM A276
16A	Spindle Nut Locknut	Plated Steel
16B	Spindle Nut Locknut (860 Series)	316 SST ASTM A582
17	Lifting Lever Packed Cap	316 SST ASTM A276
18	Packed Cap Plug	316 SST ASTM A276
19	Cap Snap Ring	SST AMS 5813, S15700
20	Lifting Lever Open Cap	Plated Steel
21	Lifting Cap Pin Open Lever	Steel
22	Nameplate (Not Shown)	SST
23	Drive Screw (Not Shown)	SST

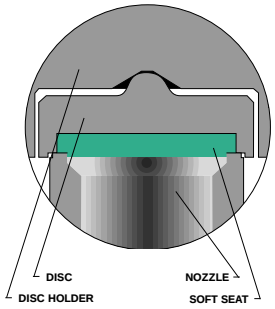
(1) ½, ¾ & 1 (15, 20, 25 mm) Metal and Soft Seat disc holders are different. 1¼ & 1½ (32 & 40mm) disc holders are identical.

(2) ½ & ¾ (15, 20 mm) Gas and Liquid bases are identical. 1, 1¼ & 1½ (25, 32 & 40 mm) Liquid Bases differ from Gas bases.

(3) TFE cap o-ring for models 816, 826, 866.

FIGURE 800 SERIES SOFT SEATS

Safety Valves with metal seats will start to leak at 90% of set pressure. A Spence Safety Valve equipped with a soft seat seals on both the metal and soft seats (see illustration). As a result, it will not begin to leak until system pressure reaches 95% of set pressure, minimizing system energy loss.



The o-rings in standard soft seat safety valves tend to blow out during discharge. Spence Soft Seat Safety Valves utilize a flat soft seat insert in the disc assembly of the valve that stays in place during operation, thus providing hassle-free operation.

There are many troublesome applications where using a Spence Soft Seat Safety Valve can reduce costly downtime and repair costs. Consider a Spence Soft Seat Safety Valve for:

- Operating very close to set pressure
- Heavy vibration
- Hard-to-hold fluids
- Occasional foreign particles
- Icing problems
- Pipe strain due to excessive discharge

SERVICE RECOMMENDATIONS*

EPDM Soft Seat

WET - -20 to 422°F (-29 to 216°C)
DRY - -20 to 250°F (-29 to121°C)

Acetone
Acetylene Gas
Beer
Bleach Liquor
Brake Fluid
Calcium Chloride
Carbon Monoxide
Carbonic Acid
Citric Acid
Denatured Alcohol
Ethylene Diamine
Freon 22
Hydrazine
Lindol Hydraulic Fluid
Lye
Methanol
Methyl Alcohol
Methyl Butyl Ketone
Nitrogen
STEAM
Sulfur Hexafluoride
WATER

Viton Soft Seat

-20 to 400°F (-29 to 204°C)

AIR
Benzoic Acid
Benzul Alcohol
Butane
Butyl Alcohol
Carbon Disulfide
Carbon Tetrachloride
Castor Oil
Chlorine
Chromic Acid
Corn Oil
Crude Oil
Diesel Oil
Dowtherm A
Ethane
Ethyl Alcohol
Ethyl Chloride
Ethylene
Ethylene Glycol
Fuel Oil
Gasoline
Glucose
Glycerin
Helium
Hydraulic Oil
Hydrogen Gas
Iodine
Kerosene
Linseed Oil
Methane
Mineral Oils
Natural Gas
Petroleum Oil
Propane
Propyl Alcohol
Propylene
Sulfur Dioxide
Turpentine

TFE/25% Glass Soft Seat

-400 to 400°F (-240 to 204°C)

Helium
Hydrogen
Nitrogen

*These recommendations should be used as a guide only. It is the sole responsibility of the user to select suitable materials.

SATURATED STEAM CAPACITY CHART
MODEL 800
ASME Section VIII "UV" 90% rated at 10% Overpressure LBS/HR (KGS/HR)
Flow Coefficient = .9 x .975 = .878

LBS/HR

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479
5 *	122	217	341	557	870
10 *	149	265	416	679	1062
15	176	313	491	802	1254
20	203	361	566	925	1445
25	229	409	641	1047	1637
30	256	456	716	1170	1829
35	286	509	798	1305	2040
40	315	562	881	1440	2251
45	345	614	963	1575	2461
50	374	667	1046	1709	2672
55	404	720	1128	1844	2883
60	434	772	1211	1979	3094
65	463	825	1293	2114	3305
70	493	877	1376	2249	3516
75	522	930	1458	2384	3727
80	552	983	1541	2519	3937
85	581	1035	1623	2654	4148
90	611	1088	1706	2789	4359
95	640	1140	1788	2923	4570
100	670	1193	1871	3058	4781
105	699	1246	1953	3193	4992
110	729	1298	2036	3328	5203
115	758	1351	2118	3463	5414
120	788	1404	2201	3598	5624
125	818	1456	2283	3733	5835
130	847	1509	2366	3868	6046
135	877	1561	2448	4003	6257
140	906	1614	2531	4137	6468
145	936	1667	2614	4272	6679
150	965	1719	2696	4407	6890
155	995	1772	2779	4542	7100
160	1024	1825	2861	4677	7311
165	1054	1877	2944	4812	7522
170	1083	1930	3026	4947	7733
175	1113	1982	3109	5082	7944
180	1143	2035	3191	5217	8155
185	1172	2088	3274	5352	8366
190	1202	2140	3356	5486	8577
195	1231	2193	3439	5621	8787
200	1261	2246	3521	5756	8998
205	1290	2298	3604	5891	9209
210	1320	2351	3686	6026	9420
215	1349	2403	3769	6161	9631
220	1379	2456	3851	6296	9842
225	1408	2509	3934	6431	10053
230	1438	2561	4016	6566	10263
235	1468	2614	4099	6700	10474
240	1497	2667	4181	6835	10685
245	1527	2719	4264	6970	10896
250	1556	2772	4346	7105	11107
255	1586	2824	4429	7240	11318
260	1615	2877	4511	7375	11529
265	1645	2930	4594	7510	11740
270	1674	2982	4676	7645	11950
275	1704	3035	4759	7780	12161
280	1733	3088	4841	7914	12372
285	1763	3140	4924	8049	12583
290	1793	3193	5007	8184	12794
295	1822	3245	5089	8319	13005
300	1852	3298	5172	8454	13216
1.0	6.0	10.5	16.5	27.0	42.2

KGS/HR

Set Pressure Barg	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47
0.4*	57	102	160	261	409
0.6*	64	115	180	294	459
0.8*	71	127	199	326	509
1*	78	140	219	358	560
1.2	86	152	239	390	610
1.4	93	165	259	423	661
1.6	100	177	278	455	711
1.8	107	190	298	487	762
2	114	203	318	519	812
2.2	121	216	339	554	866
2.4	129	230	360	589	921
2.6	137	244	382	625	977
2.8	145	258	404	660	1032
3	152	271	426	696	1088
3.2	160	285	447	731	1143
3.4	168	299	469	767	1199
3.6	176	313	491	802	1254
3.8	183	327	512	838	1309
4	191	341	534	873	1365
4.2	199	354	556	909	1420
4.4	207	368	578	944	1476
4.6	215	382	599	980	1531
4.8	222	396	621	1015	1587
5	230	410	643	1051	1642
5.2	238	424	664	1086	1698
5.4	246	438	686	1122	1753
5.6	253	451	708	1157	1809
5.8	261	465	729	1192	1864
6	269	479	751	1228	1920
6.2	277	493	773	1263	1975
6.4	284	507	795	1299	2031
6.6	292	521	816	1334	2086
7	308	548	860	1405	2197
7.5	327	583	914	1494	2336
8	347	617	968	1583	2474
8.5	366	652	1022	1671	2613
9	386	687	1077	1760	2752
9.5	405	721	1131	1849	2890
10	424	756	1185	1938	3029
10.5	444	790	1240	2026	3168
11	463	825	1294	2115	3306
11.5	483	860	1348	2204	3445
12	502	894	1402	2292	3584
12.5	522	929	1457	2381	3722
13	541	964	1511	2470	3861
13.5	560	998	1565	2559	4000
14	580	1033	1619	2647	4138
14.5	599	1067	1674	2736	4277
15	619	1102	1728	2825	4416
15.5	638	1137	1782	2913	4554
16	658	1171	1836	3002	4693
16.5	677	1206	1891	3091	4832
17	696	1240	1945	3179	4970
17.5	716	1275	1999	3268	5109
18	735	1310	2053	3357	5248
18.5	755	1344	2108	3446	5386
19	774	1379	2162	3534	5525
19.5	794	1413	2216	3623	5664
20	813	1448	2271	3712	5802
20.5	832	1483	2325	3800	5941
0.1	3.9	6.9	10.9	17.7	27.7

* Pressure settings below 15 PSIG (1.034 barg) are non code.

AIR CAPACITY CHART – MODEL 800

ASME Section VIII "UV"
90% rated at 10% Overpressure SCFM at 60°F **
Flow Coefficient = .9 x .975 = .878

SCFM

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479
5 *	43	77	121	198	310
10 *	53	94	148	242	378
15	63	111	175	285	446
20	72	128	201	329	514
25	82	145	228	373	583
30	91	162	255	416	651
35	102	181	284	464	726
40	112	200	313	512	801
45	123	219	343	560	876
50	133	237	372	608	951
55	144	256	402	656	1026
60	154	275	431	704	1101
65	165	294	460	753	1176
70	175	312	490	801	1251
75	186	331	519	849	1326
80	196	350	548	897	1402
85	207	368	578	945	1477
90	217	387	607	993	1552
95	228	406	637	1041	1627
100	238	425	666	1089	1702
105	249	443	695	1137	1777
110	259	462	725	1185	1852
115	270	481	754	1233	1927
120	280	500	783	1281	2002
125	291	518	813	1329	2077
130	302	537	842	1377	2152
135	312	556	872	1425	2227
140	323	575	901	1473	2302
145	333	593	930	1521	2377
150	344	612	960	1569	2452
155	354	631	989	1617	2527
160	365	649	1018	1665	2602
165	375	668	1048	1713	2677
170	386	687	1077	1761	2753
175	396	706	1106	1809	2828
180	407	724	1136	1857	2903
185	417	743	1165	1905	2978
190	428	762	1195	1953	3053
195	438	781	1224	2001	3128
200	449	799	1253	2049	3203
205	459	818	1283	2097	3278
210	470	837	1312	2145	3353
215	480	855	1341	2193	3428
220	491	874	1371	2241	3503
225	501	893	1400	2289	3578
230	512	912	1430	2337	3653
235	522	930	1459	2385	3728
240	533	949	1488	2433	3803
245	543	968	1518	2481	3878
250	554	987	1547	2529	3953
255	564	1005	1576	2577	4028
260	575	1024	1606	2625	4104
265	585	1043	1635	2673	4179
270	596	1062	1665	2721	4254
275	606	1080	1694	2769	4329
280	617	1099	1723	2817	4404
285	628	1118	1753	2865	4479
290	638	1136	1782	2913	4554
295	649	1155	1811	2961	4629
300	659	1174	1841	3009	4704
1.0	2.2	3.6	6.0	9.6	15.0

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479
305	670	1099	1723	2817	4404
310	680	1116	1750	2861	4472
315	691	1133	1777	2904	4540
320	701	1249	1958	3201	5004
325	712	1268	1988	3249	5079
330	722	1286	2017	3297	5154
335	733	1305	2046	3345	5229
340	743	1324	2076	3393	5304
345	754	1342	2105	3441	5380
350	764	1361	2134	3489	5455
355	775	1380	2164	3537	5530
360	785	1399	2193	3585	5605
365	796	1417	2223	3633	5680
370	806	1436	2252	3681	5755
375	817	1455	2281	3729	5830
380	827	1474	2311	3777	5905
385	838	1492	2340	3825	5980
390	848	1511	2369	3873	6055
395	859	1530	2399	3921	6130
400	869	1549	2428	3969	6205
405	880	1567	2458	4017	6280
410	890	1586	2487	4065	6355
415	901	1605	2516	4113	6430
420	911	1623	2546	4161	6505
425	922	1642	2575	4209	6580
430	933	1661	2604	4257	6655
435	943	1680	2634	4305	6731
440	954	1698	2663	4354	6806
445	964	1717	2693	4402	6881
450	975	1736	2722	4450	6956
455	985	1755	2751	4498	7031
460	996	1773	2781	4546	7106
465	1006	1792	2810	4594	7181
470	1017	1811	2839	4642	7256
475	1027	1829	2869	4690	7331
480	1038	1848	2898	4738	7406
485	1048	1867	2927	4786	7481
490	1059	1886	2957	4834	7556
495	1069	1904	2986	4882	7631
500	1080	1923	3016	4930	7706
505	1090	1942	3045	4978	-
510	1101	1961	3074	5026	-
515	1111	1979	3104	5074	-
520	1122	1998	3133	5122	-
525	1132	2017	3162	5170	-
530	1143	2036	3192	5218	-
535	1153	2054	3221	5266	-
540	1164	2073	3251	5314	-
545	1174	2092	3280	5362	-
550	1185	2110	3309	5410	-
555	1195	2129	3339	5458	-
560	1206	2148	3368	5506	-
565	1216	2167	3397	5554	-
570	1227	2185	3427	5602	-
575	1237	2204	3456	5650	-
580	1248	2223	3486	5698	-
585	1259	2242	3515	5746	-
590	1269	2260	3544	5794	-
595	1280	2279	3574	5842	-
600	1290	2298	3603	5890	-
1.0	2.2	3.6	6.0	9.6	15.0

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116
605	1301	2121
610	1311	2138
615	1322	2155
620	1332	2373
625	1343	2391
630	1353	2410
635	1364	2429
640	1374	2448
645	1385	2466
650	1395	2485
655	1406	2504
660	1416	2523
665	1427	2541
670	1437	2560
675	1448	2579
680	1458	2597
685	1469	2616
690	1479	2635
695	1490	2654
700	1500	2672
705	1511	2691
710	1521	2710
715	1532	2729
720	1542	2747
725	1553	2766
730	1563	2785
735	1574	2804
740	1585	2822
745	1595	2841
750	1606	2860
755	1616	2878
760	1627	2897
765	1637	2916
770	1648	2935
775	1658	2953
780	1669	2972
785	1679	2991
790	1690	3010
795	1700	3028
800	1711	3047
805	1721	3066
810	1732	3084
815	1742	3103
820	1753	3122
825	1763	3141
830	1774	3159
835	1784	3178
840	1795	3197
845	1805	3216
850	1816	3234
855	1826	3253
860	1837	3272
865	1847	3291
870	1858	3309
875	1868	3328
880	1879	3347
885	1889	3365
890	1900	3384
895	1911	3403
900	1921	3422
1.0	2.2	3.6

* Pressure settings below 15 PSIG (1.034 barg) are non code.

**For other temperatures, please use temperature correction factor.

AIR CAPACITY CHART – MODEL 800 – CONT'D.

ASME Section VIII "UV"

90% rated at 10% Overpressure NM³/HR at 15.68°C**

Flow Coefficient = .9 x .975 = .878

NM³/HR

Set Pressure Barg	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47
0.4*	76	136	213	349	545
0.6*	86	153	240	392	612
0.8*	95	170	266	435	679
1*	105	186	292	478	747
1.2	114	203	318	521	814
1.4	123	220	345	564	881
1.6	133	237	371	607	948
1.8	142	253	397	650	1016
2	152	270	424	693	1083
2.2	162	288	452	738	1154
2.4	172	307	481	786	1228
2.6	182	325	510	833	1302
2.8	193	343	539	880	1376
3	203	362	568	928	1450
3.2	214	380	596	975	1524
3.4	224	399	625	1022	1598
3.6	234	417	654	1070	1672
3.8	245	436	683	1117	1746
4	255	454	712	1164	1820
4.2	265	473	741	1212	1894
4.4	276	491	770	1259	1968
4.6	286	510	799	1306	2042
4.8	296	528	828	1354	2116
5	307	547	857	1401	2190
5.2	317	565	886	1448	2264
5.4	328	583	915	1496	2338
5.6	338	602	944	1543	2412
5.8	348	620	973	1590	2486
6	359	639	1002	1637	2560
6.2	369	657	1031	1685	2634
6.4	379	676	1060	1732	2708
6.6	390	694	1088	1779	2782
6.8	400	713	1117	1827	2856
7	410	731	1146	1874	2930
7.2	421	750	1175	1921	3004
7.4	431	768	1204	1969	3077
7.6	442	786	1233	2016	3151
7.8	452	805	1262	2063	3225
8	462	823	1291	2111	3299
8.2	473	842	1320	2158	3373
8.4	483	860	1349	2205	3447
8.6	493	879	1378	2253	3521
8.8	504	897	1407	2300	3595
9	514	916	1436	2347	3669
9.2	524	934	1465	2394	3743
9.4	535	953	1494	2442	3817
9.6	545	971	1523	2489	3891
9.8	556	990	1552	2536	3965
10	566	1008	1581	2584	4039
10.2	576	1026	1609	2631	4113
10.4	587	1045	1638	2678	4187
10.6	597	1063	1667	2726	4261
10.8	607	1082	1696	2773	4335
11	618	1100	1725	2820	4409
11.2	628	1119	1754	2868	4483
11.4	638	1137	1783	2915	4557
11.6	649	1156	1812	2962	4631
11.8	659	1174	1841	3010	4705
12	670	1193	1870	3057	4779
12.2	680	1211	1899	3104	4853
0.1	5.2	9.2	14.6	23.6	37

Set Pressure Barg	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47
12.4	690	1229	1928	3151	4927
12.6	701	1248	1957	3199	5001
12.8	711	1266	1986	3246	5074
13	721	1285	2015	3293	5148
13.5	747	1331	2087	3412	5333
14	773	1377	2159	3530	5518
14.5	799	1423	2232	3648	5703
15	825	1469	2304	3767	5888
15.5	851	1516	2376	3885	6073
16	877	1562	2449	4003	6258
16.5	903	1608	2521	4121	6443
17	929	1654	2594	4240	6628
17.5	955	1700	2666	4358	6813
18	980	1746	2738	4476	6998
18.5	1006	1792	2811	4595	7182
19	1032	1839	2883	4713	7367
19.5	1058	1885	2955	4831	7552
20	1084	1931	3028	4949	7737
20.5	1110	1977	3100	5068	7922
21	1136	2023	3172	5186	8107
21.5	1162	2069	3245	5304	8292
22	1188	2115	3317	5423	8477
22.5	1214	2162	3389	5541	8662
23	1240	2208	3462	5659	8847
23.5	1265	2254	3534	5777	9031
24	1291	2300	3607	5896	9216
24.5	1317	2346	3679	6014	9401
25	1343	2392	3751	6132	9586
25.5	1369	2438	3824	6251	9771
26	1395	2485	3896	6369	9956
26.5	1421	2531	3968	6487	10141
27	1447	2577	4041	6605	10326
27.5	1473	2623	4113	6724	10511
28	1499	2669	4185	6842	10696
28.5	1524	2715	4258	6960	10881
29	1550	2761	4330	7079	11065
29.5	1576	2808	4402	7197	11250
30	1602	2854	4475	7315	11435
30.5	1628	2900	4547	7433	11620
31	1654	2946	4620	7552	11805
31.5	1680	2992	4692	7670	11990
32	1706	3038	4764	7788	12175
32.5	1732	3084	4837	7907	12360
33	1758	3131	4909	8025	12545
33.5	1784	3177	4981	8143	12730
34	1809	3223	5054	8261	12915
34.5	1835	3269	5126	8380	13099
35	1861	3315	5198	8498	—
35.5	1887	3361	5271	8616	—
36	1913	3408	5343	8735	—
36.5	1939	3454	5416	8853	—
37	1965	3500	5488	8971	—
37.5	1991	3546	5560	9089	—
38	2017	3592	5633	9208	—
38.5	2043	3638	5705	9326	—
39	2069	3684	5777	9444	—
39.5	2094	3731	5850	9563	—
40	2120	3777	5922	9681	—
40.5	2146	3823	5994	9799	—
41	2172	3869	6067	9917	—
0.1	5.2	9.2	14.6	23.6	37

Set Pressure Barg	Orifice Area cm² D .766	E 1.365
41.5	2198	3915
42	2224	3961
42.5	2250	4007
43	2276	4054
43.5	2302	4100
44	2328	4146
44.5	2354	4192
45	2379	4238
45.5	2405	4284
46	2431	4330
46.5	2457	4377
47	2483	4423
47.5	2509	4469
48	2535	4515
48.5	2561	4561
49	2587	4607
49.5	2613	4653
50	2639	4700
50.5	2664	4746
51	2690	4792
51.5	2716	4838
52	2742	4884
52.5	2768	4930
53	2794	4976
53.5	2820	5023
54	2846	5069
54.5	2872	5115
55	2898	5161
55.5	2923	5207
56	2949	5253
56.5	2975	5299
57	3001	5346
57.5	3027	5392
58	3053	5438
58.5	3079	5484
59	3105	5530
59.5	3131	5576
60	3157	5622
60.5	3183	5669
61	3208	5715
61.5	3234	5761
62	3260	5807
0.1	5.2	9.2

* Pressure settings below 15 PSIG (1.034 barg) are non code.

**For other temperatures, please use temperature correction factor.

WATER CAPACITY CHART – MODEL 800

ASME Section VIII "UV"
90% rated at 10% Overpressure GPM at 60°F**
Flow Coefficient = .9 x .836 = .752

GPM

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479
5 *	9.6	17.1	26.8	43.9	68.6
10 *	12.3	21.8	34.2	55.9	87.4
15	14.4	25.7	40.3	65.8	102.9
20	16.3	29.0	45.5	74.4	116.3
25	18.0	32.0	50.2	82.1	128.3
30	19.5	34.8	54.5	89.1	139.3
35	21.1	37.6	58.9	96.3	150.5
40	22.5	40.1	63.0	102.9	160.9
45	23.9	42.6	66.8	109.2	170.6
50	25.2	44.9	70.4	115.1	179.9
55	26.4	47.1	73.8	120.7	188.7
60	27.6	49.2	77.1	126.0	197.0
65	28.7	51.2	80.3	131.2	205.1
70	29.8	53.1	83.3	136.1	212.8
75	30.9	55.0	86.2	140.9	220.3
80	31.9	56.8	89.0	145.5	227.5
85	32.9	58.5	91.8	150.0	234.5
90	33.8	60.2	94.4	154.4	241.3
95	34.7	61.9	97.0	158.6	247.9
100	35.6	63.5	99.5	162.7	254.4
105	36.5	65.1	102.0	166.7	260.7
110	37.4	66.6	104.4	170.7	266.8
115	38.2	68.1	106.7	174.5	272.8
120	39.0	69.5	109.0	178.3	278.7
125	39.8	71.0	111.3	181.9	284.4
130	40.6	72.4	113.5	185.5	290.0
135	41.4	73.8	115.7	189.1	295.6
140	42.2	75.1	117.8	192.5	301.0
145	42.9	76.4	119.9	195.9	306.3
150	43.7	77.7	121.9	199.3	311.6
155	44.4	79.0	123.9	202.6	316.7
160	45.1	80.3	125.9	205.8	321.8
165	45.8	81.5	127.9	209.0	326.8
170	46.5	82.8	129.8	212.2	331.7
175	47.1	84.0	131.7	215.3	336.5
180	47.8	85.2	133.6	218.3	341.3
185	48.5	86.3	135.4	221.3	346.0
190	49.1	87.5	137.2	224.3	350.6
195	49.8	88.6	139.0	227.2	355.2
200	50.4	89.8	140.8	230.1	359.7
205	51.0	90.9	142.5	233.0	364.2
210	51.6	92.0	144.3	235.8	368.6
215	52.3	93.1	146.0	238.6	373.0
220	52.9	94.2	147.6	241.4	377.3
225	53.5	95.2	149.3	244.1	381.6
230	54.1	96.3	151.0	246.8	385.8
235	54.6	97.3	152.6	249.5	390.0
240	55.2	98.3	154.2	252.1	394.1
245	55.8	99.4	155.8	254.7	398.2
250	56.4	100.4	157.4	257.3	402.2
255	56.9	101.4	159.0	259.9	406.2
260	57.5	102.4	160.5	262.4	410.2
265	58.0	103.3	162.0	264.9	414.1
270	58.6	104.3	163.6	267.4	418.0
275	59.1	105.3	165.1	269.9	421.8
280	59.6	106.2	166.6	272.3	425.7
285	60.2	107.2	168.0	274.7	429.4
290	60.7	108.1	169.5	277.1	433.2
295	61.2	109.0	171.0	279.5	436.9
300	61.7	110.0	172.4	281.9	440.6
1.0	0.10	0.20	0.28	0.48	0.74

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479
305	62.2	110.9	173.8	284.2	444.3
310	62.8	111.8	175.3	286.5	447.9
315	63.3	112.7	176.7	288.8	451.5
320	63.8	113.6	178.1	291.1	455.0
325	64.3	114.4	179.5	293.4	458.6
330	64.7	115.3	180.8	295.6	462.1
335	65.2	116.2	182.2	297.8	465.6
340	65.7	117.1	183.6	300.1	469.1
345	66.2	117.9	184.9	302.3	472.5
350	66.7	118.8	186.2	304.4	475.9
355	67.2	119.6	187.6	306.6	479.3
360	67.6	120.4	188.9	308.8	482.7
365	68.1	121.3	190.2	310.9	486.0
370	68.6	122.1	191.5	313.0	489.3
375	69.0	122.9	192.8	315.1	492.6
380	69.5	123.8	194.0	317.2	495.9
385	69.9	124.6	195.3	319.3	499.1
390	70.4	125.4	196.6	321.4	502.4
395	70.8	126.2	197.8	323.4	505.6
400	71.3	127.0	199.1	325.5	508.8
405	71.7	127.8	200.3	327.5	511.9
410	72.2	128.5	201.6	329.5	515.1
415	72.6	129.3	202.8	331.5	518.2
420	73.0	130.1	204.0	333.5	521.3
425	73.5	130.9	205.2	335.5	524.4
430	73.9	131.6	206.4	337.4	527.5
435	74.3	132.4	207.6	339.4	530.6
440	74.8	133.2	208.8	341.3	533.6
445	75.2	133.9	210.0	343.3	536.6
450	75.6	134.7	211.2	345.2	539.6
455	76.0	135.4	212.3	347.1	542.6
460	76.4	136.2	213.5	349.0	545.6
465	76.9	136.9	214.7	350.9	548.5
470	77.3	137.6	215.8	352.8	551.5
475	77.7	138.4	217.0	354.7	554.4
480	78.1	139.1	218.1	356.5	557.3
485	78.5	139.8	219.2	358.4	560.2
490	78.9	140.5	220.4	360.2	563.1
495	79.3	141.2	221.5	362.0	566.0
500	79.7	142.0	222.6	363.9	568.8
505	80.1	142.7	223.7	365.7	-
510	80.5	143.4	224.8	367.5	-
515	80.9	144.1	225.9	369.3	-
520	81.3	144.8	227.0	371.1	-
525	81.7	145.5	228.1	372.9	-
530	82.1	146.1	229.2	374.6	-
535	82.4	146.8	230.2	376.4	-
540	82.8	147.5	231.3	378.1	-
545	83.2	148.2	232.4	379.9	-
550	83.6	148.9	233.5	381.6	-
555	84.0	149.6	234.5	383.4	-
560	84.3	150.2	235.6	385.1	-
565	84.7	150.9	236.6	386.8	-
570	85.1	151.6	237.7	388.5	-
575	85.5	152.2	238.7	390.2	-
580	85.8	152.9	239.7	391.9	-
585	86.2	153.5	240.8	393.6	-
590	86.6	154.2	241.8	395.3	-
595	86.9	154.9	242.8	396.9	-
600	87.3	155.5	243.8	398.6	-
1.0	0.10	0.20	0.28	0.48	0.74

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116
605	87.7	156.1
610	88.0	156.8
615	88.4	157.4
620	88.7	158.1
625	89.1	158.7
630	89.5	159.3
635	89.8	160.0
640	90.2	160.6
645	90.5	161.2
650	90.9	161.8
655	91.2	162.5
660	91.6	163.1
665	91.9	163.7
670	92.3	164.3
675	92.6	164.9
680	92.9	165.5
685	93.3	166.1
690	93.6	166.8
695	94.0	167.4
700	94.3	168.0
705	94.6	168.6
710	95.0	169.2
715	95.3	169.7
720	95.6	170.3
725	96.0	170.9
730	96.3	171.5
735	96.6	172.1
740	97.0	172.7
745	97.3	173.3
750	97.6	173.9
755	97.9	174.4
760	98.3	175.0
765	98.6	175.6
770	98.9	176.2
775	99.2	176.7
780	99.5	177.3
785	99.9	177.9
790	100.2	178.4
795	100.5	179.0
800	100.8	179.6
805	101.1	180.1
810	101.4	180.7
815	101.7	181.2
820	102.1	181.8
825	102.4	182.3
830	102.7	182.9
835	103.0	183.4
840	103.3	184.0
845	103.6	184.5
850	103.9	185.1
855	104.2	185.6
860	104.5	186.2
865	104.8	186.7
870	105.1	187.2
875	105.4	187.8
880	105.7	188.3
885	106.0	188.9
890	106.3	189.4
895	106.6	189.9
900	106.9	190.4
1.0	0.10	0.20

* Pressure settings below 15 PSIG (1.034 barg) are non code.

**For other temperatures, please use temperature correction factor.

WATER CAPACITY CHART – MODEL 800 – CONT'D.

ASME Section VIII "UV"

90% rated at 10% Overpressure NM³/HR at 15.68°C**

Flow Coefficient = .9 x .836 = .752

NM³/HR

Set Pressure Barg	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47
0.4*	2.3	4.1	6.4	10.5	16.3
0.6*	2.6	4.7	7.4	12.1	18.8
0.8*	2.9	5.3	8.2	13.5	21
1*	3.2	5.8	9	14.7	23
1.2	3.5	6.2	9.7	15.9	24.9
1.4	3.7	6.6	10.4	17	26.6
1.6	4	7	11	18	28.2
1.8	4.2	7.4	11.6	19	29.7
2	4.4	7.8	12.2	19.9	31.2
2.2	4.6	8.1	12.8	20.9	32.6
2.4	4.8	8.5	13.3	21.8	34.1
2.6	5	8.9	13.9	22.7	35.5
2.8	5.2	9.2	14.4	23.5	36.8
3	5.3	9.5	14.9	24.4	38.1
3.2	5.5	9.8	15.4	25.2	39.4
3.4	5.7	10.1	15.9	25.9	40.6
3.6	5.8	10.4	16.3	26.7	41.7
3.8	6	10.7	16.8	27.4	42.9
4	6.2	11	17.2	28.1	44
4.2	6.3	11.3	17.6	28.8	45.1
4.4	6.5	11.5	18.1	29.5	46.1
4.6	6.6	11.8	18.5	30.2	47.2
4.8	6.8	12	18.9	30.8	48.2
5	6.9	12.3	19.2	31.5	49.2
5.2	7	12.5	19.6	32.1	50.2
5.4	7.2	12.8	20	32.7	51.1
5.6	7.3	13	20.4	33.3	52.1
5.8	7.4	13.2	20.7	33.9	53
6	7.5	13.4	21.1	34.5	53.9
6.2	7.7	13.7	21.4	35	54.8
6.4	7.8	13.9	21.8	35.6	55.7
6.6	7.9	14.1	22.1	36.2	56.5
6.8	8	14.3	22.4	36.7	57.4
7	8.2	14.5	22.8	37.2	58.2
7.2	8.3	14.7	23.1	37.8	59
7.4	8.4	14.9	23.4	38.3	59.8
7.6	8.5	15.1	23.7	38.8	60.6
7.8	8.6	15.3	24	39.3	61.4
8	8.7	15.5	24.3	39.8	62.2
8.2	8.8	15.7	24.7	40.3	63
8.4	8.9	15.9	24.9	40.8	63.8
8.6	9	16.1	25.2	41.3	64.5
8.8	9.1	16.3	25.5	41.7	65.3
9	9.2	16.5	25.8	42.2	66
9.2	9.3	16.7	26.1	42.7	66.7
9.4	9.4	16.8	26.4	43.1	67.4
9.6	9.5	17	26.7	43.6	68.2
9.8	9.6	17.2	26.9	44.1	68.9
10	9.7	17.4	27.2	44.5	69.6
10.2	9.8	17.5	27.5	44.9	70.3
10.4	9.9	17.7	27.8	45.4	70.9
10.6	10	17.9	28	45.8	71.6
10.8	10.1	18	28.3	46.2	72.3
11	10.2	18.2	28.6	46.7	73
11.2	10.3	18.4	28.8	47.1	73.6
11.4	10.4	18.5	29.1	47.5	74.3
11.6	10.5	18.7	29.3	47.9	74.9
11.8	10.6	18.9	29.6	48.3	75.6
12	10.7	19	29.8	48.7	76.2
12.2	10.8	19.2	30.1	49.2	76.8
.1	0.02	0.05	0.06	0.11	0.17

Set Pressure Barg	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47
12.4	10.9	19.3	30.3	49.6	77.5
12.6	10.9	19.5	30.6	50	78.1
12.8	11	19.6	30.8	50.3	78.7
13	11.1	19.8	31	50.7	79.3
13.5	11.3	20.2	31.6	51.7	80.8
14	11.5	20.5	32.2	52.7	82.3
14.5	11.7	20.9	32.8	53.6	83.8
15	11.9	21.3	33.3	54.5	85.2
15.5	12.1	21.6	33.9	55.4	86.6
16	12.3	22	34.4	56.3	88
16.5	12.5	22.3	35	57.2	89.4
17	12.7	22.6	35.5	58	90.7
17.5	12.9	23	36	58.9	92
18	13.1	23.3	36.5	59.7	93.3
18.5	13.3	23.6	37	60.5	94.6
19	13.4	23.9	37.5	61.3	95.9
19.5	13.6	24.2	38	62.1	97.1
20	13.8	24.6	38.5	62.9	98.4
20.5	14	24.9	39	63.7	99.6
21	14.1	25.2	39.4	64.5	100.8
21.5	14.3	25.5	39.9	65.2	102
22	14.5	25.7	40.4	66	103.2
22.5	14.6	26	40.8	66.7	104.3
23	14.8	26.3	41.3	67.5	105.5
23.5	14.9	26.6	41.7	68.2	106.6
24	15.1	26.9	42.2	68.9	107.8
24.5	15.3	27.2	42.6	69.7	108.9
25	15.4	27.4	43	70.4	110
25.5	15.6	27.7	43.5	71.1	111.1
26	15.7	28	43.9	71.8	112.2
26.5	15.9	28.3	44.3	72.4	113.2
27	16	28.5	44.7	73.1	114.3
27.5	16.2	28.8	45.1	73.8	115.4
28	16.3	29	45.6	74.5	116.4
28.5	16.5	29.3	46	75.1	117.4
29	16.6	29.6	46.4	75.8	118.5
29.5	16.7	29.8	46.8	76.4	119.5
30	16.9	30.1	47.1	77.1	120.5
30.5	17	30.3	47.5	77.7	121.5
31	17.2	30.6	47.9	78.4	122.5
31.5	17.3	30.8	48.3	79	123.5
32	17.4	31.1	48.7	79.6	124.4
32.5	17.6	31.3	49.1	80.2	125.4
33	17.7	31.5	49.5	80.8	126.4
33.5	17.8	31.8	49.8	81.4	127.3
34	18	32	50.2	82.1	128.3
34.5	18.1	32.2	50.6	82.7	129.2
35	18.2	32.5	50.9	83.3	-
35.5	18.4	32.7	51.3	83.8	-
36	18.5	32.9	51.6	84.4	-
36.5	18.6	33.2	52	85	-
37	18.7	33.4	52.4	85.6	-
37.5	18.9	33.6	52.7	86.2	-
38	19	33.8	53.1	86.7	-
38.5	19.1	34.1	53.4	87.3	-
39	19.2	34.3	53.8	87.9	-
39.5	19.4	34.5	54.1	88.4	-
40	19.5	34.7	54.4	89	-
40.5	19.6	34.9	54.8	89.6	-
41	19.7	35.2	55.1	90.1	-
.1	0.02	0.05	0.06	0.11	0.17

Set Pressure Barg	Orifice Area cm² D .766	E 1.365
41.5	19.9	35.4
42	20	35.6
42.5	20.1	35.8
43	20.2	36
43.5	20.3	36.2
44	20.4	36.4
44.5	20.6	36.6
45	20.7	36.8
45.5	20.8	37
46	20.9	37.2
46.5	21	37.4
47	21.1	37.6
47.5	21.2	37.8
48	21.4	38
48.5	21.5	38.2
49	21.6	38.4
49.5	21.7	38.6
50	21.8	38.8
50.5	21.9	39
51	22	39.2
51.5	22.1	39.4
52	22.2	39.6
52.5	22.3	39.8
53	22.4	40
53.5	22.5	40.2
54	22.6	40.3
54.5	22.8	40.5
55	22.9	40.7
55.5	23	40.9
56	23.1	41.1
56.5	23.2	41.3
57	23.3	41.4
57.5	23.4	41.6
58	23.5	41.8
58.5	23.6	42
59	23.7	42.2
59.5	23.8	42.3
60	23.9	42.5
60.5	24	42.7
61	24.1	42.9
61.5	24.2	43.1
62	24.3	43.2
.1	0.02	0.05

* Pressure settings below 15 PSIG (1.034 barg) are non code.

**For other temperatures, please use temperature correction factor.

WATER CAPACITY CHART – MODEL 800 – CONT'D

NON CODE

90% rated at 25% Overpressure GPM at 60°F**

Flow Coefficient = .9 x .836 = .752

GPM

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479
5	8.5	15.1	23.7	38.8	60.6
10	12.0	21.4	33.6	54.9	85.8
15	14.7	26.2	41.1	67.2	105.0
20	17.0	30.3	47.5	77.6	121.3
25	19.0	33.8	53.1	86.7	135.6
30	20.8	37.1	58.1	95.0	148.5
35	22.5	40.0	62.8	102.6	160.4
40	24.0	42.8	67.1	109.7	171.5
45	25.5	45.4	71.2	116.4	181.9
50	26.9	47.9	75.0	122.7	191.7
55	28.2	50.2	78.7	128.6	201.1
60	29.4	52.4	82.2	134.4	210.0
65	30.6	54.6	85.6	139.9	218.6
70	31.8	56.6	88.8	145.1	226.9
75	32.9	58.6	91.9	150.2	234.8
80	34.0	60.5	94.9	155.2	242.5
85	35.0	62.4	97.8	159.9	250.0
90	36.0	64.2	100.7	164.6	257.3
95	37.0	66.0	103.4	169.1	264.3
100	38.0	67.7	106.1	173.5	271.2
105	38.9	69.3	108.7	177.8	277.9
110	39.8	71.0	111.3	181.9	284.4
115	40.7	72.6	113.8	186.0	290.8
120	41.6	74.1	116.2	190.0	297.1
125	42.5	75.7	118.6	193.9	303.2
130	43.3	77.2	121.0	197.8	309.2
135	44.1	78.6	123.3	201.6	315.1
140	45.0	80.1	125.6	205.2	320.9
145	45.8	81.5	127.8	208.9	326.5
150	46.5	82.9	130.0	212.5	332.1
155	47.3	84.3	132.1	216.0	337.6
160	48.1	85.6	134.2	219.4	343.0
165	48.8	86.9	136.3	222.8	348.3
170	49.5	88.2	138.4	226.2	353.6
175	50.3	89.5	140.4	229.5	358.7
180	51.0	90.8	142.4	232.7	363.8
185	51.7	92.0	144.3	235.9	368.8
190	52.4	93.3	146.3	239.1	373.8
195	53.1	94.5	148.2	242.2	378.7
200	53.7	95.7	150.1	245.3	383.5
205	54.4	96.9	151.9	248.4	388.3
210	55.1	98.1	153.8	251.4	393.0
215	55.7	99.2	155.6	254.4	397.6
220	56.4	100.4	157.4	257.3	402.2
225	57.0	101.5	159.2	260.2	406.8
230	57.6	102.6	160.9	263.1	411.3
235	58.2	103.7	162.7	265.9	415.7
240	58.9	104.8	164.4	268.7	420.1
245	59.5	105.9	166.1	271.5	424.4
250	60.1	107.0	167.8	274.3	428.8
255	60.7	108.1	169.5	277.0	433.0
260	61.3	109.1	171.1	279.7	437.2
265	61.8	110.2	172.7	282.4	441.4
270	62.4	111.2	174.4	285.0	445.6
275	63.0	112.2	176.0	287.7	449.7
280	63.6	113.2	177.6	290.3	453.8
285	64.1	114.2	179.1	292.8	457.8
290	64.7	115.2	180.7	295.4	461.8
295	65.3	116.2	182.3	297.9	465.8
300	65.8	117.2	183.8	300.5	469.7
1.0	0.10	0.20	0.30	0.50	0.80

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479
305	66.4	118.2	185.3	302.9	473.6
310	66.9	119.2	186.8	305.4	477.4
315	67.4	120.1	188.3	307.9	481.3
320	68.0	121.1	189.8	310.3	485.1
325	68.5	122.0	191.3	312.7	488.9
330	69.0	122.9	192.8	315.1	492.6
335	69.5	123.9	194.2	317.5	496.3
340	70.1	124.8	195.7	319.9	500.0
345	70.6	125.7	197.1	322.2	503.7
350	71.1	126.6	198.5	324.5	507.3
355	71.6	127.5	199.9	326.8	510.9
360	72.1	128.4	201.3	329.1	514.5
365	72.6	129.3	202.7	331.4	518.1
370	73.1	130.2	204.1	333.7	521.6
375	73.6	131.0	205.5	335.9	525.1
380	74.1	131.9	206.9	338.1	528.6
385	74.5	132.8	208.2	340.4	532.1
390	75.0	133.6	209.6	342.6	535.5
395	75.5	134.5	210.9	344.8	538.9
400	76.0	135.3	212.2	346.9	542.3
405	76.5	136.2	213.6	349.1	545.7
410	76.9	137.0	214.9	351.2	549.1
415	77.4	137.9	216.2	353.4	552.4
420	77.9	138.7	217.5	355.5	555.7
425	78.3	139.5	218.8	357.6	559.0
430	78.8	140.3	220.0	359.7	562.3
435	79.2	141.1	221.3	361.8	565.6
440	79.7	142.0	222.6	363.9	568.8
445	80.1	142.8	223.8	365.9	572.0
450	80.6	143.6	225.1	368.0	575.2
455	81.0	144.4	226.3	370.0	578.4
460	81.5	145.1	227.6	372.0	581.6
465	81.9	145.9	228.8	374.1	584.7
470	82.4	146.7	230.1	376.1	587.9
475	82.8	147.5	231.3	378.1	591.0
480	83.2	148.3	232.5	380.0	594.1
485	83.7	149.0	233.7	382.0	597.2
490	84.1	149.8	234.9	384.0	600.3
495	84.5	150.6	236.1	385.9	603.3
500	85.0	151.3	237.3	387.9	606.4
505	85.4	152.1	238.5	389.8	-
510	85.8	152.8	239.6	391.7	-
515	86.2	153.6	240.8	393.7	-
520	86.6	154.3	242.0	395.6	-
525	87.1	155.1	243.1	397.5	-
530	87.5	155.8	244.3	399.4	-
535	87.9	156.5	245.4	401.2	-
540	88.3	157.3	246.6	403.1	-
545	88.7	158.0	247.7	405.0	-
550	89.1	158.7	248.9	406.8	-
555	89.5	159.4	250.0	408.7	-
560	89.9	160.1	251.1	410.5	-
565	90.3	160.9	252.2	412.3	-
570	90.7	161.6	253.3	414.1	-
575	91.1	162.3	254.5	416.0	-
580	91.5	163.0	255.6	417.8	-
585	91.9	163.7	256.7	419.6	-
590	86.6	154.2	241.8	395.3	-
595	86.9	154.9	242.8	396.9	-
600	87.3	155.5	243.8	398.6	-
1.0	0.10	0.20	0.28	0.48	0.74

Set Pressure PSIG	Orifice Area in² D 0.1188	E 0.2116
605	93.5	166.5
610	93.8	167.1
615	94.2	167.8
620	94.6	168.5
625	95.0	169.2
630	95.4	169.9
635	95.7	170.5
640	96.1	171.2
645	96.5	171.9
650	96.9	172.5
655	97.2	173.2
660	97.6	173.9
665	98.0	174.5
670	98.3	175.2
675	98.7	175.8
680	99.1	176.5
685	99.4	177.1
690	99.8	177.8
695	100.2	178.4
700	100.5	179.0
705	100.9	179.7
710	101.2	180.3
715	101.6	181.0
720	101.9	181.6
725	102.3	182.2
730	102.7	182.8
735	103.0	183.5
740	103.4	184.1
745	103.7	184.7
750	104.1	185.3
755	104.4	185.9
760	104.7	186.6
765	105.1	187.2
770	105.4	187.8
775	105.8	188.4
780	106.1	189.0
785	106.5	189.6
790	106.8	190.2
795	107.1	190.8
800	107.5	191.4
805	107.8	192.0
810	108.1	192.6
815	108.5	193.2
820	108.8	193.8
825	109.1	194.4
830	109.5	195.0
835	109.8	195.5
840	110.1	196.1
845	110.4	196.7
850	110.8	197.3
855	111.1	197.9
860	111.4	198.5
865	111.7	199.0
870	112.1	199.6
875	112.4	200.2
880	112.7	200.7
885	113.0	201.3
890	113.3	201.3
895	113.7	202.5
900	114.0	203.0
1.0	0.10	0.20

**For other temperatures, please use temperature correction factor.

SPENCE

WATER CAPACITY CHART – MODEL 800 – CONT'D.

