CROSBY SAFETY VALVES

STYLE HSL – DRUM AND SUPERHEATER OUTLET SERVICE

High Capacity, Steam Service, Flanged Steel Safety Valve

Introduction

Crosby Style HSL is a full nozzle reaction type safety valve designed for saturated and superheated steam service. The design is suitable for set pressures to 725 psig [50 barg] and temperatures to 1000°F [538°C], with high capacities, two choices of inlet flange ratings and a simplicity of design to facilitate ease of maintenance.

The HSL design meets the requirements of ASME Code Section I, Power Boilers and relieving capacities are certified by the National Board of Boiler & Pressure Vessel Inspectors. Style HSL may also be used in steam service applications covered by ASME Code Section VIII requirements.

Features

- **FLEXI-DISC seat design:** recessed for pressure and temperature equalization. Ensures a flat and tight seal.
- **High coefficient of discharge:** results in the most economical valve selection.
- **Replaceable full nozzle design:** facilitates ease of maintenance and longer service life. Nozzle removal requires no special tools.
- **Seat tightness:** FLEXI-DISC seat capable of containing system pressure at 94% of set pressure. Standard seat tightness testing conducted at 93% of set pressure.
- **Single bonnet design:** allows set pressure changes without the need to change-out any components besides the spring.
- **Back pressure limit:** 27.5% of set pressure

Technical data

- Saturated and superheated steam service
- Inlet sizes: 1¼" to 6" flanged
- Inlet ratings: CL 300#, CL 600#
- Outlet rating: CL 150#
- Maximum set pressure: 725 psig [50 barg]
- Temperatures to 1000°F [538°C]
- Orifices: F through Q
- Blowdown: 4%
- Back pressure limit: 27.5% of set pressure
- Capacity certification: ASME Boiler & Pressure Vessel Code Section I and VIII

Certification and type approvals

- ASME Boiler and Pressure Vessel Code Section I and VIII
- National Board of Boiler and Pressure Vessel Inspectors Capacity Certifications
- Canadian Registration Number
- Pressure Equipment Directive (97/27/EC) (ISO 4126-1) (CE)
- China Manufacturing License (TS)

Introduction

The adjustable Nozzle Ring and Guide Ring (Figure 1) utilize the reactive and expansive forces of flowing steam to provide full lift. With a high K x A, positive overpressure protection is achieved with the fewest number of valves.

Precise blowdown control is provided by the adjustable two-ring design. Blowdown may be adjusted while the valve is installed in the system.

Style HSL safety valves incorporate the Crosby FLEXI-DISC design which is recessed for pressure and temperature equalization ensuring a flat, tight seal capable of containing system pressure at 94% of the valve set pressure.

Centering of the disc through the low friction guide ensures the HSL open precisely at set pressure, even after repeated cycling.

The single bonnet design utilized in both inlet flange ratings allows set pressure changes without the need to change-out any components other than the spring. The set pressure range for Cl300# valves is 15 psig [1.034 barg] to 330 psig [22.75 barg] and 15 psig [1.034 barg] to 725 psig [50 barg] for Cl600#.

The back pressure limit of the HSL is 27.5% maximum. Blowdown may increase slightly when back pressure is present.

Style HSL safety valves are available with optional test gags, weatherhoods for outdoor applications, and Class 150# Drip Pan Elbows. Ring type joint inlet connection is also available.

The entire HSL range of F thru Q orifices uses a full nozzle design (Figure 1) to facilitate removal and ease of maintenance compared to semi-nozzle designs. (for additional information refer to instruction manual #IS-V3187)

F thru J Orifice

Bill of materials (F thru J Orifice)

Item	Part Name	Material
1	Body	ASME SA216 Grade WCB/WCC Carbon Steel (HSL-( )6) ASME SA217 Grade WC6 Chrome Moly Steel (HSL-( )8)
2	Nozzle	ASME SA479 Type 316 Stainless Steel
3	Drain Plug	Carbon Steel
4	Nozzle Ring	ASME SA351 Grade CF8M Stainless Steel
5	Nozzle Ring Set Screw	Type 416 Stainless Steel
6	Disc*	Type 422 Stainless Steel
7	Guide	Monel®
8	Guide Ring	ASME SA351 Grade CF8M Stainless Steel
9	Guide Ring Set Screw	Type 416 Stainless Steel
10	Bonnet Stud Nut	ASME SA194 - Class 2H
11	Bonnet Stud	ASME SA193 Grade B7
12	Spring Washers	Carbon Steel
13	Bonnet	ASME SA216 Grade WCB/WCC Carbon Steel (HSL-( )6) ASME SA217 Grade WC6 Chrome Moly Steel (HSL-( )8)
14	Spindle	Type 416 Stainless Steel
15	Adjusting Bolt	Type 416 Stainless Steel
16	Adjusting Bolt Nut	Steel
17	Cap	Malleable Iron
18	Cap Set Screw	Stainless Steel
19	Lever	Malleable Iron
20	Forked Lever	Malleable Iron
21	Spindle Nut	Steel
22	Spindle Nut Cotter Pin	Steel
23	Cotter Pin	Steel
24	Forked Lever Pin	Steel
28	Spring	Alloy Steel (corrosion resistant coating)**
29	Lever Pin	Steel
30	Cotter Pin	Steel
	Nameplate	Stainless Steel (not shown)