NON CODE

90% rated at 25% Overpressure NM³/HR at 15.6°C**

Flow Coefficient = .9 x .836 = .752

NM³/HR

Set Pressure Barg	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47
0.4	2.3	4.1	6.4	10.5	16.3
0.6	2.6	4.7	7.4	12.1	18.8
0.8	2.9	5.3	8.2	13.5	21
1	3.3	5.9	9.2	15	23.5
1.2	3.6	6.4	10.1	16.4	25.7
1.4	3.9	6.9	10.9	17.7	27.7
1.6	4.2	7.4	11.6	19	29.7
1.8	4.4	7.9	12.3	20.1	31.5
2	4.6	8.3	13	21.2	33.2
2.2	4.9	8.7	13.6	22.2	34.8
2.4	5.1	9.1	14.2	23.2	36.3
2.6	5.3	9.4	14.8	24.2	37.8
2.8	5.5	9.8	15.4	25.1	39.2
3	5.7	10.1	15.9	26	40.6
3.2	5.9	10.5	16.4	26.8	41.9
3.4	6.1	10.8	16.9	27.7	43.2
3.6	6.2	11.1	17.4	28.5	44.5
3.8	6.4	11.4	17.9	29.2	45.7
4	6.6	11.7	18.4	30	46.9
4.2	6.7	12	18.8	30.7	48.1
4.4	6.9	12.3	19.2	31.5	49.2
4.6	7	12.6	19.7	32.2	50.3
4.8	7.2	12.8	20.1	32.9	51.4
5	7.3	13.1	20.5	33.5	52.4
5.2	7.5	13.3	20.9	34.2	53.5
5.4	7.6	13.6	21.3	34.9	54.5
5.6	7.8	13.8	21.7	35.5	55.5
5.8	7.9	14.1	22.1	36.1	56.5
6	8	14.3	22.5	36.7	57.4
6.2	8.2	14.6	22.8	37.4	58.4
6.4	8.3	14.8	23.2	37.9	59.3
6.6	8.4	15	23.6	38.5	60.2
6.8	8.6	15.3	23.9	39.1	61.2
7	8.7	15.5	24.3	39.7	62
7.2	8.8	15.7	24.6	40.3	62.9
7.4	8.9	15.9	25	40.8	63.8
7.6	9.1	16.1	25.3	41.4	64.6
7.8	9.2	16.3	25.6	41.9	65.5
8	9.3	16.6	26	42.4	66.3
8.2	9.4	16.8	26.3	43	67.2
8.4	9.5	17	26.6	43.5	68
8.6	9.6	17.2	26.9	44	68.8
8.8	9.7	17.4	27.2	44.5	69.6
9	9.9	17.6	27.5	45	70.4
9.2	10	17.8	27.8	45.5	71.1
9.4	10.1	17.9	28.1	46	71.9
9.6	10.2	18.1	28.4	46.5	72.7
9.8	10.3	18.3	28.7	47	73.4
10	10.4	18.5	29	47.4	74.2
10.2	10.5	18.7	29.3	47.9	74.9
10.4	10.6	18.9	29.6	48.4	75.6
10.6	10.7	19.1	29.9	48.8	76.3
10.8	10.8	19.2	30.2	49.3	77.1
11	10.9	19.4	30.4	49.8	77.8
11.2	11	19.6	30.7	50.2	78.5
11.4	11.1	19.8	31	50.6	79.2
11.6	11.2	19.9	31.3	51.1	79.9
11.8	11.3	20.1	31.5	51.5	80.6
12	11.4	20.3	31.8	52	81.2
12.2	11.5	20.4	32.1	52.4	81.9
.1	0.02	0.05	0.07	0.11	0.18

Set Pressure Barg	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47
12.4	11.6	20.6	32.3	52.8	82.6
12.6	11.7	20.8	32.6	53.2	83.2
12.8	11.8	20.9	32.8	53.7	83.9
13	11.8	21.1	33.1	54.1	84.6
13.5	12.1	21.5	33.7	55.1	86.2
14	12.3	21.9	34.3	56.1	87.7
14.5	12.5	22.3	34.9	57.1	89.3
15	12.7	22.7	35.5	58.1	90.8
15.5	12.9	23	36.1	59.1	92.3
16	13.1	23.4	36.7	60	93.8
16.5	13.3	23.8	37.3	60.9	95.3
17	13.5	24.1	37.8	61.9	96.7
17.5	13.7	24.5	38.4	62.8	98.1
18	13.9	24.8	38.9	63.6	99.5
18.5	14.1	25.2	39.5	64.5	100.9
19	14.3	25.5	40	65.4	102.2
19.5	14.5	25.8	40.5	66.2	103.6
20	14.7	26.2	41	67.1	104.9
20.5	14.9	26.5	41.5	67.9	106.2
21	15.1	26.8	42.1	68.7	107.5
21.5	15.2	27.1	42.5	69.6	108.7
22	15.4	27.4	43	70.4	110
22.5	15.6	27.8	43.5	71.2	111.2
23	15.8	28.1	44	71.9	112.5
23.5	15.9	28.4	44.5	72.7	113.7
24	16.1	28.7	45	73.5	114.9
24.5	16.3	29	45.4	74.3	116.1
25	16.4	29.3	45.9	75	117.3
25.5	16.6	29.6	46.3	75.8	118.4
26	16.8	29.8	46.8	76.5	119.6
26.5	16.9	30.1	47.2	77.2	120.7
27	17.1	30.4	47.7	77.9	121.8
27.5	17.2	30.7	48.1	78.7	123
28	17.4	31	48.6	79.4	124.1
28.5	17.5	31.2	49	80.1	125.2
29	17.7	31.5	49.4	80.8	126.3
29.5	17.8	31.8	49.8	81.5	127.4
30	18	32.1	50.3	82.2	128.4
30.5	18.1	32.3	50.7	82.8	129.5
31	18.3	32.6	51.1	83.5	130.6
31.5	18.4	32.8	51.5	84.2	131.6
32	18.6	33.1	51.9	84.9	132.7
32.5	18.7	33.4	52.3	85.5	133.7
33	18.9	33.6	52.7	86.2	134.7
33.5	19	33.9	53.1	86.8	135.7
34	19.2	34.1	53.5	87.5	136.7
34.5	19.3	34.4	53.9	88.1	137.7
35	19.4	34.6	54.3	88.7	-
35.5	19.6	34.9	54.7	89.4	-
36	19.7	35.1	55.1	90	-
36.5	19.9	35.4	55.4	90.6	-
37	20	35.6	55.8	91.2	-
37.5	20.1	35.8	56.2	91.9	-
38	20.3	36.1	56.6	92.5	-
38.5	20.4	36.3	56.9	93.1	-
39	20.5	36.5	57.3	93.7	-
39.5	20.6	36.8	57.7	94.3	-
40	20.8	37	58	94.9	-
40.5	20.9	37.2	58.4	95.5	-
41	21	37.5	58.8	96.1	-
.1	0.02	0.05	0.07	0.11	0.18

Set Pressure Barg	Orifice Area cm² D .766	E 1.365
41.5	21.2	37.7
42	21.3	37.9
42.5	21.4	38.2
43	21.5	38.4
43.5	21.7	38.6
44	21.8	38.8
44.5	21.9	39
45	22	39.3
45.5	22.2	39.5
46	22.3	39.7
46.5	22.4	39.9
47	22.5	40.1
47.5	22.6	40.3
48	22.8	40.5
48.5	22.9	40.8
49	23	41
49.5	23.1	41.2
50	23.2	41.4
50.5	23.3	41.6
51	23.5	41.8
51.5	23.6	42
52	23.7	42.2
52.5	23.8	42.4
53	23.9	42.6
53.5	24	42.8
54	24.1	43
54.5	24.3	43.2
55	24.4	43.4
55.5	24.5	43.6
56	24.6	43.8
56.5	24.7	44
57	24.8	44.2
57.5	24.9	44.4
58	25	44.6
58.5	25.1	44.8
59	25.2	45
59.5	25.3	45.1
60	25.5	45.3
60.5	25.6	45.5
61	25.7	45.7
61.5	25.8	45.9
62	25.9	46.1
.1	0.02	0.05

**For other temperatures, please use temperature correction factor.

VACUUM CAPACITY CHART – MODEL 800

NON CODE – Plain or Packed Cap
90% rated SCFM (NM³/HR) at 60°F (15.6°C)**
Flow Coefficient = .9 x .975 = .878

SCFM

Set Pressure in.HG	Orifice Area in² D 0.1188	E 0.2116	F 0.3318	G 0.5424	H 0.8479
10	27	48	76	124	194
11	28	50	78	127	199
12	28	51	80	130	204
13	29	52	82	133	208
14	29	53	83	135	211
15	30	53	84	137	214
16	30	54	85	138	216
17	30	54	85	139	218
18	30	55	86	140	219
19	31	55	86	140	220
20	31	55	86	141	220
21	31	55	86	141	220
22	31	55	86	141	220
23	31	55	86	141	220
24	31	55	86	141	220
25	31	55	86	141	220
26	31	55	86	141	220
27	31	55	86	141	220
28	31	55	86	141	220
29	31	55	86	141	220
30	31	55	86	141	220

NM³/HR

Set Pressure mmHG	Orifice Area cm² D .766	E 1.365	F 2.141	G 3.499	H 5.47
254.0	46	82	129	211	330
279.4	48	85	133	216	338
304.8	48	87	136	221	347
330.2	49	88	139	226	353
355.6	49	90	141	229	358
381.0	51	90	143	233	364
406.4	51	92	144	234	367
431.8	51	92	144	236	370
457.2	51	93	146	238	372
482.6	53	93	146	238	374
508.0	53	93	146	240	374
533.4	53	93	146	240	374
558.8	53	93	146	240	374
584.2	53	93	146	240	374
609.6	53	93	146	240	374
635.0	53	93	146	240	374
660.4	53	93	146	240	374
685.8	53	93	146	240	374
711.2	53	93	146	240	374
736.6	53	93	146	240	374
762.0	53	93	146	240	374

** For other temperatures, please use temperature correction factor.

FIGURE 10 SERIES

SIZES ¾" – 3"
PRESSURES to 15 PSIG at 250°F

FIGURE 10 SERIES SAFETY VALVE

- **Meets ASME Section IV Code for Steam Service**
- **"HV" National Board Certified**
- **Low Cost**
- **High Capacity**
- **Dependable**
- **Tight Shutoff**
- **Sharp Popping and Closing Action**
- **High Degree of Repeatability**
- **Unitized Body**

MODELS

- 0010 - Cast Iron Body, Bronze Seats

APPLICATION DATA

- Industrial Low Pressure Steam Heating Boilers
- Commercial Low Pressure Steam Heating Boilers

VALVE RATINGS

Model	Pressure PSIG (bar)	Temperature °F (°C)
All	5 to 15 (.3 to 1)	-20 to 250 (-29 to 121)

APPLICABLE CODES

- ASME Section IV "HV" for Low Pressure Steam (when set @ 15 PSI)
- Canadian Registration #0G0591.9C

CODE SELECTION CHART

Model				Orifice	Inlet Size	Connec-tions	–	Set Pressure		
0	0	1	0	Z	H	A	-	0	1	5
1	2	3	4	5	6	7		8	9	10

Model -
Position 1, 2, 3 & 4
0010 = Cast Iron Body, Bronze Seats

Orifice -
Position 5
Z

Inlet Size -
Position 6
D = ¾
E = 1
F = 1¼
G = 1½
H = 2
J = 2½
K = 3

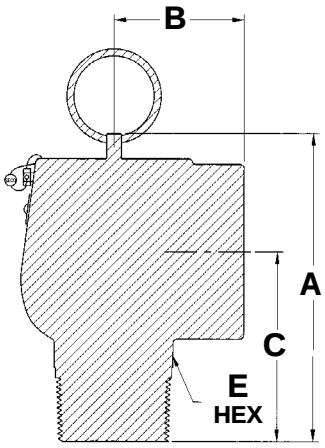
Connections -
Position 7
A = MPT x FPT

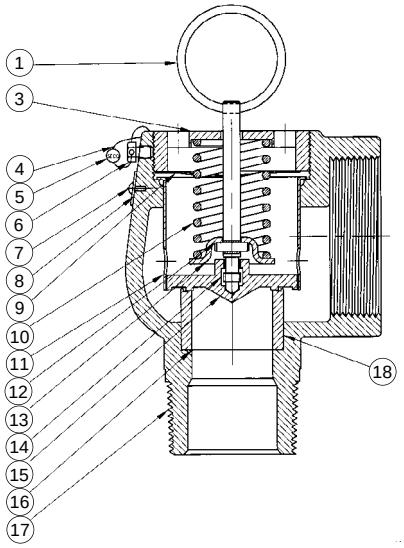
Set Pressure -
Position 8, 9 & 10
__ __ __ = Actual Setting

FIGURE 10 SERIES

SPECIFICATION

The valve shall meet the ASME Section IV Code for low pressure steam service. It shall be "HV" National Board Certified. The valve inlet and outlet shall be one integral casting assuring proper alignment of disc, seat and spindle for smooth action. The valve shall maintain a high degree of repeatability. The valve shall be top guided by a disc guide fitted into the body. The valve shall have an open lever assembly. The valve shall have a non-adjustable blowdown.





MATERIALS OF CONSTRUCTION

Ref	Part Name	Material
1	Pull Ring	SST
3	Compression Screw	Stl. plated CI ASTM A108/A126
4	Seal Wire	SST
5	Seal	Lead
6	Lock Screw	Brass ASTM B16
7	Drive Screw	SST
8	Nameplate	SST
9	Wave Washer	Plated Steel
10	Spring	Plated Steel
11	Disc Guide	Brass/Bronze ASTM B135/B505
12	Spindle Pin	Plated Steel
13	Spring Washer	Plated Steel
14	Spindle	Steel ASTM A108
15	Disc	Brass/Bronze ASTM B16/B62
16	Seat	Brass/Bronze ASTM B16/B505
17	Body	Cast Iron ASTM A126
18	Sealant	Sealant

DIMENSIONS inches (mm) **AND WEIGHTS** pounds (kg)

Model	Inlet	Orifice	Outlet	A*	B	C	E Hex	Weight
0010ZDA	¾ (20)	Z	1 (25)	3 5/16 (76)	1½ (38)	2 3/16 (56)	1¼ (32)	1 (.4)
0010ZEA	1 (25)	Z	1¼ (32)	4 (95)	2 (51)	2⅝ (67)	1½ (38)	2 (.9)
0010ZFA	1¼ (32)	Z	1½ (40)	5 (108)	2⅛ (54)	3 (76)	1⅞ (48)	3 (1.4)
0010ZGA	1½ (40)	Z	2 (50)	5⅛ (117)	2 3/16 (56)	3 3/16 (81)	2 (51)	4 (1.8)
0010ZHA	2 (50)	Z	2½ (65)	6 11/16 (156)	2⅞ (73)	4 (102)	3 (76)	8 (3.6)
0010ZJA	2½ (65)	Z	2½ (65)	8⅜ (194)	3⅜ (95)	4⅜ (111)	3¼ (83)	14 (6.3)
0010ZKA	3 (80)	Z	3 (80)	9½ (229)	3⅞ (98)	5⅛ (130)	4 (102)	22 (10)

* Add 1/4" to "A" dimension to allow for lift.

SATURATED STEAM CAPACITY CHART—MODEL 0010

ASME Section IV "HV" 90% rated at 33.3% Overpressure** LBS/HR (KGS/HR)

LBS/HR

Set Pressure PSIG	Valve & Orifice Area, in²						
	¾ Z 1	1 Z 1¼	1¼ Z 1½	1½ Z 2	2 Z 2½	2½ Z 2½	3 Z 3
	0.276	0.49	0.765	1.107	1.961	3.063	4.43
5*	243	431	673	974	1725	2694	3896
10*	318	565	883	1277	2263	3534	5112
15	394	700	1093	1581	2801	4375	6327

* Pressure settings below 15 PSIG (1.034 barg) are non code.

** Pressure settings below 15 PSIG (1 barg) are at 10% overpressure.

KGS/HR

Set Pressure Barg	Valve & Orifice Area cm²						
	20 Z 25	25 Z 32	32 Z 40	40 Z 50	50 Z 65	65 Z 65	80 Z 80
	1.78	3.16	4.94	7.14	12.65	19.76	25.58
0.4*	255	452	706	1022	1811	2828	4091
0.7*	321	569	889	1286	2279	3559	5148

Consult Factory for capacities below 5 PSIG

FIGURE 15 SERIES

SIZES ¾" – 3"
PRESSURES to 15 PSIG at 400°F

- **Air & Non-hazardous Service**
- **Low Cost**
- **High Capacity**
- **Cast Iron or Aluminum Body**
- **Dependable**
- **Tight Shutoff**
- **Sharp Popping & Closing Action**
- **High Degree of Repeatability**
- **Unitized Body**

FIGURE 15LC SAFETY VALVE

Application Data

- Bulk Hauling Railroad and Truck Tank Cars
- High Volume Blowers
- Compressors
- Dryers
- Pneumatic Equipment
- Tanks

Valve Ratings

Model	Pressure PSIG (bar)	Temperature °F (°C)
All	5 to 15 (.3 to 1)	-20 to 400 (-29 to 204)

Applicable Codes

- Canadian Registration #0G0591.9C — 015C, 015LC
  #0H0591.9C — 015A, 015LA

Options

- Stainless Trim
- Set Pressures 15 to 60 psi (Consult Factory)
- Polyurethane Soft Seat Available (Consult Factory)

Models

- 015C - Cast Iron Body, Bronze Seats, Pull Ring
- 015A - Cast Iron Body, Bronze Seats, Sealed Cap
- 15LC - Aluminum Body on 015C (2 x 2½ only)
- 15LA - Aluminum Body on 015A (2 x 2½ only)

CODE SELECTION CHART

Model			Orientation	Inlet Size	Connections	–	Set Pressure		
0	1	5	C	Z	K	A	- 0	1	5
1	2	3	4	5	6	7	8	9	10

Model -
Position 1, 2, 3 & 4
015C = Cast Iron Body, Brz Seats, Pull Ring
015A = Cast Iron Body, Brz Seats, Sealed Cap
15LC = Aluminum Body on 015C (2 x 2½ only)
15LA = Aluminum Body on 015A (2 x 2½ only)

Orifice -
Position 5
Z

Inlet Size -
Position 6
D = ¾
E = 1
F = 1¼
G = 1½
H = 2
J = 2½
K = 3

Connections -
Position 7
A = MPT x FPT

Set Pressure -
Position 8, 9 & 10
__ __ __ = Actual Setting
LAS - Loosely Assembled†

† Spence Certified Assemblers Only

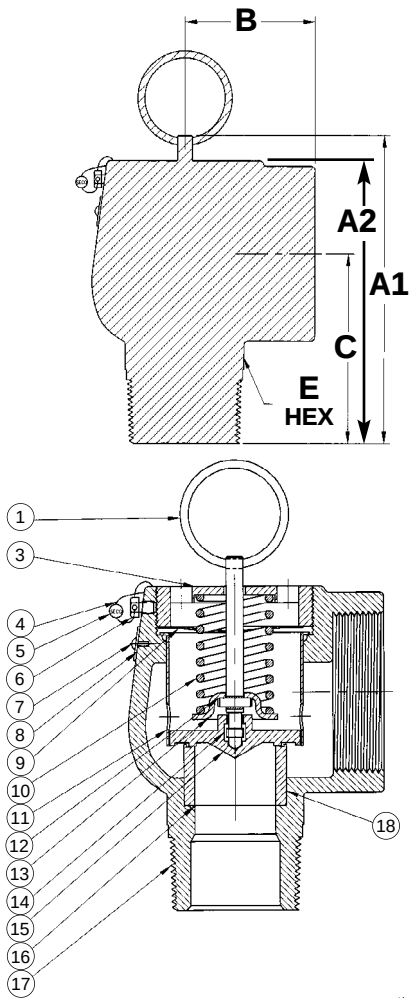
FIGURE 15 SERIES

SPECIFICATION

The valve inlet and outlet shall be one integral casting assuring proper alignment of disc, seat and spindle for smooth action. The valve shall maintain a high degree of repeatability. The valve shall be top guided by a disc guide fitted into the body. The valve shall have a non-adjustable blowdown.

MATERIALS OF CONSTRUCTION

Ref	Part Name	Material
1	Pull Ring	SST
3	Compression Screw	Stl. plated CI ASTM A108/A126
4	Seal Wire	SST
5	Seal	Lead
6	Lock Screw	Brass ASTM B16
7	Drive Screw	SST
8	Nameplate	SST
9	Wave Washer	Plated Steel
10	Spring	Plated Steel
11	Disc Guide	Brass/Bronze ASTM B135/B505
12	Spindle Pin	Plated Steel
13	Spring Washer	Plated Steel
14	Spindle	Steel ASTM A108
15	Disc	Brass/Bronze ASTM B16/B62
16	Seat	Brass/Bronze ASTM B16/B505
17	Body Body	Cast Iron ASTM A126 Aluminum ASTM B26, A03560, T6
18	Sealant	Sealant
19	Bushing 015A/15LA	Brass ASTM B16



DIMENSIONS inches (mm) **AND WEIGHTS** pounds (kg)

Model	Inlet	Orifice	Outlet	A1	A2	B	C	E Hex	Weight
****ZDA	¾ (20)	Z	1 (25)	3 5/16 (76)	3 (76)	1½ (38)	2 3/16 (56)	1¼ (32)	1 (.4)
****ZEA	1 (25)	Z	1¼ (32)	4 (95)	3¾ (95)	2 (51)	2⅝ (67)	1½ (38)	2 (.9)
****ZFA	1¼ (32)	Z	1½ (40)	5 (108)	4¼ (108)	2⅛ (54)	3 (76)	1⅞ (48)	3 (1.4)
****ZGA	1½ (40)	Z	2 (50)	5⅛ (117)	4⅝ (117)	2 3/16 (56)	3 3/16 (81)	2 (51)	4 (1.8)
****ZHA	2 (50)	Z	2½ (65)	6 11/16 (156)	6⅛ (156)	2⅞ (73)	4 (102)	3 (76)	8 (3.6)
****ZJA	2½ (65)	Z	2½ (65)	8⅜ (194)	7⅝ (194)	3⅜ (95)	4⅜ (111)	3¼ (83)	14 (6.3)
****ZKA	3 (80)	Z	3 (80)	9½ (229)	9 (229)	3⅞ (98)	5⅛ (130)	4 (102)	22 (10)

**** Use appropriate Model Number.

AIR CAPACITY CHART – MODELS 015C, 015A, 15LC, 15LA

**ASME Section VIII "UV" 90% rated at 3 PSI Overpressure SCFM (M^3/HR)

SCFM

Set Pressure PSIG	Valve & Orifice Area, in² ¾ Z 1 0.276	1 Z 1¼ 0.49	1¼ Z 1½ 0.765	1½ Z 2 1.107	2 Z 2½ 1.961	2½ Z 2½ 3.063	3 Z 3 4.43
5*	82	145	226	328	579	906	1311
10*	100	177	276	400	706	1105	1599
15	118	209	326	472	834	1305	1888

* Pressure settings below 15 PSIG (1.034 barg) are non code.
**Only 2" size is ASME Certified.

M^3/HR

Set Pressure Barg	Valve & Orifice Area cm² 20 Z 25 1.78	25 Z 32 3.16	32 Z 40 4.94	40 Z 50 7.14	50 Z 65 12.65	65 Z 65 19.76	80 Z 80 25.58
0.4*	144	255	398	576	1018	1593	2305
0.7*	171	302	472	683	1207	1888	2732
1.0*	197	350	545	790	1395	2183	3159

Consult factory for capacities below 5 psi or between 15 to 60 psi.

FIGURE 15V SERIES

SIZES ¾" – 3"
PRESSURES to 30" HG at 400°F

- **Vacuum Service**
- **Low Cost**
- **High Capacity**
- **Cast Iron or Aluminum Body**
- **Dependable**
- **Tight Shutoff**
- **Sharp Popping & Closing Action**
- **High Degree of Repeatability**
- **Unitized Body**

FIGURE 15V SERIES SAFETY VALVE

Application Data

- Vacuum Pumps
- Bulk Hauling Railroad & Truck Tank Cars
- Pneumatic Equipment
- Tanks

Valve Ratings

Model	Pressure in.HG (mmHG)	Temperature °F (°C)
All	5 to 30 (.2 to 1)	-20 to 400 (-29 to 204)

Applicable Codes

- Canadian Registration #0H0591.9C

Options

- Stainless Trim

Models

- 015V - Cast Iron Body, Bronze Seats, Vacuum Service
- 015LV - Aluminum Body on 015V (2" x 2½" only)

CODE SELECTION CHART

Model				Orifice	Inlet Size	Connec-tions	–	Set Pressure		
0	0	5	2	Z	H	Z	-	0	1	5
1	2	3	4	5	6	7	8	9	10	

Model -
Position 1, 2, 3 & 4
0050 = Bronze Body, Viton Soft Seat
0051 = Pull Ring on 0050
0052 = Aluminum Body, Viton Soft Seat
0053 = Pull Ring on 0052

Orifice -
Position 5
Z

Inlet Size -
Position 6
H = 2

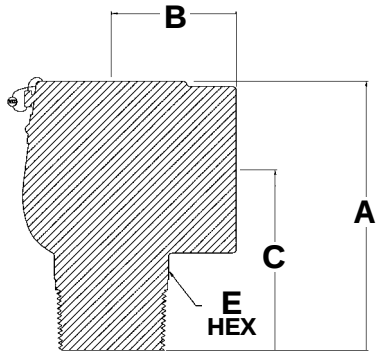
Connections -
Position 7
Z

Set Pressure -
Position 8, 9 & 10
__ __ __ = Actual Setting

FIGURE 15V SERIES

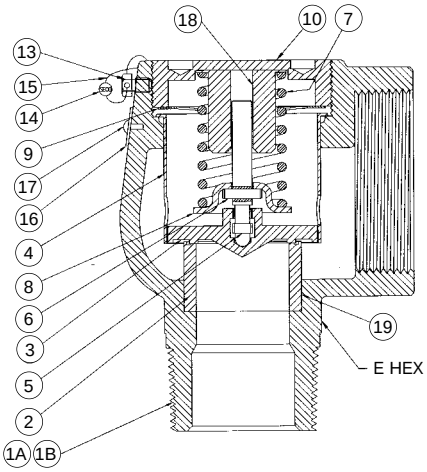
SPECIFICATION

The valve inlet and outlet shall be one integral casting assuring proper alignment of disc, seat and spindle for smooth action. The valve shall maintain a high degree of repeatability. The valve shall be top guided by a disc guide fitted into the body. The valve shall have a non-adjustable blowdown.



MATERIALS OF CONSTRUCTION

Ref	Part Name	Material
1A	Body	Cast ASTM A126
1B	Body	Aluminum ASTM B26, A03560, T6
2	Seat	Bronze ASTM B505
3	Disc	Brass/Bronze ASTM B505
4	Disc Guide	Brass ASTM B135
5	Spindle	Steel ASTM A108
6	Spindle Pin	Plated Steel
7	Spring	Plated Steel
8	Spring Washer	Plated Steel
9	Wave Washer	Plated Steel
10	Compression Screw	Cast Iron ASTM A126
13	Lock Screw	Brass ASTM B16
14	Seal	Lead
15	Seal Wire	SST
16	Nameplate	SST
17	Drive Screw	SST
18	Bushing	Brass ASTM B16



DIMENSIONS inches (mm) **AND WEIGHTS** pounds (kg)

Model	Inlet	Orifice	Outlet*	A1	B	C	E Hex	Weight
****ZDA	¾ (20)	Z	1 (25)	3 (76)	1½ (38)	2 3/16 (56)	1¼ (32)	1 (.4)
****ZEA	1 (25)	Z	1¼ (32)	3¾ (95)	2 (51)	2⅝ (67)	1½ (38)	2 (.9)
****ZFA	1¼ (32)	Z	1½ (40)	4¼ (108)	2⅛ (54)	3 (76)	1⅞ (48)	3 (1.4)
****ZGA	1½ (40)	Z	2 (50)	4⅝ (117)	2 3/16 (56)	3 3/16 (81)	2 (51)	4 (1.8)
****ZHA	2 (50)	Z	2½ (65)	6⅛ (156)	2⅞ (73)	4 (102)	3 (76)	8 (3.6)
****ZJA	2½ (65)	Z	2½ (65)	7⅝ (194)	3⅜ (95)	4⅜ (111)	3¼ (83)	14 (6.3)
****ZKA	3 (80)	Z	3 (80)	9 (229)	3⅞ (98)	5⅛ (130)	4 (102)	22 (10)

**** Add appropriate model number

* Valve outlet should be mounted at vacuum side of system.

AIR CAPACITY CHART – MODELS 015V & 015LV

Rated Flow SCFM (M³/HR)

SCFM

Set* Pressure in. HG	Valve & Orifice Area, in²*						
	¾ Z 1 0.276	1 Z 1¼ 0.49	1¼ Z 1½ 0.765	1½ Z 2 1.107	2 Z 2½ 1.961	2½ Z 2½ 3.063	3 Z 3 4.43
5	36	85	132	191	337	528	764
6	39	90	140	203	359	561	812
7	41	94	147	213	376	588	851
8	42	98	152	221	389	609	881
9	43	100	156	227	400	625	904
10	44	102	159	231	407	637	922
11	45	104	161	234	412	645	933
12	45	104	162	236	415	650	940
12.8-30	45	105	163	236	417	651	943

*Valve outlet should be mounted at vacuum side of system.

M³/HR

Set Pressure mmHG	Valve & Orifice Area cm²*						
	20 Z 25 1.78	25 Z 32 3.16	32 Z 40 4.94	40 Z 50 7.14	50 Z 65 12.65	65 Z 65 19.76	80 Z 80 25.58
127	62	144	224	325	573	897	1297
152	66	153	238	346	610	953	1380
178	69	160	249	362	639	999	1445
203	71	166	258	375	661	1034	1497
229	73	171	265	385	679	1062	1536
254	75	174	270	392	692	1082	1566
279	76	176	274	397	701	1096	1586
305	76	177	276	400	706	1104	1597
325-762	76	178	276	401	708	1107	1601

FIGURE 50 SERIES

SIZES 2"
PRESSURES to 30 PSIG at 225°F

- **Air, Gas, Vapors and Powdered Solids**
- **High Capacity**
- **Tamper Proof Spring Setting**
- **Weatherproof**
- **Spring Chamber Isolated from Process Fluid**
- **Soft Seat Seal**
- **Bronze or Aluminum Body**

FIGURE 50 SERIES SAFETY VALVE

MODELS

- 0050 - Bronze Body, Viton Soft Seat
- 0051 - Pull Ring on 0050
- 0052 - Aluminum Body, Viton Soft Seat
- 0053 - Pull Ring on 0052

APPLICATION DATA

- Bulk Hauling Truck Tank Trailers
- Bulk Hauling Railroad Tank Cars
- Storage Vessels for Powdered Solids (flour, cement, etc.)

VALVE RATINGS

Model	Pressure PSIG (bar)	Temperature °F (°C)
All	10 to 30 (.7 to 2.1)	-20 to 225 (-29 to 107)

APPLICABLE CODES

- Canadian Registration #0G0591.9C

CODE SELECTION CHART

Model | Orifice | Inlet Size | Connec- tions | – | Set Pressure

0	0	5	2	Z	H	Z	-	0	1	5
1	2	3	4	5	6	7	8	9	10	

Model -
Position 1, 2, 3 & 4
0050 = Bronze Body, Viton Soft Seat
0051 = Pull Ring on 0050
0052 = Aluminum Body, Viton Soft Seat
0053 = Pull Ring on 0052

Orifice -
Position 5
Z

Inlet Size -
Position 6
H = 2

Connections -
Position 7
Z

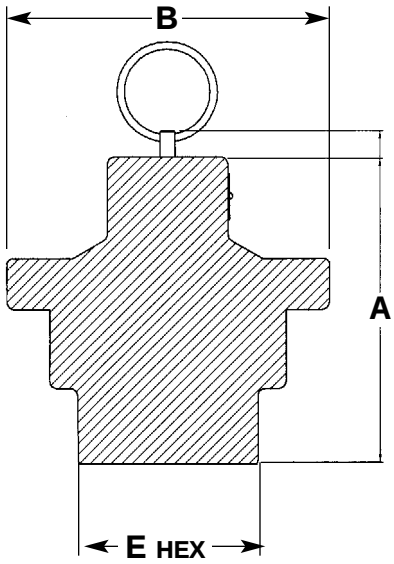
Set Pressure -
Position 8, 9 & 10
__ __ __ = Actual Setting
LAS - Loosely Assembled†

†Spence Certified Assemblers Only

FIGURE 50 SERIES

SPECIFICATION

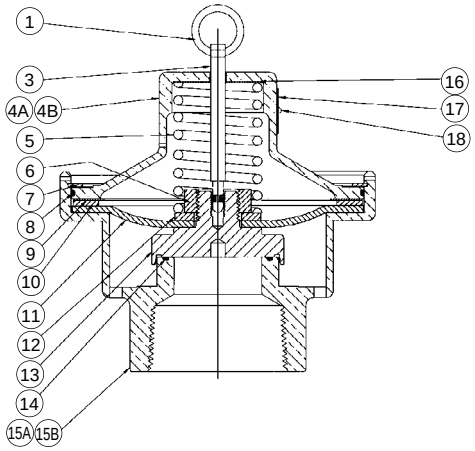
The valve shall meet the ASME Section VIII Code for air services. It shall be "UV" National Board Certified. The valve setting shall be tamper resistant. The valve shall be weatherproof and the diaphragm shall completely seal the spring chamber from the process fluid. The valve shall have an O-ring seat seal for tight shutoff.



MATERIALS OF CONSTRUCTION

Ref	Part Name	Material
1	Pull Ring	SST
3	Spindle (0051/0053)	Steel ASTM A108. 12L14
4A 4B	Cover Cover	Bronze ASTM B62 Aluminum ASTM B 26, A03560, T6
5	Spring	Steel ASTM A228, Plated
6	Disc Nut	Steel, Plated
7	Retaining Ring	Steel, Plated
8	Weather Seal	Viton
9	Wave Spring	Steel, Plated
10	Washer	Steel, Plated
11	Diaphragm	Nylon Reinforced
12	Disc Washer	Plated Steel
13	Disc	ASTM B16, C36000, H02
14	Seat Seal	Viton
15A 15B	Body Body	Bronze ASME SB62 Aluminum ASTM B26, A03560, T6
16	Fender Washer	Steel, Plated
17	Nameplate	SST
18	Drive Screw	SST

Lead seal plus SS wire not shown



DIMENSIONS* inches (mm) **AND WEIGHTS** pounds (kg)

Model	Inlet	Orifice	Outlet	A	B	E	Weight
0050ZHZ	2 (50)	Z	Atmosphere	5 3/32 (129)	5 3/8 (136)	3 (76)	7 (3.2)
0051ZHZ	2 (50)	Z	Atmosphere	6 (152)	5 3/8 (136)	3 (76)	7 (3.2)
0052ZHZ	2 (50)	Z	Atmosphere	5 3/32 (129)	5 3/8 (136)	3 (76)	3 (1.4)
0053ZHZ	2 (50)	Z	Atmosphere	6 (152)	5 3/8 (136)	3 (76)	3 (1.4)

AIR CAPACITY CHART – MODELS 0050, 0051, 0052, 0053

ASME Section VIII "UV" 90% rated at 10% Slope SCFM (NM³/HR)

SCFM

Set Pressure PSIG	Orifice Area, in²
	2.011
10*	637
15	752
20	867
25	982
30	1097
1.0	25.3

NM³/HR

Set Pressure Barg	Orifice Area cm²
	12.97
0.6*	1082
0.8*	1278
1.0*	1473
1.2	1669
0.1	43.0

* Pressure settings below 15 PSIG (1.034 barg) are non code.

DRIP PAN ELBOW

SIZES 3/4" – 8"
PRESSURES to 250 PSIG at 406°F

- **Collects Discharge Condensate from Steam Systems**
- **Returns Condensate to Safe Areas**
- **Increases Life of Safety Valves**
- **Reduces Discharge Piping Strain**
- **Female NPT or Flange Connections**
- **Compatible with All Spence ASME Safety Valves**
- **Helps Prevent Injury & Property Damage**

Application Data

- Steam Boilers
- Steam Pressure Reducing Stations
- Steam Pressure Vessels & Lines

Valve Ratings

Model	Pressure PSIG (bar)	Temperature °F (°C)
All	250 (17.2)	406 (208)

Models

- DPE - Drip Pan Elbow, Cast Iron

CODE SELECTION CHART

Model			Size
D	P	E	- H
1	2	3	4

Model -
Position 1, 2 & 3
DPE = Drip Pan Elbow, Cast Iron

Size -
Position 4
D = ¾
E = 1
F = 1¼
G = 1½
H = 2
J = 2½
K = 3
M = 4
P = 6
Q = 8

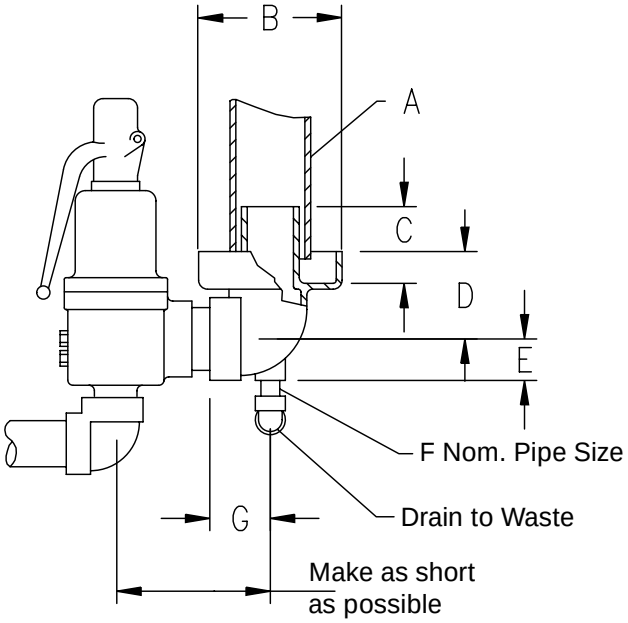
DRIP PAN ELBOW

SPECIFICATION

The Drip Pan Elbow shall be a minimum of the size of the safety valve discharge and installed on the discharge side of the safety valve. It shall be made of cast iron and conform to the Power Piping Code. It shall have a pan to collect condensate in the steam riser pipe and a drain to pipe away the condensate.

MATERIALS OF CONSTRUCTION

Body .....Cast Iron
ASTM A126 Class B



DIMENSIONS* inches (mm) **AND WEIGHTS** pounds (kg)

Model	Outlet	A	B	C	D	E	F	G	Weight
DPE-D	¾	2 (51)	3¾ (95)	2¾ (70)	2 (51)	1 (25)	⅜ (10)	1½ (38)	2 (.9)
DPE-E	1	2 (51)	3¾ (95)	2¾ (70)	2 (51)	1 (25)	⅜ (10)	1½ (38)	2 (.9)
DPE-F	1¼	2.5 (65)	5½ (140)	4 15/16 (125)	4⅛ (105)	1 7/16 (37)	⅜ (10)	2⅛ (54)	4 (1.8)
DPE-G	1½	2.5 (65)	5½ (140)	4 15/16 (125)	4⅛ (105)	1 7/16 (37)	⅜ (10)	2⅛ (54)	4 (1.8)
DPE-H	2	3 (76)	6¼ (159)	4⅝ (117)	3⅝ (92)	1⅝ (41)	½ (13)	2¼ (57)	6 (2.7)
DPE-J	2½	4 (102)	7⅜ (187)	5 9/16 (141)	4 5/16 (110)	1 15/16 (49)	¾ (19)	2 11/16 (68)	11 (5.0)
DPE-K	3	4 (102)	8 (203)	6½ (165)	4⅞ (124)	2 5/16 (59)	¾ (19)	3⅛ (79)	14 (6.4)
DPE-M	4	6 (152)	9⅝ (244)	8¼ (210)	5¾ (146)	2⅞ (73)	¾ (19)	3¾ (95)	26 (11.8)
DPE-P*	6	8 (203)	12¾ (324)	11 9/16 (294)	7 9/16 (192)	4 3/16 (106)	¾ (19)	8 (203)	74 (33.6)
DPE-Q*	8	10 (254)	16½ (419)	14⅜ (378)	9 9/16 (243)	5¾ (146)	1 (25)	10¾ (273)	100 (45.4)

*6" and 8" Drip Pan Elbows have integral 125# flange.

NOTES:

DESIGN

BASICS OF RELIEF VALVES

Types of Relieving Devices

Pressure Relief Valve - A pressure relief device designed to re-close and prevent the further flow of fluid after normal conditions have been restored.

- **Safety Valve** - An automatic pressure relieving device actuated by the static pressure upstream of the valve, and characterized by rapid full opening or pop action. It is used for steam, gas or vapor service
- **Relief Valve** - An automatic pressure relieving device actuated by the static pressure upstream of the valve, opening in direct proportion to the pressure increase. It is used primarily for liquid service.
- **Safety Relief Valve** - An automatic pressure relieving device suitable for use as either a safety or relief valve, depending on application.
- **Conventional Safety Relief Valve** - A safety relief valve having its spring housing vented to the discharge side and which is directly affected by fluctuations in backpressure.
- **Balanced-Bellows Safety Relief Valve** - A safety relief valve incorporation in its design a means of compensation for fluctuations due to backpressure.
- **Pilot Operated Pressure Relief Valve** - A pressure relief valve in which the major relieving valve is combined with and is controlled by a self-actuated auxiliary pressure relief valve.

Temperature Relief Valve (P&T) - A pressure relief valve which may be actuated by external or internal temperature or by pressure o the inlet side.

Rupture Disc - A nonre-closing pressure relief device actuated by inlet static pressure and designed to function by the bursting of a pressure containing disc.

Breaking Pin Device - A nonre-closing pressure relief device actuated by inlet static pressure and designed to function by the breakage of a load-carrying section of a pin which supports a pressure containing member.

Parts

Nozzle - The pressure containing element which constitutes the inlet flow passage and includes the fixed portion of the seat closure. The nozzle can be of two designs: Full-nozzle or Semi-nozzle.

- **Full Nozzle** - a single member extending from the face of the inlet flange to the valve seat.
- **Semi-Nozzle** - the lower part of the inlet throat is formed by the body casting and the upper part is valve seat threaded or welded into the valve body

Disc - The pressure containing movable element of a pressure relief valve which effects closure.

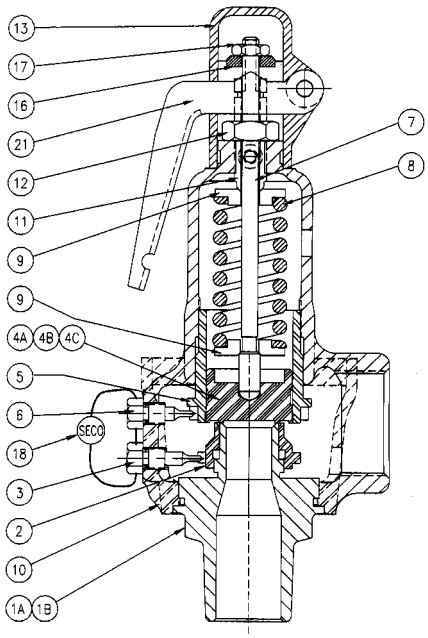
Trim - Internal parts. Specifically the seat (nozzle) & disc.

Orifice - A computed area of flow for use in flow formulas to determine the capacity of a pressure relief valve.

Huddling Chamber - The annular pressure chamber located beyond the valve seat for the purpose of generating a popping characteristic.

Lifting Device (Lever) - A device to manually open a pressure relief valve by the application of external force to lessen the spring loading which holds the valve closed. Lifting devices can be an open lever or a packed lever (fully enclosed design).

Balanced Bellows - A bellows designed so that the effective area of the bellow is equivalent to that of the valve seat, thereby canceling out the additive effect of the backpressure. Balanced bellows are used for the following reasons: Backpressure is excessive or variable, fluid is highly viscous or slurry, or the fluid is corrosive to the upper works of the valve.



BASICS OF RELIEF VALVES, CONT'D.

Operational Characteristics

Rated Capacity - The measured flow at an authorized percent overpressure permitted by the applicable code. Rated capacity is generally expressed in lbs/hr for Steam, SCFM for gases and GPM for liquids.

Operating Pressure - The pressure to which the vessel is usually subjected in normal service.

Set Pressure - The inlet pressure at which the valve is adjusted to open under service conditions. On a relief valve (liquid service), this is considered the point at which the first continuous stream of water starts to discharge and runs vertically down from the outlet of the valve. On a safety valve (Steam, air or gas) it is the inlet pressure at which the valve "pops" (not the point of first audible simmer or warning).

Cold Differential Test Pressure (CDTP) - The inlet static pressure at which a pressure relief valve is adjusted to open on the test stand. This test pressure includes corrections for service conditions of backpressure and/or temperature.

Simmer (Warn/Pre-Open) - The audible or visible escape of fluid between the seat and disc at an inlet static pressure below set pressure and at no measurable capacity. All pressure relief valves will have some simmer. Typically a metal seated valve will simmer at 90% of the set pressure and a soft seated valve will simmer at 95% of the set pressure.

Coefficient of Discharge - The ratio of the measured relieving capacity to the theoretical relieving capacity.

Maximum Allowable Working Pressure (MAWP) - The maximum gauge pressure permissible in a vessel at a designated temperature.

Overpressure - The pressure increase over the set pressure of a pressure relief valve, usually expressed as a percentage of the set pressure.

Accumulation - The pressure increase over the maximum allowable working pressure (MAWP) of the vessel during discharge through the pressure relief valve usually expressed as a percentage of the set pressure.

Blowdown - The difference between the actual set pressure of a pressure relief valve and the actual reseating pressure, expressed as a percentage of the set pressure or in pressure units.

Leak Test Pressure - The specified inlet static pressure at which a standard quantitative seat leakage test is performed.

Backpressure - Pressure from the discharge side of a pressure relief valve. There are two types of backpressure: Constant Backpressure and Variable Backpressure.

- **Constant Backpressure** - Backpressure which does not change appreciably under any condition of operation, whether or not the pressure relief valve is open or closed. A conventional relief valve may be used, provided the spring setting is reduced by the amount of the constant backpressure.
- **Variable Backpressure** - Pressure from the outlet side of the relief valve as a result of the Superimposed Variable Backpressure or Built-up Backpressure.
- **Superimposed Variable Backpressure** - A variable backpressure that is present before the pressure relief valve starts to open. It is usually the result of one or more valves discharging into a common header, causing a varying degree of backpressure on each valve connected to the system. It will cause the spring set pressure to be increased an amount equal to the backpressure. It can be negated by the use of a bellows-style relief valve.
- **Built-up Backpressure** - Pressure which develops at the valve outlet as a result of flow after the pressure relief valve has opened.

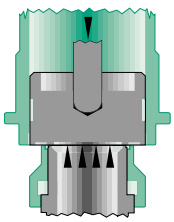
Lift - The actual travel of the disc away from the closed position when a valve is relieving.

Chatter - Abnormal, rapid reciprocation movement of the disc on the seat of a pressure relief valve.

DUAL RING CONTROL

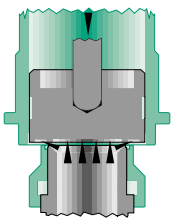
Safety Valves are pressure relief devices actuated by inlet static pressure and characterized by rapid opening or "pop" action. The difference between Safety Valves from different manufacturers is how well they do this.

Spence Figure 31 Safety Valves' Dual Ring Control allows for finer adjustment of the "popping" action and length of "blowdown". This allows exceptional flow efficiency and maximum lifting force while minimizing system energy loss.



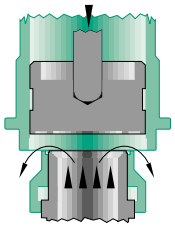
CLOSED

System pressure is pushing upward against the disk which is held closed by the downward force of the spring against the spindle.



OPENING

When system pressure rises above the set pressure of the spring, the disc begins to lift. This simmer/warn stage allows system pressure to enter the "huddling chamber" where it acts on a larger, secondary area of the disc. This magnified force causes the valve to "pop" open.



OPEN

As pressure increases, the disc continues to lift until fully open. When pressure is reduced to a level below the set point of the valve, the spring force against the spindle will snap shut the disc.

SIZING GUIDELINES

General

1. Recommend a 20% or 10 PSIG differential between operating and set pressure, whichever is greater. The set pressure of each pressure relief valve must be in conformance with limits specified in the appropriate ASME code.
2. Relieving Capacity
   a. ASME Section I - The minimum required relieving capacity of the pressure relief valve for all types of boilers shall not be less than the maximum designed steaming capacity as determined by the Manufacturer and shall be based on the capacity of all the fuel burning equipment as limited by other boiler functions. (ASME Section I, PG-67.2.1, 1998)
   b. ASME Section VIII - The minimum required relieving capacity shall be sufficient to carry off the maximum quantity that can be generated or supplied to the attached equipment without permitting a rise in pressure within the vessel with appropriate overpressure condition above the maximum allowable working pressure.
3. Pressure relief valves should not be oversized. Oversizing a pressure relief valve will cause chatter. A multiple valve selection should be used in order to eliminate the possibility of chattering. Use a multiple valve installation when:
   a. The maximum specified capacity requires selection of a pressure relief valve greater than 6 inch pipe size.
   b. When it is more economical to install two smaller valves than one very large one.
   c. If the normal operating capacity of the system is less than approximately 50% of the valve capacity. In this case the volume is not sufficient to keep the valve in its open position and the spring will push the valve closed causing chattering. The first pressure relief valve should be sized on the normal operating capacity and the remaining should be sized on the additional capacity that can be required during the maximum possible capacity of the system.

Single Valve Installation

1. Set pressure of the pressure relief valve shall be set at or below the Maximum Allowable Working Pressure (MAWP) of the weakest item in the system. This includes but is not limited to Steam Boilers, Pressure Vessels and Equipment and Piping Systems.
2. Overpressure
   a. ASME Section I - The pressure cannot rise more than 6% above the maximum allowable working pressure (ASME Section I, PG-67.2, 1998)
   b. ASME Section VIII - The pressure cannot rise more than 10% or 3 psi, whichever is greater, above the MAWP. (ASME Section VIII, UG-125 (c), 1998).

Multiple Valve Installation

1. Overpressure
   a. ASME Section I - The pressure cannot rise more than 6% above the maximum allowable working pressure (ASME Section I, PG-67.2, 1998)
   b. ASME Section VIII - The pressure cannot rise more than 16% or 4 psi, whichever is greater, above the maximum allowable working pressure (ASME Section VIII, UG-125 (c)(1), 1998).
2. Set Pressure
   a. ASME Section I - One or more safety valves shall be set at or below the maximum allowable working pressure. If additional valves are used the highest pressure setting shall not exceed the MAWP by more than 3%. The complete range of pressure settings of all the saturated steam safety valves shall not exceed 10% of the highest set pressure to which any valve is set. (ASME Section I, PG-67.3, 1998)
   b. Section VIII - One valve need to be set at or below the MAWP and the other valves can be set at a higher pressure not to exceed 105% of the MAWP of the weakest item in the system. (ASME Section VIII, UG-134, 1998)

Pressure Relief Valves In Pressure Reducing Stations

There has been much debate in regards to the sizing of Pressure Relief Valves in Pressure Reducing Stations. The sizing guidelines presented below are the recommendations of Spence Engineering. These recommendations are conservative and based on the worst case scenarios. The guidelines are in agreement with the ASME Section VIII code, the National Board Inspection Code and the Power Piping Code ASME B31.1. It is important to understand that each local jurisdiction may have its own set of approved practices and those practices should be followed.

All sizing is based on maximum capacity from the source and piping is in accordance with handling the maximum pressure from the source. Determination of capacity through a given pipe size is complicated. Spence recommends the computation of such values should be through published fluid dynamics reference materials. If the capacity through the pipe is unknown, Spence suggests that when sizing for the limiting value, use the maximum capacity of the first pressure reducing valve and by-pass in the system or maximum capacity from the source, whichever is less.

A. Single Stage Reducing Stations

1. Where pressure reducing valves are used, one or more pressure relief valves shall be provided on the low pressure side of the system. Otherwise, the piping and equipment on the low pressure side of the system shall be designed to withstand the upstream design pressure. The relieving capacity provided shall be such that the design pressure of the low pressure system will not be exceeded if the reducing valve fails open ③ (ASME B31.1 section 122.5.1, 1995)

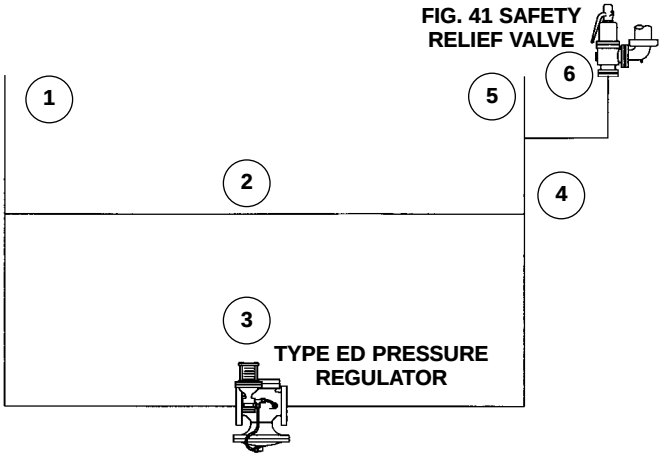


FIGURE A

SIZING GUIDELINES – CONT'D

2. Size SRV for pressure drop across regulator using regulator high side pressure and the safety relief valve set pressure.
3. Hand controlled bypass valves having a capacity no greater than the reducing valve may be installed around pressure reducing valves if the downstream piping is protected by relief valves as required in section ASME B31.1 Section 122.5.1 or if the design pressure of the downstream piping system and equipment is at least as high as the upstream pressure (ASME B31.1 section 122.5.2, 1995)
4. When a pressure reducing valve is installed, there are two possibilities of introducing boiler pressure into the low pressure system. It is necessary to determine the flow under both circumstances and check that the size of the pressure relief valve under either condition will be adequate. The two possibilities are:

   a) the failure of the pressure reducing valve so that it remains at 100% full travel ③

   b) the possibility of the by-pass valve being wide open ②

   (National Board Inspection Code ANSI/NB-23, Appendix G, 1999)

   When taking into consideration the worst possible scenario, Spence Engineering recommends that the pressure relief valve be sized for the maximum flow through both the pressure reducing valve ③ and the by-pass ② or the maximum possible flow through the downstream piping ④ whichever is less. Consideration should be given to the maximum capacity of the source ①.

   For unknown regulator and/or bypass valve capacities, see Section E for approximate sizing formulas
5. When calculating the maximum possible flow through the regulator, in all cases your sizing should be based on the largest orifice size available in the pipe size of the regulator ③. It may be possible that an originally supplied reduced orifice can be changed in the field to a full port orifice without any consideration to the effect on the capacity of the Pressure Relief Valve.
6. In determining the maximum flow through the pressure reducing valve when the valve fails, the failure mode should be considered when the valve plug has reached 100% full travel ③.

B. Parallel Pressure Reducing Stations

1. When sizing a pressure relief valve in a parallel pressure reducing station, the conditions listed above in (A) should all be met.

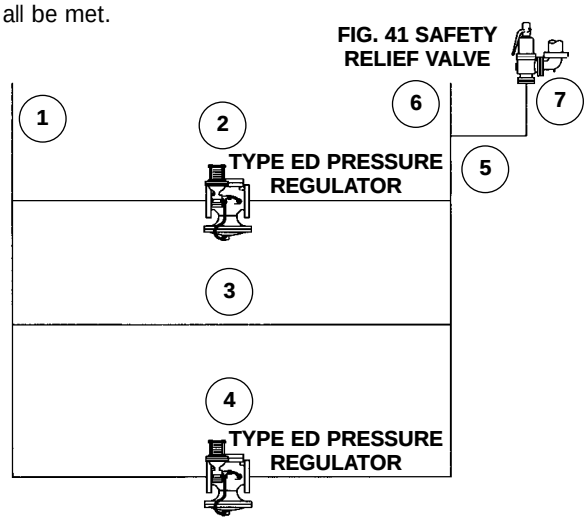


FIGURE B

2. In the case of failure of the pressure reducing valve, the capacity shall be sized on the basis of the possibility that both valves ② & ④ would fail open at the same time plus the by-pass ③ or the maximum possible flow through the downstream piping, whichever is less ⑤. Consideration should be given to the maximum capacity of the source ①.
3. Size SRV for pressure drop across regulator using regulator high side pressure and the safety relief valve set pressure.

C. Two Stage Pressure Reducing Stations

1. When sizing a pressure relief valve in a two stage pressure reducing station, the conditions listed above in (A) should all be met.
2. In the case of failure of the pressure reducing valve, the capacity shall be sized on the basis of the high side pressure regulator (National Board Inspection Code ANSI/NB-23, Appendix G, 1999) having the largest possible orifice size plus the bypass ② or the maximum possible flow through the downstream piping, whichever is less. Consideration should be given to the maximum capacity of the source ①.

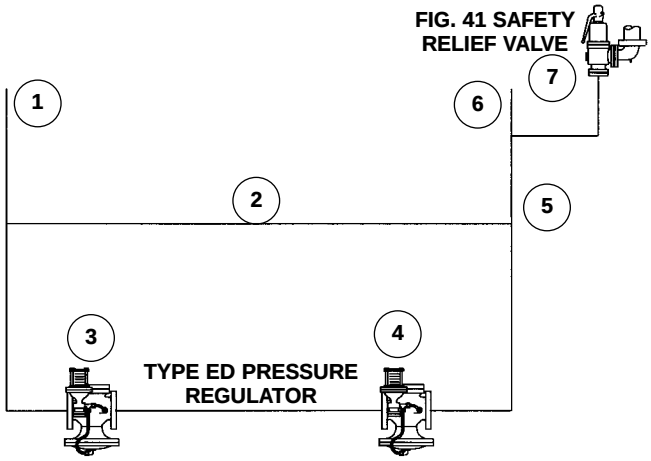


FIGURE C

3. If an intermediate pressure line is taken off between the pressure reducing valves then this line and the final low side shall be protected by pressure relief valves sized on the basis of the high side pressure and the largest possible orifice size of the first pressure reducing valve ③ in the line (National Board Inspection Code ANSI/NB-23, Appendix G, 1999) plus the bypass ② or the maximum possible flow through the downstream pipe ⑦, whichever is less. Consideration should be given to the maximum capacity of the source ①.

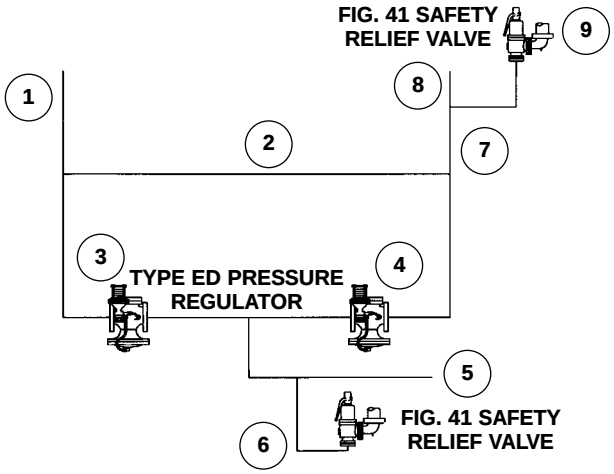


FIGURE D

SIZING GUIDELINES – CONT'D

4. If an intermediate by-pass line is designed in between the pressure reducing valves then the final low side shall be protected by a pressure relief valve sized on the basis of the high side pressure and the largest possible orifice size of the first of the two pressure reducing valves plus the bypass valves ②, ③ and ⑤ or the maximum possible flow through the downstream piping ⑦, whichever is less. Consideration should be given to the maximum capacity of the source ①.
5. Size SRV for pressure drop across regulator using regulator high side pressure and the safety relief valve set pressure.

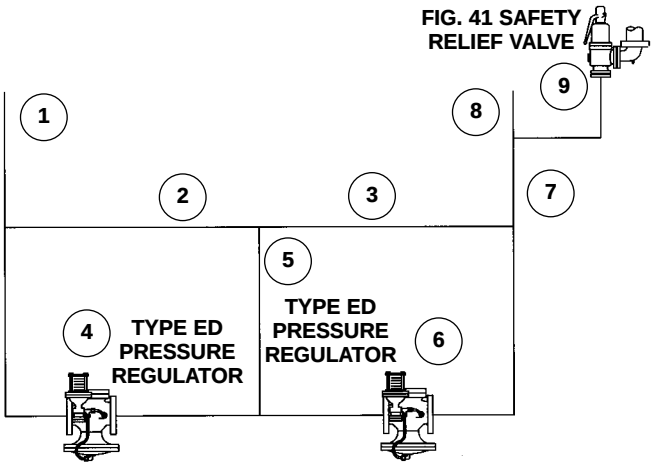


FIGURE E

D. Two Stage Parallel Pressure Reducing Station

1. Sizing is based whenever any condition from (B) and any condition from (C) applies.
2. In addition, all sizing should be based on maximum capacity from sources.

E. When Flow Coefficients Are Not Known

For sizing Spence regulators and/or control valves:
See Main Valve Sizing Formulas on page 68
See CV Data beginning on page 69

For all other manufacturer's valves where flow coefficients are not known, the following may be approximated.

It is possible that the flow coefficients K and K_1 may not be known and in such instances for approximating the flow, a factor of 1/3 may be substituted for K and 1/2 for K_1.

The formulas in E above then become:

W = 1/3AC for the capacity through the pressure reducing valve and

W = 1/2A_1 for the capacity through the by-pass valve

WHERE:

W = steam flow, in lbs/hr through the pressure reducing valve

A = internal area in sq. in. of the inlet pipe size of the pressure reducing valve (See Pipe Data Table)

A_1 = internal area in sq. in. of the pipe size of the bypass around the pressure reducing valve (See Pipe Data Table)

C = flow of saturated steam through a 1 sq. in. pipe at various pressure differentials (See Steam Capacity Table)

C_1 = flow of saturated steam through a 1 sp. In. pipe at various pressure differentials (See Steam Capacity Table)

Caution should be exercised when substituting these factors for the actual coefficients since this method will provide approximate values only and the capacities so obtained may in fact be lower than actual. It is recommended that the actual flow coefficient be obtained from the pressure reducing valve manufacture and reference books be consulted for the flow coefficient of the by-pass valve (National Board Inspection Code ANSI/NB-23, Appendix G, 1998).

PIPE DATA TABLE

Nominal Pipe Size, Inches	Actual external diameter, inches	Approx. internal diameter, inches	Approx. internal area square inches
3/8	0.675	0.49	0.19
1/2	0.840	0.62	0.3
3/4	1.050	0.82	0.53
1	1.315	1.05	0.86
1 1/4	1.660	1.38	1.5
1 1/2	1.900	1.61	2.04
2	2.375	2.07	3.36
2 1/2	2.875	2.47	4.78
3	3.500	3.07	7.39
3 1/3	4.000	3.55	9.89
4	4.500	4.03	12.73
5	5.563	5.05	19.99
6	6.625	6.07	28.89
8	8.625	8.07	51.15
10	10.750	10.19	81.55
12	12.750	12.09	114.8

Note: In applying these rules, the area of the pipe is always based upon standard weight pipe and the inlet size of the pressure reducing valve.

Adapted from National Board Inspection Code ANSI/NB-23, Appendix G, 1998.

CAPACITY OF SATURATED STEAM TABLE

(lb/hr) per sq. in. of pipe area

Outlet pres.	PRESSURE REDUCING VALVE INLET PRESSURE, PSI												
psi	1500	1450	1400	1350	1300	1250	1200	1150	1100	1050	1000	950	900
1000	76560	72970	69170	64950	60540	55570	49930	43930	35230	25500	—	—	—
950	77430	74180	70760	67000	63100	58770	53920	48610	42380	34890	24910	—	—
900	77750	74810	71720	68340	64870	61040	56820	52260	47050	41050	33490	23960	—
850	77830	74950	72160	69130	66020	62610	58900	54930	50480	45470	39660	29080	23190
800	—	75070	72330	69490	66700	63680	60390	56910	53060	48800	43980	38340	31610
750	—	—	—	69610	66880	64270	61260	58200	54840	51170	47080	42420	37110
700	—	—	—	—	66900	64270	61520	58820	55870	52670	49170	45230	40860
650	—	—	—	—	—	—	61550	56260	56260	53480	50440	47070	43400
600	—	—	—	—	—	—	—	56270	56270	53660	51020	48470	45010
550	—	—	—	—	—	—	—	—	—	53810	51040	48470	45800
500	—	—	—	—	—	—	—	—	—	—	—	—	45850
450	—	—	—	—	—	—	—	—	—	—	—	—	45870

Outlet pres.	PRESSURE REDUCING VALVE INLET PRESSURE, PSI												
psi	850	800	750	700	650	600	550	500	450	400	350	300	250
800	22550	—	—	—	—	—	—	—	—	—	—	—	—
750	30600	21800	—	—	—	—	—	—	—	—	—	—	—
700	35730	29420	21020	—	—	—	—	—	—	—	—	—	—
650	39200	34250	28260	20190	—	—	—	—	—	—	—	—	—
600	41500	37470	32800	27090	19480	—	—	—	—	—	—	—	—
550	42840	39850	35730	31310	25940	18620	—	—	—	—	—	—	—
500	43330	40530	37610	33880	29760	24630	17720	—	—	—	—	—	—
450	43330	40730	38150	35260	31980	28080	23290	16680	—	—	—	—	—
400	—	40760	38220	35680	33050	29980	26380	21870	15760	—	—	—	—
350	—	—	—	—	33120	30690	27910	24570	20460	14790	—	—	—
300	—	—	—	—	33240	—	28140	25610	22620	18860	13630	—	—
250	—	—	—	—	—	—	28150	25650	23200	21000	17100	10800	—
200	—	—	—	—	—	—	—	—	—	21350	18250	15350	10900
175	—	—	—	—	—	—	—	—	—	—	18250	16000	12600
150	—	—	—	—	—	—	—	—	—	—	18250	16200	13400
125	—	—	—	—	—	—	—	—	—	—	18780	—	13600
110	—	—	—	—	—	—	—	—	—	—	—	—	13600
100	—	—	—	—	—	—	—	—	—	—	—	—	13600
85	—	—	—	—	—	—	—	—	—	—	—	—	13600
75	—	—	—	—	—	—	—	—	—	—	—	—	13600
60	—	—	—	—	—	—	—	—	—	—	—	—	13630

Outlet pres.	PRESSURE REDUCING VALVE INLET PRESSURE, PSI												
psi	200	175	150	125	100	85	75	60	50	40	30	25	0
175	7250	—	—	—	—	—	—	—	—	—	—	—	—
150	9540	6750	—	—	—	—	—	—	—	—	—	—	—
125	10800	8780	6220	—	—	—	—	—	—	—	—	—	—
110	11000	9460	7420	4550	—	—	—	—	—	—	—	—	—
100	11000	9760	7970	5630	—	—	—	—	—	—	—	—	—
85	11000	—	8480	6640	4070	—	—	—	—	—	—	—	—
75	11000	—	—	7050	4980	3150	—	—	—	—	—	—	—
60	11000	—	—	7200	5750	4540	3520	—	—	—	—	—	—
50	11000	—	—	—	5920	5000	4230	2680	—	—	—	—	—
40	11000	—	—	—	—	5140	4630	3480	2470	—	—	—	—
30	11050	—	—	—	—	—	—	3860	3140	2210	—	—	—
25	—	—	—	—	—	—	—	—	3340	2580	1485	—	—
15	—	—	—	—	—	—	—	—	—	2830	2320	1800	—
10	—	—	—	—	—	—	—	—	—	—	—	2060	—

Where capacities are not shown for inlet and outlet conditions, use the highest capacity shown under the applicable inlet pressure column.

Adapted from National Board Inspection Code ANSI/NB-23, Appendix G, 1998.

SAFETY VALVE SIZING BY COMPUTATION

FORMULA KEY

A = Actual discharge area through the valve at developed lift, inches² *See formulas below*

C = Constant for gas or vapor based on ratio of specific heats C_p/C_v *See Tables E2 and E3 beginning on page 55*

G = Specific gravity of fluid (Relates the densities of a fluid to that of a standard fluid) *See Table E2 on page 55*
1.0 for water @70°F and air at 14.7 psia and 60°F

K_b = Dimensionless number used to correct for the reduction in capacity due to effect of backpressure:
For conventional valves: *See Graph E5 on page 58*
For balanced bellows valves: *See Graph E6 on page 59*

K_d = Coefficient of discharge (including 90% de-rating) *See Table E1 on page 55*

K_n = Napier steam correction factor for set pressures between 1423 and 2900 psig:
≤1423 psig $K_n = 1.00$
>1423 psig $K_n = \frac{.1906P - 1000}{.2292P - 1061}$

K_p = Correction factor for overpressure *See Table E7 on page 59*
= 1.0 at 25% overpressure

K_{sh} = Steam superheat correction factor (use 1.00 for saturated steam) *See Table E4 on page 57*

K_v = Capacity correction factor for viscosity *See Graph E8 on page 60*

K_w = Liquid capacity correction factor for backpressure service balanced bellows valves only *See Graph E9 on page 60*

M = Molecular weight *See Table E2 on page 55*

P = Stamped set pressure + overpressure + 14.7 psia *See Spence Testing Specification Chart page 61*

ΔP = [Stamped set pressure + 3 psi or 10% (whichever is greater)] – backpressure, psi

ΔP_1 = [Stamped set pressure + 3 psi or 25% (whichever is greater)] – backpressure, psi

T = Absolute temperature at inlet, °R (degrees F + 460)

W = Rated capacity, Steam (lbs/hr), Air (SCFM), Gas or Vapor (lbs/hr or SCFM), Liquid (GPM)

Z = Compressibility factor corresponding to T and P for gas and vapor (If unknown, use 1.0)

ASME SECTION I POWER BOILERS

$$A = \frac{W}{51.45\ K_d P K_{sh} K_b K_n}$$

ASME SECTION IV HEATING BOILERS

$$A = \frac{W}{51.45\ K_d P K_b}$$

ASME SECTION VIII – PRESSURE VESSELS

STEAM (LBS/HR)

$$A = \frac{W}{51.5\ K_d P K_{sh} K_b K_n}$$

GAS OR VAPOR (LBS/HR)

$$A = \frac{W\sqrt{T}\sqrt{Z}}{C K_d P \sqrt{M}\ K_b}$$

AIR (SCFM)

$$A = \frac{W\sqrt{T}}{418\ K_d P K_b}$$

LIQUID–10% OVERPRESSURE (GPM) CODE

$$A = \frac{W\sqrt{G}}{38.0\ K_d \sqrt{\Delta P}\ K_v K_w}$$

GAS OR VAPOR (SCFM)

$$A = \frac{W\sqrt{G}\sqrt{T}\sqrt{Z}}{1.175\ C K_d P K_b}$$

LIQUID–25% OVERPRESSURE (GPM) NON CODE

$$A = \frac{W\sqrt{G}}{38.0\ K_d \sqrt{\Delta P_1}\ K_p K_v K_w}$$

All sizing equations are in compliance with API 520 Part I 1997. Please refer to that document for further information on sizing. The user is responsible for verifying that these are the currently accepted formulae and for contacting the manufacturer(s) for all applicable required coefficients. Neither Spence Engineering Company nor it's agents assume any liability for improperly sized valves.

TABLE E1–SPENCE VALVE COEFFICIENTS (K_d)

(90% de-rated, as required by ASME)

Model	Steam/Air/Gas/Vapor (Kd)	Liquid (Kd)
Figure 31 Series Bronze	.878	—
Figure 31 Series Cast Iron	.878	—
Figure 800 Series	.878	.752
Figure 10 Series	.800	—
Figure 15 Series	.711	—
Figure 50 Series	.624	—

TABLE E2–TYPICAL PROPERTIES OF GASES

Gas or Vapor	Ratio of Specific Heats (k) @14.7 psia	Coefficient (C)	Molecular Weight (M)	Specific Gravity (Air=1)
Acetylene	1.25	342	26.04	.899
Acetic Acid	1.15	332	60.05	2.073
Air	1.40	356	28.97	1.00
Ammonia	1.30	347	17.03	.588
Argon	1.66	377	39.94	1.379
Benzene	1.12	329	78.11	2.696
N-Butane	1.18	335	58.12	2.006
Iso-Butane	1.19	336	58.12	2.006
Carbon Dioxide	1.29	346	44.01	1.519
Carbon Monoxide	1.40	356	28.01	.967
Chlorine	1.35	352	70.90	2.447
Ethane	1.19	336	30.07	1.038
Ethyl Alcohol	1.13	330	46.07	1.590
Ethylene	1.24	341	28.03	0.968
Freon 11	1.14	331	137.37	4.742
Freon 12	1.14	331	120.92	4.742
Freon 22	1.18	335	86.48	2.985
Freon 114	1.09	326	170.93	5.900
Helium	1.66	377	4.02	0.139
Hydrochloric Acid	1.41	357	36.47	1.259
Hydrogen	1.41	357	2.02	0.070
Hydrogen Chloride	1.41	357	36.47	1.259
Methane	1.31	348	16.04	0.554
Methyl Alcohol	1.20	337	32.04	1.106
Natural Gas	1.27	344	19.00	0.656
Nitric Oxide	1.40	356	30.00	1.036
Nitrogen	1.40	356	28.02	0.967
Nitrous Oxide	1.31	348	44.02	1.520
Oxygen	1.40	356	32.00	1.105
Propane	1.13	330	44.09	1.522
Propylene	1.15	332	42.08	3.60
Sulfur Dioxide	1.27	344	64.04	2.211

TABLE E3–GAS CONSTANT (C)

k	C
1.00	315
1.02	318
1.04	320
1.06	322
1.08	324
1.10	327
1.12	329
1.14	331
1.16	333
1.18	335
1.20	337
1.22	339
1.24	341
1.26	343
1.28	345
1.30	347
1.32	349
1.34	351
1.36	352
1.38	354
1.40	356
1.42	358
1.44	359
1.46	361
1.48	363
1.50	364
1.52	366
1.54	368
1.56	369
1.58	371
1.60	372
1.62	374
1.64	376
1.66	377
1.68	379
1.70	380
2.00	400
2.20	412

The relationship of (C) to (k) is expressed by the following equation:

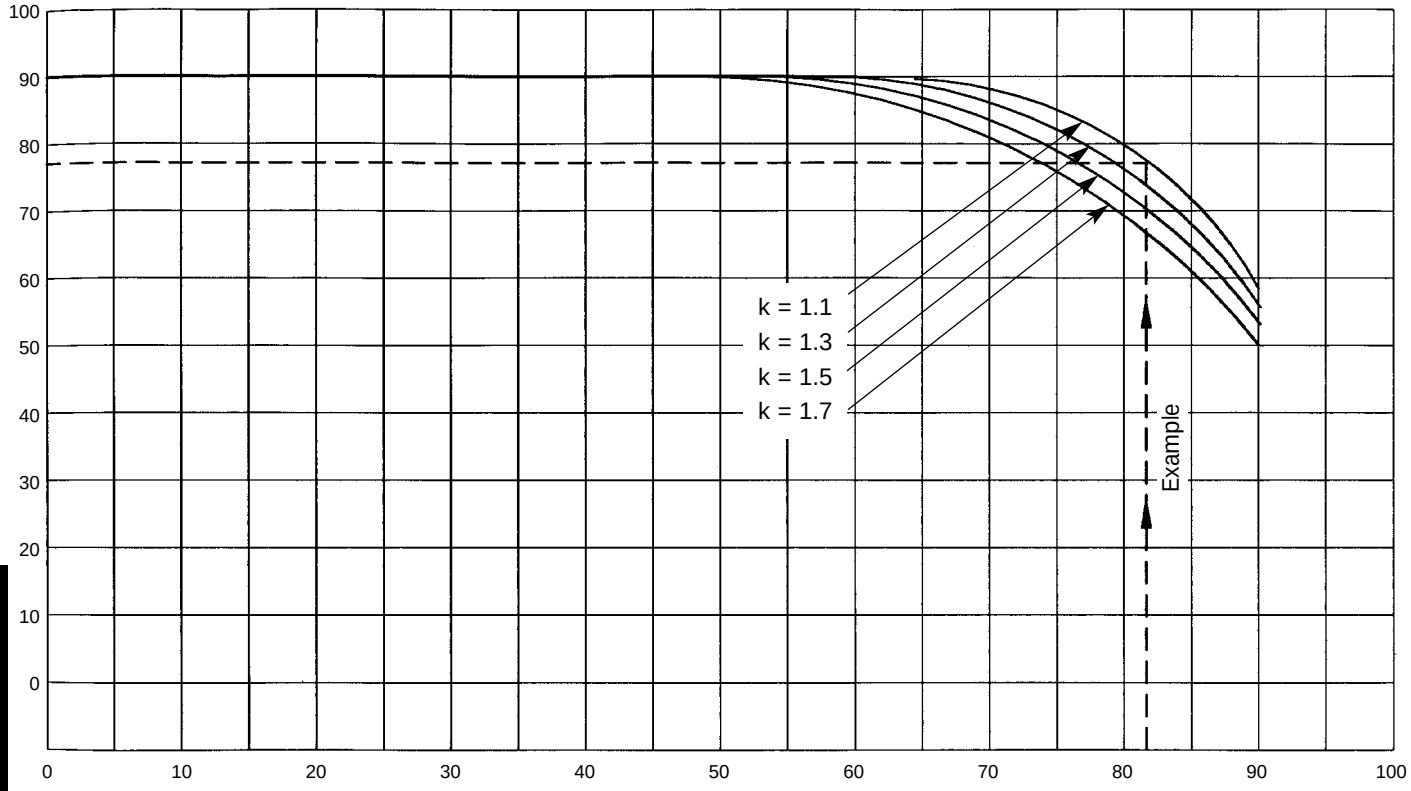
$$C = 520\sqrt{k\left(\frac{2}{k+1}\right)^{\frac{k+1}{k-1}}}$$

Table E4–Superheat Correction Factor (K_{sh})

Set Press. (psig)	Sat. Stm. Temp. °F	Total Temperature of Superheated Steam °F 280	300	320	340	360	380	400	420	440	460	480	500	520	540	560	580	600	620	640	660	680	700	720	740	760	780	800	820	840	860	880	900	920	940	960	980	1,000
15	250	1.00	1.00	1.00	0.99	0.99	0.98	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.86	0.85	0.84	0.83	0.83	0.82	0.81	0.81	0.80	0.79	0.79	0.78	0.78	0.77	0.76	0.76	0.75	0.75
20	259	1.00	1.00	1.00	0.99	0.99	0.98	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.96	0.86	0.85	0.84	0.83	0.83	0.82	0.81	0.81	0.80	0.79	0.79	0.78	0.78	0.77	0.77	0.76	0.75	0.75
40	287	—	1.00	1.00	1.00	0.99	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.82	0.81	0.80	0.79	0.79	0.78	0.78	0.77	0.77	0.76	0.75	0.75
60	308	—	—	1.00	1.00	0.99	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.77	0.76	0.76	0.75
80	324	—	—	—	1.00	1.00	0.99	0.99	0.98	0.97	0.96	0.94	0.93	0.92	0.91	0.90	0.89	0.89	0.88	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.77	0.76	0.76	0.75
100	338	—	—	—	—	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.77	0.76	0.76	0.75
120	350	—	—	—	—	1.00	1.00	0.99	0.98	0.97	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.77	0.76	0.76	0.75
140	361	—	—	—	—	—	1.00	1.00	0.99	0.98	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.77	0.76	0.76	0.75
160	371	—	—	—	—	—	1.00	1.00	0.99	0.98	0.97	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.86	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.79	0.78	0.77	0.77	0.76	0.76	0.75
180	380	—	—	—	—	—	—	1.00	0.99	0.98	0.97	0.96	0.95	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.86	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.79	0.78	0.77	0.77	0.76	0.76	0.75
200	388	—	—	—	—	—	—	1.00	0.99	0.99	0.97	0.96	0.95	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.86	0.85	0.84	0.83	0.83	0.82	0.81	0.81	0.80	0.79	0.79	0.78	0.77	0.77	0.76	0.76	0.75
220	395	—	—	—	—	—	—	1.00	1.00	0.99	0.98	0.96	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.79	0.78	0.78	0.77	0.76	0.76	0.75
240	403	—	—	—	—	—	—		1.00	0.99	0.98	0.97	0.95	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.79	0.78	0.78	0.77	0.76	0.76	0.75
260	409	—	—	—	—	—	—	—	1.00	0.99	0.98	0.97	0.96	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.79	0.78	0.78	0.77	0.76	0.76	0.75
280	416	—	—	—	—	—	—	—	1.00	1.00	0.99	0.97	0.96	0.95	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.77	0.76	0.75
300	422	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.96	0.95	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.86	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.77	0.76	0.75
350	436	—	—	—	—	—	—	—	—	1.00	1.00	0.99	0.97	0.96	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.78	0.77	0.77	0.76	0.76
400	448	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.96	0.95	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.79	0.78	0.77	0.77	0.76	0.76
450	460	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.96	0.94	0.93	0.92	0.91	0.89	0.88	0.87	0.86	0.86	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.79	0.79	0.78	0.78	0.77	0.76	0.76
500	470	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.96	0.94	0.93	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.79	0.79	0.78	0.78	0.77	0.76	0.76
550	480	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.95	0.94	0.92	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.76	0.76
600	489	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.96	0.94	0.93	0.92	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.76	0.76
650	497	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.95	0.94	0.92	0.91	0.90	0.89	0.87	0.86	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.78	0.77	0.77	0.76
700	506	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.96	0.94	0.93	0.91	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.79	0.78	0.77	0.77	0.76
750	513	—	—	—	—	—	—	—	—	—	—	—	—	1.00	1.00	0.98	0.96	0.95	0.93	0.92	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.83	0.82	0.81	0.80	0.79	0.79	0.78	0.77	0.77	0.76
800	520	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.95	0.94	0.92	0.91	0.90	0.88	0.87	0.86	0.85	0.84	0.84	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.78	0.77	0.76
850	527	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.96	0.94	0.93	0.92	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.78	0.77	0.76
900	533	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	1.00	0.99	0.97	0.95	0.93	0.92	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.79	0.78	0.77	0.77
950	540	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.95	0.94	0.92	0.91	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.82	0.81	0.80	0.79	0.79	0.78	0.77	0.77
1000	546	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.96	0.94	0.93	0.91	0.90	0.89	0.87	0.86	0.85	0.84	0.83	0.83	0.82	0.81	0.80	0.79	0.79	0.78	0.77	0.77
1050	552	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	1.00	0.99	0.97	0.95	0.93	0.92	0.90	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.77	0.77
1100	558	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.95	0.94	0.92	0.91	0.89	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.78	0.77
1150	563	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.96	0.94	0.92	0.91	0.90	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.78	0.77
1200	569	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.97	0.95	0.93	0.91	0.90	0.89	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.78	0.77
1250	574	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.95	0.93	0.92	0.90	0.98	0.88	0.87	0.85	0.85	0.84	0.83	0.82	0.81	0.80	0.79	0.79	0.78	0.77
1300	579	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.96	0.94	0.92	0.91	0.98	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.80	0.79	0.79	0.78	0.77
1350	584	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.98	0.96	0.94	0.93	0.91	0.90	0.88	0.87	0.86	0.85	0.84	0.83	0.82	0.81	0.80	0.80	0.79	0.78	0.78
1400	588	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	1.00	0.99	0.97	0.95	0.93	0.92	0.90	0.89	0.88	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.78
1450	593	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.95	0.94	0.92	0.90	0.89	0.88	0.86	0.85	0.84	0.83	0.82	0.81	0.81	0.80	0.79	0.78	0.78
1500	597	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.96	0.94	0.92	0.91	0.89	0.88	0.87	0.86	0.84	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.78
1600	606	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.98	0.97	0.96	0.94	0.93	0.91	0.89	0.88	0.86	0.85	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.78	0.77
1700	615	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.99	0.97	0.96	0.95	0.93	0.91	0.89	0.88	0.86	0.85	0.84	0.83	0.82	0.81	0.79	0.79	0.78	0.77	0.77
1800	622	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.99	0.98	0.97	0.95	0.93	0.91	0.89	0.88	0.86	0.85	0.84	0.82	0.81	0.80	0.79	0.79	0.78	0.77	0.76
1900	630	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.98	0.97	0.96	0.93	0.91	0.89	0.88	0.86	0.85	0.84	0.82	0.81	0.80	0.79	0.78	0.78	0.77	0.76
2000	636	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.98	0.96	0.93	0.91	0.89	0.87	0.86	0.84	0.83	0.82	0.81	0.80	0.79	0.78	0.77	0.76	0.76
2100	644	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.98	0.95	0.93	0.91	0.89	0.87	0.86	0.84	0.83	0.82	0.81	0.79	0.78	0.77	0.77	0.76	0.75
2200	650	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.98	0.95	0.93	0.91	0.89	0.87	0.85	0.84	0.82	0.81	0.80	0.79	0.78	0.77	0.76	0.75	0.74
2300	658	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.98	0.95	0.93	0.91	0.89	0.87	0.85	0.84	0.82	0.81	0.79	0.78	0.77	0.76	0.75	0.75	0.74
2400	663	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.98	0.95	0.93	0.91	0.89	0.87	0.85	0.83	0.82	0.80	0.79	0.78	0.77	0.76	0.75	0.74	0.73
2500	669	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.98	0.95	0.93	0.90	0.88	0.86	0.84	0.83	0.81	0.80	0.78	0.77	0.76	0.75	0.74	0.73	0.72
2600	675	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.96	0.93	0.90	0.88	0.85	0.84	0.82	0.80	0.79	0.77	0.76	0.75	0.74	0.73	0.72	0.71
2700	680	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.95	0.90	0.88	0.85	0.83	0.81	0.79	0.78	0.76	0.75	0.74	0.73	0.72	0.71	0.70
2800	686	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.95	0.90	0.88	0.85	0.82	0.80	0.78	0.76	0.75	0.74	0.73	0.72	0.71	0.70	0.69
2900	691	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.00	0.90	0.87	0.84	0.82	0.80	0.78	0.76	0.75	0.73	0.72	0.71	0.70	0.69	0.68

GRAPH E5–SUPERIMPOSED (CONSTANT) BACKPRESSURE SIZING FACTOR (K_b)

CONVENTIONAL VALVES (Vapors and Gases Only)



FORMULA KEY

P_b = Backpressure, psia
P_s = Set Pressure, psia
P_o = Overpressure, psi

$$\% \text{ of absolute backpressure} = \frac{P_b}{P_s + P_o} \times 100$$

EXAMPLE: (ASME SECTION VIII)

Set pressure	= 100 psig
Overpressure (10%)	= 10 psi
Superimposed backpressure	= 70 psig
k	= 1.3

SOLUTION:

$$\% \text{ of absolute backpressure} = \frac{(70+10+14.7)}{(100+10+14.7)} \times 100 = 76$$

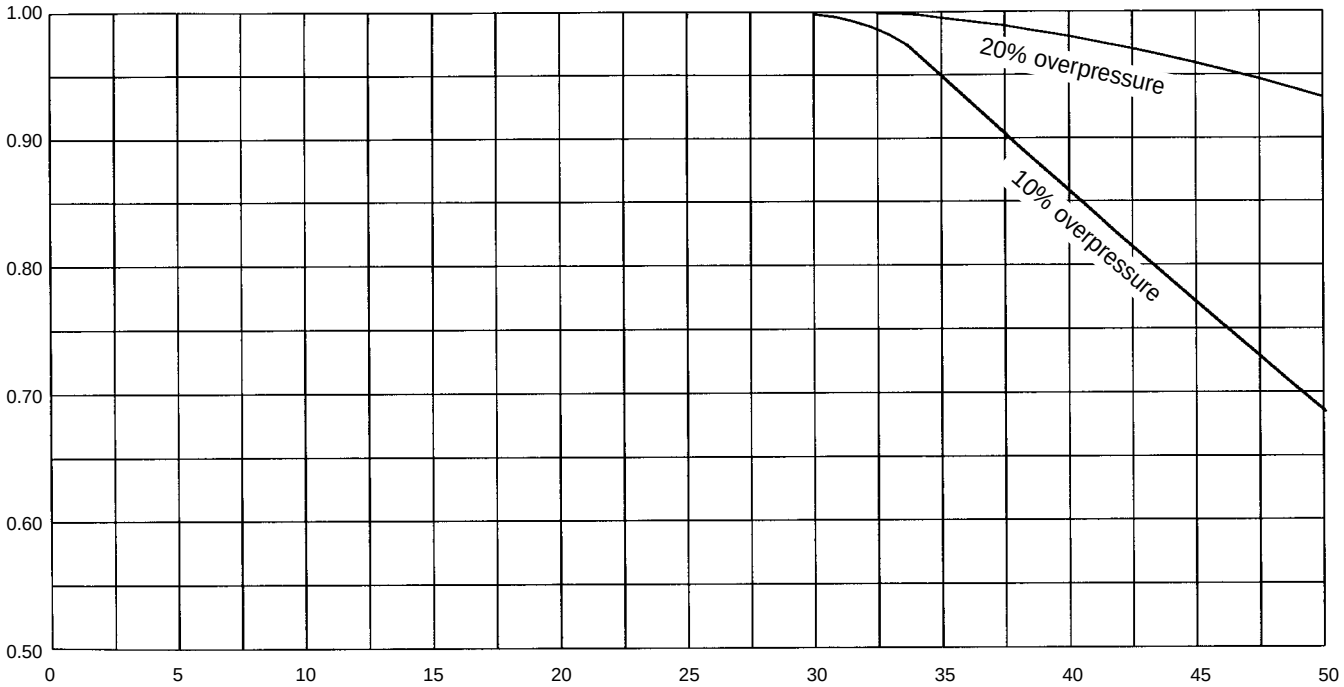
K_b (follow dotted line) = .89 (from curve)
Capacity with backpressure = .89 (rated capacity without backpressure

Note: This chart is typical and suitable for use only when the make of the valve or the actual critical flow pressure point for the vapor or gas is unknown; otherwise, the valve manufacturer should be consulted for specific data. This correction factor should be used only in the sizing of conventional pressure relief valves that have their spring setting adjusted to compensate for the superimposed backpressure. It should not be used to size Balanced Bellow type valves (see next page).