* Recommended spare part
** Crosby may upgrade to Inconel® X 750

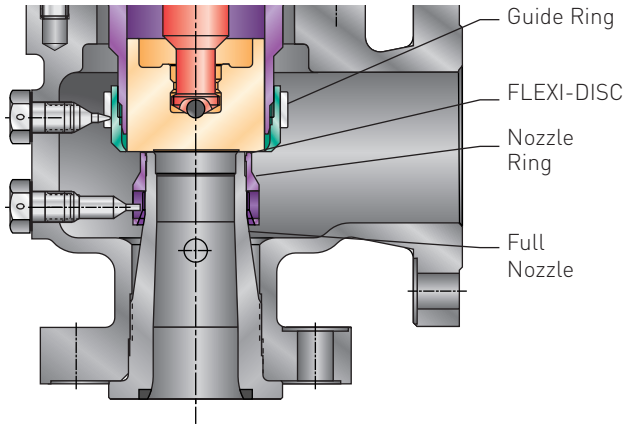
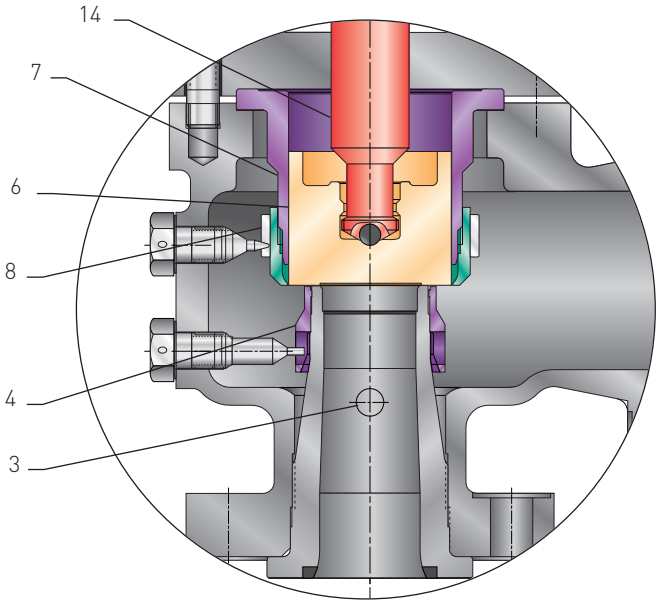
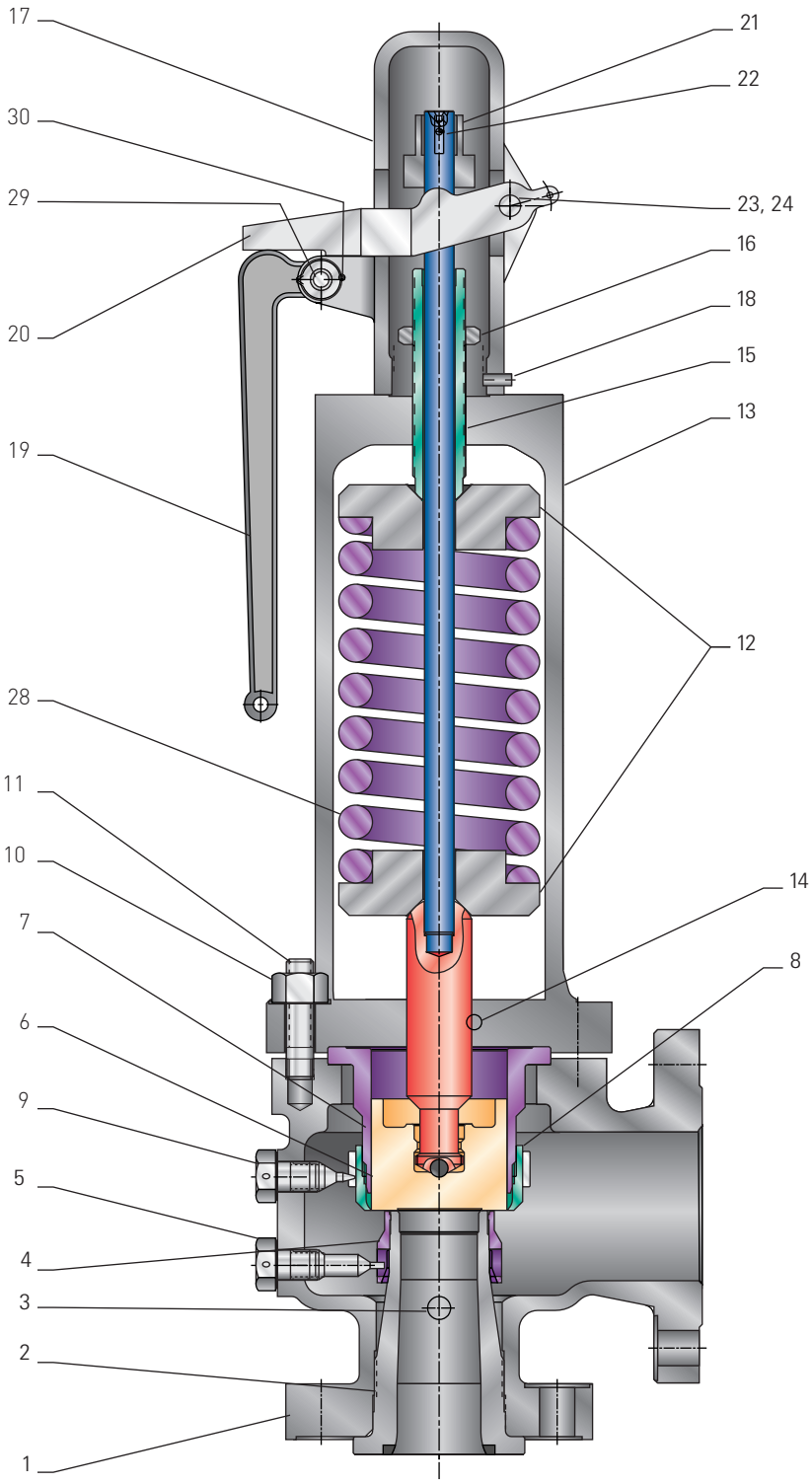