Information from API 520 Part I, 1997

GRAPH E6–SUPERIMPOSED OR VARIABLE BACKPRESSURE SIZING FACTOR (K_b)

BELLOWS VALVES

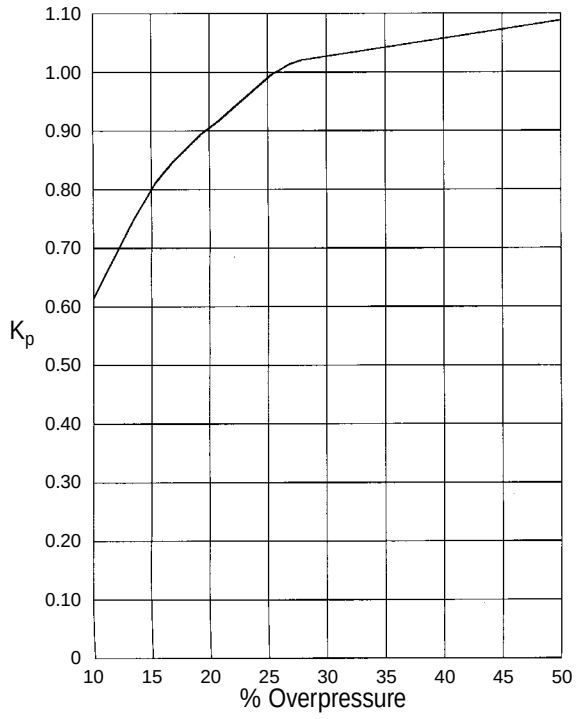


FORMULA KEY

P_b = Backpressure, psia
P_s = Set Pressure, psia

$$\% \text{ of gauge backpressure} = \frac{P_b}{P_s} \times 100$$

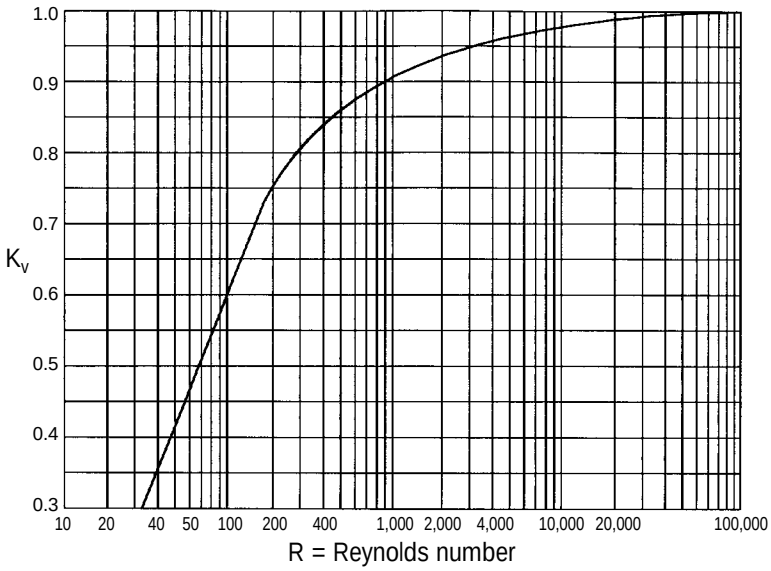
Note: The curves above represent a compromise of the values recommended by a number of relief valve manufacturers and may be used when the make of the valve or the actual critical flow pressure point for the vapor of the gas is unknown. When make is known, the manufacturer should be consulted for the correction factor. These curves are for set pressure of 50 psig and above. They are limited to backpressure below critical flow pressure for a given set pressure. For subcritical flow backpressure below 50 psig, the manufacturer must be consulted for values of K_b . Information from API 520 Part I, 1997



GRAPH E7–CAPACITY CORRECTION FACTORS DUE TO OVERPRESSURE

VALVES IN LIQUID SERVICE

Note: The curve on the left shows that, at 25% or less overpressure, capacity is affected by the change in lift, the change in orifice discharge coefficient and the change in over-pressure, Above 25% overpressure, capacity is affected only by the change in over-pressure. Valves operating at low overpressure tend to chatter, therefore, over-pressures of less than 10% should be avoided.
Information from API 520 Part I, 1997



GRAPH E8–CAPACITY CORRECTION FACTOR DUE TO VISCOSITY

When a relief valve is sized for viscous liquid service, it is suggested that it first be sized for nonviscous type application in order to obtain a preliminary required discharge area, (A). The next larger manufacturers' standard orifice orifice size should be used in determining the Reynold's number from either of the formulae below.

After the value of R is determined, the factor K_v is obtained from the graph on the left. K_v is applied to correct the preliminary required discharge area. If the corrected area exceeds the chosen standard orifice area, the above calculation should be repeated using the next larger standard orifice size.

Information from API 520 Part I, 1997

FORMULA KEY

A = Effective discharge area, inches^2
G = Specific gravity of the liquid (referred to as water) at the flowing temperature, G = 1.00 at 70°F
Q = Flow rate at the flowing temperature, GPM
μ = Absolute viscosity at the flowing temperature, centipoises
U = Viscosity at the flowing temperature, Saybolt Universal seconds

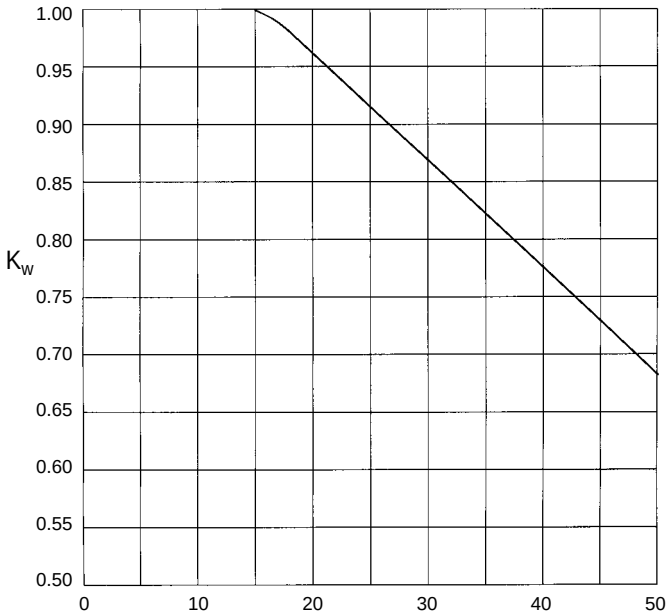
$$R = \frac{Q(2800G)}{\mu\sqrt{A}} \quad \text{or} \quad R = \frac{12{,}700Q}{U\sqrt{A}}$$

Second equation not recommended for viscosities less than 100 Saybolt Universal seconds.

GRAPH E9–CAPACITY CORRECTION FACTOR DUE TO BACKPRESSURE (K_w)

BALANCED BELLOWS VALVES IN LIQUID SERVICE

$$\% \text{ of gauge backpressure} = \frac{P_b}{P_s} \times 100$$



FORMULA KEY

P_b = Backpressure, psia
P_s = Set Pressure, psia

Note: The curve above represents values recommended various manufacturers. This curve may be used when the manufacturer is not known. Otherwise, the manufacturer should be consulted for the applicable correction factor.

Information from API 520 Part I, 1997

SPENCE SRV TESTING SPECIFICATIONS

Spence Safety and Relief Valves (unlike some competitor's valves) are tested and conform to API 527. These Spence Testing Specifications are in conformance with applicable ASME Code ***and*** API 527.

SET PRESSURE TOLERANCE/BLOWDOWN/OVERPRESSURE

Set Pressure psig or inches HG	Set Pressure Tolerance	Blowdown	Overpressure
ASME Section I – Power Boilers			
15 to 66	± 2 psig	2 to 4 psig	2 psig
67 to 70	± 2 psig	2 psig to 6%	3%
71 to 100	± 3%	2 psig to 6%	3%
101 to 250	± 3%	2% to 6%	3%
251 to 300	± 3%	2% to 15 psig	3%
301 to 375	± 10 psig	2% to 15 psig	3%
376 to 1000	± 10 psig	2% to 4%	3%
1001 and higher	± 1%	2% to 4%	3%
ASME Section IV – Heating Boilers			
Steam ≤ 15 psig	± 2 psig	2 to 4 psig	33.3%
Hot Water 15 to 60	± 3 psig	N/A *	10%
Hot Water 60 and higher	± 5%	N/A *	10%
ASME Section VIII – Pressure Vessels			
15 to 30	± 2 psig	N/A *	3 psig
31 to 70	± 2 psig	N/A *	10%
71 and higher	± 3%	N/A *	10%
Non-Code Set Pressure Tolerance			
5	± .5 psig	N/A *	3 psig
6 to 9	± 1 psig	N/A *	3 psig
10 to 14	± 2 psig	N/A *	3 psig
Vacuum Set Point Tolerances			
0 to 9	± 1 inch HG	N/A *	6 inch HG
10 to 19	± 2 inches HG	N/A *	6 inch HG
20 and higher	± 4 inches HG	N/A *	6 inch HG

* Contact factory for accurate blowdown setting.

LEAK TESTING (in accordance with API 527)

Test Pressures - ≤ 50 psig test at 5 psig below set pressure
> 50 psig test at 90% of set pressure

Service	Set Pressure psig	Size	Acceptable Leakage rate
Metal Seats			
Steam	15 – higher	All	No audible or visible leakage for 1 min
Air	15 – 1000	≤ .307 sq in orifice	40 bubbles/min
		> .307 sq in orifice	20 bubbles/min
Liquid	15 – higher	< 1" inlet	10 cc/hr per inch of inlet size
		≥ 1" inlet	10 cc/hr
Soft Seats			
Steam	15 – higher	All	No audible or visible leakage for 1 min
Air	15 – 1000	≤ .307" orifice size	0 bubbles/min
		> .307" orifice size	0 bubbles/min
Liquid	15 – higher	< 1" inlet size	0 cc/hr per inch of inlet size
		≥ 1" inlet size	0 cc/hr

SUMMARY OF ASME CODES & STANDARDS

The American Society of Mechanical Engineers (ASME) through its committees have established Boiler and Pressure Vessel codes for safety through rules and formulae indicating good practice.

The National Board of Boiler and Pressure Vessel Inspectors (NB) verify, administer and enforce the ASME codes wherever the codes have been adopted.

The ASME Codes are broken down into the following sections:

Sec I - Power Boilers
Sec II - Material Specifications
Sec III - Nuclear Power Plant Components
Sec IV - Heating Boilers (Low Pressure Steam & Hot Water)
Sec V - Non-destructive Examination
Sec VI - Recommended Rules for Care & Operation of Heating Boilers
Sec VII - Recommended Rules for Care of Power Boilers
Sec VIII - Pressure Vessels
Sec IX - Welding and Brazing Qualifications
Sec X - Fiberglass Reinforced Plastic Pressure Vessels
Sec XI - Rules for in service Inspection of Nuclear Power Plant Components

The three codes that pertain to Spence Pressure Relief Valves are as follows:

Section I (Power Boilers) - This is a construction code covering power, electric and miniature boilers and high temperature boilers used in stationary service. This section includes power boilers used in locomotive, portable and traction service.

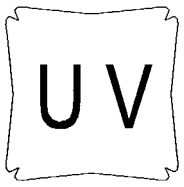
Section IV (Heating Boilers) - This is another construction code covering the design, fabrication, installation and inspection of steam heating, hot water heating and hot water supply boilers which are directly fired by oil, gas, electricity or coal.

Section VIII (Pressure Vessels) - Basic rules for the construction, design, fabrication, inspection and certification of pressure vessels. These rules have been formulated on the basis of design principles and construction practices applicable to vessels designed for pressures up to 3000 PSI. Stamping and coding are also covered in this section.

The appropriate symbols (below) are required on all ASME coded Pressure Relief Valves:

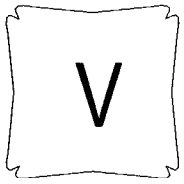
National Board Approved

And one of the following for the applicable ASME code:



Pressure vessel safety valves

Heating Boiler safety valves



Boiler safety Valve

COMPARISON OF ASME SECTION I TO SECTION VIII

CRITERIA	SECTION I	SECTION VIII
Set Point Tolerances	≤ 70 2 psig >70 & ≤ 300 3% > 300 & ≤ 1000 10 psig > 1000 1% (ASME Section I, PG-72.1, 1995)	≤ 70 2 psig > 70 3% (ASME Section VIII, UG-126 (d), 1995)
Blowdown Tolerances	< 67 4 psig > 67 & < 250 6% > 250 & < 375 15 psig > 375 4% minimum blowdown for all valves: 2 psi or 2%, whichever is greater (ASME Section I, PG-72.2, 1995)	No blowdown requirement in service.
Capacity Certifications	Full lift at no greater than 3% or 2 psig, (whichever is greater) above the set pressure without chattering. The published rated capacity is 90% of the average capacity of the valves tested. (ASME Section I, PG-69.1.4 & 69.2.1, 1995)	Full lift at no greater than 10% or 3 psig, (whichever is greater) above the set pressure without chattering. The published rated capacity is 90% of the average capacity of the valves tested. (ASME Section VIII, UG-131 (c)(1) & (d)(1), 1995)
Lifting Device	Lifting devices are required to enable lifting the disc while 75% of the set pressure is present. (ASME Section I, PG-73.1.3, 1995)	Lifting devices are required to enable lifting the disc while 75% of the set pressure is present for Air, Steam & Hot Water (over 140°F). (ASME Section VIII, UG-136 (a)(3), 1995)
Sealing of Adjustments	All external adjustments are to be (wire) sealed to prevent changing the adjustment without breaking the seal. It also serves to identify the manufacturer or his authorized assembler making the adjustment. (ASME Section I, PG-73.1.8, 1995)	All external adjustments are to be (wire) sealed to prevent changing the adjustment without breaking the seal. It also serves to identify the manufacturer or his authorized assembler making the adjustment. (ASME Section VIII, UG-136 (a)(7), 1995)
Markings on Valve	The markings shall be placed on the valve or on a nameplate securely fastened to the valve by the manufacturer or assembler. The markings shall include: the ASME Code "V" symbol, the name of the manufacturer and assembler, model number, inlet size, set pressure, rated capacity, year built and the "NB" symbol. (ASME Section I, PG-110, 1995)	The markings shall be placed on the valve or on a nameplate securely fastened to the valve by the manufacturer or assembler. The markings shall include: the ASME Code "UV" symbol, the name of the manufacturer and assembler, model number, inlet size, set pressure (if applicable, the CDTP),rated capacity in lbs/hr of steam, gal/min of water, SCFM or lb/min of air, year built and the "NB" symbol. (ASME Section VIII, UG-129) (a), 1995)
Materials	Seats, discs, springs and sliding surfaces shall be of corrosion resistant material and listed in ASTM specifications. Bodies and bonnets must be listed in ASME Section II. (ASME Section I, PG-73.2, 1995)	Seats, discs, springs and sliding surfaces shall be of corrosion resistant material and listed in ASTM specifications. Bodies and bonnets must be listed in ASME Section II. (ASME Section VIII, UG-136 (b), 1995)

INSTALLATION, MAINTENANCE & TROUBLESHOOTING GUIDELINES

Spence Pressure Relief valves are safety devices designed to protect pressurized vessels, lines or systems during an overpressure event. The recommendations below are general and it is the responsibility of the user to assure that installation and maintenance are in accordance with the applicable ASME Codes, API 520 Part II, local jurisdictional requirements and any other requirements. Neither Spence Engineering nor its agents assume any liability for valves improperly installed, maintained or troubleshot.

A. INSTALLATION - SINGLE VALVE

1. Installation must be performed by qualified service personnel only.
2. Pressure relief devices intended for use in compressible fluid service shall be connected to the vessel in the vapor space above any contained liquid or to piping connected to the vapor space in the vessel that is to be protected. Pressure relief devices intended for use in liquid service shall be connected below the normal liquid level (ASME Section VIII, UG-135 (a), 1998).
3. The operating pressure of the system should be a minimum of 20% or 10 PSI, whichever is greater, below the set pressure of the valve. The set pressure of each pressure relief valve must be in conformance with pressure limits of the system and of the limits specified in the appropriate ASME codes.
4. Valves must be installed in an upright position with the spindle vertical. (ASME Section VIII, Appendix M, 1998). Mounting valves in any other position will cause additional friction on the guiding surfaces and the valve performance will be affected. Mounting valves in other positions may allow dirt and other foreign substances to accumulate in the valve and adversely affect the valve action.
5. The connection to the vessel should be provided with a radius to permit smooth flow to the valve - sharp corners should be avoided.
6. Pressure Relief Valves for use on steam, air and water (over 140(F) shall be supplied with a lifting device (ASME Section VIII, UG-136 (a)(3), 1998).
7. Do not plug or cap any drain or vent openings. Remove any and all shipping plugs.
8. Test gags must be removed (if supplied). Failure to do so renders the valve inoperable and, due to overpressure may damage the Pressure Relief Valve, the system and/or cause personal injury.
9. Make sure the system is clean and free of any dirt, sediment or scale that might become lodged on the valve seats.
10. Apply a small amount of sealant only to the male threads and tighten valve by hand. Use the proper wrench on the hex area of the base, taking care not use excessive force during tightening.
11. The valve should be normally placed close to the protected equipment so that the valve will be fed properly under flowing conditions. However, valves should be mounted downstream from any device at a distance sufficient to avoid turbulence.
12. In a pressure reducing valve station, it is recommended that the pressure relief valve be installed a minimum of 20 pipe diameters from the outlet of the pressure reducing valve to avoid turbulent flow and an unstable condition.
13. When Pressure Relief Valves are left on line during an extended shutdown, the valves should be inspected and re-tested due to the potential of corrosion, fouling or tampering.

Inlet Piping

14. The opening through all pipe, fittings, and nonreclosing pressure relief devices (if installed) between a pressure vessel and its pressure relief valve shall have at least the area of the pressure relief valve inlet. (ASME Section VIII, UG-135 (b)(1), 1998).
15. The flow characteristics of the upstream system shall be such that the cumulative total of all nonrecoverable inlet losses shall not exceed 3% of the valve set pressure (ASME Section VIII, Appendix M-7(a), 1998)

Outlet Piping

16. Discharge pipes shall be at least of the same size as the pressure relief valve outlet (ASME Section VIII, Appendix M-8(a), 1998).
17. Where feasible, the use of a short discharge pipe or vertical riser, connected through long-radius elbows from each individual device, blowing directly to the atmosphere, is recommended (ASME Section VIII, Appendix M-8(a), 1998). Discharge piping should be designed to place the minimum load on the valve under all conditions of valve operation. See 16 of this Section.
18. When the nature of the discharge permits, whereby condensed vapor in the discharge line, or rain, is collected and piped to a drain, a Drip Pan Elbow (Spence DPE) is recommended. This construction has the further advantage of not transmitting discharge-pipe strains to the valve (ASME Section VIII, Appendix M, 1998).
19. The discharge piping should be anchored to prevent any swaying or vibration while the valve is discharging.
20. If excessive lengths of discharge piping and fittings are required, they should be sized larger than the valve outlet. Any discharge piping that appears to be excessive should be reviewed by calculation for back-pressure and piping strains.
21. Discharge lines from Pressure Relief Valves shall be designed to facilitate drainage or shall be fitted with drains to prevent liquid from lodging in the discharge side of the pressure relief device, and such lines shall lead to a safe place of discharge (ASME Section VIII UG-135(f), 1998).

Stop Valves

22. ASME Section I - No valve of any description shall be placed between the required safety valve or safety relief

INSTALLATION, MAINTENANCE & TROUBLESHOOTING GUIDELINES - CONT'D

valve or valves and the boiler, nor on the discharge pipe between the safety valve or safety relief valve and the atmosphere (ASME Section I PG 71.2, 1998).

23. ASME Section VIII - There shall be intervening stop valves between the vessel and its pressure relief device or devices, or between the pressure relief device or devices and the point of discharge, except as under the conditions as stated in ASME Section VIII UG-135(d)(1) and in Appendix M.

B. INSTALLATION -MULTIPLE VALVES

1. All items listed above in the Installation of Single Valves should be followed.
2. When two or more required pressure relief devices are placed on one connection, the inlet internal cross-sectional area of this connection shall be either sized to avoid restricting flow to the pressure relief devices or made at least equal to the combined inlet areas of the safety devices connected to it. (ASME Section VIII UG-136 (c)1998)
3. The sizing of any section of a common-discharge header downstream from each of the two or more pressure relieving devices that may reasonably be expected to discharge simultaneously shall be based on the total of their outlet areas. The effect of the back-pressure that may be developed when certain valves operate must be considered (ASME Section VIII, Appendix M-8 (b), 1998).
4. It is recommended that the smaller orifice valve be set at the lower set pressure and that it is installed up stream of the other valves.

C. MAINTENANCE

1. Valves are set and sealed to prevent tampering, guarantee is void if any seal is broken. The setting, adjustment or repair should be done only by an Authorized Pressure Relief Valve repair facility.
2. The valves should be checked periodically to see that they are not clogged or seized due to dirt or other foreign matter and that they will operate satisfactorily.
3. Installation conditions should be reviewed, seals should be checked to verify that they are not broken and no unauthorized adjustments have been made.
4. Valves may be manually operated by means of the lifting lever only when the system pressure is at least 75% of the nameplate set pressure. A Pressure Relief Valve should never be lifted without 75% of the nameplate set pressure.
5. Pressure Relief Valves should be re-tested as part a normal routine inspection program. The intervals between tests can vary in accordance with the severity of the service condition. Guidelines for inspection are provided in the API Inspection Code and the National Board Inspection Code. However, consideration should be given to your local jurisdictional policies, your insurance company polices and/or your company policies.
6. Only original, unmodified manufacturer parts should be used to assure safe and proper operation.

D. TROUBLESHOOTING

1. Valves are set and sealed to prevent tampering, guarantee is void if any seal is broken. The setting, adjustment or repair should be done only by an Authorized Pressure Relief Valve repair facility.
2. Occasionally a newly installed valve may leak as a result of shipping and handling or installation procedures. For valves with levers, apply pressure to the inlet side equal to 75% of the operating pressure so that the lift lever can be manually activated. For valves without lift levers, raise the system pressure to the point of valve operation. In most instances, the valve will properly reseat and the leakage will stop.
3. If a valve is leaking under normal operating conditions, the following three scenarios should be checked:
   a. Make sure that a minimum operating to set point differential is maintained according to the guidelines specified in the Spence Sizing Guidelines. *See page 50*
   b. It is possible that dirt or foreign material is lodged under the seat. Perform the check as outlined in part 2 of the troubleshooting.
   c. Valve seating surface could be worn or damaged. Please contact your local Pressure Relief Valve Repair Facility.
4. If a valve is chattering it may be the result of the following:
   a. Improper piping at valve inlet or outlet. See the appropriate ASME Codes and the Spence Installation Guidelines. *See page 67*
   b. Valves are oversized. Review the Spence Sizing Guidelines. *See page 68*
   c. Back-pressure may be present which may not have been accounted for in the original sizing. Review Sizing Formulas. *See page 68*
   d. Valve holes may be plugged. Check to make sure all holes are not plugged and any shipping plugs have been removed.
   e. Valve may be worn or damaged. Please contact your local Pressure Relief Valve Repair Facility.
5. If a valve is not popping at the set pressure as stamped on the nameplate, the following should be checked:
   a. All Pressure Relief Valves have tolerance built into the set pressure. Review the Spence Engineering Testing Specifications and/or the appropriate ASME codes to ensure the valve is operating within the allowed tolerances.
   b. Make sure the gauge reading the pressure is properly installed and calibrated. Compensate for the water leg between the valve and gauge.
   c. Review the inlet piping to make sure that the inlet piping is at least the area of the Pressure Relief Valve

INSTALLATION, MAINTENANCE & TROUBLESHOOTING GUIDELINES - CONT'D

inlet. Review the inlet piping to ensure no other pressure drops can occur. See the Spence Installation Guidelines. *See page 67*

d. Review the outlet piping to ensure that backpressure has been accounted for in the original sizing and selection of the valve. See the Spence Installation Guidelines. *See page 67*

e. Valve may be worn or damaged. Please contact your local Pressure Relief Valve Repair Facility.

6. If a valve is not closing or has an excessive blowdown, the following should be checked:

a. It is possible that dirt or foreign material is lodged under the seat. Perform the check as outlined in part 2 of this Section.

b. Operating pressure may not be reduced below the reseating pressure of the valve. Reduce the operating pressure of the system to 50% of the normal operating pressure and then slowly bring the system back to the normal operating pressure. Make sure that a minimum operating to set point differential is maintained according the guidelines specified in the Spence Sizing Guidelines. *See page 68*

c. Valve may be worn or damaged. Please contact your local Pressure Relief Valve Repair Facility.

PLANNING MAIN VALVE INSTALLATION

A. PLANNING THE INSTALLATION

1. Locate the valve in a straight run of horizontal pipe. See Fig. 1.
2. Allow headroom above the valve for access through the blind flange. Provide clearance for stem withdrawal underneath.
3. Prevent water hammer and erratic operation by installing traps to provide proper drainage before and after the valve, and before secondary PRV or control valve.
4. Avoid damaging affects of scale and dirt in pipe lines by using a strainer as shown in Fig. 1 .
5. Provide a 3-valve by-pass to facilitate inspection without interrupting service.
6. To eliminate excessive noise and erratic regulation with steam and other compressible fluids enlarge the delivery pipe size to effect a reasonable flow velocity at the reduced pressure. A tapered transition is recommended. If possible, avoid a sharp turn close to the regulator outlet and a bull-headed tee connection to the low pressure main.
7. Install initial and delivery pressure gauges to indicate performance. If the pressure rating of the delivery system or connected equipment is less than the initial steam pressure, provide a safety valve.

B. CONTROL PIPE

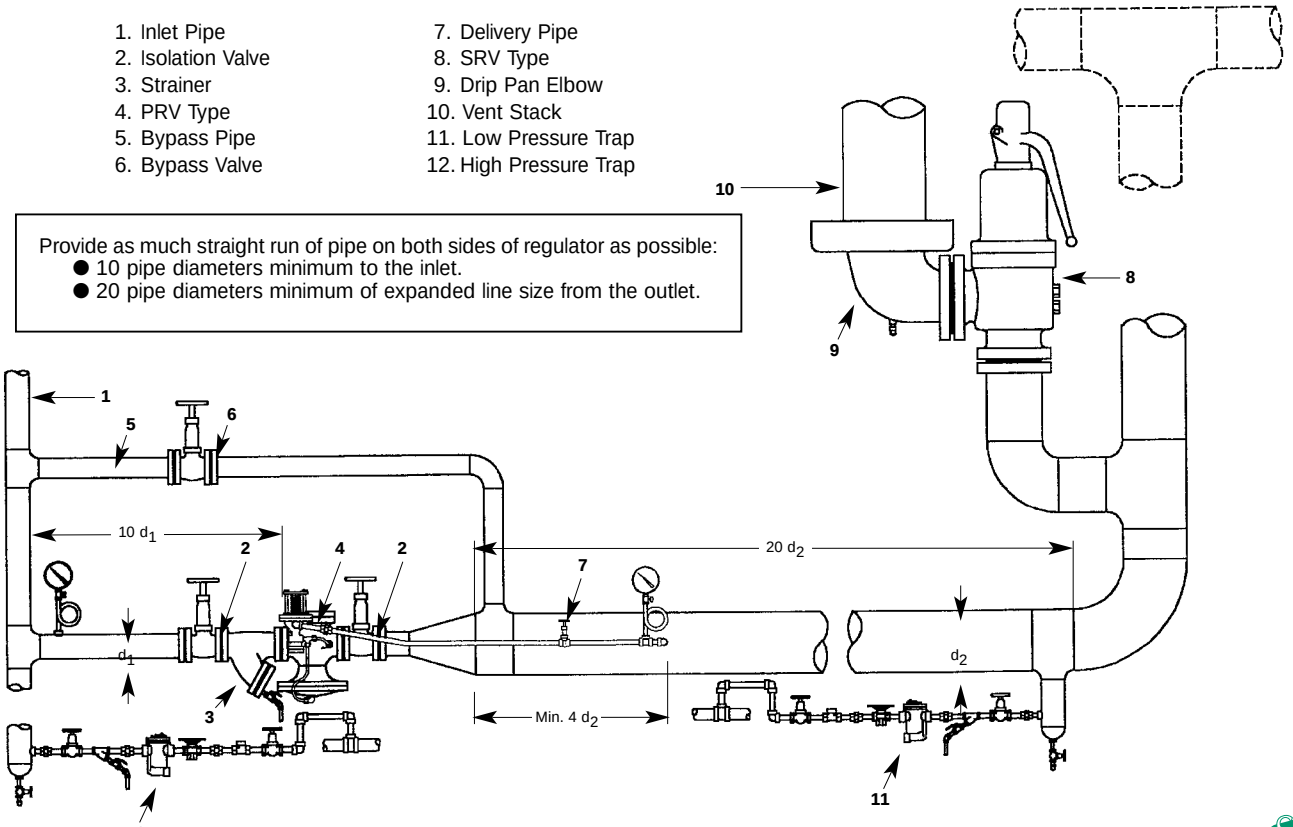
1. Use 1/4" pipe for this line which connects the pilot diaphragm chamber to the desired point of pressure control. See Fig. 1.
2. Take the control at a point of minimum turbulence. Avoid control immediately at the valve outlet or after a turn. When the delivery pipe expands in size select a spot at least 4 pipe diameters beyond the point of enlargement.
3. Pitch away from pilot to avoid erratic operation and fouling. Eliminate water pockets.
4. Locate delivery pressure gauge in control pipe to show pressure actually reaching pilot diaphragm.

C. DESIGN GUIDELINES TO MINIMIZE NOISE

1. Size the regulator to provide a maximum inlet velocity of about 10,000 FPM.
2. Determine the regulator outlet velocity. if it would exceed 30,000 FPM, use a Spence muffling orifice or a second stage regulator.
3 Expand regulator outlet piping to limit discharge line velocity to about 10,000 FPM.
4. Avoid abrupt changes in pipe size. Limit pipe diameter changes to two pipe sizes per stage of expansion. Do not use eccentric reducers.
5. Directional changes in downstream piping should be made only after the line size has been increased. Use long radius fittings; avoid bull-head tee connection.
6. Provide as much straight run of pipe on both sides of regulator as possible:
   a - 10 pipe diameters minimum to the inlet.
   b - 20 pipe diameters minimum of expanded line size from the outlet.
7. Size all piping components, including strainer and stop valves for a maximum flow velocity of about 10,000 FPM (Exception: An outlet stop valve mounted at the regulator outlet should be equal in size to the regulator). In areas where low sound levels are specified, reduce this limit by 25% to 50%.
8. To limit noise transmission through the building's structure. keep the regulator and piping at least 3 feet away from solid surfaces. Use sound-isolating piping supports.
9. Apply high density insulation to the regulator body, piping and system components. Insulation reduces heat loss significantly and can provide moderate (3-6 dB) local noise attenuation.
10. Use a Spence noise suppressor to reduce the propagation of noise via the downstream piping.

1. Inlet Pipe
2. Isolation Valve
3. Strainer
4. PRV Type
5. Bypass Pipe
6. Bypass Valve
7. Delivery Pipe
8. SRV Type
9. Drip Pan Elbow
10. Vent Stack
11. Low Pressure Trap
12. High Pressure Trap

Provide as much straight run of pipe on both sides of regulator as possible:
- 10 pipe diameters minimum to the inlet.
- 20 pipe diameters minimum of expanded line size from the outlet.



MAIN VALVE SIZING BY COMPUTATION

FORMULA KEY

A = Area of Pipe in $(inches)^2$
C_V = Valve Coefficient
EDR = Equivalent Direct Radiation (Sq. Ft.)
F = Pipe Area Factor (see Pipe Factors Table)
ft = Feet
G = Specific Gravity
ΔP = Pressure Drop, $P_1 - P_2$ psi
P_1 = Inlet Pressure, psia (psi + 14.7)
P_2 = Reduced Pressure, psia (psi + 14.7)
P_C = Pressure at Thermodynamic Critical Point, psia (water = 3206 psia)
P_V = Vapor Pressure, psia

$\Delta P_S = P_1 - P_V$ when $P_2 > P_V$

$\Delta P_S = P_1 - (.96 - .28\sqrt{P_V/P_C})\ P_V$ when $P_2 \leq P_V$

q = Liquid Flow Rate, U.S. gpm
Q = Flow Rate, SCFH
T = Absolute T (T + 460)°R
T_{SH} = Steam Superheat (°F) = Total Steam Temp. – Saturated Steam Temp.
$\bar{v}$ = Specific Volume $F_T^3/\#$
V = Velocity, FPM
W = Steam Flow, #/Hr.
W_S = Flow, #/Hr. Superheated Steam

To avoid interpolation or solve problems beyond the scope of the table, valve sizes may be determined by calculation as follows:

C_V

	SUBCRITICAL	CRITICAL
SATURATED STEAM:	$P_2 > .58\ P_1$ $C_V = \frac{W}{2.1\sqrt{\Delta P\ (P_1 + P_2)}}$	$P_2 \leq .58\ P_1$ $C_V = \frac{W}{1.71\ P_1}$
SUPERHEATED STEAM:	$P_2 > .55\ P_1$ $C_V = \frac{W\ (1 + .0007T_{SH})}{2.1\sqrt{\Delta P\ (P_1 + P_2)}}$	$P_2 \leq .55\ P_1$ $C_V = \frac{W\ (1 + .0007T_{SH})}{1.75\ P_1}$
GAS:	$P_2 > .5\ P_1$ $C_V = \frac{Q}{963}\sqrt{\frac{GT}{\Delta P\ (P_1 + P_2)}}$	$P_2 \leq .5\ P_1$ $C_V = \frac{Q\sqrt{GT}}{834\ P_1}$
LIQUID:	$P_2 > P_1 - .85\ \Delta P_S$ $C_V = q\sqrt{\frac{G}{\Delta P}}$	$P_2 \leq P_1 - .85\ \Delta P_S$ $C_V = .93q\sqrt{\frac{G}{\Delta P_S}}$

LOADS

WATER	$W = \frac{GPM}{2}$ X Temp. Rise (°F)
FUEL OIL	$W = \frac{GPM}{4}$ X Temp. Rise (°F)
AIR	$W = \frac{CFM}{900}$ X Temp. Rise (°F)
RADIATION	$W = \frac{f^2EDR}{4}$
ABSORPTION	W = 16-20 #/Hr./Ton-Hr.
STM. ATOM	W = 0.1 #/Hr./#Oil

VELOCITY

STEAM $V = 2.4\frac{W\bar{v}}{A}$

FLOW

STEAM $W = \frac{.0433 \times V \times F}{\bar{v}}$

AIR & GASES $Q = \frac{.0259 \times V \times F \times P_1}{T}$

LIQUIDS $q = .0054 \times V \times F$

PIPE FACTORS FOR STANDARD (SCHEDULE 40) PIPE

SIZE	FACTOR	SIZE	FACTOR
1/8	.55	3 1/2	95
1/4	1.0	4	122
3/8	1.8	5	192
1/2	2.9	6	278
3/4	5.1	8	481
1	8.3	10	758
1 1/4	14	12	1076
1 1/2	20	14	1301
2	32	16	1699
2 1/2	46	18	2151
3	71	20	2673

REGULATOR CV DATA

Valve Size	E						E2	E5,E6		C20	C34	D	D34	D50	N6	Series 2000
	Normal 50%	Normal 75%	Normal	Full 50%	Full 75%	Full		Normal	Full				60%		50%	
1/4	—	—	—	—	—	—	—	—	—	—	—	.25	—	—	—	—
3/8	—	—	.65	—	—	1.5	—	—	—	—	—	.32	—	—	—	—
1/2	—	—	1.5	1.4	2.1	2.8	—	—	—	—	—	.32	—	2.2	—	.4-5.22
3/4	—	—	4.8	2.7	4.0	5.4	7.6	5.7	7.6	—	—	—	—	3.3	5.3	6.85
1	—	—	7.5	4.4	6.6	8.8	11.7	10.0	11.7	7.5	5.5	—	3.3	4.9	9.2	9.15
1 1/4	—	—	10.4	7.0	10.6	14.1	18.9	13.4	18.9	14.0	12.5	—	7.5	5.0	14.3	14.3
1 1/2	—	—	14.6	9.9	14.8	19.8	27.4	19.8	27.4	20.0	17.3	—	10.4	10.1	20.8	15.1
2	—	—	17.6	15.5	23.3	31	44	25	43	30	24	—	14.4	10.8	37.5	17.2
2 1/2	12	18	24	22	33	44	68	35	67	47	36	—	21.6	—	60	—
3	22	33	43	37	56	74	96	59	95	69	53	—	32	—	—	—
4	39	59	78	55	82	109	143	120	159	115	86	—	52	—	—	—
5	58	87	115	85	127	169	202	176	258	186	139	—	84	—	—	—
6	76	114	151	124	186	248	255	228	350	250	196	—	118	—	—	—
8	125	187	249	222	333	444	465	366	665	436	—	—	—	—	—	—
10	189	283	377	353	530	706	748	525	1018	700	—	—	—	—	—	—
12	316	474	631	557	835	1113	1118	952	1611	1083	—	—	—	—	—	—

75% AND 50% REDUCED TRIM (Parabolic)

The Parabolic Discs given in the above table are designed to:

a) Improve performance at minimum flows by improving stability over wide flow ranges.
b) Provide easy field conversion to obtain a substantial increase or decrease in regulator Cv to meet system load requirements.
c) Facilitate selection of smaller size safety relief valves.
d) Size more precisely to the required Cv, thereby eliminating one of the most frequent causes of poor performance.

CONTROL VALVE CV DATA

KOMBAT Cv TABLE

Valve Size	Orifice	Cv
1/2	C	0.7
	E	2.1
	A	3.3
	B	4.3
	T	5.2
3/4	T	7.0
1	T	11.0
1-1/4	T	20.0
1-1/2	T	25.0
2	T	30.0
2-1/2	T	71
3	T	94
4	T	146

INTIMIDATOR Cv TABLE

SIZE	PORT SIZE	Cv
1/2	1/8	0.08
	3/16	0.5
	1/4	1.5
	5/8	5.1
3/4	1/8	0.08
	3/16	0.5
	1/4	1.5
	5/8	6
	7/8	10.3
1	5/8	6.2
	7/8	12.1
	1-1/4	18.2
1-1/2	7/8	13.2
	1-1/4	22
	1-3/4	37
2	1-1/4	23
	1-3/4	43
	2-1/4	67

DOCTOR Cv TABLE

Valve Size	Mixing Cv	Diverting Cv
1/2	5	5
3/4	7	7
1	12	12
1-1/2	28	28
2	50	52
2-1/2	70	76
3	116	108
4	158	160
6	352	365
8	475	475

BOSS Cv TABLE

Valve Size	Full Port Cv	40% Red. Cv	Seco-Sonic Cv	Seco-Cav Cv
2	65	26	48	32
2½	90	36	70	40
3	125	50	97	63
4	205	82	156	103
6	435	174	349	217
8	760	304	579	304

EXCERPTS FROM
ASME CODE

NOTES:

EXCERPTS FROM ASME CODE SECTION I

NOTES:

SAFETY VALVES AND SAFETY RELIEF VALVES[16]

PG-67 BOILER SAFETY VALVE REQUIREMENTS

PG-67.1 Each boiler shall have at least one safety valve or safety relief valve and if it has more than 500 sq ft (47 m^2) of bare tube water-heating surface, or if an electric boiler has a power input more than 1100 kW, it shall have two or more safety valves or safety relief valves. For a boiler with combined bare tube and extended water-heating surface exceeding 500 sq ft (47 m^2), two or more safety valves or safety relief valves are required only if the design steam generating capacity of the boiler exceeds 4000 lb/hr (1800 kg/hr). Organic fluid vaporizer generators require special consideration as given in Part PVG.

PG-67.2 The safety valve or safety relief valve capacity for each boiler (except as noted in PG-67.4) shall be such that the safety valve, or valves will discharge all the steam that can be generated by the boiler without allowing the pressure to rise more than 6% above the highest pressure at which any valve is set and in no case to more than 6% above the maximum allowable working pressure.

PG-67.2.1 The minimum required relieving capacity of the safety valves or safety relief valves for all types of boilers shall not be less than the maximum designed steaming capacity as determined by the Manufacturer and shall be based on the capacity of all the fuel burning equipment as limited by other boiler functions.

PG-67.2.2 The minimum required relieving capacity for a waste heat boiler shall be determined by the Manufacturer. When auxiliary firing is to be used in combination with waste heat recovery, the maximum output as determined by the boiler Manufacturer shall include the effect of such firing in the total required capacity. When auxiliary firing is to be used in place of waste heat recovery, the minimum required relieving capacity shall be based on auxiliary firing or waste heat recovery, whichever is higher.

PG-67.2.3 The minimum required relieving capacity for electric boilers shall be in accordance with PEB-15.

PG-67.2.4 The minimum required relieving capacity in lb/hr for a high-temperature water boiler shall be determined by dividing the maximum output in Btu/hr at the boiler nozzle, produced by the highest heating value fuel for which the boiler is designed, by 1000.

PG-67.2.5 The minimum required relieving capacity for organic fluid vaporizers shall be in accordance with PVG-12.

PG-67.2.6 Any economizer which may be shut off from the boiler, thereby permitting the economizer to become a fired pressure vessel, shall have one or more safety relief valves with a total discharge capacity, in lbs/hr, calculated from the maximum expected heat absorption in Btu/hr, as determined by the Manufacturer, divided by 1000. This absorption shall be stated in the stamping (PG-106.4).

PG-67.3 One or more safety valves on the boiler proper shall be set at or below the maximum allowable working pressure (except as noted in PG-67.4). If additional valves are used the highest pressure setting shall not exceed the maximum allowable working pressure by more than 3%. The complete range of pressure settings of all the saturated-steam safety valves on a boiler shall not exceed 10% of the highest pressure to which any valve is set. Pressure setting of safety relief valves on high-temperature water boilers[17] may exceed this 10% range.

PG-67.4 For a forced-flow steam generator with no fixed steam and waterline, equipped with automatic controls and protective interlocks responsive to steam pressure, safety valves may be provided in accordance with the above paragraphs or the following protection against overpressure shall be provided.

PG-67.4.1 One or more power-actuated pressure relieving valves[18] shall be provided in direct communication with the boiler when the boiler is under pressure and shall

[16]Safety Valve: An automatic pressure relieving device actuated by the static pressure upstream of the valve and characterized by full-opening pop action. It is used for gas or vapor service.

Relief Valve: An automatic pressure relieving device actuated by the static pressure upstream of the valve which opens further with the increase in pressure over the opening pressure. It is used primarily for liquid service.

Safety Relief Valve: An automatic pressure-actuated relieving device suitable for use either as a safety valve or relief valve, depending on application.

Unless otherwise defined, the definitions relating to pressure relief devices in Appendix 1 of ASME PTC 25-1994, Pressure Relief Devices shall apply.

[17]Safety relief valves in hot water service are more susceptible to damage and subsequent leakage, than safety valves relieving steam. It is recommended that the maximum allowable working pressure of the boiler and the safety relief valve setting for high-temperature water boilers be selected substantially higher than the desired operating pressure so as to minimize the times the safety relief valve must lift.

[18]The power-actuated pressure relieving valve is one whose movements to open or close are fully controlled by a source of power (electricity, air, steam, or hydraulic). The valve may discharge to atmosphere or to a container at lower pressure. The discharge capacity may be affected by the downstream conditions, and such effects shall be taken into account. If power-actuated pressure relieving valves are also positioned in response to other control signals, the control impulse to prevent overpressure shall be responsive only to pressure and shall override any other control function.

receive a control impulse to open when the maximum allowable working pressure at the superheater outlet, as shown in the master stamping (PG-106.3), is exceeded. The total combined relieving capacity of the power-actuated relieving valves shall be not less than 10% of the maximum design steaming capacity of the boiler under any operating condition as determined by the Manufacturer. The valve or valves shall be located in the pressure part system where they will relieve the overpressure.

An isolating stop valve of the outside-screw-and-yoke type may be installed between the power-actuated pressure relieving valve and the boiler to permit repairs provided an alternate power-actuated pressure relieving valve of the same capacity is so installed as to be in direct communication with the boiler in accordance with the requirements of this paragraph.

Power-actuated pressure relieving valves discharging to intermediate pressure and incorporated into bypass and/or startup circuits by the boiler Manufacturer need not be capacity certified. Instead, they shall be marked by the valve manufacturer with a capacity rating at a set of specified inlet pressure and temperature conditions. Power-actuated pressure relieving valves discharging directly to atmosphere shall be capacity certified. This capacity certification shall be conducted in accordance with the provisions of PG-69.3. The valves shall be marked in accordance with the provisions of PG-69.4 and PG-69.5.

PG-67.4.2 Spring-loaded safety valves shall be provided, having a total combined relieving capacity, including that of the power-actuated pressure relieving capacity installed under PG-67.4.1, of not less than 100% of the maximum designed steaming capacity of the boiler, as determined by the Manufacturer, except the alternate provisions of PG-67.4.3 are satisfied. In this total, no credit in excess of 30% of the total required relieving capacity shall be allowed for the power-actuated pressure relieving valves actually installed. Any or all of the spring-loaded safety valves may be set above the maximum allowable working pressure of the parts to which they are connected, but the set pressures shall be such that when all of these valves (together with the power-actuated pressure relieving valves) are in operation the pressure will not rise more than 20% above the maximum allowable working pressure of any part of the boiler, except for the steam piping between the boiler and the primer mover.

PG-67.4.3 The total installed capacity of spring-loaded safety valves may be less than the requirements of PG-67.4.2 provided all of the following conditions are met.

PG-67.4.3.1 The boiler shall be of no less steaming capacity than 1,000,000 lb/hr (450,000 kg/hr) and installed in a unit system for power generation (i.e., a single boiler supplying a single turbine-generator unit).

PG-67.4.3.2 The boiler shall be provided with automatic devices, responsive to variations in steam pressure, which include no less than all the following:

PG-67.4.3.2.1 A control capable of maintaining steam pressure at the desired operating level and of modulating firing rates and feedwater flow in proportion to a variable steam output; and

PG-67.4.3.2.2 A control which overrides PG-67.4.3.2.1 by reducing the fuel rate and feedwater flow when the steam pressure exceeds the maximum allowable working pressure as shown in the master stamping (PG-106.3) by 10%; and

PG-67.4.3.2.3 A direct-acting overpressure-trip-actuating mechanism, using an independent pressure sensing device, that will stop the flow of fuel and feedwater to the boiler, at a pressure higher than the set pressure of PG-67.4.3.2.2, but less than 20% above the maximum allowable working pressure as shown in the master stamping (PG-106.3).

PG-67.4.3.3 There shall be not less than two spring-loaded safety valves and the total rated relieving capacity of the spring-loaded safety valves shall be not less than 10% of the maximum designed steaming capacity of the boiler as determined by the Manufacturer. These spring-loaded safety valves may be set above the maximum allowable working pressure of the parts to which they are connect but shall be set such that the valves will lift at a pressure no higher than 20% above the maximum allowable working pressure as shown in the master stamping (PG-106.3).

PG-67.4.3.4 At least two of these spring-loaded safety valve shall be equipped with a device that directly transmits the valve stem lift action to controls that will stop the flow of fuel and feedwater to the boiler. The control circuitry to accomplish this shall be arranged in a "fail-safe" manner (see Note).

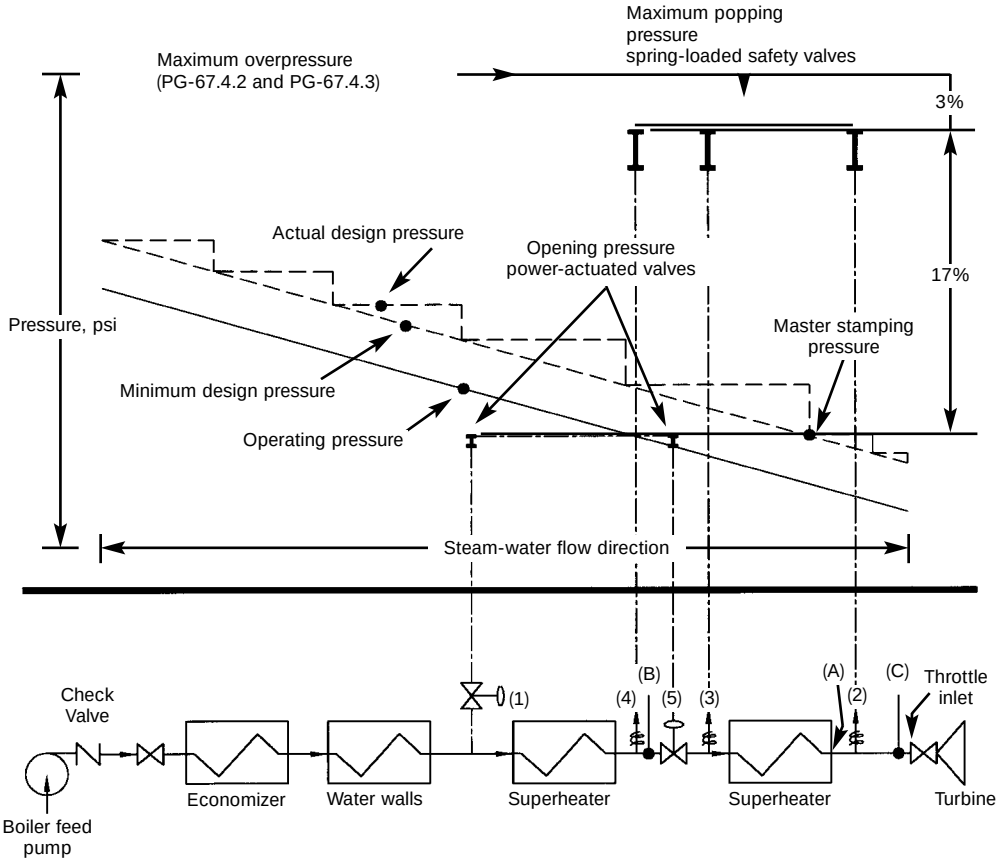
NOTE: "Fail-safe" shall mean a circuitry arranged as either of the following:

(1) Energize to trip: There shall be at least two separate and independent trip circuits served by two power sources, to initiate and perform the trip action. One power source shall be a continuously charged dc battery. The second source shall be an ac-to-dc converter connected to the dc system to charge the battery and capable of performing the trip action. The trip circuits shall be continuously monitored for availability.

It is not mandatory to duplicate the mechanism that actually stops the flow of fuel and feedwater.

(2) De-energize to trip: If the circuits are arranged in such a way that a continuous supply of power is required to keep the circuits closed and operating and such that any interruption of power supply will actuate the trip mechanism, then a single trip circuit and single power supply will be enough to meet the requirements of this subparagraph.

PG-67.4.3.5 The power supply for all controls and devices required by PG-67.4.3 shall include at least one source contained within the same plant as the boiler and which is arranged to actuate the controls and devices continuously in the event of failure or interruption of any other power sources.



Pressure
(A) = master stamping (PG-106.3)
(B) = component design at inlet to stop valve (5) (PG-67.4.4.1)
(C) = turbine throttle inlet (ANSI/ASME B31.1, paragraph 122.1.2, A.4)

Pressure Relief Valves
(1) = power actuated (PG-67.4.1)
(2), (3), and (4) = spring loaded safety (PG-67.4.2)
(5) = superheater stop (PG-67.4.4)

Relief Valve Flow Capacity (minimum, based on rated capacity of boiler)
(1) = 10-30% (PG-67.4.1)
(2) = minimum of one valve (PG-68.1)
(2) + (3) when downstream to stop valve (5) = that required for independently fired superheaters (PG-68.3)
(2) + (3) + (4) = 100% - (1) (PG-67.4.2)

Relief valve Opening Pressure (maximum)
(1) = (A), and (B) when there is stop valve (5) (PG-67.4.1)
(2), (3), and (4) = (A) + 17% (PG-67.4.2)
(5 = (A) (PG-67.4.1)

Alternate Requirements for Safety Valves

Relief Valve Flow Capacity (minimum, based on rated capacity of boiler)
(1) = 10 - 30% (PG-67.4.1)
(2) = one valve minimum (PG-68.1)
(2) + (3) when downstream to stop valve (5) = that required for independently fired superheaters (PG-68.3)
(4) = 10% total with minimum of 2 valves when there is a stop valve (5) (PG-67.5.3.3)
(2) + (4) = 10% with minimum of 2 valves when there is no stop valve (5) (PG-67.4.3.3)

Relief Valve Opening Pressure (maximum)
(1) = (A), and (B) when there is stop valve (5) (PG-67.4.1)
(2), (3), and (4) = (A) + 20% (PG-67.4.3.3)
(5) = (A) (PG-67.4.1)

Automatic Pressure Controls (PG-67.4.3)
(a) at (C) for normal operation under load (PG-67.4.3.2.1)
(b) at (A) + 10% to override control (a) (PG-67.4.3.2.2)
(c) at (A) + 20% to shut off flow of fuel and feedwater (PG-67.4.3.2.3)
***(d) safety valves at (4) to shut off flow of fuel and feedwater* by "fail-safe" power circuit (PG-67.4.3.4)**

FIG. PG-67.4 REQUIREMENTS FOR PRESSURE RELIEF FORCED-FLOW STEAM GENERATOR

PG-67.4.4 When stop valves are installed in the water-steam flow path between any two sections of a forced-flow steam generator with no fixed steam and waterline:

PG-67.4.4.1 The power-actuated pressure relieving valve(s) required by PG-67.4.1 shall also receive a control impulse to open when the maximum allowable working pressure of the component, having the lowest pressure level upstream to the stop valve, is exceeded; and

PG-67.4.4.2 The spring-loaded safety valves shall be located to provide the pressure protection requirements in PG-67.4.2 or PG-67.4.3.

PG-67.4.5 A reliable pressure-recording device shall always be in service and records kept to provide evidence of conformity to the above requirements.

PG-67.5 All safety valve or safety relief valves shall be so constructed that the failure of any part cannot obstruct the free and full discharge of steam and water from the valve. Safety valves shall be of the direct spring-loaded pop type, with seat inclined at any angle between 45 deg. and 90 deg., inclusive, to the center line of the spindle. The coefficient of discharge of safety valves shall be determined by actual steam flow measurements at a pressure not more than 3% above the pressure at which the valve is set to blow and when adjusted for blowdown in accordance with PG-72. The valves shall be credited with capacities as determined by the provisions of PG-69.2.

Safety valves or safety relief valves may be used which give any opening up to the full discharge capacity of the area of the opening of the inlet of the valve (see PG-69.5), provided the movement of the steam safety valve is such as not to induce lifting of water in the boiler.

Deadweight or weighted lever safety valves or safety relief valves shall not be used.

For high-temperature water boilers safety relief valves shall be used. Such valves shall have a closed bonnet. For purposes of selection the capacity rating of such safety relief valves shall be expressed in terms of actual steam flow determined on the same basis as for safety valves. In addition the safety relief valves shall be capable of satisfactory operation when relieving water at the saturation temperature corresponding to the pressure at which the valve is set to blow.

A99 **PG-67.6** A safety valve or safety relief valve over NPS 3 (DN 80), used for pressures greater than 15 psig (103 kPa), shall have a flanged inlet connection or a weld-end inlet connection. The dimensions of flanges subjected to boiler pressure shall conform to the applicable ASME Standards as given in PG-42. The facing shall be similar to those illustrated in the Standard.

PG-67.7 Safety valves or safety relief valves may have bronze parts complying with either SB-61 or SB-62, provided the maximum allowable stresses and temperatures do not exceed the values given in Table 1B of Section II, Part D, and shall be marked to indicate the class of material used. Such valves shall not be used on superheaters delivering steam at a temperature over 450ºF (232ºC) and 306ºF (152ºC) respectively, and shall not be used for high-temperature water boilers.

PG-68 SUPERHEATER AND REHEATER SAFETY VALVE REQUIREMENTS 98

PG-68.1 Except as permitted in PG-58.3.1, every attached superheater shall have one or more safety valves in the steam flow path between the superheater outlet and the first stop valve. The location shall be suitable for the service intended and shall provide the overpressure protection required. The pressure drop upstream of each safety valve shall be considered in the determination of set pressure and relieving capacity of that valve. If the superheater outlet header has a full, free steam passage from end to end and is so constructed that steam is supplied to it at practically equal intervals throughout its length so that there is a uniform flow of steam through the superheater tubes and the header, the safety valve, or valves, may be located anywhere in the length of the header.

PG-68.2 The discharge capacity of the safety valve, or valves, on an attached superheater may be included in determining the number and size of the safety valves for the boiler, provided there are no intervening valves between the superheater safety valve and the boiler, and provided the discharge capacity of the safety valve, or valves, on the boiler, as distinct from the superheater is at least 75% of the aggregate valve capacity required.

PG-68.3 Every separately fired superheater which may 98
be shut off from the boiler and permit the superheater to become a fired pressure vessel shall have one or more safety valves having a discharge capacity equal to 6 lb of steam per hour per square foot of superheater surface measured on the side exposed to the hot gases. As an alternative the Manufacturer may also calculate the minimum safety valve discharge capacity in lbs. of steam per hour from the maximum expected heat absorption (as determined by the Manufacturer) in Btu/hr, divided by 1,000. In the case of electrically heated superheaters, the safety valve capacity shall be based upon 3½ lb/hr/kW input. The number of safety valves installed shall be such that the total capacity is at least equal to that required.

PG-68.4 Every reheater shall have one or more safety valves, such that the total relieving capacity is at least equal to the maximum steam flow for which the heater is designed. The capacity of the reheater safety valves shall not

be included in the required relieving capacity for the boiler and superheater.

One or more valves with a combined relieving capacity not less than 15% of the required total shall be located along the steam flow path between the reheater outlet and the first stop valve. The pressure drop upstream of the valves on the outlet side of the reheater shall be considered in determining their set pressure.

PG-68.5 A soot blower connection may be attached to the same outlet from the superheater or reheater that is used for the safety valve connection.

PG-68.6 Every safety valve used on a superheater or reheater discharging superheated steam at a temperature over 450ºF (232ºC) shall have a casing, including the base, body, and bonnet and spindle, of steel, steel alloy, or equivalent heat-resisting material.

The valve shall have a flanged inlet connection, or a weld-end inlet connection. It shall have the seat and disk of suitable heat erosive and corrosive resisting material, and the spring fully exposed outside of the valve casing so that it shall be protected from contact with the escaping steam.

PG-69 CERTIFICATION OF CAPACITY OF SAFETY AND SAFETY RELIEF VALVES

PG-69.1 Before the Code symbol is applied to any safety or safety relief valve, the valve manufacturer shall have the relieving capacity of his valves certified in accordance with the provisions of this paragraph.

PG-69.1.1 Capacity certification tests shall be conducted using dry saturated steam. The limits for test purposes shall be 98% minimum quality and 20ºF (11ºC) maximum superheat. Correction from within these limits may be made to the dry saturated condition.

PG-69.1.2 Tests shall be conducted at a place which meets the requirements of Appendix A-312.

PG-69.1.3 Capacity test data reports for each valve design and size, signed by the manufacturer and Authorized Observer witnessing the tests, together with drawings showing the valve construction, shall be submitted to the ASME designee for review and acceptance.[19]

PG-69.1.4 Capacity certification tests shall be conducted at a pressure which does not exceed the set pressure by 3% or 2 psi, whichever is greater. Safety and safety relief valves shall be adjusted so that the blowdown does not exceed 4% of the set pressure. For valves set at or below 100 psi (690 kPa), the blowdown shall be adjusted so as not to exceed 4 psi (28 kPa). Safety valves used on forced-flow steam generators with no fixed steam and waterline, and safety relief valves used on high-temperature water boilers shall be adjusted so that the blowdown does not exceed 10% of the set pressure. The reseating pressure shall be noted and recorded.

PG-69.2 Relieving capacities shall be determined using one of the following methods.

PG-69.2.1 Three Valve Method. A capacity certification test is required on a set of three valves for each combination of size, design, and pressure setting. The capacity of each valve of the set shall fall within a range of ±5% of the average capacity. If one of the three valves tested falls outside this range, it shall be replaced by two valves, and a new average shall be calculated based on all four valves, excluding the replaced valve. Failure of any of the four capacities to fall within a range of ±5% of the new average shall be cause to refuse certification of that particular valve design.

The rated relieving capacity for each combination of design, size, and test pressure shall be 90% of the average capacity.

PG-69.2.2 Slope Method. If a Manufacturer wishes to apply the Code Symbol to a design of pressure relief valves, four valves of each combination of pipe size and orifice size shall be tested. These four valves shall be set at pressures which cover the approximate range of pressures for which the valve will be used or covering the range available at the certified test facility that shall conduct the tests. The capacities based on these four tests shall be as follows: 98

(a) The slope W/P of the actual measured capacity versus the flow pressure for each test point shall be calculated and averaged:

$$\text{slope} = \frac{W}{P} = \frac{\text{measured capacity}}{\text{absolute flow rating pressure, psia}}$$

All values derived from the testing must fall within ±5% of the average value:

minimum slope = 0.95 x average slope

maximum slope = 1.05 x average slope

If the values derived from the testing do not fall between the minimum and maximum slope values, the Authorized Observer shall require that additional valves be tested at the rate of two for each valve beyond the maximum and minimum values with a limit of four additional valves.

The relieving capacity to be stamped on the valve shall not exceed 90% of the average slope times the absolute accumulation pressure:

[19]Valve capacities are published in "Pressure Relief Device Certifications." This publication may be obtained from the National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Ave., Columbus, Ohio 43229.

rated slope = 0.90 x average slope

stamped capacity ≤ rated slope (1.03 x set pressure + 14.7) or (set pressure + 2 psi + 14.7), whichever is greater

98 **PG-69.2.3 Coefficient of Discharge Method** A coefficient of discharge for the design, K, may be established for a specific valve design according to the following procedure.

(a) For each design, the safety or safety relief valve manufacturer shall submit for test at least three valves for each of three different sizes (a total of nine valves). Each valve of a given size shall be set at a different pressure, covering the range of pressures for which the valve will be used or the range available at the facility where the tests are conducted.

(b) Tests shall be made on each safety or safety relief valve to determine its lift at capacity, popping, and blowdown pressures, and actual relieving capacity. An individual coefficient, K_D, shall be established for each valve as follows:

$$K_D = \frac{\text{actual flow}}{\text{theoretical flow}} = \text{individual coefficient of discharge}$$

Where actual flow is determined by test and theoretical flow, W_T is calculated by one of the following equations:

For 45 deg. seat

$$W_T = 51.5 \times \pi DLP \times 0.707$$

For flat seat

$$W_T = 51.5 \times \pi DLP$$

For nozzle

$$W_T = 51.5\,AP$$

Where

W_T = theoretical flow, lb/hr
A = nozzle throat area, sq in.
P = (1.03 x set pressure + 14.7), or
= (set pressure + 2 + 14.7), whichever is greater, psia
L = lift pressure at P, in.
D = seat diameter, in.

The average of the coefficients K_D of the nine tests required shall be multiplied by 0.90, and this product shall be taken as the coefficient K of that design. All individual coefficients of discharge, K_D, shall fall within a range of ±5% of the average coefficient found. If a valve fails to meet this requirement, the Authorized Observer shall require two additional valves to be tested as replacements for each valve having an individual coefficient, K_D, outside the ±5% range, with a limit of four additional valves. Failure of a coefficient, K_D, to fall within ±5% of the new average value, excluding the replaced valve(s), shall be cause to refuse certification of that particular valve design.

The rated relieving capacity of all sizes and set pressures of a given design, for which K has been established under the provision of this paragraph, shall be determined by the equation:

$$W \le W_T \times K$$

where

W = rated relieving capacity lb/hr
W_T = theoretical flow defined by the same equation used to determine K_D lb/hr
K = coefficient of discharge for the design

The coefficient of discharge for the design shall not be greater than 0.878 (the product of 0.9 x 0.975). The coefficient shall not be applied to valves whose beta ratio (ratio of valve throat to inlet diameter) lies outside the range of 0.15 to 0.75, unless tests have demonstrated that the individual coefficient of discharge, K_D, for valves at the extreme ends of a larger range, is within ±5% of the average coefficient, K.

For designs where the lift is used to determine the flow area, all valves shall have the same nominal lift to seat diameter ratio (L/D).

For pressures over 1500 psig and up to 3200 psig, the value of W shall be multiplied by the correction factor:

$$\frac{0.1906P - 1000}{0.2292P - 1061}$$

PG-69.3 If a manufacturer wishes to apply the Code symbol to a power-actuated pressure relieving valve under PG-67.4.1, one valve of each combination of inlet pipe size and orifice size to be used with that inlet pipe size shall be tested. The valve shall be capacity tested at four different pressures approximately covering the range of the certified test facility on which the tests are conducted. The capacities, as determined by these four tests, shall be plotted against the absolute flow test pressure and a line drawn through these four test points. All points must lie within ±5% in capacity value of the plotted line and must pass through 0-0. From the plotted line, the slope of the line dW/dP shall be determined and a factor of (0.90/51.45) x(dW/dP) shall be applied to capacity computations in the supercritical region at elevated pressures by means of the isentropic flow equation

$$W_T = 1135.8 \frac{0.90}{51.45} \times \frac{dW}{dP} \sqrt{\frac{P}{v}}$$

where

W = capacity, lb of steam/hr
P = absolute inlet pressure, psia
V = inlet specific volume, cu ft/lb
dW/dP = rate of change of measured capacity with respect to absolute pressure

NOTE: The constant 1135.8 is based on a y factor of 1.30 which is accurate for superheated steam at temperature above approximately 800ºF. In interest of accuracy, other methods of capacity computations must be used at temperatures below 800ºF at supercritical pressures.

PG-69.4 Power-actuated pressure relieving valves, having capacities certified in accordance with the provision of PG-69.3 and computed in accordance with the formula contained therein, shall be marked as required by PG-110 with the computed capacity, corresponding to 3% above the full load operating pressure and temperature conditions at the valve inlet when the valve is operated by the controller, and they shall also be stamped with the set pressure of the controller. When the valve is marked as required by this paragraph, it shall be the guarantee by the manufacturer that the valve also conforms to the details of construction herein specified.

PG-69.6 When changes are made in the design of a safety or safety relief valve in such a manner as to affect the flow path, lift, or performance characteristics of the valve, new tests in accordance with this Section shall be performed.

PG-70 CAPACITY OF SAFETY VALVES

PG-70.1 Subject to the minimum number required by PG-67.1, the number of safety valves or safety relief valves required shall be determined on the basis of the maximum designed steaming capacity, as determined by the boiler Manufacturer, and the relieving capacity marked on the valves by the manufacturer.

PG-71 MOUNTING

PG-71.1 When two or more safety valves are used on a boiler, they may be mounted either separately or as twin valves made by placing individual valves on Y-bases, or duplex valves having two valves in the same body casing. Twin valves made by placing individual valves on Y-bases, or duplex valves having two valves in the same body, shall be of approximately equal capacity.

When not more than two valves of different sizes are mounted singly the relieving capacity of the smaller valve shall be not less than 50% of that of the larger valve.

PG-71.2 The safety valve or safety relief valve or valves shall be connected to the boiler independent of any other connection, and attached as close as possible to the boiler or the normal steam flow path, without any unnecessary intervening pipe or fitting. Such intervening pipe or fitting shall be not longer than the face-to-face dimension of the corresponding tee fitting of the same diameter, and pressure under the applicable ASME Standard listed in PG-42 and shall also comply with PG-8 and PG-39. Every safety valve or safety relief valve shall be connected so as to stand in an upright position, with spindle vertical. On high-temperature water boilers of the watertube forced-circulation type, the valve shall be located at the boiler outlet. A99

PG-71.3 The opening or connection between the boiler and the safety valve or safety relief valve shall have at least the area of the valve inlet. No valve of any description shall be placed between the required safety valve or safety relief valve or valves and the boiler, nor on the discharge pipe between the safety valve or safety relief valve and the atmosphere. When a discharge pipe is used, the cross-sectional area shall be not less than the full area of the valve outlet or of the total of the areas of the valve outlets, discharging thereinto. It shall be as short and straight as possible and so arranged as to avoid undue stresses on the valve or valves.

All safety valve or safety relief valve discharges shall be so located or piped as to be carried clear from running boards or platforms. Ample provision for gravity drain shall be made in the discharge pipe at or near each safety valve or safety relief valve, and where water of condensation may collect. Each valve shall have an open gravity drain through the casing below the level of the valve seat. For iron- and steel-bodied valves exceeding NPS $2^{1}/_{2}$ (DN 65), the drain hole shall be tapped not less than NPS $^{3}/_{8}$ (DN 10).

Discharge piping from safety relief valves on high-temperature water boilers shall be provided with adequate provisions for water drainage as well as the steam venting.

The installation of cast iron bodied safety relief valves for high-temperature water boilers is prohibited.

PG-71.4 If a muffler is used on a safety valve or safety relief valve, it shall have sufficient outlet area to prevent back pressure from interfering with the proper operation and discharge capacity of the valve. The muffler plates or other devices shall be so constructed as to avoid a possibility of restriction of the steam passages due to deposit. Mufflers shall not be used on high-temperature water boiler safety relief valves.

When a safety valve or safety relief valve is exposed to outdoor elements which may affect operation of the valve, it is permissible to shield the valve with a satisfactory cover. The shield or cover shall be properly vented and arranged to permit servicing and normal operation of the valve.

PG-71.5 When a boiler is fitted with two or more safety valves or safety relief valves on one connection, this connection to the boiler shall have a cross-sectional area not less than the combined areas of inlet connections of all the safety valves or safety relief valves with which it connects and shall also meet the requirements of PG-71.3.

PG-71.6 Safety valves may be attached to drums or headers by welding provided the welding is done in accordance with Code requirements

PG-71.7 Every boiler shall have proper outlet connections for the required safety valve, or safety relief valve, or valves, independent of any other outside steam connection, the area of opening to be at least equal to the aggregate areas of inlet connections of all of the safety valves or safety relief valves to be attached thereto. An internal collecting pipe, splash plate, or pan may be used, provided the total area for inlet of steam thereto is not less than twice the aggregate areas of the inlet connections of the attached safety valves. The holes in such collecting pipes shall be at least $^{1}/_{4}$ in. (6 mm) in diameter and the least dimension in any other form of opening for inlet of steam shall be $^{1}/_{4}$ in,. (6 mm).

Such dimensional limitations to operation for steam need not apply to steam scrubbers or driers provided the net free steam inlet area of the scrubber or drier is at least 10 times the total area of the boiler outlets for the safety valves.

PG-71.8 If safety valves are attached to a separate steam drum or dome, the opening between the boiler proper and the steam drum or dome shall be not less than required by PG-71.7.

98 PG-72 OPERATION

PG-72.1 Safety valves shall be designed and constructed to operate without chattering and to attain full lift at a pressure no greater than 3% above their set pressure. After blowing down, all valves set at pressures of 375 psi or greater shall close at a pressure not lower than 96% of their set pressure, except that all drum valves installed on a single boiler may be set to reseat at a pressure not lower than 96% of the set pressure of the lowest set drum valve. All valves set at pressures below 375 psi shall have a blowdown not greater than that specified in the following table:

Set Pressure, psi	Maximum Blowdown
< 67	4 psi
≥ 67 and ≤ 250	6% of set pressure
> 250 and < 375	15 psi

The minimum blowdown for all safety or safety relief valves shall be 2 psi (13.8 kPa) or 2% of the set pressure, whichever is greater.

Safety valves used on forced-flow steam generators with no fixed steam and waterline, and safety relief valves used on high-temperature water boilers may be set and adjusted to close after blowing down not more than 10% of the set pressure. The valves for these special uses must be so adjusted and marked by the manufacturer.

PG-72.2 The popping point tolerance plus or minus shall not exceed that specified in the following table:

Set Pressure, psi	Tolerance, plus or minus from set pressure
≤ 70	2 psi
> 70 and ≤ 300	3% of set pressure
> 300 and ≤ 1000	10 psi
> 1000	1% of set pressure

PG-72.3 The spring in a safety valve or safety relief valve shall not be reset for any pressure more than 5% above or below that for which the valve is marked unless the new setting is within the spring design range established by the manufacturer or is determined to be acceptable to the manufacturer.

If the set pressure is to be adjusted within the limits specified above, the adjustment shall be performed by the manufacturer, his authorized representative, or an assembler. An additional valve data tag identifying the new set pressure, capacity, and date shall be furnished and installed, and the valve shall be resealed.

PG-72.4 If the set pressure of a valve is changed so as to require a new spring, the spring shall be acceptable to the manufacturer. The spring installation and valve adjustment shall be performed by the manufacturer, his authorized representative, or an assembler. A new nameplate as described in PG-110 shall be furnished and installed, and the valve shall be resealed.

PG-73 MINIMUM REQUIREMENTS FOR SAFETY AND SAFETY RELIEF VALVES

PG-73.1 Mechanical Requirements

PG-73.1.1 The design shall incorporate guiding arrangements necessary to insure consistent operation and tightness.

PG-73.1.2 The spring shall be designed so that the full lift spring compression shall be no greater than 80% of the nominal solid deflection. The permanent set of the spring (defined as the difference between the free height and height measured 10 min after the spring has been compressed solid three additional times after presetting at room temperature) shall not exceed 0.5% of the free height.

PG-73.1.3 To provide a means for verifying whether it is free, each safety valve or safety relief valve shall have a substantial lifting device, which when activated will release the seating force on the disk when the valve is subjected to pressure of at least 75% of the set pressure. The lifting device shall be such that it cannot lock or hold the valve disk in lifted position when the exterior lifting force is released. Disks of safety relief valves used on high-temperature water boilers shall not be lifted while the temperature of the water exceeds 200ºF (93ºC). If it is desired to lift the valve disk to assure that it is free, this shall be done when the valve is subjected to a pressure of at least 75% of the set pressure. For high-temperature water boilers, the lifting mechanism shall be sealed against leakage.

PG-73.1.4 The seat of a safety valve shall be fastened to the body of the valve in such a way that there is no possibility of the seat lifting.

PG-73.1.5 A body drain below seat level shall be provided in the valve and this drain shall not be plugged during or after field installation. For valves exceeding NPS 2½ (DN 65), the drain hole or holes shall be tapped not less than NPS ⅜ (DN 10). For valves of NPS 2½ (DN 65) or smaller, the drain hole shall not be less than ¼ in. (6 mm) in diameter.

PG-73.1.6 In the design of the body of the valve, consideration shall be given to minimizing the effects of water deposits.

PG-73.1.7 Valves having screwed inlet or outlet connections shall be provided with wrenching surfaces to allow for normal installation without damaging operating parts.

PG-73.1.8 Means shall be provided in the design of all valves for use under this Section, for sealing all external adjustments. Seals shall be installed by the manufacturer, his authorized representative, or an assembler at the time of the initial adjustment. After spring replacement and/or subsequent adjustment, the valve shall be resealed. Seals shall be installed in such a manner as to prevent changing the adjustment without breaking the seal and, in addition, shall serve as a means of identifying the manufacturer, his authorized representative, or the assembler making the adjustment.

PG-73.2 Material Selections

PG-73.2.1 Cast iron seats and disks are not permitted.

PG-73.2.2 Adjacent sliding surfaces such as guides and disks or disk holders shall both be of corrosion resistant material. Springs of corrosion resistant material or having a corrosion resistant coating are required. The seats and disks of safety valves or safety relief valves shall be of suitable material to resist corrosion by the lading fluid.

NOTE: The degree of corrosion resistance, appropriate to the intended service, shall be a matter of agreement between the manufacturer and the purchaser.

PG-73.2.3 Materials used in bodies and bonnets or yokes shall be listed in Section II, Parts A and B, and identified in Tables 1A and 1B of Section II, Part D, as permitted for Section I construction. Materials used in nozzles, disks, and other parts contained within the external structure of the safety or safety relief valves shall be one of the following categories:

(1) listed in ASME Section II;

(2) listed in ASTM Specifications (see Note below);

(3) controlled by the manufacturer of the safety or safety relief valve by a specification insuring control of chemical and physical properties and quality at least equivalent to ASTM Standards (see Note below).

NOTE: It shall be the manufacturer's responsibility to insure that the allowable stresses at temperature meet the requirements of Section II, Part D, Appendix 1, Nonmandatory Basis for Establishing Stress Values in Tables 1A and 1B.

PG-73.3 Inspection of Manufacturing and/or Assembly

PG-73.3.1 A manufacturer shall demonstrate to the satisfaction of an ASME designee that his manufacturing, production, and test facilities and quality control procedures will insure close agreement between the performance of random production samples and the performance of those valves submitted for capacity certification.

PG-73.3.2 Manufacturing, assembly, inspection, and test operations including capacity, are subject to inspections at any time by an ASME designee.

PG-73.3.3 A Manufacturer or assembler may be granted permission to apply the V Code Symbol to production pressure relief valves capacity-certified in

accordance with PG-69, provided the following tests are successfully completed. This permission shall expire on the fifth anniversary of the date it is initially granted. This permission may be extended for 5 year periods if the following tests are successfully repeated within the 6 month period before expiration.

(1) Two sample production pressure relief valves of a size and capacity within the capability of an ASME accepted laboratory shall be selected by an ASME designee.

(2) Operational and capacity tests shall be conducted in the presence of an ASME designee at an ASME accepted laboratory. The valve manufacturer or assembler shall be notified of the time of the test and may have representatives present to witness the test.

(3) Should any valve fail to relieve at or above its certified capacity or should it fail to meet performance requirements of this Section, the test shall be repeated at the rate of two replacement valves, selected in accordance with PG-73.3.3(1), for each valve that failed.

(4) Failure of any of the replacement valves to meet capacity or the performance requirements of this Section shall be cause for revocation within 60 days of the authorization to use the Code Symbol on that particular type of valve. During this period, the Manufacturer or assembler shall demonstrate the cause of such deficiency and the action taken to guard against future occurrence, and the requirements of PG-73.3.3 above shall apply.

98 A99 **PG-73.3.4** Use of the Code Symbol Stamp by an assembler indicates the use of original unmodified parts in strict accordance with the instructions of the manufacturer of the valve. However, an assembler may convert original finished parts by machining to another finished part for a specific application under the following conditions:

(a) Conversions shall be specified by the Manufacturer. Drawings and/or written instructions used for part conversion shall be obtained from the Manufacturer and shall include a drawing or description of the converted part before and after machining.

(b) The Assembler's quality control system, as accepted by a representative from an ASME designated organization, must describe in detail the conversion of original parts, provisions for inspection and acceptance, personnel training, and control of current Manufacturer's drawings and/or written instructions.

(c) The Assembler must document each use of a converted part.

(d) The Assembler must demonstrate to the Manufacturer the ability to perform each type of conversion. The Manufacturer shall document all authorizations granted to perform part conversions. The Manufacturer and Assembler shall maintain a file of such authorizations.

(e) At least annually a review shall be performed by the Manufacturer of an Assembler's system and machining capabilities. The Manufacturer shall document the results of these reviews. A copy of this documentation shall be kept on file by the Assembler. The review results shall be made available to a representative from an ASME designated organization.

PG-73.3.5 In addition to the requirements of PG-110, the same plate marking shall include the name of the Manufacturer and the assembler. The Code Symbol Stamp shall be that of the assembler.

NOTE: Within the requirements of PG-73.3 and PG-73.4, a manufacturer is defined as a person or organization who is completely responsible for design, material selection, capacity certification, manufacture of all component parts, assembly, testing, sealing, and shipping of safety and safety relief valves certified under this Section.

An assembler is defined as a person or organization who purchases or receives from a manufacturer the necessary component parts or valves and assembles, adjusts, tests, seals, and ships safety or safety relief valves certified under this Section at a geographical location other than and using facilities other than those used by the manufacturer.

PG-73.4 Testing by Manufacturers or Assemblers

PG-73.4.1 Valves exceeding 1 in. (DN 25) inlet size or 300 psig (2070 kPa) set pressure shall meet the following requirements. Primary pressure containing cast and welded parts of pressure relief valves shall be tested at a pressure at 1.5 times the design pressure of the parts. These tests shall be conducted after all machining operations to the parts have been completed. There shall be no visible signs of leakage.

Closed bonnet pressure relief valves designed for discharge to a closed system shall be tested with a minimum of 30 psig (207 kPa) air or other gas in the secondary pressure zone. There shall be no visible signs of leakage.

PG-73.4.2 Every valve shall be tested with steam by the manufacturer or assembler to demonstrate the popping point, blowdown, tightness, and pressure containing integrity. Valves beyond the capability of production test facilities may be shop tested with air, provided required field tests and applicable adjustments are made.

PG-73.4.3 A seat tightness test shall be conducted at maximum expected operating pressure, but at a pressure not exceeding the reseating pressure of the valve. When being tested, a valve exhibiting no visible signs of leakage shall be considered adequately tight.

PG-73.4.4 A manufacturer or assembler shall have a documented program for the application, calibration, and maintenance of test gages.

PG-73.4.5 Testing time on steam valves shall be sufficient to assure that test results are repeatable and representative of field performance.

PG-73.4.6 Test fixtures and test drums, where applicable, shall be of adequate size and capacity to assure that the observed set pressure is consistent with the stamped set pressure within the tolerance required by PG-72.2.

PG-73.5 Design Requirements. At the time of submission of valves for capacity certification or testing in accordance with PG-69, the ASME designee has the authority to review design for conformity with the requirements of this Section and to reject or require modification of designs which do not conform, prior to capacity testing.

PG-110 STAMPING OF SAFETY VALVES

Each safety valve shall be plainly marked with the required data by the Manufacturer or Assembler (see PG-73.3.4) in such a way that the marking will not be obliterated in service. The marking shall be placed on the valve or on a nameplate securely fastened to the valve. The Code "V" symbol shall be stamped on the valve or nameplate, but the other required data may be stamped, etched, impressed, or cast on the valve or nameplate. The marking shall include the following:

(1) the name (or an acceptable abbreviation) of the Manufacturer and Assembler;

(2) Manufacturer's design or type number;

(3) NPS (the nominal pipe size of the valve inlet);

(4) set pressure____psi;

(5) capacity____lb/hr (in accordance with PG-67.5 and with the valve adjusted for the blowdown permitted by PG-72);

(6) year built, or alternatively, a coding may be marked on the valve such that the valve manufacturer or assembler can identify the year the valve was assembled and tested;

(7) ASME symbol as shown in Fig. PG-105.4.

PG-105 CODE SYMBOL STAMPS

PG-105.1 Authorization. Except as permitted in PG-105.6, no organization may assume responsibility for Code construction without having first received from the ASME a Certificate of Authorization to use one of the Code symbol stamps shown in Figs. PG-105.1 through PG-105.4. There are six such stamps, defined as follows:

S – power boiler symbol stamp	see Fig. PG-105.1
M – miniature boiler symbol stamp	see Fig. PG-105.1
E – electric boiler symbol stamp	see Fig. PG-105.1
A – boiler assembly symbol stamp	see Fig. PG-105.2
PP – pressure piping symbol stamp	see Fig. PG-105.3
V – safety valve symbol stamp	see Fig. PG-105.4

FIG. PG-105.1 OFFICIAL SYMBOLS FOR STAMPS TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR BOILERS

FIG. PG-105.2 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR ASSEMBLY

FIG. PG-105.3 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR WELDED PIPING

FIG. PG-105.4 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR SAFETY VALVES

Stamps for applying the Code symbol shall be obtained from the Society. Each boiler, superheater, waterwall, economizer, or boiler part to which a Code symbol is to be applied shall be fabricated by a Manufacturer who is in possession of an appropriate Code symbol stamp. A Certificate of Authorization to use the Code symbol "S", "M", "E", "A", "PP", or "V" stamp will be granted by the Society pursuant to the provisions of these paragraphs.

PG-105.2 Application for Certificate of Authorization. Any organization desiring a Certificate of Authorization shall apply to the Boiler and Pressure Vessel Committee of the Society, on forms issued by the Society, specifying the stamp desired and the scope of Code activities to be

performed. When an organization intends to build Code items in plants in more than one geographical area, separate applications for each plant or a single application listing the addresses of all such plants may be submitted. Each application shall identify the Authorized Inspection Agency providing Code inspection at each plant. A separate Certificate of Authorization will be prepared and a separate fee charged by the Society for each plant.

Each applicant must agree that each Certificate of Authorization and each Code symbol stamp are at all times the property of the Society, that they will be used according to the rules and regulations of this Section of the Code, and that they will be promptly returned to the Society upon demand, or when the applicant discontinues the Code activities covered by his certificate, or when the Certificate of Authorization has expired and no new certificate has been issued. The holder of a Code symbol stamp shall not allow any other organization to use it.

Authorization to use Code symbol stamps may be granted or withheld by the Society in its absolute discretion. If authorization is granted, and the proper administrative fee paid, a Certificate of Authorization evidencing permission to use any such symbol, expiring on the triennial anniversary date thereafter, will be forwarded to the applicant. Each such certificate will identify the Code symbol to be used, and the type of shop and/or field operations for which authorization is granted. (See Appendix A-370). The certificate will be signed by the Chairman of the Boiler and Pressure Vessel Committee and the Director of Accreditation. Six months prior to the date of expiration of any such certificate, the applicant must apply for a renewal of such authorization and the issuance of a new certificate. The Society reserves the absolute right to cancel or refuse to renew such authorization returning pro rata, fees paid for the unexpired term.

PG-105.3 Agreement With Authorized Inspection Agency. As a condition of obtaining and maintaining a Certificate of Authorization to use the "S", "M", "E", "A", or "PP" Code symbol stamps, the Manufacturer or Assembler must have in force at all times, an inspection contract or agreement with an Authorized Inspection Agency as defined in PG-91 to provide inspection services. This inspection contract is a written agreement between the Manufacturer or Assembler and the inspection agency which specifies the terms and conditions under which the inspection services are to be furnished and which states the mutual responsibilities of the Manufacturer or Assembler and the Authorized Inspectors. The certificate holder shall notify the Society whenever its agreement with an Authorized Inspection Agency is cancelled or changed to another Authorized Inspection Agency.

Manufacturers or assemblers of safety valves are not required to have an inspection agreement with an Authorized Inspection Agency. A Certificate of Authorization may be granted to a manufacturer or assembler of safety valves to use the safety valve symbol stamp providing such stamp is applied only to safety valves that have been capacity certified in accordance with the requirements of this Section.

PG-105.4 Quality Control System. Any Manufacturer or Assembler holding or applying for a Certificate of Authorization to use the "S", "M", "E", "A", "PP", or "V" stamp shall have, and demonstrate, a quality control system to establish that all Code requirements including material, design, fabrication, examination (by the Manufacturer), and inspection for boilers and boiler parts (by the Authorized Inspector) will be met. The quality control system shall be in accordance with the requirements of Appendix A-300.

Before issuance or renewal of a Certificate of Authorization for use of the "S", "M", "E", "A", or "PP" stamps, the Manufacturer's facilities and organization are subject to a joint review by a representative of his inspection agency and an individual certified as an ASME designee who is selected by the concerned legal jurisdiction. When the jurisdiction assumes responsibility for leading the review, it shall have certified that its representative has met ASME criteria. A written description or checklist of the quality control system which identifies what documents and what procedures the Manufacturer will use to produce a Code item shall be available for review. The purpose of the review is to evaluate the applicant's quality control system and its implementation. The applicant shall demonstrate sufficient administrative and fabrication functions of the system to show that he has the knowledge and ability to produce the Code items covered by his quality control system. Fabrication functions may be demonstrated using current work, a mock-up, or a combination of the two. A written report to the Society shall be made jointly by the jurisdiction and the inspection agency employed by the Manufacturer to do his Code inspection. This report is then reviewed by the Subcommittee on Boiler and Pressure Vessel Accreditation, which will either issue a Certificate of Authorization or notify the applicant of deficiencies revealed by the review. In such a case, the applicant will be given an opportunity to explain or correct these deficiencies.

Certificates of Authorization will be endorsed to indicate the scope of activity authorized. Authorization may include field operations if the review team determines that these operations are adequately described in the quality

control manual, and this determination is accepted by the Society.

Before issuance or renewal of a Certificate of Authorization for use of the "V" stamp, the valve manufacturer's or assembler's facilities or organization are subject to a review by an ASME designee. A written description or checklist of the quality control system, which identifies the documents and procedures the manufacturer or assembler will use to produce Code safety and safety relief valves, shall be available for review. The ASME designee shall make a written report to the Society, where the Subcommittee on Boiler and Pressure Vessel Accreditation will act on it as described above.

The Manufacturer may at any time make changes in the quality control system concerning the methods of achieving results subject to acceptance by the Authorized Inspector. For manufacturers and assemblers of "V" stamped safety or safety relief valves, such acceptance shall be by the ASME designee.

For those areas where there is no jurisdiction or where a jurisdiction does not choose to select an ASME designee to review a vessel or vessel parts manufacturer's facility, that function shall be performed by an ASME designee selected by ASME. In either case, the ASME designee shall certify its representative has met ASME criteria. Where the jurisdiction is the Manufacturer's inspection agency, the joint review and joint report shall be made by the jurisdiction and another representative designated by the Society.

PG-105.5 Code Construction Before Receipt of Certificate of Authorization. When used to demonstrate his quality control system, a Manufacturer may start fabricating Code items before receipt of a Certificate of Authorization to use a Code symbol stamp under the following conditions:

(1) The fabrication is done with the participation of the Authorized Inspector and is subject to his acceptance.

(2) The activity shall have been performed in conformance with the applicant's accepted quality control system.

(3) The item is stamped with the appropriate Code symbol and certified once the applicant receives his Certificate of Authorization from the Society.