Figure 1 – HSL Full Nozzle



F – J Orifice Construction

F thru J Orifice

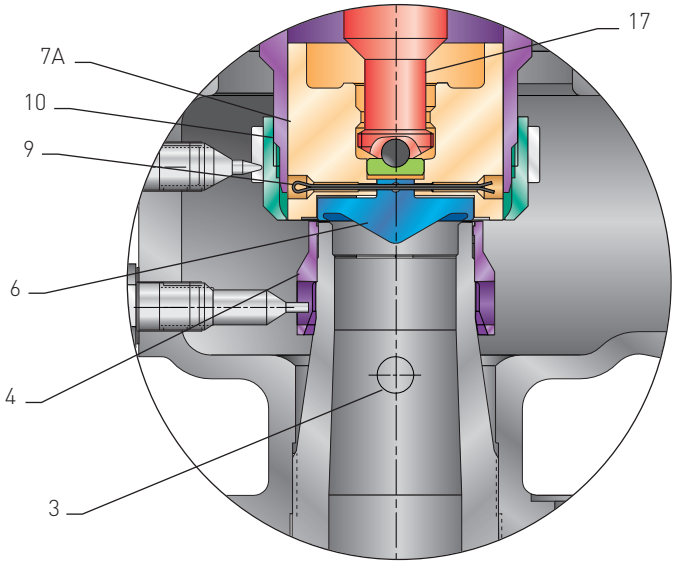


K thru Q Orifice

Bill of materials (K thru Q Orifice)