PG-105.6 Regulations on Use of Code Symbol Stamps. The Boiler and Pressure Vessel Committee may at any time make such regulations concerning the issuance and use of Code symbol stamps as it deems appropriate, and all such regulations shall become binding upon the holders of any valid Certificates of Authorization.

PART PVG
REQUIREMENTS FOR ORGANIC FLUID VAPORIZERS

PVG-12 SAFETY VALVES

PVG-12.1 Safety valves shall be of a totally enclosed type so designed that vapors escaping beyond the valve seat shall not discharge into the atmosphere, except through an escape pipe that will carry such vapors to a safe point of discharge outside of the building. A suitable condenser that will condense all the vapors discharged from the safety valve may be used in lieu of piping the vapors to the atmosphere. The safety valve shall not have a lifting lever. The vaporizer shall be designed in accordance with the rules in this Code for a working pressure of at least 40 psi (256 kPa) above the operating pressure at which it will be used. Valve body drains are not mandatory.

PVG-12.2 Safety valves shall be disconnected from the vaporizer at least once yearly, when they shall be inspected, repaired if necessary, tested, and then replaced on the vaporizer.

PVG-12.3 In order to minimize the loss by leakage of material through the safety valve, a rupture disk may be installed between the safety valve and the vaporizer provided the following requirements are met.

PVG-12.3.1 The cross-sectional area of the connection to a vaporizer shall be not less than the required relief area of the rupture disk.

PVG-12.3.2 Every rupture disk shall have a specified bursting pressure at a specified temperature, shall be marked with a lot number, and shall be guaranteed by its manufacturer to burst within 5% (plus or minus) of its specified bursting pressure.

PVG-12.3.3 The specified bursting pressure at the coincident specified temperature shall be determined by bursting two or more specimens from a lot of the same material and of the same size as those to be used. The tests shall be made in a holder of the same form and pressure area dimensions as that with which the disk is to be used.

PVG-12.3.4 A rupture disk may be installed between a safety valve and the vaporizer provided:

PVG-12.3.4.1 The maximum pressure of the range for which the disk is designed to rupture does not exceed the opening pressure for which the safety valve is set or the maximum allowable working pressure of the vessel.

PVG-12.3.4.2 The opening provided through the rupture disk, after breakage, is sufficient to permit a flow equal to the capacity of the attached valve and there is no chance of interference with the proper functioning of the valve; but in no case shall this area be less than the inlet area of the valve.

PVG-12.3.4.3 The space between a rupture disk and the valve should be provided with a pressure gage, try cock, free vent, or a suitable telltale indicator. This arrangement permits the detection of disk rupture or leakage.[1]

PVG-12.4 Safety valve discharge capacity shall be determined from the formula:

$$W = CKAP\ M/T$$

where

W = flow of vapor lb/hr

C = constant for vapor which is a function of the ratio of Specific Heats $k = Cp/Cv$ (see Fig. PVG-12)
Note: Where k is not known, $k = 1.001$.

[1]Users are warned that a rupture disk will not burst at its designed pressure if back pressure builds up in the space between the disk and the safety valve which will occur should leakage develop in the rupture disk due to corrosion or other cause.

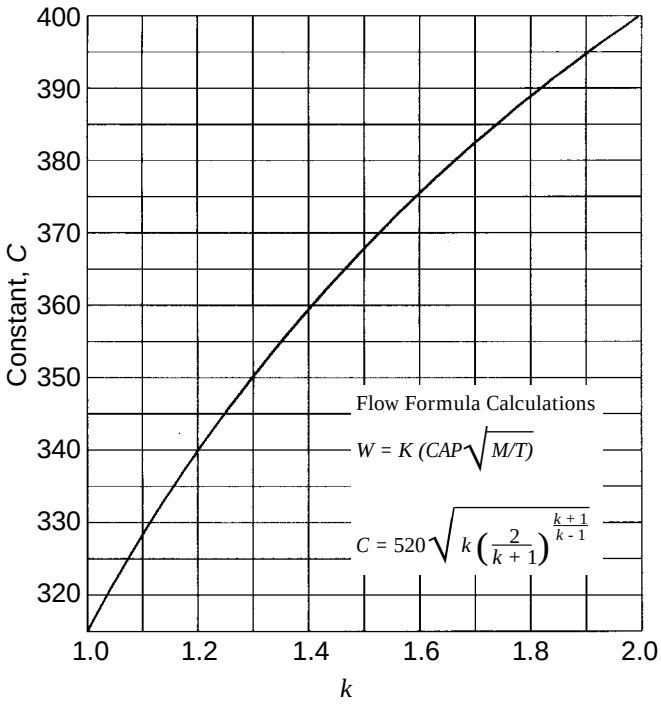


FIG. PVG-12 CONSTANT C FOR VAPOR RELATED TO RATIO OF SPECIFIC HEATS (K=CP/CV)

K = coefficient of discharge for the design
A = discharge area of safety valve, sq in.
P = (set pressure x 1.03) + Atmosphere Pressure, psia
M = molecular weight
T = absolute temperature at inlet, F + 460

PVG-12.5 Safety valves for organic fluid vaporizers shall be tested and certified under PG-69, and they shall be stamped with the rated relieving capacity in pounds per hour at coincident temperature as determined in PVG-12.4. The fluid identification shall be stamped on the nameplate.

PVG-12.6 The required minimum safety valve relieving capacity shall be determined from the formula:

$$W = \frac{C \times H \times 0.75}{h}$$

where
h = latent heat of heat transfer fluid at relieving pressure, Btu/lb
W = weight of organic fluid vapor generated per hour, lb
C = maximum total weight or volume of fuel burned per hour, lb or cu ft
H = heat of combustion of fuel, Btu/lb or Btu/cu ft (see A-17)

The sum of the safety valve capacities marked on the valves shall be equal to or greater than W.

PFT-44 OPENING BETWEEN BOILER AND SAFETY VALVE

The opening or connection between the boiler and safety valve shall have at least the area of the valve inlet.

After the boiler Manufacturer provides for the opening required by the Code, a bushing may be inserted in the opening in the shell to suit a safety valve that will have the capacity to relieve all the steam that can be generated in the boiler and which will meet the Code requirements.

No valve of any description shall be placed between the required safety valve or safety relief valve or valves and the boiler, or on the discharge pipe between the safety valve or safety relief valve and the atmosphere. When a discharge pipe is used, the cross-sectional area shall be not less than the full area of the valve outlet or of the total of the areas of the valve outlets discharging thereinto and shall be as short and straight as possible and so arranged as to avoid undue stresses on the valve or valves.

NOTES:

EXCERPTS FROM
ASME CODE
SECTION IV

NOTES:

ARTICLE 4
PRESSURE RELIEVING DEVICES

HG-400 PRESSURE RELIEVING VALVE REQUIREMENTS

HG-400.1 Safety Valve Requirements for Steam Boilers

(a) Each steam boiler shall have one or more officially rated safety valves that are identified with the V or HV Symbol of the spring pop type adjusted and sealed to discharge at a pressure not to exceed 15 psi (103 kPa).

(b) No safety valve for a steam boiler shall be smaller than NPS 1/2 (DN 15). No safety valve shall be larger than NPS 4 1/2 (DN 115). The inlet opening shall have an inside diameter equal to, or greater than, the seat diameter.

(c) The minimum relieving capacity of valve or valves shall be governed by the capacity marking on the boiler called in HG-530.

(d) The minimum valve capacity in pounds per hour shall be the greater of that determined by dividing the maximum Btu output at the boiler nozzle obtained by the firing of any fuel for which the unit is installed by 1000, or shall be determined on the basis of the pounds of steam generated per hour per square foot of boiler heating surface as given in Table HG-400.1. For cast iron boilers constructed to the requirements of Part HC, the minimum valve capacity shall be determined by the maximum output method. In many cases a greater relieving capacity of valves will have to be provided than the minimum specified by these rules. In every case, the requirement of HG-400.1(e) shall be met.

(e) The safety valve capacity for each steam boiler shall be such that with the fuel burning equipment installed, and operated at maximum capacity, the pressure cannot rise more than 5 psi (35 kPa) above the maximum allowable working pressure.

(f) When operating conditions are changed, or additional boiler heating surface is installed, the valve capacity shall be increased, if necessary, to meet the new conditions and be in accordance with HG-400.1(e).

TABLE HG-400.1
MINIMUM POUNDS OF STEAM PER HOUR PER SQUARE FOOT OF HEATING SURFACE

Boiler Heating Surface	Firetube Boilers	Watertube Boilers
Hand fired	5	6
Stoker fired	7	8
Oil, gas, or pulverized fuel fired	8	10
Waterwall heating surface:		
Hand fired	8	8
Stoker fired	10	12
Oil, gas, or pulverized fuel fired	14	16

GENERAL NOTES:
(a) When a boiler is fired only by a gas having a heat value not in excess of 200 Btu/cu ft., the minimum safety valves or safety relief valve relieving capacity may be based on the values given for hand fired boilers above.
(b) The minimum safety valve or safety relief valve relieving capacity for electric boilers shall be 3 1/2 lb/hr/kw input.
(c) For heating surface determination, see HG-403.

The additional valves required, on account of changed conditions, may be installed on the outlet piping provided there is no intervening valve.

HG-400.2 Safety Relief Valve Requirements for Hot Water Boilers

(a) Each hot water heating or supply boiler shall have at least one officially rated safety relief valve, of the automatic reseating type, identified with the V or HV Symbol, and set to relieve at or below the maximum allowable working pressure of the boiler.

(b) Hot water heating or supply boilers limited to a water temperature not in excess of 210ºF (99ºC) may have, in lieu of the valve(s) specified in (a) above, one or more officially rated temperature and pressure safety relief valves of the automatic reseating type identified with the HV symbol, and set to relieve at or below the maximum allowable working pressure of the boiler.

(c) When more than one safety relief valve is used on either hot water heating or hot water supply boilers, the additional valves shall be officially rated and may have a set pressure within a range not to exceed 6 psi (42 kPa), above the maximum allowable working pressure of the boiler up to and including 60 psi (414 kPa), and 5% for those having a maximum allowable working pressure exceeding 60 psi (414 kPa).

(d) No safety relief valve shall be smaller than NPS 3/4 (DN 20) nor larger than NPS 4 1/2 (DN 115) except that boilers having a heat input not greater than 15,000 Btu/hr (4.4 kW) may be equipped with a rated safety relief valve of NPS 1/2 (DN 15).

(e) The required steam relieving capacity, in pounds per hour, of the pressure relieving device or devices on a boiler shall be the greater of that determined by dividing the maximum output in Btu at the boiler nozzle obtained by the firing of any fuel for which the unit is installed by 1000, or shall be determined on the basis of pounds of steam generated per hour per square foot of boiler heating surface as given in Table HG-400.1. For cast iron boilers constructed to the requirements of Part HC, the minimum valve capacity shall be determined by the maximum output method. In many cases a greater relieving capacity of valves

will have to be provided than the minimum specified by these rules. In every case, the requirements of HG-400.2(g) shall be met.

(f) When operating conditions are changed, or additional boiler heating surface is installed, the valve capacity shall be increased, if necessary, to meet the new conditions and shall be in accordance with HG-400.2(g). The additional valves required, on account of changed conditions, may be installed on the outlet piping provided there is no intervening valve.

(g) Safety relief valve capacity for each boiler with a single safety relief valve shall be such that, with the fuel burning equipment installed and operated at maximum capacity, the pressure cannot rise more than 10% above the maximum allowable working pressure. When more than one safety relief valve is used, the overpressure shall be limited to 10% above the set pressure of the highest set valve allowed by HG-400.2(a).

HG-400.3 Safety and Safety Relief Valves for Tanks and Heat Exchangers

(a) Steam to Hot Water Supply. When a hot water supply is heated indirectly by steam in a coil or pipe within the service limitations set forth in HG-101, the pressure of the steam used shall not exceed the safe working pressure of the hot water tank, and a safety relief valve at least NPS 1 (DN 25), set to relieve at or below the maximum allowable working pressure of the tank, shall be applied to the tank.

(b) High Temperature Water to Water Heat Exchanger.[1] When high temperature water is circulated through the coils or tubes of a heat exchanger to warm water for space heating or hot water supply, within the service limitations set forth in HG-101, the heat exchanger shall be equipped with one or more officially rated safety relief valves that are identified with the V or HV Symbol, set to relieve at or below the maximum allowable working pressure of the heat exchanger, and of sufficient rated capacity to prevent the heat exchanger pressure from rising more than 10% above the maximum allowable working pressure of the vessel.

(c) High Temperature Water to Steam Heat Exchanger.[1] When high temperature water is circulated through the coils or tubes of a heat exchanger to generate low pressure steam, within the service limitations set forth in HG-101, the heat exchanger shall be equipped with one or more officially rated safety valves that are identified with the V or HV Symbol, set to relieve at a pressure not to exceed 15 psi (103 kPa), and of sufficient rated capacity to prevent the heat exchanger pressure from rising more than 5 psi (35 kPa) above the maximum allowable working pressure of the vessel. For heat exchangers requiring steam pressures greater than 15 psi (103 kPa), refer to Section I or Section VIII, Division 1.

[1]Suggested installation practices for the secondary side of heat exchangers.

HG-401 MINIMUM REQUIREMENTS FOR SAFETY AND SAFETY RELIEF VALVES

HG-401.1 Mechanical Requirements

(a) The inlet opening shall have an inside diameter approximately equal to, or greater than, the seat diameter. In no case shall the maximum opening through any part of the valve be less than 1/4 in. (6 mm) in diameter or its equivalent area.

(b) Safety relief valves officially rated as to capacity shall have pop action when tested by steam.

(c) O-rings or other packing devices when used on the stems of safety relief valves shall be so arranged as not to affect their operation or capacity.

(d) The design shall incorporate guiding arrangements necessary to insure consistent operation and tightness. Excessive lengths of guiding surfaces should be avoided. Bottom guided designs are not permitted on safety relief valves.

(e) Safety valves shall have a controlled blowdown of 2 psi to 4 psi (13.8 kPa to 28 kPa) and this blowdown need not be adjustable.

(f) Safety valves shall be spring loaded. The spring shall be designed so that the full lift spring compression shall be no greater than 80% of the nominal solid deflection. The permanent set of the spring (defined as the difference between the free height and height measured 10 min after the spring has been compressed solid three additional times after presetting at room temperature) shall not exceed 0.5% of the free height.

(g) There shall be a lifting device and a mechanical connection between the lifting device and the disk capable of lifting the disk from the seat a distance of at least 1/16 in. (1.6 mm) with no pressure on the boiler.

(h) A body drain below seat level shall be provided by the Manufacturer for all safety valves and safety relief valves, except that the body drain may be omitted when the valve seat is above the bottom of the inside diameter of the discharge piping. For valves exceeding NPS 2 1/2 (DN 65) the drain hole or holes shall be tapped not less than NPS 3/8 (DN 10). For valves NPS 2 1/2 (DN 65) or smaller, the drain hole shall not be less than 1/4 in. (6 mm) in diameter. Body drain connections shall not be plugged during or after field installation. In safety relief valves of the diaphragm type, the space above the diaphragm shall be vented to prevent a buildup of pressure above the diaphragm. Safety relief valves of the diaphragm type shall be so designed that failure or deterioration of the diaphragm material will not impair the ability of the valve to relieve at the rated capacity.

(i) In the design of the body of the valve consideration shall be given to minimizing the effects of water deposits.

(j) Valves shall be provided with wrenching surfaces to allow for normal installation without damaging operating parts.

(k) The set pressure tolerances plus or minus, of safety valves shall not exceed 2 psi (13.8 kPa), and for safety relief

valves shall not exceed 3 psi (20.6 kPa) for pressures up to and including 60 psig (414 kPa) and 5% for pressures above 60 psig (414 kPa).

(l) Safety valves shall be arranged so that they cannot be reset to relieve a higher pressure than the maximum allowable working pressure of the boiler.

HG-401.2 Material Selection

(a) Cast iron seats and disks are not permitted.

(b) Adjacent sliding surfaces such as guides and disks shall both be of corrosion resistant material.

(c) Springs of corrosion resistant material or having a corrosion resistant coating are required.

(d) Material for seats and disks should be such as to provide a reasonable degree of resistance to steam cutting.

(e) Material for valve bodies and bonnets or their corresponding metallic pressure containing parts shall be listed in Section II, except that in cases where manufacturer desires to make use of materials other than those listed in Section II, he shall establish and maintain specifications requiring equivalent control of chemical and physical properties and quality.

(f) Synthetic disk inserts of O-ring or other types if used shall be compatible with the maximum design temperature established for the valve.

(g) No materials liable to fail due to deterioration or vulcanization when subjected to saturated steam temperature corresponding to capacity test pressure shall be used.

HG-401.3 Manufacture and Inspection

(a) A Manufacturer shall demonstrate to the satisfaction of an ASME designee that his manufacturing, production, and testing facilities and quality control procedures will insure close agreement between the performance of random production samples and the performance of those valves submitted for capacity certification.

(b) Manufacturing, inspection, and test operations including capacity are subject to inspections at any time by an ASME designee.

(c) A Manufacturer may be granted permission to apply the HV Code Symbol to production pressure relief valves capacity certified in accordance with HG-402.3 provided the following tests are successfully completed. This permission shall expire on the fifth anniversary of the date it is initially granted. The permission may be extended for 5 year periods if the following tests are successfully repeated within the 6 month period before expiration.

(1) Two sample production pressure relief valves of a size and capacity within the capability of an ASME accepted laboratory shall be selected by an ASME designee.

(2) Operational and capacity tests shall be conducted in the presence of an ASME designee at an ASME accepted laboratory. The valve Manufacturer shall be notified of the time of the test and may have representatives present to witness the test.

(3) Should any valve fail to relieve at or above its certified capacity or should it fail to meet performance requirements of this Section, the test shall be repeated at the rate of two replacement valves, selected in accordance with HG-401.3(c)(1), for each valve that failed.

(4) Failure of any of the replacement valves to meet the capacity or the performance requirements of this Section shall be cause for revocation within 60 days of the authorization to use the Code Symbol on that particular type of valve. During this period, the Manufacturer shall demonstrate the cause of such deficiency and the action taken to guard against future occurrence, and the requirements of HG-401.3(c) above shall apply.

(d) Safety valves shall be sealed in a manner to prevent the valve from being taken apart without breaking the seal. Safety relief valves shall be set and sealed so that they cannot be reset without breaking the seal.

HG-401.4 Manufacturer's Testing

(a) Every safety valve shall be tested to demonstrate its popping point, blowdown, and tightness. Every safety relief valve shall be tested to demonstrate its opening point and tightness. Safety valves shall be tested on steam or air and safety relief valves on water, steam, or air. When the blowdown is nonadjustable, the blowdown test may be performed on a sampling basis.

(b) A Manufacturer shall have a well-established program for the application, calibration, and maintenance of test gages.

*(c)*Testing time on safety valves shall be sufficient, depending on size and design, to insure that test results are repeatable and representative of field performance.

(d) Test fixtures and test drums shall be of adequate size and capacity to assure representative pop action and accuracy of blowdown adjustment.

(e) A tightness test shall be conducted at maximum expected operating pressure, but not at a pressure exceeding the reseating pressure of the valve.

HG-401.5 Design Requirements. At the time of the submission of valves for capacity certification, or testing in accordance with this Section, the ASME Designee has the authority to review the design for conformity with the requirements of this Section, and to reject or require modification of designs which do not conform, prior to capacity testing.

HG402 DISCHARGE CAPACITIES OF SAFETY AND SAFETY RELIEF VALVES

A99 **HG-402.1 Valve Markings.** Each safety or safety relief valve shall be plainly marked with the required data by the Manufacturer in such a way that the markings will not be obliterated in service. The markings shall be stamped, etched, impressed, or cast on the valve or on a nameplate, which shall be securely fastened to the valve.

(a) The markings shall include the following:

(1) the name or an acceptable abbreviation of the Manufacturer;

(2) Manufacturer's design or type number;

(3) NPS size ____ in. (the nominal pipe size of the valve inlet);

(4) set pressure ____ psi;

(5) capacity ____ lb/hr, or capacity ____ Btu/hr in accordance with HG-402.7(a);

(6) year built or, alternatively, a coding may be marked on the valves such that the valve Manufacturer can identify the year the valve was assembled and tested; and

(7) ASME Symbol as show in Fig. HG-402.

(b) Nameplates of safety or safety-relief valves may be marked solely in metric units under the following conditions:

(1) The pressure-relief device will be installed in a location where metric units are required or accepted by local authorities, if any.

(2) Metric units shall be those required by the user when not mandated by enforcement authorities.

(3) The Manufacturer's quality control system shall provide the conversion from U.S. customary units to the metric units that will be marked on the nameplate.

HG-402.2 Authorization to Use ASME Stamp

Each safety valve to which the Code Symbol (Fig. HG-402) is to be applied shall be produced by a Manufacturer and/or Assembler who is in possession of a valid Certificate of Authorization (See HG-540)

98 **HG-402.3 Determination of Capacity to Be Stamped on Valves.** The Manufacturer of the valves that are to be stamped with the Code symbol shall submit valves for testing to a place where adequate equipment and personnel are available to conduct pressure and relieving-capacity tests which shall be made in the presence of and certified by an authorized observer. The place, personnel, and authorized observer shall be approved by the Boiler and Pressure Vessel Committee. The valves shall be tested in one of the following three methods:

(a) Coefficient Method. Tests shall be made to determine the lift, popping, and blowdown pressures, and the capacity of at least three valves each of three representative sizes (a total of nine valves). Each valve of a given size shall be set at a different pressure. However, safety valves for steam boilers shall have all nine valves set at 15 psig (103 kPa). A coefficient shall be established for each test as follows:

$$K_D = \frac{\text{Actual steam flow}}{\text{Theoretical steam flow}} = \text{Coefficient of discharge}$$

The average of the coefficients K_D of the nine tests required shall be multiplied by 0.90, and this product shall be taken as the coefficient K of that design. The stamped capacity of all sizes and pressures shall not exceed the value determined from the following formulas:

For 45 deg. seat,

$$W = 51.5\,\pi DLP \times 0.707K$$

For flat seat,

$$W = 51.5\,\pi DLPK$$

For nozzle,

$$W = 51.5\,APK$$

Where

W = weight of steam/hr, lb.
D = seat diameter, in.
L = lift, in.
P = (1.10 x set pressure + 14.7) psia for hot water applications or
= (5.0 psi + 15 psi set + 14.7) psia for steam boilers
K = coefficient of discharge for the design
A = nozzle-throat area, sq in.

NOTE: The maximum and minimum coefficient determined by the tests of a valve design shall not vary more than +-5% from the average. If one or more tests are outside the acceptable limits, one valve of the Manufacturer's choice shall be replaced with another valve of the same size and pressure setting or by a modification of the original valve. Following this test a new average coefficient shall be calculated, excluding the replaced the valve test. If one or more tests are now outside the acceptable limits, as determined by the new average coefficient, a valve of the Manufacturer's choice must be replaced by two valves of the same size and pressure as the rejected valve. A new average coefficient, including the replacement valves, shall be calculated. If any valve, excluding the two replaced valves, now falls outside the acceptable limits, the tests shall be considered unsatisfactory.

FIG. HG-402 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD

(b) Slope Method. If a Manufacturer wishes to apply the Code Symbol to a design of pressure relief valves, four valves of each combination of pipe and orifice size shall be tested. These four valves shall be set at pressures that cover the approximate range of pressures for which the valve will be used, or that cover the range available at the certified test facility that shall conduct the tests. The capacities shall be based on these four tests as follows.

(1) The slope (W/P) of the actual measured capacity versus the flow pressure for each test point shall be calculated and averaged:

$$\text{slope} = W/P = \frac{\text{measured capacity}}{\text{absolute flow pressure, psia}}$$

All values derived from the testing must fall within $\pm$5% of the average value:

minimum slope = 0.95 x average slope

maximum slope = 1.05 x average slope

If the values derived from the testing do not fall between the minimum and maximum slope values, the Authorized Observer shall require that additional valves be tested at the rate of two for each valve beyond the maximum and minimum values with a limit of four additional valves.

(2) The relieving capacity to be stamped on the valve shall not exceed 90% of the average slope times the absolute accumulation pressure:

rated slope = 0.90 x average slope

stamped capacity ≤ rated slope x (1.10 x set pressure + 14.7) psia for hot water applications

(c)Three-Valve Method. If a Manufacturer wishes to apply the Code Symbol to steam safety valves or safety relief valves of one or more sizes of a design set at one pressure, he shall submit three valves of each size of each design set at one pressure for testing and the stamped capacity of each size shall not exceed 90% of the average capacity of the three valves tested.

NOTE: The discharge capacity as determined by the test of each valve tested shall not vary by more than +-5% of the average capacity of the three valves tested. If one of the three valve tests falls outside of the limits, it may be replaced by two valves and a new average calculated based on all four valves, excluding the replaced valve.

HG-402.4 Pressures at Which Capacity Tests Shall Be Conducted. Safety valves for steam boilers shall be tested for capacity at 5 psi (35 kPa) over the set pressure for which the valve is set to operate. Capacity certification tests of safety relief valves for hot water heating and hot water supply boilers shall be conducted at 110% of the pressure for which the valve is set to operate.

HG-402.5 Opening Tests of Temperature and Pressure Safety Relief Valves. For the purpose of determining the set (opening) pressure, the test medium shall be room temperature water. The actual set pressure is defined as the pressure at the valve inlet when the flow rate through the valve is 40 cc/min. Capacity tests shall be conducted with steam (see HG-402.7) at a pressure 10% above the actual water set pressure. For production capacity check tests, the rated capacity shall be based on the actual water set pressure.

HG-402.6 Capacity Tests of Temperature and Pressure Safety Relief Valves. For the purpose of determining the capacity of temperature and pressure safety relief valves, dummy elements of the same size and shape as the regularly applied thermal element shall be substituted and the relieving capacity shall be based on the pressure element only. Valves selected to meet the requirements of production testing, HG-401.3, shall have their temperature elements deactivated by the Manufacturer prior to or at the time of capacity testing.

HG-402.7 Fluid Medium for Capacity Tests. The tests shall be made with dry saturated steam. For test purposes the limits of 98% minimum quality and 20ºF (11ºC) maximum superheat shall apply. Correction from within these limits may be made to the dry saturated condition. The relieving capacity shall be measured by condensing the steam or with a calibrated steam flowmeter.

(a) To determine the discharge capacity of safety relief valves in terms of Btu, the relieving capacity in pounds for steam per hour W is multiplied by 1000.

HG-402.8 Where and by Whom Capacity Tests Shall be Conducted

(a) Tests shall be conducted at a place where the testing facilities, methods, procedures, and person supervising the tests (Authorized Observer) meet the applicable requirements of ASME PTC 25-1994. The tests shall be made under the supervision of and certified by an Authorized Observer. The testing facilities, methods, procedures, and qualifications of the Authorized Observer shall be subject to the acceptance of ASME on recommendation of an ASME Designee. Acceptance of the testing facility is subject to review within each 5 year period.

(b) Capacity test data reports for each valve model, type, and size, signed by the Manufacturer and the Authorized Observer witnessing the tests, shall be submitted to the ASME Designee for review and acceptance.[2]

NOTE: When changes are made in the design, capacity certification tests shall be repeated.

[2]Valve capacities are published in "Pressure Relief Device Certifications." This publication may be obtained from The National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, OH 43229

HG-402.9 Test Record Data Sheet. A data sheet for each valve shall be filled out and signed by the authorized observer witnessing the test. Such data sheet will be the manufacturer's authority to build and stamp valves of corresponding design and construction. When changes are made in the design of a safety or safety relief valve in such a manner as to affect the flow path, lift, or performance characteristics of the valve, new tests in accordance with this Section shall be performed.

NOTE: See HG-512 for safety and safety relief valve accumulation test requirements. See HG-701 for safety and safety relief valve installation requirements.

HG-403 HEATING SURFACE

The heating surface shall be computed as follows.

(a) Heating surface, as part of a circulating system in contact on one side with water or wet steam being heated and on the other side with gas or refractory being cooled, shall be measured on the side receiving heat.

(b) Boiler heating surface and other equivalent surface outside the furnace shall be measured circumferentially plus any extended surface.

(c) Waterwall heating surface and other equivalent surface within the furnace shall be measured as the projected tube area (diameter x length) plus any extended surface on the furnace side. In computing the heating surface for this purpose, only the tubes, fireboxes, shells, tubesheets, and the projected area of headers need be considered, except that for vertical firetube steam boilers, only that portion of the tube surface up to the middle of the gage glass is to be computed.

HG-405 TEMPERATURE AND PRESSURE SAFETY RELIEF VALVES

The thermal sensing elements for temperature and pressure safety relief valves shall be so designed and constructed that they will not fail in any manner which could obstruct flow passages or reduce capacities of the valves when the elements are subjected to saturated steam temperature corresponding to capacity test pressure. Temperature and pressure safety relief valves incorporating these elements shall comply with a nationally recognized standard.[3]

HG-512 SAFETY AND SAFETY RELIEF VALVE ACCUMULATION TESTS

If the safety valve or safety relief valve capacity cannot be computed or if it is desirable to prove the computations, it may be checked in any one of the following ways, and if found insufficient, additional capacity shall be provided:

(a) by making an accumulation test, that is, by shutting off all discharge outlets from the boiler and forcing the fires to the maximum, the safety valve equipment shall be sufficient to prevent an excess pressure beyond the specified in HG-400.1(f) and HG-400.2(f);

(b) by measuring the maximum amount of fuel that can be burned, and computing the corresponding evaporative capacity upon the basis the heating value of the fuel. (See B-100, B-101, and B-102.)

[3]An example of a nationally recognized standard is ANSI Z21.22, Relief Valves and Automatic Gas Shutoff Devices for Hot Water Supply Systems.

ARTICLE 7
INSTALLATION REQUIREMENTS

HG-701 MOUNTING SAFETY AND SAFETY RELIEF VALVES

HG-701.1 Permissible Mounting. Safety valves and safety relief valves shall be located in the top or side[1] of the boiler. They shall be connected directly to a tapped or flanged opening in the boiler, to a fitting connected to the boiler by a short nipple, to a Y-base, or to a valveless header connecting steam or water outlets on the same boiler. Coil or header type boilers shall have the safety valve or safety relief valve located on the steam or hot water outlet end. Safety valves and safety relief valves shall be installed with their spindles vertical. The opening or connection between the boiler and any safety valve or safety relief valve shall have at least the area of the valve inlet.

HG-701.2 Requirements for Common Connections for Two or More Valves

(a) When a boiler is fitted with two or more safety valves on one connection, this connection shall have a cross-sectional area not less than the combined areas of inlet connections of all the safety valves with which it connects.

(b) When a Y-base is used, the inlet area shall be not less than the combined outlet areas. When the size of the boiler requires a safety valve or safety relief valve larger than 4½ in. (115 mm) in diameter, two or more valves having the required combined capacity shall be used. When two or more valves are used on a boiler, they may be single, directly attached, or mounted on a Y-base.

HG-701.3 Threaded Connections. A threaded connection may be used for attaching a valve.

HG-701.4 Prohibited Mountings. Safety and safety relief valves shall not be connected to an internal pipe in the boiler.

[1]The top or side of the boiler shall mean the highest practicable part of the boiler proper but in no case shall the safety valve be located below the normal operating level and in no case shall the safety relief valve be located below the lowest permissible water level.

HG-701.5 Use of Shutoff Valves Prohibited. No shutoff of any description shall be placed between the safety or safety relief valve and the boiler, or on discharge pipes between such valves and the atmosphere.

HG-701.6 SAFETY AND SAFETY RELIEF VALVE DISCHARGE PIPING

(a) A discharge pipe shall be used. Its internal cross-sectional area shall be not less than the full area of the valve outlet or of the total of the valve outlets discharging thereinto and shall be as short and straight as possible and so arranged as to avoid undue stress on the valve or valves. A union may be installed in the discharge piping close to the valve outlet. When an elbow is placed on a safety or safety relief valve discharge pipe, it shall be located close to the valve outlet downstream of the union.

(b) The discharge from safety or safety relief valves shall be so arranged that there will be no danger of scalding attendants. The safety or safety relief valve discharge shall be piped away from the boiler to the point of discharge, and there shall be provisions made for properly draining the piping. The size and arrangement of discharge piping shall be independent of other discharge piping and shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the relieving devices below that required to protect the boiler.

HG-701.7 Temperature and Pressure Safety Relief Valves. Hot water heating or supply boilers limited to a water temperature of 210ºF (99ºC) may have one or more officially rated temperature and pressure safety relief valves installed. The requirements of HG-701.1 through HG-701.6 shall be met, except as follows:

(a) A Y-type fitting shall not be used.

(b) If additional valves are used they shall be temperature and pressure safety relief valves.

(c) When the temperature and pressure safety relief valve is mounted directly on the boiler with no more than 4 in. (102 mm) maximum interconnecting piping, the valve may be installed in the horizontal position with the outlet pointed down.

ARTICLE 8
INSTALLATION REQUIREMENTS

HLW-800 SAFETY RELIEF VALVES

HLW-800.1 Safety Relief Valve Requirements for Water Heaters

(a) Each water heater shall have at least one officially rated temperature and pressure safety relief valve or at least one officially rated safety relief valve. The valve(s) shall be marked with the ASME Code Symbol V or HV to evidence compliance with the construction and rating requirements of the ASME Boiler and Pressure Vessel Code. No safety relief valve shall be smaller than NPS 3/4 (DN 20).

(b) The pressure setting shall be less than or equal to the maximum allowable working pressure of the water heater. However, if any of the other components in the hot water supply system (such as valves, pumps, expansion or storage tanks, or piping) have a lesser working pressure rating than the water heater, the pressure setting for the relief valve(s) shall be based upon the component with the lowest maximum allowable working pressure rating. If more than one safety relief valve is used, the additional valve(s) may be set within a range not to exceed 10% over the set pressure of the first valve.

(c) The required relieving capacity in Btu/hr of the safety relief valve shall not be less than the maximum allowable input unless the water heater is marked with the rated burner input capacity of the water heater on the casing in a readily visible location, in which case the rated burner input capacity may be used on a basis for sizing the safety relief valves. The relieving capacity for electric water heaters shall be 3500 Btu/hr (1.0 kW) per kW of input. In every case, the following requirements shall be met. Safety relief valve capacity for each water heater shall be such that with the fuel burning equipment installed and operated at maximum capacity the pressure cannot rise more than 10% of maximum allowable working pressures.

(d) If operating conditions are changed or additional heater heating surface is installed, the safety relief valve capacity shall be increased, if necessary, to meet the new conditions and shall be in accordance with the above provisions. In no case shall the increased input capacity exceed the maximum allowable input capacity. The additional valves required, on account of changed conditions, may be installed on the outlet piping provided there is no intervening valve.

HLW-801 MOUNTING SAFETY RELIEF VALVES

HLW-801.1 Installation. Safety relief valves shall be installed by either the installer or the manufacturer before a water heater is placed in operation.

HLW-801.2 Permissible Mountings. Safety relief valves shall be connected to the top of water heaters or directly to a tapped or flanged opening in the water heater, to a fitting connected to the water heater by short nipple, to a Y-base, or to a valveless header connecting water outlets on the same heater. Safety relief valves shall be installed with their spindles upright and vertical with no horizontal connecting pipe, except that, when the safety relief valve is mounted directly on the water heater vessel with no more than 4 in. (102 mm) maximum interconnecting piping, the valve may be installed in the horizontal position with the outlet pointed down. The center line of the safety relief valve connection shall be no lower than 4 in. (102 mm) from the top of the shell. No piping or fitting used to mount the safety relief valve shall be of a nominal pipe size less than that of the valve inlet.

HLW-801.3 Requirements for Common Connection for Two or More Valves

(a) When a water heater is fitted with two or more safety relief valves on one connection, this connection shall have a cross-sectional area not less than the combined areas of inlet connections of all the safety relief valves with which it connects.

(b) When a Y-base is used, the inlet area shall be not less than the combined outlet areas. When the size of the water heater requires a safety relief valve larger than 4 1/2 in. (114 mm) diameter, two or more valves having the required combined capacity shall be used. When two or more valves are used on a water heater, they may be single, directly attached, or mounted on a Y-base.

HLW-801.4 Threaded Connections. A threaded connection may be used for attaching a valve.

HLW-801.5 Prohibited Mounting. Safety relief valves shall not be connected to an internal pipe in the water heater or a cold water feed line connected to the water heater.

HLW-801.6 Use of Shutoff Valves Prohibited. No shutoff of any description shall be placed between the safety relief valve and the water heater, or on discharge pipes between such valves and the atmosphere.

HLW-801.7 Safety Relief Valve Discharge Piping

(a) When a discharge pipe is used, its internal cross-sectional area shall be not less than the full area of the valve outlet or of the total of the valve outlets discharging thereinto, and shall be as short and straight as possible and so arranged as to avoid undue stress on the valve or valves. When an elbow is placed on a safety relief discharge pipe, it shall be located close to the valve outlet.

(b) The discharge from safety relief valves shall be so arranged that there will be no danger of scaling attendants. When the safety relief valve discharge is piped away from the water heater to the point of discharge, there shall be provisions for properly draining the piping and valve body. The size and arrangement of discharge piping shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the relieving devices below that required to protect the water heater.

EXCERPTS FROM
ASME CODE
SECTION VIII

NOTES:

PRESSURE RELIEF DEVICES

98 UG-125 GENERAL

(a) All pressure vessels within the Scope of this Division, irrespective of size or pressure, shall be provided with pressure relief devices in accordance with the requirements of UG-125 through UG-137. It is the responsibility of the user to ensure that the required pressure relief devices are properly installed prior to initial operation. These pressure relief devices need not be supplied by the vessel Manufacturer. Unless otherwise defined in this Division, the definitions relating to pressure relief devices in Section 2 of ASME PTC 25 shall apply.

(b) An unfired steam boiler, as defined in U-1(g), shall be equipped with pressure relief devices required by Section I insofar as they are applicable to the service of the particular installation

(c) All pressure vessels other than unfired steam boilers shall be protected by a pressure relief device that shall prevent the pressure from rising more than 10% or 3psi, whichever is greater, above the maximum allowable working pressure except as permitted in (1) and (2) below. (See UG-134 for pressure settings.)

(1) When multiple pressure relief devices are provided and set in accordance with UG-134(a), they shall prevent the pressure from rising more than 16% or 4 psi, whichever is greater, above the maximum allowable working pressure.

(2) Where an additional hazard can be created by exposure of a pressure vessel to fire or other unexpected sources of external heat, supplemental pressure relief devices shall be installed to protect against excessive pressure. Such supplemental pressure relief devices shall be capable of preventing the pressure from rising more than 21% above the maximum allowable working pressure. The same pressure relief devices may be used to satisfy the capacity requirements of (c) or (c)(1) above and this paragraph provided the pressure setting requirements of UG-134(a) are met.

(3) Pressure relief devices, intended primarily for protection against exposure of a pressure vessel to fire or other unexpected sources of external heat installed on vessels having no permanent supply connection and used for storage at ambient temperatures of nonrefrigerated liquefied compressed gases,[41] are excluded from the requirements of (c)(1) and (c)(2) above, provided:

(a) the pressure relief devices are capable of preventing the pressure from rising more than 20% above the maximum allowable working pressure of the vessels;

(b) the set pressure marked on these devices shall not exceed the maximum allowable working pressure of the vessels;

(c) the vessels have sufficient ullage to avoid a liquid full condition;

(d) the maximum allowable working pressure of the vessels on which these pressure relief devices are installed is greater than the vapor pressure of the stored liquefied compressed gas at the maximum anticipated temperature[42] that the gas will reach under atmospheric conditions; and

(e) pressure relief valves used to satisfy these provisions also comply with the requirements of UG-129(a)(5), UG-131(c)(2), and UG-134(d)(2).

(d) Pressure relief devices shall be constructed, located, and installed so that they are readily accessible for inspection, replacement, and repair so that they cannot be readily rendered inoperative (see Appendix M), and should be selected on the basis of their intended service.

(e) Pressure relief valves or nonreclosing pressure relief devices[43] may be used to protect against overpressure. Nonreclosing pressure relief devices may be used either alone or, if applicable, in combination with pressure relief valves on vessels.

NOTE: Use of nonclosing pressure relief devices of some types may be advisable on vessels containing substances that may render a pressure relief valve inoperative, where a loss of valuable material by leakage should be avoided, or where contamination of the atmosphere by leakage of noxious fluids must be avoided. The use of rupture disk devices may also be advisable when very rapid rates of pressure rise may be encountered.

(f) Vessels that are to operate completely filled with liquid shall be equipped with pressure relief devices designed for liquid service, unless otherwise protected against overpressure.

(g) The pressure relief devices required in (a) above need not be installed directly on a pressure vessel when the source of pressure is external to the vessel and is under such positive control that the pressure in the vessel cannot exceed the maximum allowable working pressure at the operating temperature except as permitted in (c) above (see UG-98).

NOTE: Pressure reducing valves and similar mechanical or electrical control instruments, except for pilot operated pressure relief valves as permitted in UG-126(b), are not considered as sufficiently positive in action to prevent excess pressures from being developed.

(h) Pressure relief valves for steam service shall meet the requirements of UG-131(b).

UG-126 PRESSURE RELIEF VALVES[44]

(a) Safety, safety relief, and relief valves shall be of the direct spring loaded type.

[41]For the purpose of these rules, gases are considered to be substances having a vapor pressure greater than 40 psia at 100ºF.

[42]Normally this temperature should not be less than 115ºF.

[43]A *pressure relief valve* is a pressure relief device which is designed to reclose and prevent the further flow of fluid after normal conditions have been restored. A *nonreclosing pressure relief device* is a pressure relief device designed to remain open after operation.

(b) Pilot operated pressure relief valves may be used, provided that the pilot is self-actuated and the main valve will open automatically at not over the set pressure and will discharge its full rated capacity if some essential part of the pilot should fail.

(c) The spring in a pressure relief valve shall not be set for any pressure more than 5% above or below that for which the valve is marked, unless the setting is within the spring design range established by the valve Manufacturer or is determined to be acceptable to the manufacturer. The initial adjustment shall be performed by the Manufacturer, his authorized representative, or an Assembler, and a valve data tag shall be provided that identifies the set pressure capacity and date. The valve shall be sealed with a seal identifying the Manufacturer, his authorized representative, or the Assembler performing the adjustment.

(d) The set pressure tolerances, plus or minus, of pressure relief valves shall not exceed 2 psi (13.8 kPa) for pressures up to and including 70 psi (483 kPa) and 3% for pressures above 70 psi (483 kPa).

UG-127 NONRECLOSING PRESSURE RELIEF DEVICES

(a) Rupture Disk Devices[45]

A99

(1) General. Every rupture disk shall have a marked burst pressure established by rules of UG-137(d)(3) within a manufacturing design range[46] at a specified disk temperature[47] and shall be marked with a lot[48] number. The burst pressure tolerance at the specified disk temperature shall not exceed ±2% psi (±13.8 kPa) for marked burst pressure up to and including 40 psi (276 kPa) and ±5% for marked burst pressure above 40 psi (276 kPa).

(2) Relieving Capacity. The rated flow capacity of a pressure relief system which uses a rupture disk device as the sole relief device shall be determined by a value calculated under the requirements of (a) using a coefficient of discharge or (b) using flow resistances below.

(a) When the rupture disk device discharges directly to atmosphere and

(1) is installed within eight pipe diameters from the vessel nozzle entry; and

(2) with a length of discharge pipe not greater than five pipe diameters from the rupture disk device; and

(3) the nominal diameters of the inlet and discharge piping are equal to or greater than the stamped NPS designator of the device,

the calculated relieving capacity of a pressure relief system shall not exceed a value based on the applicable theoretical flow equation [see UG-131(e)(2) and Appendix 11] for the various media multiplied by a coefficient of discharge K equal to 0.62. The area A in the theoretical flow equation shall be the minimum net flow area[49] as specified by the rupture disk device Manufacturer.

(b) The calculated capacity of any pressure relief system may be determined by analyzing the total system resistance to flow. This analysis shall take into consideration the flow resistance of the rupture disk device, piping and piping components including the exit nozzle on the vessels, elbows, tees, reducers, and valves. The calculation shall be made using accepted engineering practices for determining fluid flow through piping systems. This calculated relieving capacity shall be multiplied by a factor of 0.90 or less to allow for uncertainties inherent with this method. The certified flow resistance[50] K_R for the rupture disk device, expressed as the velocity head loss, shall be determined in accordance with UG-131(k) through (r).

(3) Application of Rupture Disks

(a) A rupture disk device may be used as the sole pressure relieving device on a vessel.

NOTE: When rupture disk devices are used, it is recommended that the design pressure of the vessel be sufficiently above the intended operating pressure to provide sufficient margin between operating pressure and rupture disk bursting pressure to prevent premature failure of the rupture disk due to fatigue or creep.

Application of rupture disk devices to liquid service should be carefully evaluated to assure that the design of the rupture disk device and the dynamic energy of the system on which it is installed will result in sufficient opening of the rupture disk.

(b) A rupture disk device may be installed between a pressure relief valve51 and the vessel provided:

[44] A *safety valve* is a pressure relief valve actuated by inlet static pressure and characterized by rapid opening or pop action. A *relief valve* is a pressure relief valve actuated by inlet static pressure which opens in proportion to the increase in pressure over the opening pressure. A *safety relief valve* is a pressure relief valve characterized by rapid opening or pop action, or by opening in proportion to the increase in pressure over the opening pressure, depending on application. A *pilot operated pressure relief valve* is a pressure relief valve in which the major relieving device is combined with an is controlled by a self-actuated auxiliary pressure relief valve.

[45] A *rupture disk device* is a nonreclosing pressure relief device actuated by inlet static pressure and designed to function by the bursting of a pressure containing disk. A *rupture disk* is the pressure containing and pressure sensitive element of a *rupture disk device*. Rupture disks may be designed in several configurations, such a plain flat, prebulged, or reverse buckling. A *rupture disk holder* is the structure which encloses and clamps the rupture disk in position.

[46] The *manufacturing design range* is a range of pressure within which the marked burst pressure must fall to be acceptable for a particular requirement as agreed upon between the rupture disk Manufacturer and the user or his agent.

[47] The specified disk temperature supplied to the rupture disk Manufacturer shall be the temperature of the disk when the disk is expected to burst.

[48] A *lot of rupture disks* is those disks manufactured of a material at the same time, of the same size, thickness, type, heat, and manufacturing process including heat treatment.

[49] The *minimum net flow area* is the calculated net area after a complete burst of the disk with appropriate allowance for any structural members which may reduce the net flow area through the rupture disk device. The net flow area for sizing purposes shall not exceed the nominal pipe size area of the rupture disk device.

[50] The *certified flow resistance* K_R is a dimensionless factor used to calculate the velocity head loss that results from the presence of a rupture disk device in a pressure relief system.

[51] Use of a rupture disk device in combination with a pressure relief valve shall be carefully evaluated to ensure that the media being handled and the valve operational characteristics will result in opening of the valve coincident with the bursting of the rupture disk.

(1) the combination of the pressure relief valve and the rupture disk device is ample in capacity to meet the requirements of UG-133(a) and (b);

(2) the marked capacity of a pressure relief valve (nozzle type) when installed with a rupture disk device between the inlet of the valve and the vessel shall be multiplied by a factor of 0.90 of the rated relieving capacity of the valve alone, or alternatively, the capacity of such a combination shall be established in accordance with (3) below;

(3) the capacity of the combination of the rupture disk device and the pressure relief valve may be established in accordance with the appropriate paragraphs of UG-132;

(4) the space between a rupture disk device and a pressure relief valve shall be provided with a pressure gage, a try cock, free vent, or suitable telltale indicator. This arrangement permits detection of disk rupture or leakage.[52]

(5) the opening[49] provided through the rupture disk, after burst, is sufficient to permit a flow equal to the capacity of the valve [(2) and (3) above], and there is no chance of interference with proper functioning of the valve; but in no case shall this area be less than the area of the inlet of the valve unless the capacity and functioning of the specific combination of rupture disk device and pressure relief valve have been established by test in accordance with UG-132.

(c) A rupture disk device may be installed on the outlet side[53] of a pressure relief valve which is opened by direct action of the pressure in the vessel provided:

(1) the pressure relief valve will not fail to open at its proper pressure setting regardless of any back pressure that can accumulate between the pressure relief valve disk and the rupture disk. The space between the pressure relief valve disk and the rupture disk shall be vented or drained to prevent accumulation of pressure, or suitable means shall be provided to ensure that an accumulation of pressure does not affect the proper operation of the pressure relief valve.[54]

(2) the pressure relief valve is ample in capacity to meet the requirements of UG-125(c);

(3) the marked burst pressure of the rupture disk at the specified disk temperature plus any pressure in the outlet piping shall not exceed the design pressure of the outlet portion of the pressure relief valve and any pipe or fitting between the valve and the rupture disk device. However, in no case shall the marked burst pressure of the rupture disk at the specified disk temperature plus any pressure in the outlet piping exceed the maximum allowable working pressure of the vessel or the set pressure of the pressure relief valve.

(4) the opening provided through the rupture disk device after breakage is sufficient to permit a flow equal to the rated capacity of the attached pressure relief valve without exceeding the allowable overpressure;

(5) any piping beyond the rupture disk cannot be obstructed by the rupture disk or fragment;

(6) the system is designed to consider the adverse effects of any leakage through the pressure relief valve or through the outlet side rupture disk device, to ensure system performance and reliability.[62]

(7) the bonnet of a balancing bellows or diaphragm type pressure relief valve shall be vented to prevent accumulation of pressure in the bonnet.

(b) Breaking Pin Device[55]

(1) Breaking pin devices shall not be used as single devices but only in combination between the pressure relief valve and the vessel.

(2) The space between a breaking pin device and a pressure relief valve shall be provided with a pressure gage, a try cock, a free vent, or suitable telltale indicator. This arrangement permits detection of breaking pin device operation or leakage.

(3) Each breaking pin device shall have a rated pressure and temperature at which the pin will break. The breaking pin shall be identified to a lot number and shall be guaranteed by the Manufacturer to break when the rated pressure, within the following tolerances, is applied to the device:

Rated Pressure, psi		
Minimum	Maximum	Tolerance, Plus or Minus, psi
30	150	5
151	275	10
276	375	15

(4) The rated pressure of the breaking pin plus the tolerance in psi shall not exceed 105% of the maximum allowable working pressure of the vessel to which it is applied.

[52]Users are warned that a rupture disk will not burst at its design pressure if back pressure builds up in the space between the disk and the pressure relief valve which will occur should leakage develop in the rupture disk due to corrosion or other cause.

[53]This use of a rupture disk device in series with the pressure relief valve is permitted to minimize the loss by leakage through the valve of valuable or of noxious or otherwise hazardous materials, and where a rupture disk alone or disk located on the inlet side of the valve is impracticable, or to prevent corrosive gases from a common discharge line from reaching the valve internals.

A99 [54]Users are warned that many types of pressure relief valves will not open at the set pressure if pressure builds up in the space between the pressure relief valve disk and the rupture disk device. A specially designed pressure relief valve such as a diaphragm valve, pilot operated valve, or a valve equipped with a balancing bellows above the disk may be required.

[55]A *breaking pin device* is a nonreclosing pressure relief device actuated by inlet static pressure and designed to function by the breakage of a load-carrying section of a pin which supports a pressure containing member. A *breaking pin* is the load-carrying element of a breaking pin device. A *breaking pin housing* is the structure which encloses the breaking pin mechanism. The material of the housing shall be listed in Section II and be permitted for use in this Division.

[56]The specified temperature supplied to the breaking pin manufacturer shall be the temperature of the breaking pin when an emergency condition exists and the pin is expected to break.

[62]Some adverse effects resulting from leakage may include obstructing the flow path, corrosion of pressure relief valve components, and undesirable bursts of the outlet side rupture disk.

(5) The rated pressure at the specified temperature[56] shall be verified by breaking two or more sample breaking pins from each lot of the same material and the same size as those to be used. The lot size shall not exceed 25. The test shall be made in a device of the same form and pressure dimensions as that in which the breaking pin is to be used.

(c) Spring Loaded Nonreclosing Pressure Relief Device

(1) A spring loaded nonreclosing pressure relief device, pressure actuated by means which permit the spring loaded portion of the device to open at the specified set pressure and remain open until manually reset, may be used provided the design of the spring loaded nonreclosing device is such that if the actuating means fail, the device will achieve full opening at or below its set pressure. Such a device may not be used in combination with any other pressure relief device. The tolerance on opening point shall not exceed ±5%.

(2) The calculated capacity rating of the spring loaded nonreclosing pressure relief device shall not exceed a value based on the applicable theoretical formula (see UG-131) for the various media, multiplied by: K = coefficient = 0.62.

The area A (square inches) in the theoretical formula shall be the flow area through the minimum opening of the spring loaded nonreclosing pressure relief device.

(3) In lieu of the method of capacity rating in (2) above, a Manufacturer may have the capacity of a spring loaded nonreclosing pressure relief device design certified in general accordance with the procedures of UG-131, as applicable.

UG-128 LIQUID PRESSURE RELIEF VALVES

Any liquid pressure relief valve used shall be at least NPS ½.

UG-129 MARKING

(a) Safety, Safety Relief, Relief, Liquid Pressure Relief, and Pilot Operated Pressure Relief Valves. Each safety, safety relief, relief, liquid pressure relief, and pilot operated pressure relief valve NPS ½ (DN 15) and larger shall be plainly marked by the Manufacturer or Assembler with the required data in such a way that the marking will not be obliterated in service. The marking may be placed on the valve or on a plate or plates that satisfy the requirements of UG-119:

(1) the name, or an acceptable abbreviation, of the Manufacturer and the Assembler;

(2) Manufacturer's design or type number;

(3) NPS size ____ (the nominal pipe size of the valve inlet);

(4) set pressure ____ psi, and if applicable per UG-136(d)(4), cold differential test pressure ____ psi.

(5) certified capacity (as applicable);

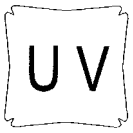


FIG. UG-129.1 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR PRESSURE RELIEF VALVES

(a) lb/hr of saturated steam at an overpressure of 10% or 3 psi (20.6 kPa), whichever is greater for valves certified on steam complying with UG-131(b); or

(b) gal/min of water at 70ºF (21ºC) at an overpressure of 10% or 3 psi (20.6 kPa), whichever is greater for valves certified on water; or

(c) SCFM [standard cubic feet per minute at 60ºF and 14.7 psia (16ºC and 101 kPa), or lb/min, of air at an overpressure of 10% or 3 psi (20.6 kPa), whichever is greater. Valves that are capacity certified in accordance with UG-131(c)(2) shall be marked "at 20% overpressure".

(d) In addition to one of the fluids specified above, the Manufacturer may indicate the capacity in other fluids (see Appendix 11).

(6) year built, or alternatively, a coding may be marked on the valve such that the valve Manufacturer or Assembler can identify the year the valve was assembled or tested;

(7) ASME Symbol as shown in Fig. UG-129.1. The pilot of a pilot operated pressure relief valve shall be plainly marked by the Manufacturer or Assembler showing the name of the Manufacturer, the Manufacturer's design or type number, the set pressure in pounds per square inch, and the year built, or alternatively, a coding that the Manufacturer can use to identify the year built.

On valves smaller than NPS ½ (DN 15), the markings may be made on a metal tag attached by wire or adhesive meeting the requirements of UG-119 or other means suitable for the service conditions.

(b) Safety and safety relief valves certified for a steam discharging capacity under the provisions of Section I and bearing the official code Symbol Stamp of Section I for safety valves may be used on pressure vessels. The rated capacity in terms of other fluids shall be determined by the method of conversion given in Appendix 11. [See UG-131(h)].

(c) Pressure Relief Valves in Combination With Rupture Disk Devices. Pressure relief valves in combination with rupture disk devices shall be marked with the capacity as established in accordance with UG-127(a)(3)(b)(2) (using 0.90 factor) or the combination capacity factor established by test in accordance with UG-132(a) or (b), in addition to the marking of UG-129(a) and (f) below. The marking may be placed on the pressure relief valve or rupture disk device or on a plate or plates that satisfy the requirements of UG-119. The marking shall include the following:

(1) name of Manufacturer of valve;
(2) design or type number of valve;
(3) name of Manufacturer of rupture disk device;
(4) design or type number of rupture disk device;
(5) capacity or combination capacity factor;
(6) name of organization responsible for this marking. This shall be either the vessel user, vessel Manufacturer, rupture disk Manufacturer, or pressure relief valve Manufacturer.

(d) Pressure Relief Valves in Combination With Breaking Pin Devices. Pressure relief valves in combination with breaking pin devices shall be marked in accordance with (a) above. In addition, the rated pressure shall be marked on the breaking pin and the breaking pin housing.

(e) Rupture Disk Devices. Every rupture disk shall be plainly marked by the Manufacturer in such a way that the marking will not be obliterated in service. The rupture disk marking may be placed on the flange of the disk or on a metal tab that satisfies the requirements of UG-119. The marking shall include the following:

(1) the name or identifying trademark of the Manufacturer;
(2) Manufacturer's design or type number;
(3) lot number;
(4) disk material;
(5) size ____ (NPS of rupture disk holder);
(6) marked burst pressure ____ psi;
(7) specified disk temperature ____ °F;
(8) minimum net flow area ____ sq in.;
(9) certified flow resistance K_R ____ ;
(10) ASME symbol as shown in Fig. UG-129.2;
(11) year built, or alternatively, a coding may be marked on the rupture disk such that the rupture disk device Manufacturer can identify the year the rupture disk device was assembled and tested.

Items (1), (2), and (5) above and flow direction shall also be marked on the rupture disk holder.

(f) Spring Loaded Nonreclosing Pressure Relief Devices. Spring loaded nonreclosing pressure relief devices shall be marked in accordance with (a) above except that the Code Symbol Stamp is to be applied only when the capacity has been established and certified in accordance with UG-127(c)(3) and all other requirements of UG-130 have been met.

A99 UG-130 CODE SYMBOL STAMP

Each pressure relief device[57] to which the Code Symbol (see Figs. UG-129.1 and UG-129.2) will be applied shall have been fabricated or assembled by a Manufacturer or Assembler holding a valid Certificate of Authorization (UG-117) and capacity certified in accordance with the requirements of this Division.

[57]Vacuum relief devices are not covered by Code Symbol Stamp requirements.

FIG. UG-129.2 OFFICIAL SYMBOL FOR STAMP TO DENOTE THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS' STANDARD FOR RUPTURE DISK DEVICES

UG-131 CERTIFICATION OF CAPACITY OF PRESSURE RELIEF DEVICES

(a) Before the Code Symbol is applied to any pressure relief device, the device Manufacturers shall have the capacity of their devices certified in accordance with the provisions of these paragraphs. For pressure relief valves, (b) through (j) below apply for rupture disk devices, (k) through (r) below apply except where noted.

(b)(1) Capacity certification tests for pressure relief valves for compressible fluids shall be conducted on dry saturated steam, or air, or gas. When dry saturated steam is used, the limits for test purposes shall be 98% minimum quality and 20ºF (11ºC) maximum superheat. Correction from within these limits may be made to the dry saturated condition. Pressure relief valves for steam service may be rated as above, but at least one valve of each series shall be tested on steam to demonstrate the steam capacity and performance.

(2) Capacity certification tests for pressure relief valves for incompressible fluids shall be conducted on water at a temperature between 40F and 125ºF (4ºC and 52ºC).

(c)(1) Capacity certification tests shall be conducted at a pressure which does not exceed the pressure for which the pressure relief valve is set to operate by more than 10% or 3 psi (20.6 kPa), whichever is greater, except as provided in (c)(2) below. Minimum pressure for capacity certification tests shall be at least 3 psi (20.6 kPa) above set pressure. The reseating pressure shall be noted and recorded.

(2) Capacity certification tests of pressure relief valves for use in accordance with UG-125(c)(3) may be conducted at a pressure not to exceed 120% of the stamped set pressure of the valve.

(3) (a) Pressure relief valves for compressible fluids having an adjustable blowdown construction shall be adjusted prior to testing so that the blowdown does not exceed 5% of the set pressure or 3 psi (20.6 kPa), whichever is greater.

(b) The blowdown of pressure relief valves for incompressible fluids and pressure relief valves for compressible fluids having nonadjustable blowdown shall be noted and recorded.

(4) Capacity certification of pilot operated pressure relief valves may be based on tests without the pilot valves installed, provided prior to capacity tests it has been demonstrated by test to the satisfaction of the Authorized

Observer that the pilot valve will cause the main valve to open fully at a pressure which does not exceed the set pressure by more than 10% or 3 psi (20.6 kPa), whichever is greater, and that the pilot valve in combination with the main valve will meet all the requirements of this Division.

(d)(1) A capacity certification test is required on a set of three valves for each combination of size, design, and pressure setting. The stamped capacity rating for each combination of design, size, and test pressure shall not exceed 90% of the average capacity of the three valves tested. The capacity for each set of three valves shall fall within a range of ±5% of the average capacity. Failure to meet this requirement shall be cause to refuse certification of that particular pressure relief valve design.

(2) If a Manufacturer wishes to apply the Code Symbol to a design of pressure relief valves, four valves of each combination of pipe size and orifice size shall be tested. These four valves shall be set at pressures which cover the approximate range of pressures for which the valve will be used or covering the range available at the certified test facility that shall conduct the tests. The capacities based on these four tests shall be as follows.

(a) For compressible fluids, the slope *W/P* of the actual measured capacity versus the flow pressure for each test point shall be calculated and averaged:

$$\text{slope} = \frac{W}{P} = \frac{\text{measured capacity}}{\text{absolute flow pressure, psia}}$$

All values derived from the testing must fall within ±5% of the average value:

minimum slope = 0.95 x average slope

maximum slope = 1.05 x average slope

If the values derived from the testing do not fall between the minimum and maximum slope values, the Authorized Observer shall require that additional valves be tested at the rate of two for each valve beyond the maximum and minimum values with a limit of four additional valves.

The relieving capacity to be stamped on the valve shall not exceed 90% of the average slope times the absolute accumulation pressure:

rated slope = 0.90 x average slope

stamped capacity ≤ rated slope (1.10 x set pressure + 14.7) or (set pressure + 3 psi + 14.7), whichever is greater

For valves certified in accordance with (c)(2) above,

stamped capacity ≤ rated slope (1.20 x set pressure + 14.7) or (set pressure + 3 psi + 14.7), whichever is greater

(b) For incompressible fluids, the capacities shall be plotted on log-log paper against the differential (inlet minus discharge pressure) test pressure and a straight line drawn through these four points. If the four points do not establish a straight line, two additional valves shall be tested for each unsatisfactory point, with a limit of two unsatisfactory points. Any point that departs from the straight line by more than 5% should be considered an unsatisfactory point. The relieving capacity shall be determined from this line. The certified capacity shall not exceed 90% of the capacity taken from the line.

(e) Instead of individual capacity certification as provided in (d) above, a coefficient of discharge *K* may be established for a specific pressure relief valve design according to the following procedure.

(1) For each design, the pressure relief valve Manufacturer shall submit for test at least three valves for each of three different sizes (a total of nine valves) together with detailed drawings showing the valve construction. Each valve of a given size shall be set at a different pressure.

(2) Tests shall be made on each pressure relief valve to determine its capacity-lift, popping and blowdown pressures, and actual capacity in terms of the fluid used in the test. A coefficient KD shall be established for each test run as follows:

$$K_D = \frac{\text{actual flow}}{\text{theoretical flow}} = \text{coefficient of discharge}$$

where actual flow is determined quantitatively by test, and theoretical flow is calculated by the appropriate formula which follows:

For tests with dry saturated steam,

$$W_T = 51.5AP$$

NOTE: For dry saturated steam pressures over 1500 psig and up to 3200 psig, the value of W_T, calculated by the above equation, shall be corrected by being multiplied by the following factors:

$$\left(\frac{0.1906P - 1000}{0.2292P - 1061} \right)$$

For tests with air,

$$W_T = 356AP \sqrt{\frac{M}{T}}$$

For tests with natural gas,

$$W_T = CAP \sqrt{\frac{M}{ZT}}$$

For tests with water,

$$W_T = 2407A\sqrt{(P-P_d)w}$$

where

W_T = theoretical flow, lb/hr
A = actual discharge area through the valve at developed lift, sq in.
P = (set pressure x 1.10) plus atmospheric pressure, psia, or set pressure plus 3 psi plus atmospheric pressure, whichever is greater
P_d = pressure at discharge from valve, psia
M = molecular weight
T = absolute temperature at inlet, °F + 460°F
C = constant for gas or vapor based on the ratio of specific heats
k = c_p/c_v (see Fig. 11-1)
Z = compressibility factor corresponding to P and T
w = specific weight of water at valve inlet conditions

The average of the coefficients K_D of the nine tests required shall be multiplied by 0.90, and this product shall be taken as the coefficient K of that design. The coefficient of the design shall not be greater than 0.878 (the product of 0.9 x 0.975).

NOTE: All experimentally determined coefficients K_D shall fall within a range of ±5% of the average K_D found. Failure to meet this requirement shall be cause to refuse certification of that particular valve design.

To convert lb/hr of water to gal/min of water, multiply the capacity in lb/hr by 1/500.

(3) The official relieving capacity of all sizes and pressures of a given design, for which K has been established under the provisions of (e)(2) above, that are manufactured subsequently shall not exceed the value calculated by the appropriate formula in (e)(2) above multiplied by the coefficient K (see Appendix 11).

(4) The coefficient shall not be applied to valves whose beta ratio (ratio of valve throat to inlet diameter) lies outside the range of 0.15 to 0.75, unless tests have demonstrated that the individual coefficient of discharge K_D for valves at the extreme ends of a larger range is within ±5% of the average coefficient K. For designs where lift is used to determine the flow area, all valves shall have the same nominal lift-to-seat diameter ratio *(L/D)*.

(f) Tests shall be conducted at a place where the testing facilities, methods, procedures, and person supervising the tests (Authorized Observer) meet the applicable requirements of ASME PTC 25. The tests shall be made under the supervision of and certified by an Authorized Observer. The testing facilities, methods, procedures, and qualifications of the Authorized observer shall be subject to the acceptance of the ASME on recommendation of a representative from an ASME designated organization. Acceptance of the testing facility is subject to review within each 5 year period.

(g) Capacity test data reports for each valve model, type, and size, signed by the Manufacturer and the Authorized Observer witnessing the tests shall be submitted to the ASME designated organization for review and acceptance.[58] Where changes are made in the design, capacity certification tests shall be repeated.

(h) For absolute pressures up to 1500 psia, it is permissible to rate safety valves under PG-69.1.2 of Section I with capacity ratings at a flow pressure of 103% of the set pressure, for use on pressure vessels, without further test. In such instances, the capacity rating of the valve may be increased to allow for the flow pressure permitted in (c)(1) and (c)(3) above, namely, 110% of the set pressure, by the multiplier

$$\frac{1.10p + 14.7}{1.03p + 14.7}$$

where

p = set pressure, psig

Such valves shall be marked in accordance with UG-129. This multiplier shall not be used as a divisor to transform test ratings from a higher to a lower flow.

For steam pressures above 1500 psig (10 MPa), the above multiplier is not applicable. For pressure relief valves with relieving pressures between 1500 psig (10 MPa) and 3200 psig (22 MPa), the capacity shall be determined by using the equation for steam and the correction factor for high pressure steam in (e)(2) above with the permitted absolute relieving pressure (1.10p + 14.7) and the coefficient K for that valve design.

(i) Rating of nozzle type pressure relief valves, i.e., coefficient K_D, greater than 0.90 and nozzle construction, for saturated water shall be according to 11-2.

(j) When changes are made in the design of a pressure relief valve in such a manner as to affect the flow path, lift, or performance characteristics of the valve, new tests in accordance with this Division shall be performed.

(k) The certified flow resistance K_R of the rupture disk device used in UG-127(a)(2) shall be either $K_R = 2.4$, or as determined in accordance with (1) through (r) below.

(l) Flow resistance certification tests for rupture disk devices shall be conducted with air or gas.

(m) Flow resistance certification tests shall be conducted at a rupture disk device inlet pressure which does not exceed 110% of the device set pressure.

(n)(1) The flow resistance for rupture disk devices tested with nonpressure containing disk items, such as seals, support rings, and vacuum supports, is applicable for the same rupture device design without seals, support rings, or vacuum supports.

[58] Valve capacities and rupture disk device flow resistances are published in "Pressure Relief Device Certifications". This publication may be obtained from the National Board of Boiler and Pressure Vessel Inspectors, 1055 Crupper Avenue, Columbus, Ohio 43229.

(2) A change in material for rupture disks and their nonpressure containing disk items, such as seals, support rings, and vacuum supports, is not considered a design change and does not require retesting.

(3) Additional linings, coatings, or platings may be used for the same design of rupture disk devices provided:

(a) the certificate holder has performed a verification burst test of rupture disks with the additional linings, coatings, or platings and has documented that the addition of these materials does not affect the rupture disk opening configuration; and

(b) such verification tests shall be conducted with rupture disks of the smallest size and minimum burst pressure for which the certified flow resistance with additional materials to be used.

(o) Flow resistance certification of rupture disk devices shall be determined by one of the following methods.

(1) One Size Method

(a) For each rupture disk device design, three rupture disks from the same lot shall be individually burst and flow tested in accordance with (p) below. The burst pressure shall be the minimum of the rupture disk device design of the size tested.

(b) The certified flow resistance K_R determined in (p) below shall apply only to the rupture disk design of the size tested.

(c) When additional rupture disks of the same design are constructed at a later date, the test results on the original rupture disks may be included as applicable in the three size method described in (o)(2) below.

(2) Three Size Method

(a) This method of flow resistance certification may be used for a rupture disk device design of three or more sizes. The burst pressure shall be the minimum of the rupture disk device design for each of the sizes submitted for test.

(b) For each rupture disk device design, three rupture disks from the same lot shall be burst and flow tested in accordance with (p) below for each of three different sizes of the same design.

(c) The certified flow resistance K_R shall apply to all sizes and pressures of the design of the rupture disk device tested.

(p) A certified flow resistance K_R may be established for a specific rupture disk device design according to the following procedure.

(1) For each design, the rupture disk Manufacturer shall submit for test the required rupture disk devices in accordance with (o) above together with the cross section drawings showing the rupture disk device design.

(2) Tests shall be made on each rupture disk device to determine its burst pressure and flow resistance at a facility which meets the requirements of (f) above.

(3) Calculate an average flow resistance using the individual flow resistances determined in (p)(2) above. All individual flow resistances shall fall within the average flow resistance by an acceptance band of plus or minus three times the average of the absolute values of the deviations of the individual flow resistances from the average flow resistance. Any individual flow resistance that falls outside of this band shall be replaced on a two for one basis. A new average flow resistance shall be computed and the individual flow resistances evaluated as stated above.

(4) The certified flow resistance KR for a rupture disk design shall not be less than zero and shall not be less than the sum of the average flow resistance plus three times the average of the absolute values of the deviations of individual flow resistances from the average flow resistance.

(q) Flow resistance test data reports for each rupture disk device design, signed by the Manufacturer and the Authorized Observer witnessing the tests, shall be submitted to the ASME designated organization for review and acceptance.[58]

(r) When changes are made in the design of a rupture disk device which affect the flow path or burst performance characteristics of the device, new tests in accordance with this Division shall be performed.

UG-132 CERTIFICATION OF CAPACITY OF PRESSURE RELIEF VALVES IN COMBINATION WITH NONRECLOSING PRESSURE RELIEF DEVICES A99

(a) Capacity of Pressure Relief Valves in Combination With a Rupture Disk Device at the Inlet

(1) For each combination of pressure relief valve design and rupture disk device design, the pressure relief valve Manufacturer or the rupture disk device Manufacturer may have the capacity of the combination certified as prescribed in (3) and (4) below.

(2) Capacity certification tests shall be conducted on saturated steam, air, or natural gas. When saturated steam is used, corrections for moisture content of the steam shall be made.

(3) The pressure relief valve Manufacturer or the rupture disk device Manufacturer may submit for tests the smallest rupture disk device size with the equivalent size of pressure relief valve that is intended to be used as a combination device. The pressure relief valve to be tested shall have the largest orifice used in the particular inlet size.

(4) Tests may be performed in accordance with the following subparagraphs. The rupture disk device and pressure relief valve combination to be tested shall be arranged to duplicate the combination assembly design.

(a) The test shall embody the minimum burst pressure of the rupture disk device design which is to be used in combination with the pressure relief valve design. The marked burst pressure shall be between 90% and 100% of the marked set pressure of the valve.

(b) The test procedure to be used shall be as follows.

The pressure relief valve (one valve) shall be tested for capacity as an individual valve, without the rupture disk device at a pressure 10% or 3 psi (13.8 kPa), whichever is greater, above the valve set pressure.

The rupture disk device shall then be installed at the inlet of the pressure relief valve and the disk burst to operate the valve. The capacity test shall be performed on the combination at 10% or 3 psi (13.8 kPa), whichever is greater, above the valve set pressure duplicating the individual pressure relief valve capacity test.

(c) Tests shall be repeated with two additional rupture disks of the same nominal rating for a total of three rupture disks to be tested with the single pressure valve. The results of the test capacity shall fall within a range of 10% of the average capacity of the three tests. Failure to meet this requirement shall be cause to require retest for determination of cause of the discrepancies.

(d) From the results of the tests, a Combination Capacity Factor shall be determined. The Combination Capacity Factor is the ratio of the average capacity determined by the combination tests to the capacity determined on the individual valve.

The Combination Capacity Factor shall be used as a multiplier to make appropriate changes in the ASME rated relieving capacity of the pressure relief valve in all sizes of the design. The value of the Combination Capacity Factor shall not be greater than one. The Combination Capacity Factor shall apply only to combinations of the same design of pressure relief valve and the same design of rupture disk device as those tested.

(e) The test laboratory shall submit the test results to the ASME designated organization for acceptance of the Combination Capacity Factor.[58]

(b) Optional Testing of Rupture Disk Devices and Pressure Relief Valves

(1) If desired, a valve Manufacturer or a rupture disk Manufacturer may conduct tests in the same manner as outlined in (a)(4)(c) and (a)(4)(d) above using the next two larger sizes of the design of rupture disk device and pressure relief valve to determine a Combination Capacity Factor applicable to larger sizes. If a greater Combination Capacity Factor is established and can be certified, it may be used for all larger sizes of the combination, but shall not be greater than one.

(2) If desired, additional tests may be conducted at higher pressures in accordance with (a)(4)(c) and (a)(4)(d) above to establish a maximum Combination Capacity Factor to be used at all pressures higher than the highest tested, but shall not be greater than one.

(c) Capacity of Breaking Pin Devices in Combination With Pressure Relief Valves

(1) Breaking pin devices in combination with pressure relief valves shall be capacity tested in compliance with UG-131(d) or UG-131(e) as a combination.

(2) Capacity certification and Code Symbol stamping shall be based on the capacity established in accordance with these paragraphs.

UG-133 DETERMINATION OF PRESSURE RELIEVING REQUIREMENTS

(a) Except as permitted in (b) below, the aggregate capacity of the pressure relief devices connected to any vessel or system of vessels for the release of a liquid, air, steam, or other vapor shall be sufficient to carry off the maximum quantity that can be generated or supplied to the attached equipment without permitting a rise in pressure within the vessel of more than 16% above the maximum allowable working pressure when the pressure relief devices are blowing.

(b) Pressure relief devices as permitted in UG-125(c)(2), a protection against excessive pressure caused by exposure to fire or other sources of external heat, shall have a relieving capacity sufficient to prevent the pressure from rising more than 21% above the maximum allowable working pressure of the vessel when all pressure relief devices are blowing.

(c) Vessels connected together by a system of adequate piping not containing valves which can isolate any vessel may be considered as one unit in figuring the required relieving capacity of pressure relief devices to be furnished.

(d) Heat exchangers and similar vessels shall be protected with a pressure relief device of sufficient capacity to avoid overpressure in case of an internal failure.

(e) The official rated capacity, or the certified flow resistance and minimum net flow area, of a pressure relief device shall be that which is stamped on the device and guaranteed by the Manufacturer.

(f) The rated pressure relieving capacity of a pressure relief valve for other than steam or air shall be determined by the method of conversion given in Appendix 11.

(g) To prorate the relieving capacity at any relieving pressure greater than 1.10p, as permitted under UG-125, a multiplier may be applied to the official relieving capacity of a pressure relief device as follows:

$$\frac{P + 14.7}{1.10p + 14.7}$$

where

P = relieving pressure, psig

p = set pressure, psig

For steam pressures above 1500 psig, the above multiplier is not applicable. For steam valves with relieving pressures greater than 1500 psig and less than or equal to 3200 psig, the capacity at relieving pressures greater than 1.10p shall be determined using the equation for steam and the correction factor for high pressure steam in UG-131(e)(2) with the permitted absolute relieving pressure and the coefficient K for that valve design.

UG-134 PRESSURE SETTING OF PRESSURE RELIEF DEVICES

(a) When a single pressure relief device is used, the set pressure[59] marked on the device shall not exceed the maximum allowable working pressure of the vessel. When the required capacity is provided in more than one pressure relief device, only one pressure relief device need be set at or below the maximum allowable working pressure, and the additional pressure relief devices may be set to open at higher pressures but in no case at a pressure higher than 105% of the maximum allowable working pressure, except as provided in (b) below.

(b) For pressure relief devices permitted in UG-125(c)(2) as protection against excessive pressure caused by exposure to fire or other sources of external heat, the device marked set pressure shall not exceed 110% of the maximum allowable working pressure of the vessel. If such a pressure relief device is used to meet the requirements of both UG-125(c) and UG-125(c)(2), the device marked set pressure shall not be over the maximum allowable working pressure.

(c) The pressure relief device set pressure shall include the effects of static head and constant back pressure.

(d)(1) The set pressure tolerance for pressure relief valves shall not exceed (2 psi (13.8 kPa) for pressures up to and including 70 psi (483 kPa) and (3% for pressures above 70 psi (483 kPa), except as covered in (d)(2) below.

(2) The set pressure tolerance of pressure relief valves which comply with UG-125(c)(3) shall be within -0%, + 10%.

(e) The burst pressure tolerance for rupture disk devices at the specified disk temperature shall not exceed (2 psi (13.8 kPa) of marked burst pressure up to 40 psi (276 kPa) and (5% of marked burst pressure 40 psi (276 kPa) and over.

UG-135 INSTALLATION

(a) Pressure relief devices intended for use in compressible fluid service shall be connected to the vessel in the vapor space above any contained liquid or to piping connected to the vapor space in the vessel which is to be protected. Pressure relief devices intended for use in liquid service shall be connected below the normal liquid level.

(b)(1) The opening through all pipe, fittings, and nonreclosing pressure relief devices (if installed) between a pressure vessel and its pressure relief valve shall have at least the area of the pressure relief valve inlet. The characteristics of this upstream system shall be such that the pressure drop will not reduce the relieving capacity below that required or adversely affect the proper operation of the pressure relief valve.

(2) The opening in the vessel wall shall be designed to provide unobstructed flow between the vessel and its pressure relief device (see Appendix M).[60]

(c) When two or more required pressure relief devices are placed on one connection, the inlet internal cross-sectional area of this connection shall be either sized to avoid restricting flow to the pressure relief devices or made at least equal to the combined inlet areas of the safety devices connected to it. The flow characteristics of the upstream system shall satisfy the requirements of (b) above. (See Appendix M.)

(d) There shall be no intervening stop valves between the vessel and its pressure relief device or devices, or between the pressure relief device or devices and the point of discharge, except:

(1) when these stop valves are so constructed or positively controlled that the closing of the maximum number of block valves possible at one time will not reduce the pressure relieving capacity provided by the unaffected pressure relief devices below the required relieving capacity; or

(2) under conditions set forth in Appendix M.

(e) The pressure relief devices on all vessels shall be so installed that their proper functioning will not be hindered by the nature of the vessel's contents.

(f) Discharge lines from pressure relief devices shall be designed to facilitate drainage or shall be fitted with drains to prevent liquid from lodging in the discharge side of the pressure relief device, and such lines shall lead to a safe place of discharge. The size of the discharge lines shall be such that any pressure that may exist or develop will not reduce the relieving capacity of the pressure relief devices below that required to properly protect the vessel, or adversely affect the proper operation of the pressure relief devices. [See UG-136(a)(8) and Appendix M.]

UG-136 MINIMUM REQUIREMENTS FOR PRESSURE RELIEF VALVES A99

UG-136(a) Mechanical Requirements

UG-136(a)(1) The design shall incorporate guiding arrangements necessary to ensure consistent operation and tightness.

[59]The set pressure is the value of increasing inlet static pressure at which a pressure relief device displays one of the operational characteristics as defined by opening pressure, popping pressure, start-to-leak pressure, burst pressure, or breaking pressure. (The applicable operating characteristic for a specific device design is specified by the device Manufacturer.

[60]Users are warned that the proper operation of various rupture disk devices depends upon following the Manufacturer's installation instructions closely with regard to the flow direction marked on the device. Some device designs will burst at pressures much greater than their marked burst pressure when installed with the process pressure on the vent side of the device.

UG-136(a)(2) The spring shall be designed so that the full lift spring compression shall be no greater than 80% of the nominal solid deflection. The permanent set of the spring (defined as the difference between the free height and height measured 10 min after the spring has been compressed solid three additional times after presetting at room temperature) shall not exceed 0.5% of the free height.

UG-136(a)(3) Each pressure relief valve on air, water over 140F (60C), or steam service shall have a substantial lifting device which when activated will release the seating force on the disk when the pressure relief valve is subjected to a pressure of at least 75% of the set pressure of the valve. Pilot operated pressure relief valves used on these services shall be provided with either a lifting device as described above or means for connecting and applying pressure to the pilot adequate to verify that the moving parts critical to proper operation are free to move.

UG-136(a)(4) The seat of a pressure relief valve shall be fastened to the body of the pressure relief valve in such a way that there is no possibility of the seat lifting.

UG-136(a)(5) In the design of the body of the pressure relief valve, consideration shall be given to minimizing the effects of deposits.

UG-136(a)(6) Pressure relief valves having screwed inlet or outlet connections shall be provided with wrenching surfaces to allow for normal installation without damaging operating parts.

UG-136(a)(7) Means shall be provided in the design of all pressure relief valves for use under this Division for sealing all initial adjustments which can be made without disassembly of the valve. Seals shall be installed by the Manufacturer or Assembler at the time of initial adjustment. Seals shall be installed in a manner to prevent changing the adjustment without breaking the seal. For pressure relief valves larger than NPS 1/2 (DN 15), the seal shall serve as a means of identifying the Manufacturer or Assembler making the initial adjustment.

UG-136(a)(8) If the design of a pressure relief valve is such that liquid can collect on the discharge side of the disk, except as permitted in (a)(9) below, the valve shall be equipped with a drain at the lowest point where liquid can collect (for installation, see UG-135).

UG-136(a)(9) Pressure relief valves that cannot be equipped with a drain as required in (a)(8) above because of design or application may be used provided:

(a) the pressure relief valves are used only on gas service where there is neither liquid discharged from the valve nor liquid formed by condensation on the discharge side of the valve; and

(b) the pressure relief valves are provided with a cover or discharge piping per UG-135(g) to prevent liquid or other contaminant from entering the discharge side of the valve; and

(c) the pressure relief valve is marked FOR GAS SERVICE ONLY in addition to the requirements of UG-129.

UG-136(a)(10) For pressure relief valves of the diaphragm type, the space above the diaphragm shall be vented to prevent a buildup of pressure above the diaphragm. Pressure relief valves of the diaphragm type shall be designed so that failure or deterioration of the diaphragm material will not impair the ability of the valve to relieve at the rated capacity.

UG-136(b) Material Selections

UG-136(b)(1) Cast iron seats and disks are not permitted.

UG-136(b)(2) Adjacent sliding surfaces such as guides and disks or disk holders shall both be of corrosion resistant material. Springs of corrosion resistant material or having a corrosion resistant coating are required. The seats and disks of pressure relief valves shall be of suitable material to resist corrosion by the fluid to be contained.

NOTE: The degree of corrosion resistance, appropriate to the intended service, shall be a matter of agreement between the manufacturer and the purchaser.

UG-136(b)(3) Materials used in bodies and bonnets or yokes shall be listed in Section II and this Division. Carbon and low alloy steel bodies, bonnets, yokes and bolting (UG-20) subject to in-service temperatures colder than -20ºF (-23ºC) shall meet the requirements of UCS-66, unless exempted by the following.

(a) The coincident ratio defined in Fig. UCS-66.1 is 0.35 or less.

(b) The material(s) is exempted from impact testing per Fig. UCS-66.

UG-136(b)(4) Materials used in nozzles, disks, and other parts contained within the external structure of the pressure relief valves shall be one of the following categories:

(a) listed in Section II;

(b) listed in ASTM specifications;

(c) controlled by the Manufacturer of the pressure relief valve by a specification ensuring control of chemical and physical properties and quality at least equivalent to ASTM standards.

UG-136(c) Inspection of Manufacturing and/or Assembly of Pressure Relief Valves

UG-136(c)(1) A Manufacturer or Assembler shall demonstrate to the satisfaction of a representative from an ASME designated organization that his manufacturing, production, and testing facilities and quality control procedures will insure close agreement between the performance of random production samples and the performance of those valves submitted for Capacity Certification.

UG-136(c)(2) Manufacturing, assembly, inspection and test operations including capacity are subject to inspections at any time by a representative from an ASME designated organization.

UG-136(c)(3) A Manufacturer or Assembler may be granted permission to apply the UV Code Symbol to production pressure relief valves capacity certified in accordance with UG-131 provided the following tests are successfully completed. This permission shall expire on the fifth anniversary of the date it is initially granted. The permission may be extended for 5 year periods if the following tests are successfully repeated within the 6-month period before expiration.

(a) Two sample production pressure relief valves of a size and capacity within the capability of an ASME accepted laboratory shall be selected by a representative from an ASME designated organization.

(b) Operational capacity tests shall be conducted in the presence of a representative from an ASME designated organization at an ASME accepted laboratory. The pressure relief valve Manufacturer or Assembler shall be notified of the time of the test and may have representatives present to witness the test. Pressure relief valves having an adjustable blowdown construction shall be adjusted by the Manufacturer or Assembler following successful testing for operation but prior to flow testing so that the blowdown does not exceed 7% of the set pressure or 3 psi (20.6 kPa), whichever is greater. This adjustment may be made on the flo*w test facility*.

(c) Should any pressure relief valve fail to relieve at or above its certified capacity or should it fail to meet performance requirements of this Division, the test shall be repeated at the rate of two replacement pressure relief valves, selected in accordance with (c)(3)(a) above, for each pressure relief valve that failed.

(d) Failure of any of the replacement pressure relief valves to meet the capacity or the performance requirements of this Division shall be cause for revocation within 60 days of the authorization to use the Code Symbol on that particular type of pressure relief valve. During this period, the Manufacturer or Assembler shall demonstrate the cause of such deficiency and the action taken to guard against future occurrence, and the requirements of (c)(3) above shall apply.

UG-136(c)(4) Use of the Code Symbol Stamp by an Assembler indicates the use of original, unmodified parts in strict accordance with the instructions of the Manufacturer of the pressure relief valve.

(a) An assembler may transfer original and unmodified pressure relief parts produced by the Manufacturer to other Assemblers provided the following conditions are met:

(1) the Assemblers hold a V or UV Code Symbol Stamp and are authorized by the Manufacturer to assemble and test the specific valve type in which parts are to be used;

(2) the Quality Control System of the Assembler receiving the pressure relief valve parts shall define the controls for the procurement and acceptance of those parts; and

(3) the pressure relief valve parts are appropriately packaged, marked, or sealed by the Manufacturer to ensure that the parts are:

(a) produced by the Manufacturer; and

(b) the parts are original and unmodified.

UG-136(c)(5) In addition to the requirements of UG-129, the marking shall include the name of the Manufacturer and the final Assembler. The Code Symbol Stamp shall be that of the final Assembler.

NOTE: Within the requirements of UG-136(c) and (d): A Manufacturer is defined as a person or organization who is completely responsible for design, material selection, capacity certification, manufacture of all component parts, assembly, testing, sealing, and shipping of pressure relief valves certified under this Division. An Assembler is defined as a person or organization who purchases or receives from a Manufacturer or another Assembler the necessary component parts or pressure relief valves and assembles, adjusts, tests, seals, and ships pressure relief valves certified under this Division, at a geographical location other than and using facilities other than those used by the Manufacturer. An Assembler may be organizationally independent of a Manufacturer or may be wholly or partly owned by the Manufacturer.

UG-136(d) Production Testing by Manufacturers and Assemblers

UG-136(d)(1) Each pressure relief valve to which the Code Symbol Stamp is to be applied shall be subjected to the following tests by the Manufacturer or Assembler. A Manufacturer or Assembler shall have a documented program for the application, calibration, and maintenance of gages and instruments used during these tests.

UG-136(d)(2) The primary pressure parts of each pressure relief valve exceeding NPS 1 (DN 25) inlet size or 300 psi (2070 kPa) set pressure where the materials used are either cast or welded shall be tested at a pressure of at least 1.5 times the design pressure of the parts. These tests shall be conducted after all machining operations on the parts have been completed. There shall be no visible sign of leakage.

UG-136(d)(3) The secondary pressure zone of each closed bonnet pressure relief valve exceeding NPS 1 (DN 25) inlet size when such pressure relief valves are designed for discharge to a closed system shall be tested with air or other gas at a pressure of at least 30 psi (207 kPa). There shall be no visible sign of leakage.

UG-136(d)(4) Each pressure relief valve shall be tested to demonstrate its popping or set pressure. Pressure relief valves marked for steam service or having special internal parts for steam service shall be tested with steam, except that pressure relief valves beyond the capability of the production steam test facility either because of size or set pressure may be tested on air. Necessary corrections for differentials in popping pressure between steam and air shall be established by the Manufacturer and applied to the popping point on air. Pressure relief valves marked for gas or vapor may be tested with air. Pressure relief valves marked for liquid service shall be tested with water or other suitable liquid. When a valve is adjusted to correct for

service conditions of superimposed back pressure, temperature, or the differential in popping pressure between steam and air, the actual test pressure (cold differential test pressure) shall be marked on the valve per UG-129. Test fixtures and test drums where applicable shall be of adequate size and capacity to ensure that pressure relief valve action is consistent with the stamped set pressure within the tolerances required by UG-134(d).

UG-136(d)(5) After completion of the tests required by (d)(4) above, a seat tightness test shall be conducted. Unless otherwise designated by a Manufacturer's published pressure relief valve specification, the seat tightness test and acceptance criteria shall be in accordance with API 527.

UG-136(d)(6) Testing time on steam pressure relief valves shall be sufficient, depending on size and design, to insure that test results are repeatable and representative of field performance.

UG-136(e) Design Requirements. At the time of the submission of pressure relief valves for capacity certification, or testing in accordance with (c)(3) above, the ASME designated organization has the authority to review the design for conformity with the requirements of UG-136(a) and UG-136(b) and to reject or require modification of designs which do not conform, prior to capacity testing.

UG-136(f) Welding and Other Requirements. All welding, brazing, heat treatment, and nondestructive examination used in the construction of bodies, bonnets, and yokes shall be performed in accordance with the applicable requirements of this Division.

UG-137 MINIMUM REQUIREMENTS FOR RUPTURE DISK DEVICES

UG-137(a) Mechanical Requirements

UG-137(a)(1) The design shall incorporate arrangements necessary to ensure consistent operation and tightness.

UG-137(a)(2) Rupture disk devices having threaded inlet or outlet connections shall be designed to allow for normal installation without damaging the rupture disk.

UG-137(b) Material Selections

UG-137(b)(1) The rupture disk material is not required to conform to a material specification listed in ASME Section II. The rupture disk material shall be controlled by the Manufacturer of the rupture disk device by a specification ensuring the control of material properties.

UG-137(b)(2) Materials used in rupture disk holders shall be listed in Section II and this Division. Carbon and low alloy steel holders and bolting (UG-20) subject to in-service temperatures colder than -20ºF shall meet the requirements of UCS-66, unless exempted by the following.

(a) The coincident ratio defined in Fig. UCS-66.1 is 0.40 or less.

(b) The material(s) is exempted from impact testing per Fig. UCS-66.

UG-137(b)(3) Materials used in other parts contained within the external structure of the rupture disk holder shall be one of the following categories.

(a) listed in Section II; or

(b) listed in ASTM specifications; or

(c) controlled by the Manufacturer of the rupture disk device by a specification insuring control of chemical and physical properties and quality at least equivalent to ASTM standards.

UG-137(c) Inspection of Manufacturing of Rupture Disk Devices

UG-137(c)(1) A Manufacturer shall demonstrate to the satisfaction of a representative of an ASME designated organization that its manufacturing, production, and testing facilities and quality control procedures will insure close agreement between the performance of random production samples and the performance of those devices submitted for Certification.

UG-137(c)(2) Manufacturing, assembly, inspection, and test operations are subject to inspections at any time by an ASME designee.

UG-137(c)(3) A Manufacturer may be granted permission to apply the UD Code Symbol to production rupture disk devices certified in accordance with UG-131 provided the following tests are successfully completed. This permission shall expire on the fifth anniversary of the date it is initially granted. The permission may be extended for five year periods if the following tests are successfully repeated within the 6 month period before expiration.

(a) Two production sample rupture disk devices of a size and capacity within the capability of an ASME accepted laboratory shall be selected by a representative of an ASME designated organization.

(b) Burst and flow testing shall be conducted in the presence of a representative of an ASME designated organization at a place which meets the requirements of UG-131(f). The device Manufacturer shall be notified of the time of the test and may have representatives present to witness the test.

(c) Should any device fail to meet or exceed the performance requirements (burst pressure, minimum net flow area, and flow resistance) of UG-127, the test shall be repeated at the rate of two replacement devices, selected and tested in accordance with (c)(3)(a) and (c)(3)(b) above for each device that failed.

(d) Failure of any of the replacement devices to meet the performance requirements of this Division shall be cause for revocation within 60 days of the

NOTES:

APPENDIX M
INSTALLATION AND OPERATION

M-1 INTRODUCTION

(a) The rules in this Appendix are for general information only, because they pertain to the installation and operation of pressure vessels, which are the prerogative and responsibility of the law enforcement authorities in those states and municipalities which have made provision for the enforcement of Section VIII.

(b) It is permissible to use any departures suggested herein from provisions in the mandatory parts of this Division when granted by the authority having legal jurisdiction over the installation of pressure vessels.

M-2 CORROSION

(a) Vessels subject to external corrosion shall be so installed that there is sufficient access to all parts of the exterior to permit proper inspection of the exterior, unless adequate protection against corrosion is provided or unless the vessel is of such size and is so connected that it may readily be removed from its permanent location for inspection.

(b) Vessels having manholes, handholes, or cover plates to permit inspection of the interior shall be so installed that these openings are accessible.

(c) In vertical cylindrical vessels subject to corrosion, to insure complete drainage, the bottom head, if dished should preferably be concave to pressure.

M-3 MARKING ON THE VESSEL

The marking required by this Division shall be so located that it will be accessible after installation and when installed shall not be covered with insulation or other material that is not readily removable [see UG-116(j)].

M-4 PRESSURE RELIEVING SAFETY DEVICES

The general provisions for the installation of pressure relieving devices are fully covered in UG-135. The following paragraphs contain details in arrangement of stop valves for shutoff control of safety pressure relief devices which are sometimes necessary to the continuous operation of processing equipment of such a complex nature that the shutdown of any part of it is not feasible. There are also rules with regard to the design of inlet and discharge piping to and from safety and relief valves, which can only be general in nature because the design engineer must fit the arrangement and proportions of such a system to the particular requirements in the operation of the equipment involved.

M-5 STOP VALVES BETWEEN PRESSURE RELIEVING DEVICE AND VESSEL

(a) A vessel, in which pressure can be generated because of service conditions, may have a full-area stop valve between it and its pressure relieving device for inspection and repair purposes only. When such a stop valve is provided, it shall be so arranged that it can be locked or sealed open, and it shall not be closed except by an authorized person who shall remain stationed there during that period of the vessel's operation within which the valve remains closed, and who shall again lock or seal the stop valve in the open position before leaving the station.

(b) A vessel or system [see UG-133(c)] for which the pressure originates from an outside source exclusively may have individual pressure relieving devices on each vessel, or connected to any point on the connecting piping, or on any one of the vessels to be protected. Under such an arrangement, there may be a stop valve between any vessel and the pressure relieving devices, and this stop valve need not be locked open, provided it also closes off that vessel from the source of pressure.

M-6 STOP VALVES ON THE DISCHARGE SIDE OF A PRESSURE RELIEVING DEVICE [SEE UG-135(E)]

A full-area stop valve may be placed on the discharge side of a pressure relieving device when its discharge is

connected to a common header with other discharge lines from other pressure relieving devices on nearby vessels that are in operation, so that this stop valve when closed will prevent a discharge from any connected operating vessels from backing up beyond the valve so closed. Such a stop valve shall be so arranged that it can be locked or sealed in either the open or closed position, and it shall be locked or sealed in either position only by an authorized person. When it is to be closed while the vessel is in operation, an authorized person shall be present, and he shall remain stationed there; he shall again lock or seal the stop valve in the open position before leaving the station. Under no condition should this valve be closed while the vessel is in operation except when a stop valve on the inlet side of the safety relieving device is installed and is first closed.

M-7 INLET PRESSURE DROP FOR HIGH LIFT, TOP GUIDED SAFETY, SAFETY RELIEF, AND PILOT OPERATED PRESSURE RELIEF VALVES IN COMPRESSIBLE FLUID SERVICE

(a) The nominal pipe size of all piping, valves and fittings, and vessel components between a pressure vessel and its safety, safety relief, or pilot operated pressure relief valves shall be at least as large as the nominal size of the device inlet, and the flow characteristics of the upstream system shall be such that the cumulative total of all nonrecoverable inlet losses shall not exceed 3% of the valve set pressure. The inlet pressure losses will be based on the valve nameplate capacity corrected for the characteristics of the flowing fluid.

(b) When two or more required safety, safety relief or pilot operated pressure relief valves are placed on one connection, the inlet internal cross-sectional area of this connection shall be either sized to avoid restricting flow to the pressure relief valves or made at least equal to the combined inlet areas of the safety valves connected to it. The flow characteristics of the upstream system shall meet the requirements of (a) above with all valves relieving simultaneously.

M-8 DISCHARGE LINES FROM SAFETY DEVICES

(a) Where it is feasible, the use of short discharge pipe or vertical riser, connected through long-radius elbows from each individual device, blowing directly to the atmosphere, is recommended. Such discharge pipes shall be at least of the same size as the valve outlet. Where the nature of the discharge permits, telescopic (sometimes called “broken”) discharge lines, whereby condensed vapor in the discharge line, or rain, is collected in a drip pan and piped to a drain, are recommended.[1]

(b) When discharge lines are long, or where outlets of two or more valves having set pressures within a comparable range are connected into a common line, the effect of the back pressure that may be developed therein when certain valves operate must be considered [see UG-135(g)]. The sizing of any section of a common-discharge header downstream from each of the two or more pressure relieving devices that may reasonably be expected to discharge simultaneously shall be based on the total of their outlet areas, with due allowance for the pressure drop in all downstream sections. Use of specially designed valves suitable for use on high or variable back pressure service should be considered.

(c) The flow characteristics of the discharge system of high lift, top guided safety, safety relief, or pilot operated pressure relief valves in compressible fluid service shall be such that the static pressure developed at the discharge flange of a conventional direct spring loaded valve will not exceed 10% of the set pressure when flowing at stamp capacity. Other valve types exhibit various degrees of tolerance to back pressure and the manufacturer’s recommendation should be followed.

(d) All discharge lines shall be run as direct as is practicable to the point of final release for disposal. For the longer lines, due consideration shall be given to the advantage of long-radius elbows, avoidance of closeup fittings, and the minimizing of excessive line strains by expansion joints and well-known means of support to minimize line-sway and vibration under operating conditions.

(e) Provisions should be made in all cases for adequate drainage of discharge lines.

NOTE: It is recognized that no simple rule can be applied generally to fit the many installation requirements, which vary from simple short lines that discharge directly to the atmosphere to the extensive manifold discharge piping systems where the quantity and rate of the product to be disposed of requires piping to a distant safe place.

M-9 PRESSURE DROP, NONRECLOSING PRESSURE RELIEF DEVICES

Piping, valves and fittings, and vessel components comprising part of a nonreclosing device pressure relieving system shall be sized to prevent the vessel pressure from rising above the allowable overpressure.

[1]This construction has the further advantage of not transmitting discharge-pipe strains to the valve. In these types of installation, the back pressure effect will be negligible, and no undue influence upon normal valve operation can result.

M-10 GENERAL ADVISORY INFORMATION ON THE CHARACTERISTICS OF SAFETY RELIEF VALVES DISCHARGING INTO A COMMON HEADER

Because of the wide variety of types and kinds of safety relief valves, it is not considered advisable to attempt a description in this Appendix of the effects produced by discharging them into a common header. Several different types of valves may conceivably be connected into the same discharge header and the effect of back pressure on each type may be radically different. Data compiled by the manufacturers of each type of valve used should be consulted for information relative to its performance under the conditions anticipated.

M-11 PRESSURE DIFFERENTIALS FOR PRESSURE RELIEF VALVES

Due to the variety of service conditions and the various designs of safety and safety relief valves, only general guidance can be given regarding the differential between the set pressure of the valve (see UG-134) and the operating pressure of the vessel. Operating difficulty will be minimized by providing an adequate differential for the application. The following is general advisory information on the characteristics of the intended service and of the safety or safety relief valves that may bear on the proper pressure differential selection for a given application. These considerations should be reviewed early in the system design since they may dictate the MAWP of the system.

(a) Consideration of the Process Characteristics in the Establishment of the Operating Margin to Be Provided. To minimize operational problems, it is imperative that the user consider not only normal operating conditions of fluids, pressures, and temperatures, but also start-up and shutdown conditions, process upsets, anticipated ambient conditions, instrument response times, pressure surges due to quick closing valves, etc. When such conditions are not considered, the pressure relieving device may become, in effect, a pressure controller, a duty for which it is not designed. Additional consideration should be given to hazard and pollution associated with the release of the fluid. Larger differentials may be appropriate for fluids which are toxic, corrosive, or exceptionally valuable.

(b) Consideration of Safety Relief Valve Characteristics. The blowdown characteristic and capability is the first consideration in selecting a compatible valve and operating margin. After a self-actuated release of pressure, the valve must be capable of reclosing above the normal operating pressure. For example, if the valve is set at 100 psig with a 7% blowdown, it will close at 93 psig. The operating pressure must be maintained below 93 psig in order to prevent leakage or flow from a partially open valve. Users should exercise caution regarding the blowdown adjustment of large spring-loaded valves. Test facilities, whether owned by Manufacturers, repair houses, or users, may not have sufficient capacity to accurately verify the blowdown setting. The settings cannot be considered accurate unless made in the field on the actual installation.

Pilot-operated valves represent a special case from the standpoints of both blowdown and tightness. The pilot portion of some pilot-operating valves can be set at blowdowns as short as 2%. This characteristic is not, however, reflected in the operation of the main valve in all cases. The main valve can vary considerably from the pilot depending on the location of the two components in the system. If the pilot is installed remotely from the main valve, significant time and pressure lags can occur, but reseating of the pilot assures reseating of the main valve. The pressure drop in the connecting piping between the pilot and the main valve must not be excessive; otherwise, the operation of the main valve will be adversely affected.

The tightness of the main valve portion of these combinations is considerably improved above that of conventional valves by pressure loading the main disk or by the use of soft seats or both.

Despite apparent advantages of pilot-operated valves, users should be aware that they should not be employed in abrasive or dirty service, in applications where coking, polymerization, or corrosion of the wetted pilot parts can occur, or where freezing or condensation of the lading fluid at ambient temperatures is possible.

For all applications the valve Manufacturer should be consulted prior to selecting a valve of this type.

Tightness capability is another factor affecting valve selection, whether spring loaded or pilot operated. It varies somewhat depending on whether metal or resilient seats are specified, and also on such factors as corrosion or temperature. The required tightness and test method should be specified to comply at a pressure no lower than the normal operating pressure of the process. A recommended procedure and acceptance standard is given in API 527. It should also be remembered that any degree of tightness obtained should not be considered permanent. Service operation of a valve almost invariably reduces the degree of tightness.

Application of special designs such as O-rings or resilient seats should be reviewed with the valve Manufacturer.

The anticipated behavior of the valves includes allowance for a plus-or-minus tolerance on set pressure which varies with the pressure level. Installation conditions, such as back pressure, variations, and vibrations, influence selection of special types and an increase in differential pressure.

(c) General Recommendations. The following pressure differentials are recommended unless the safety or safety relief valve has been designed or tested in a specific or similar service and a smaller differential has been recommended by the Manufacturer.

A minimum difference of 5 psi (35 kPa) is recommended for set pressures to 70 psi. In this category, the set pressure tolerance is ±2 psi (±13.8 kPa) [UG-134(d)(1)], and the differential to the leak test pressure is 10% or 5 psi (35 kPa), whichever is greater.

A minimum differential of 10% is recommended for set pressures from 71 psi to 1000 psi (490 kPa to 6900 kPa). In this category, the set pressure tolerance is ±3% and the differential to the leak test pressure is 10%.

A minimum differential of 7% is recommended for set pressures above 1000 psi (6900 kPa). In this category, the set pressure tolerance is (3% and the differential to the leak test pressure should be 5%. Valves having small seat sizes will require additional maintenance when the pressure differential approaches these recommendations.

M-12 INSTALLATION OF SAFETY AND SAFETY RELIEF VALVES

Spring loaded safety and safety relief valves normally should be installed in the upright position with the spindle vertical. Where space or piping configuration preclude such an installation, the valve may be installed in other than the vertical position provided that:

(a) the valve design is satisfactory for such position;

(b) the media is such that material will not accumulate at the inlet of the valve; and

(c) drainage of the discharge side of the valve body and discharge piping is adequate.

M-13 REACTION FORCES AND EXTERNALLY APPLIED LOADS

(a) Reaction Thrust. The discharge of a pressure relief valve imposes reactive flow forces on the valve and associated piping. The design of the installation may require computation of the bending moments and stresses in the piping and vessel nozzle. There are momentum effects and pressure effects at steady state flow as well as transient dynamic loads caused by opening.

(b) External Loads. Mechanical forces may be applied to the valve by discharge piping as a result of thermal expansion, movement away from anchors, and weight of any unsupported piping. The resultant bending moments on a closed pressure relief valve may cause valve leakage and excessive stress in inlet piping. The design of the installation should consider these possibilities.

M-14 SIZING OF PRESSURE RELIEF DEVICES FOR FIRE CONDITIONS

(a) Excessive pressure may develop in pressure vessels by vaporization of the liquid contents and/or expansion of vapor content due to heat influx from the surroundings, particularly from a fire. Pressure relief systems for fire conditions are usually intended to release only the quantity of product necessary to lower the pressure to a predetermined safe level, without releasing an excessive quantity. This control is especially important in situations where release of the contents generates a hazard because of flammability or toxicity. Under fire conditions, consideration must also be given to the possibility that the safe pressure level for the vessel will be reduced due to heating of the vessel material, with a corresponding loss of strength.

(b) Several formulas have evolved over the years for calculating the pressure relief capacity required under fire conditions. The major differences involve heat flux rates. There is no single formula yet developed which takes into account all of the many factors which could be considered in making this determination. When fire conditions are a consideration in the design of a pressure vessel, the following references which provide recommendations for specific installations may be used:

API RP 520, Recommended Practice for the Design and Installation of Pressure-Relieving Systems in Refineries, Part I - Design, 1976, American Petroleum Institute, Washington, DC

API Standard 2000, Venting Atmospheric and Low-Pressure Storage Tanks (nonrefrigerated and refrigerated), 1973, American Petroleum Institute, Washington, DC

AAR Standard M-1002, Specifications for Tank Cars, 1978, Association of American Railroads, Washington, DC

Safety Relief Device Standards: S-1.1, Cylinders for Compressed Gases; S-1.2, Cargo and Portable Tanks; and S-1.3, Compressed Gas Storage Containers, Compressed Gas Association, Arlington, VA

NFPA Code Nos. 30, 59, and 59A, National Fire Protection Association, Boston, MA

Pressure-Relieving Systems for Marine Cargo Bulk Liquid Containers, 1973, National Academy of Sciences, Washington, DC

Bulletin E-2, How to Size Safety Relief Devices, Phillips Petroleum Company, Bartlesville, OK

A Study of Available Fire Test Data as Related to Tank Car Safety Device Relieving Capacity Formulas, 1971, Phillips Petroleum Company, Bartlesville, OK

M-15 PRESSURE INDICATING DEVICE

If a pressure indicating device is provided to determine the vessel pressure at or near the set pressure of the relief device, one should be selected that spans the set pressure of the relief device and is graduated with an upper limit that is neither less than 1.25 times the set pressure of the relief device nor more than twice the maximum allowable working pressure of the vessel. Additional devices may be installed if desired.

NOTES:

APPENDIX 11
CAPACITY CONVERSIONS FOR SAFETY VALVES

11-1

The capacity of a safety or relief valve in terms of a gas or vapor other than the medium for which the valve was officially rated shall be determined by application of the following formulas:[1]

For steam,

$$W_s = 51.5KAP$$

For air,

$$W_a = CKAP\sqrt{\frac{M}{T}}$$

$$C = 356$$

$$M = 28.97$$

T = 520 when W_a is the rated capacity

For any gas or vapor,

$$W_a = CKAP\sqrt{\frac{M}{T}}$$

where

W_s = rated capacity, lb/hr of steam
W_a = rated capacity, converted to lb/hr of air at 60F, inlet temperature
W = flow of any gas or vapor, lb/hr
C = constant for gas or vapor which is function of the ratio of specific heats, k = cp/cv (see Fig. 11-1)
K = coefficient of discharge [see UG-131(d) and (e)]
A = actual discharge area of the safety valve, sq. in.
P = (set pressure x 1.10) plus atmosphere pressure, psia
M = molecular weight
T = absolute temperature at inlet (F + 460)

These formulas may also be used when the required flow of any gas or vapor is known and it is necessary to compute the rated capacity of steam or air.

Molecular weights of some of the common gases and vapors are given in Table 11-1.

For hydrocarbon vapors, where the actual value of k is not known, the conservative value, k = 1.001 has been commonly used and the formula becomes

$$W = 315KAP\sqrt{\frac{M}{T}}$$

When desired, as in the case of light hydrocarbons, the compressibility factor Z may be included in the formulas for gases and vapors as follows:

$$W = CKAP\sqrt{\frac{M}{ZT}}$$

Example 1

GIVEN: A safety valve bears a certified capacity rating of 3020 lb/hr of steam for a pressure setting of 200 psi.
PROBLEM: What is the relieving capacity of that valve in terms of air at 100ºF for the same pressure setting?

SOLUTION:

For steam

$$W_s = 51.5KAP$$

$$3020 = 51.5KAP$$

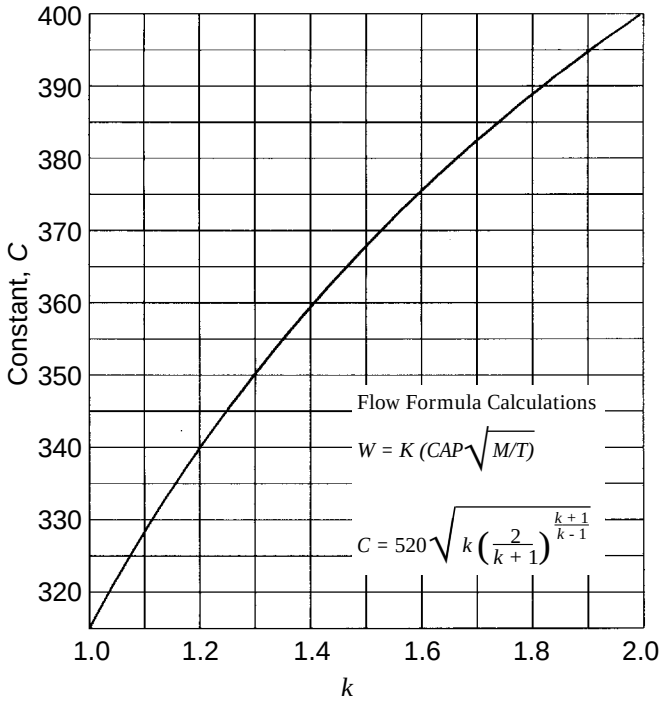
$$KAP = \frac{3020}{51.5} = 58.5$$

[1]Knowing the official rating capacity of a safety valve which is stamped on the valve, it is possible to determine the overall value of KA in either of the following formulas in cases where the value of these individual terms is not known:

Official Rating in Steam: $KA = \frac{Ws}{51.5}$

Official Rating in Air: $KA = \frac{Wa}{CP}\sqrt{\frac{T}{M}}$

This value for KA is then substituted in the above formulas to determine the capacity of the safety valve in terms of the new gas or vapor.



k	Constant C	k	Constant C	k	Constant C
1.00	315	1.26	343	1.52	366
1.02	318	1.28	345	1.54	368
1.04	320	1.30	347	1.56	369
1.06	322	1.32	349	1.58	371
1.08	324	1.34	351	1.60	372
1.10	327	1.36	352	1.62	374
1.12	329	1.38	354	1.64	376
1.14	331	1.40	356	1.66	377
1.16	333	1.42	358	1.68	379
1.18	335	1.44	359	1.70	380
1.20	337	1.46	361	2.00	400
1.22	339	1.48	363	2.20	412
1.24	341	1.50	364	...	...

FIG. 11-1 CONSTANT *C* FOR GAS OR VAPOR RELATED TO RATIO OF SPECIFIC HEATS ($k = c_p/c_v$)

For air

$$W_a = CKAP\sqrt{\frac{M}{T}}$$

$$= 356\ KAP\sqrt{\frac{28.97}{460 + 100}}$$

$$= 356\ (58.5)\sqrt{\frac{28.97}{560}}$$

$$= 4750 \text{ lb/hr}$$

EXAMPLE 2

GIVEN: It is required to relieve 5000 lb/hr of propane from a pressure vessel through a safety valve set to relieve at a pressure of Ps, psi, and with an inlet temperature at 125ºF.

PROBLEM: what total capacity in pounds of steam per hour in safety valves must be furnished?

Solution:

For propane,

$$W = CKAP\sqrt{\frac{M}{T}}$$

The value of *C* is not definitely known. Use the conservative value, *C* = 315.

TABLE 11-1
MOLECULAR WEIGHTS OF GASES AND VAPORS

Air	28.97	Freon 22	86.48
Acetylene	26.04	Freon 114	170.90
Ammonia	17.03	Hydrogen	2.02
Butane	58.12	Hydrogen Sulfide	34.08
Carbon Dioxide	44.01	Methane	16.04
Chlorine	70.91	Methyl Chloride	50.48
Ethane	30.07	Nitrogen	28.02
Ethylene	28.05	Oxygen	32.00
Freon 11	137.371	Propane	44.09
Freon 12	120.9	Sulfur Dioxide	64.06

$$5000 = 315\ KAP\sqrt{\frac{44.09}{460 + 125}}$$

$$KAP = 57.7$$

For steam,

$$W_s = 51.5\ KAP = (51.5)(57.7)$$

$$= 2970 \text{ lb/hr set to relieve at } P_s, \text{ psi}$$

Example 3

GIVEN: It is required to relieve 1000 lb/hr of ammonia from pressure vessel at 150ºF.

PROBLEM: What is the required total capacity in pounds of steam per hour at the same pressure setting?

SOLUTION:

For ammonia

$$W = CKAP\sqrt{\frac{M}{T}}$$

Manufacturer and user agree to use k = 1.33; from Fig. 11-1, C = 350.

$$1000 = 350\,KAP\sqrt{\frac{17.03}{460 + 150}}$$

$$KAP = 17.10$$

For steam,

$$W_s = 51.5\,KAP = 51.5 \times 17.10$$

$$= 880 \text{ lb/hr}$$

Example 4

GIVEN: A safety valve bearing a certified rating of 10,000 cu ft/min of air at 60ºF and 14.7 psia (atmospheric pressure).

PROBLEM: What is the flow capacity of this safety valve in pounds of saturated steam per hour for the same pressure setting?

SOLUTION:

For air: Weight of dry air at 60ºF and 14.7 psia is 0.0766 lb/cu ft.

$$Wa = 10{,}000 \times 0.0766 \times 60 = 45{,}960 \text{ lb/hr}$$

$$45{,}960 = 356\,KAP\sqrt{\frac{28.97}{460 + 60}}$$

$$KAP = 546$$

For steam,

$$W_s = 51.5\,KAP = (51.5)(546)$$

$$= 28{,}200 \text{ lb/hr}$$

NOTE: Before converting the capacity of a safety valve from any gas to steam, the requirements of UG-131(b) must be met.

11-2

(a) Since it is realized that the saturated water capacity is configuration sensitive, the following applies only to those safety valves that have a nozzle type construction (throat to inlet diameter ratio of 0.25 to 0.80 with a continuously contoured change and have exhibited a coefficient K_D in excess of 0.90). No saturated water rating shall apply to other types of construction.

NOTE: The manufacturer, user, and Inspector are all cautioned that for the following rating to apply, the valve shall be continuously subjected to saturated water. If, after initial relief the flow media changes to quality steam, the valve shall be rated as per dry saturated steam. Valves installed on vessels or lines containing steam-water mixture shall be rated dry saturated steam.

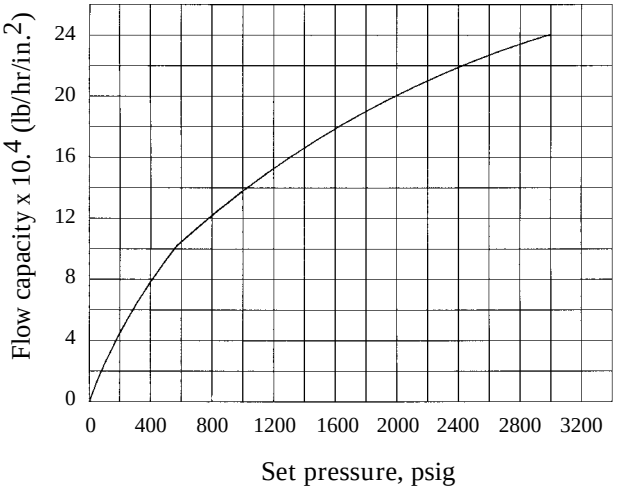


FIG. 11-2 FLOW CAPACITY CURVE FOR RATING NOZZLE TYPE SAFETY VALVES ON SATURATED WATER (BASED ON 10% OVERPRESSURE)

(b) To determine the saturated water capacity of a valve currently rated under UG-131 and meeting the requirements of (a) above, refer to Fig. 11-2. Enter the graph at the set pressure of the valve, move vertically upward to the saturated water line and read horizontally the relieving capacity. This capacity is the theoretical, isentropic value arrived at by assuming equilibrium flow and calculated values for the critical pressure ratio.

NOTES:

NOTES:

STEAM TABLE*

h = Total heat of steam, Btu per pound
v = Specific volume, cubic feet per pound

Pressure psi (gage)	Temperature F° (sat.)		Saturated Liquid	Saturated Vapor	TOTAL TEMPERATURE, °F												
					220	240	260	280	300	320	340	360	380	400	420	440	460
0	212	h	180.1	1150.4	1154.4	1164.2	1173.8	1183.3	1192.8	1202.3	1211.7	1221.1	1230.5	1239.9	1249.3	1258.8	1268.2
		v	0.0167	26.80	27.15	28.00	28.85	29.70	30.53	31.37	32.20	33.03	33.85	34.68	35.50	36.32	37.14
5	228	h	196.2	1156.3		1162.3	1172.2	1182.0	1191.6	1201.2	1210.8	1220.3	1229.7	1239.2	1248.7	1258.2	1267.6
		v	0.0168	20.089		20.48	21.11	21.74	22.36	22.98	23.60	24.21	24.82	25.43	26.04	26.65	27.25
10	240	h	208.4	1160.6			1170.7	1180.6	1190.5	1200.2	1209.8	1219.4	1229.0	1238.5	1248.1	1257.6	1267.1
		v	0.0169	16.303			16.819	17.330	17.836	18.337	18.834	19.329	19.821	20.31	20.80	21.29	21.77
15	250	h	218.8	1164.1			1169.1	1179.3	1189.3	1199.1	1208.9	1218.6	1228.3	1237.9	1247.5	1257.0	1266.6
		v	0.0170	13.746			13.957	14.390	14.816	15.238	15.657	16.072	16.485	16.897	17.306	17.714	18.121
20	259	h	227.9	1167.1			1167.5	1177.9	1188.1	1198.1	1208.0	1217.8	1227.5	1237.2	1246.8	1256A	1266.1
		v	0.0171	11.898			11.911	12.288	12.659	13.025	13.387	13.746	14.103	14.457	14.810	15.162	15.512
25	267	h	236.0	1169.7				1176.5	1186.8	1197.0	1207.0	1216.9	1226.7	1236.5	12462	1255.9	1265.5
		v	0.0171	10.498				10.711	11.040	11.364	11.684	12.001	12.315	12.628	12.938	13.247	13.555
30	274	h	243.4	1172.0				1175.0	1185.6	1195.9	1206.0	1216.0	1225.9	1235.8	1245.6	1255.3	1265.0
		v	0.0172	9.401				9.484	9.781	10.072	10.359	10.643	10.925	11.204	11.482	11.758	120033
40	287	h	256.3	1175.9					1183.0	1193.6	1204.0	1214.3	1224.4	1234.3	1244.3	1254.1	1263.9
		v	0.0173	7.787					7.947	8.192	8.432	8.668	8.902	9.134	9.364	9.592	9.819
50	298	h	267.5	1179.1					1180.3	1191.3	1202.0	1212.5	1222.7	1232.9	1242.9	1252.9	1262.8
		v	0.0174	6.655					6.676	6.889	7.096	7.300	7.501	7.700	7.896	8.091	8.285
60	308	h	277.4	1181.9						1188.9	1199.9	1210.6	1221.1	1231.4	1241.6	1251.7	1261.7
		v	0.0175	5.816						5.9321	6.116	6.296	6.473	6.648	6.820	6.991	7.161
70	316	h	286.4	1184.2						1186.4	1197.7	1208.7	1219.4	1229.9	1240.2	1250.4	1260.6
		v	0.0176	5.168						5.200	5.366	5.528	5.687	5.843	5.997	6.150	6.301
80	324	h	294.6	1186.2							1195.5	1206.7	1217.7	1228.3	1238.8	1249.2	1259.4
		v	0.0177	4.652							4.773	4.921	5.065	5.207	5.347	5.485	5.621
90	331	h	302.1	1188.1							1193.2	1204.7	1215.9	1226.7	1237.4	1247.9	1258.2
		v	0.0178	4.232							4.292	4.429	4.562	4.693	4.821	4.947	5.071
100	338	h	309.1	1189.7							1190.8	1202.7	1214.1	1225.2	1236.0	1246.6	1257.1
		v	0.0178	3.882							3.895	4.022	4.146	4.267	4.385	4.502	4.617
125	353	h	324.8	1193.0								1197.3	1209.4	1211.1	1232.3	1243.3	1254.1
		v	0.0180	3.220								3.258	3.365	3.468	3.569	3.667	3.764
150	366	h	338.5	1195.6									1204.5	1216.7	1228.4	1239.8	1251.0
		v	0.0182	2.752									2.818	2.910	2.998	3.085	3.169
175	378	h	350.8	1197.6									1199.3	1212.2	1224.5	1236.3	1247.8
		v	0.0183	2.404									2.414	2.498	2.577	2.655	2.730
200	388	h	361.9	1199.3										1207.4	1220.3	1232.6	1244.5
		v	0.0185	2.134										2.180	2.253	2.324	2.393
225	397	h	372.1	1200.6										1202.5	1216.0	1228.8	1241.1
		v	0.0186	1.9183										1.9276	1.9964	2.062	2.126
250	406	h	381.6	1201.7											1211.5	1224.9	1237.6
		v	0.0187	1.7422											1.7870	1.8488	1.9081
275	414	h	390.5	1202.6											1206.8	1220.8	1234.0
		v	0.0188	1.5954											1.6130	1.6717	1.7277
300	422	h	398.8	1203.2												1216.5	1230.3
		v	0.0190	1.4711												1.5222	1.5755
350	436	h	414.1	1204.1												1207.5	1222.4
		v	0.0192	1.2720												1.2831	1.3326
400	448	h	428.1	1204.6													1214.0
		v	0.0194	1.1194													1.1468
450	460	h	440.9	1204.6													
		v	0.0196	0.9985													
500	470	h	452.9	1204.2													
		v	0.0198	0.9004													
550	480	h	464.1	1203.7													
		v	0.0200	0.8191													
600	489	h	474.7	1203.0													
		v	0.0202	0.7503													

*Adapted with permission from “Thermodynamic Properties of Steam”, Keenan and Keyes, published by John Wiley & Sons, Inc.

STEAM TABLE*

h = Total heat of steam, Btu per pound
v = Specific volume, cubic feet per pound

TOTAL TEMPERATURE, °F																	Temperature °F (sat.)	Pressure psi (gage)
480	500	520	540	560	580	600	620	640	660	680	700	720	740	750				
1277.6	1287.1	1296.6	1306.2	1315.7	1325.3	1334.8	1344.5	1354.2	1363.8	1373.5	1383.2	1393.0	1402.8	1407.7	h	212	0
37.96	38.78	39.60	40.41	41.23	42.04	42.86	43.68	44.49	45.31	46.12	46.94	47.75	48.56	48.97	v		
1277.1	1286.6	1296.2	1305.7	1315.3	1324.8	1334.4	1344.1	1353.8	1363.5	1373.2	1382.9	1392.7	1402.6	1407.5	h	228	5
27.86	28.46	29.06	29.67	30.27	30.87	31.47	32.07	32.67	33.27	33.87	34.47	35.07	35.67	35.96	v		
1276.6	1286.2	1295.8	1305.3	1314.9	1324.5	1334.1	1343.8	1353.5	1363.2	1372.9	1382.6	1392.5	1402.3	1407.2	h	240	10
22.26	22.74	23.22	23.71	24.19	24.68	25.16	25.64	26.12	26.60	27.08	27.56	28.04	28.52	28.76	v		
1276.2	1285.7	1295.3	1304.9	1314.5	1324.2	1333.8	1343.5	1353.2	1362.9	1372.6	1382.4	1392.3	1402.1	1407.0	h	250	15
18.528	18.933	19.337	19.741	20.144	20.547	20.95	21.35	21.75	22.15	22.56	22.96	23.36	23.76	23.96	v		
1275.7	1285.3	1294.9	1304.5	1314.1	1323.8	1333.5	1343.2	1352.9	1362.6	1372.3	1382.1	1391.9	1401.8	1406.7	h	259	20
15.862	16.210	16.558	16.905	17.251	17.597	17.943	18.288	18.633	18.977	19.322	19.666	20.01	20.35	20.52	v		
1275.2	1284.8	1294.5	1304.1	1313.8	1323.4	1333.1	1342.8	1352.5	1362.3	1372.1	1381.9	1391.7	1401.6	1406.5	h	267	25
13.862	14.168	14.473	14.778	15.082	15.385	15.688	15.990	16.293	16.595	16.896	17.198	17.499	17.8001	7.951	v		
1274.7	1284.4	1294.0	1303.7	1313.4	1323.1	1332.8	1342.5	1352.2	1362.0	1371.8	1381.6	1391.5	1401.4	1406.3	h	274	30
12.307	12.580	12.852	13.123	13.394	13.665	13.935	14.204	14.473	14.742	15.011	15.279	15.547	15.815	15.949	v		
1273.7	1283.4	1293.2	1302.9	1312.6	1322.4	1332.1	1341.9	1351.7	1361.5	1371.3	1381.1	1391.0	1400.9	1405.8	h	287	40
10.044	10.269	10.493	10.717	10.940	11.162	11.384	11.605	11.826	12.047	12.268	12.488	12.708	12.927	13.037	v		
1272.7	1282.5	1292.3	1302.1	1311.9	1321.7	1331.5	1341.3	1351.1	1360.9	1370.8	1380.6	1390.5	1400.4	1405.4	h	298	50
8.478	8.670	8.861	9.051	9.240	9.429	9.618	9.806	9.993	10.181	10.368	10.555	10.741	10.928	11.021	v		
1271.6	1281.5	1291.4	1301.3	1311.1	1321.0	1330.8	1340.6	1350.5	1360.3	1370.2	1380.1	1390.0	1399.9	1404.9	h	308	60
7.329	7.496	7.663	7.829	7.994	8.159	8.323	8.486	8.649	8.812	8.975	9.138	9.300	9.462	9.543	v		
1270.6	1280.6	1290.5	1300.5	1310.4	1320.2	1330.1	1340.0	1349.9	1359.8	1369.7	1379.6	1389.6	1399.5	1404.5	h	316	70
6.450	6.599	6.747	6.894	7.041	7.187	7.332	7.477	7.622	7.766	7.910	8.054	8.198	8.341	8.413	v		
1269.5	1279.6	1289.6	1299.6	1309.6	1319.5	1329.4	1339.4	1349.3	1359.3	1369.2	1379.1	1389.1	1399.0	1404.0	h	324	80
5.756	5.891	6.024	6.156	6.288	6.419	6.550	6.680	6.810	6.940	7.069	7.199	7.327	7.456	7.520	v		
1268.5	1278.6	1288.7	1298.8	1308.8	1318.8	1328.7	1338.7	1348.7	1358.6	1368.6	1378.5	1388.5	1398.5	1403.5	h	331	90
5.195	5.317	5.439	5.559	5.679	5.799	5.918	6.036	6.154	6.272	6.389	6.506	6.623	6.740	6.798	v		
1267.4	1277.7	1287.8	1297.9	1308.0	1318.0	1328.1	1338.1	1348.0	1358.0	1368.0	1378.0	1388.1	1398.1	1403.1	h	338	100
4.730	4.843	4.955	5.066	5.176	5.285	5.394	5.503	5.611	5.719	5.827	5.934	6.041	6.148	6.201	v		
1264.7	1275.2	1285.5	1295.8	1306.0	1316.2	1326.4	1336.5	1346.6	1356.6	1366.7	1376.8	1386.9	1397.0	1402.0	h	353	125
3.860	3.954	4.047	4.140	4.232	4.323	4.413	4.503	4.593	4.683	4.772	4.861	4.949	5.038	5.082	v		
1261.9	1272.6	1283.2	1293.6	1304.0	1314.3	1324.6	1334.8	1345.0	1355.2	1365.3	1375.4	1385.6	1395.8	1400.8	h	366	150
3.252	3.334	3.414	3.494	3.573	3.652	3.730	3.807	3.884	3.960	4.037	4.113	4.188	4.264	4.301	v		
1259.0	1270.0	1280.8	1291.4	1302.0	1312.4	1322.8	1333.2	1343.5	1353.7	1363.9	1374.2	1384.4	1394.6	1399.7	h	378	175
2.804	2.877	2.948	3.019	3.089	3.157	3.226	3.294	3.361	3.429	3.495	3.562	3.628	3.694	3.727	v		
1256.0	1267.3	1278.3	1289.2	1299.9	1310.5	1321.0	1331.4	1341.8	1352.2	1362.5	1372.8	1383.1	1393.3	1398.5	h	388	200
2.460	2.525	2.590	2.653	2.716	2.777	2.839	2.900	2.960	3.019	3.079	3.139	3.198	3.256	3.286	v		
1253.0	1264.5	1275.8	1286.9	1297.8	1308.5	1319.2	1329.8	1340.3	1350.7	1361.1	1371.5	1381.9	1392.2	1397.3	h	397	225
2.187	2.247	2.306	2.364	2.421	2.477	2.533	2.587	2.642	2.696	2.750	2.804	2.857	2.910	2.936	v		
1249.9	1261.7	1273.2	1284.5	1295.6	1306.5	1317.3	1328.0	1338.7	1349.2	1359.7	1370.2	1380.6	1391.0	1396.2	h	406	250
1.9654	2.021	2,076	2.129	2.181	2.233	2.284	2.334	2.384	2.434	2.483	2.532	2.580	2.629	2.653	v		
1246.6	1258.8	1270.6	1282.1	1293.4	1304.5	1315.5	1326.3	1337.0	1347.7	1358.3	1368.8	1379.3	1389.8	1395.0	h	414	275
1.7816	1.8338	1.8846	1.9342	1.9829	2.031	2.078	2.125	2.171	2.217	2.262	2.307	2.352	2.396	2.418	v		
1243.3	1255.8	1267.9	1279.7	1291.2	1302.5	1313.6	1324.5	1335.4	1346.1	1356.8	1367.4	1378.0	1388.6	1393.8	h	422	300
1.6266	1.6759	1.7237	1.7703	1.8159	1.8607	1.9048	1.9483	1.9912	2.034	2.076	2.118	2.159	2.200	2.220	v		
1236.4	1249.6	1262.4	1274.7	1286.6	1298.2	1309.7	1320.9	1332.0	1343.0	1353.9	1364.7	1375.4	1386.1	1391.4	h	436	350
1.3795	1.4243	1.4675	1.5094	1.5501	1.5900	1.6291	1.6676	1.7056	1.7430	1.7801	1.8168	1.8531	1.8892	1.9071	v		
1229.0	1243.2	1256.6	1269.4	1281.8	1293.9	1305.7	1317.2	1328.6	1339.8	1350.9	1361.9	1372.8	1383.6	1389.0	h	448	400
1.1908	1.2325	1.2724	1.3108	1.3480	1.3842	1.4196	1.4544	1.4885	1.5222	1.5554	1.5883	1.6207	1.6529	1.6689	v		
1221.2	1236.3	1250.5	1264.0	1276.9	1289.4	1301.6	1313.5	1325.1	1336.5	1347.8	1359.0	1370.1	1381.1	1386.5	h	460	450
1.0416	1.0811	1.1186	1.1544	1.1889	1.2224	1.2550	1.2868	1.3180	1.3488	1.3789	1.4088	1.4382	1.4675	1.4819	v		
1212.8	1229.0	1244.0	1258.3	1271.8	1284.8	1297.3	1309.6	1321.5	1333.2	1344.7	1356.1	1367.3	1378.4	1384.0	h	470	500
0.9204	0.9584	0.9941	1.0280	1.0604	1.0917	1.1221	1.1516	1.1805	1.2088	1.2367	1.2641	1.2913	1.3180	1.3313	v		
	1221.4	1237.4	1252.4	1266.5	1280.0	1293.0	1305.6	1317.8	1329.8	1341.6	1353.2	1364.6	1375.8	1381.4	h	480	550
	0.8565	0.8909	0.9234	0.9542	0.9838	1.0124	1.0401	1.0671	1.0935	1.1195	1.1449	1.1700	1.1947	1.2070	v		
	1213.2	1230.3	1246.1	1261.0	1275.1	1288.5	1301.5	1314.1	1326.3	1338.3	1350.2	1361.8	1373.2	1378.9	h	489	600
	0.7703	0.8040	0.8353	0.8649	0.8931	0.9203	0.9465	0.9720	0.9968	1.0211	1.0450	1.0684	1.0916	1.1030	v		

*Adapted with permission from “Thermodynamic Properties of Steam”, Keenan and Keyes, published by John Wiley & Sons, Inc.

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