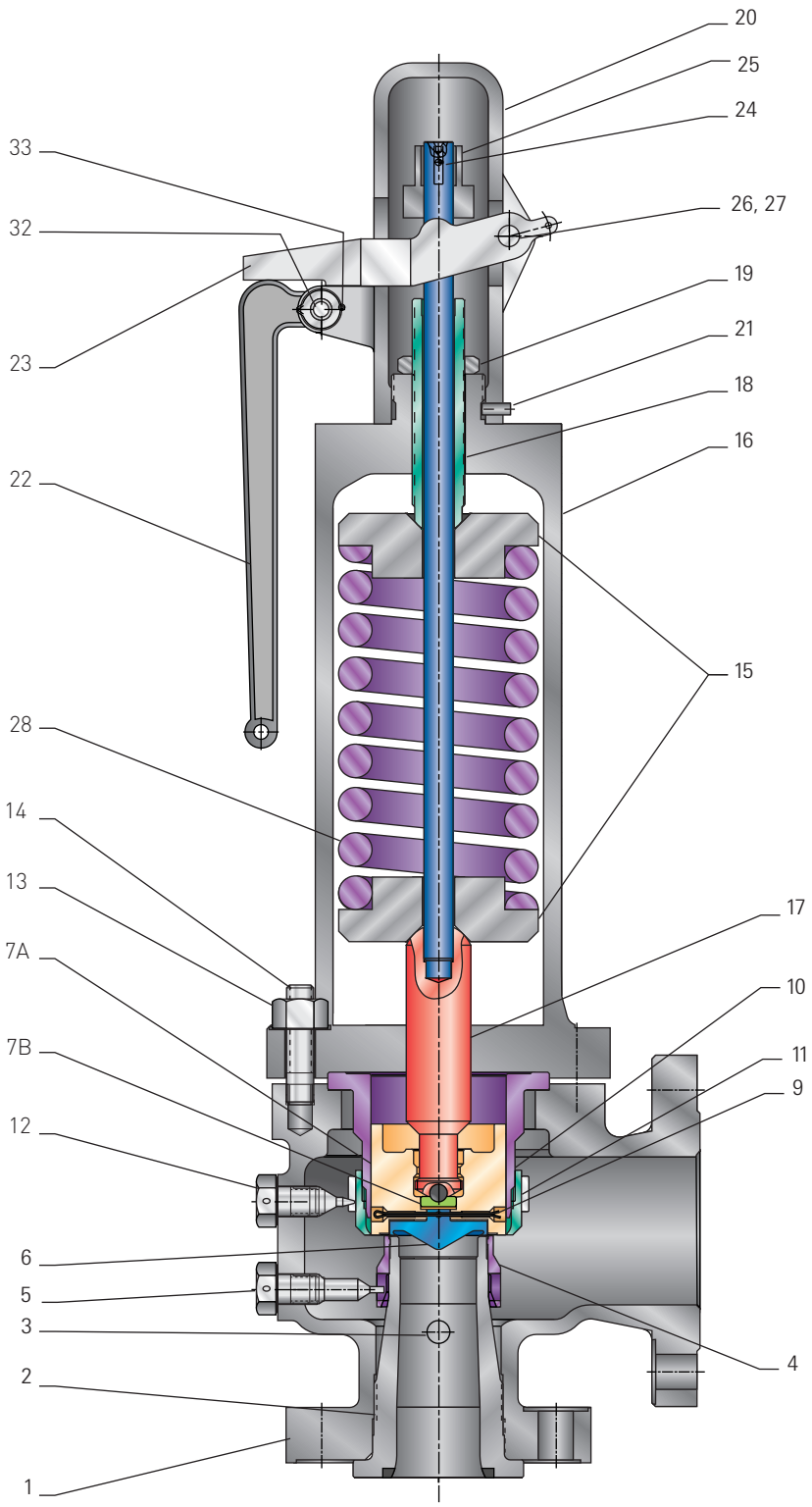
Item	Part Name	Material
1	Body	ASME SA216 Grade WCB/WCC Carbon Steel (HSL-( )6) ASME SA217 Grade WC6 Chrome Moly Steel (HSL-( )8)
2	Nozzle	ASME SA479 Type 316 Stainless Steel
3	Drain Plug	Carbon Steel
4	Nozzle Ring	ASME SA351 Grade CF8M Stainless Steel
5	Nozzle Ring Set Screw	Type 416 Stainless Steel
6	Disc Insert*	Type 422 Stainless Steel
7A & B	Disc Holder and Bushing	Monel®/440C Stainless Steel
9	Disc Insert Cotter Pin*	Stainless Steel
10	Guide	Monel®
11	Guide Ring	ASME SA351 Grade CF8M Stainless Steel
12	Guide Ring Set Screw	Type 416 Stainless Steel
13	Bonnet Stud Nut	ASME SA194 - Class 2H
14	Bonnet Stud	ASME SA193 Grade B7
15	Spring Washers	Carbon Steel
16	Bonnet	ASME SA216 Grade WCB/WCC Carbon Steel (HSL-( )6) ASME SA217 Grade WC6 Chrome Moly Steel (HSL-( )8)
17	Spindle	Type 416 Stainless Steel
18	Adjusting Bolt	Type 416 Stainless Steel
19	Adjusting Bolt Nut	Steel
20	Cap	Malleable Iron
21	Cap Set Screw	Stainless Steel
22	Lever	Malleable Iron
23	Forked Lever	Malleable Iron
24	Spindle Nut	Steel
25	Spindle Nut Cotter Pin	Steel
26	Cotter Pin	Steel
27	Forked Lever Pin	Steel
28	Spring	Alloy Steel (corrosion resistant coating)
32	Lever Pin	Steel
33	Cotter Pin	Steel
	Nameplate	Stainless Steel (not shown)

* Recommended spare parts



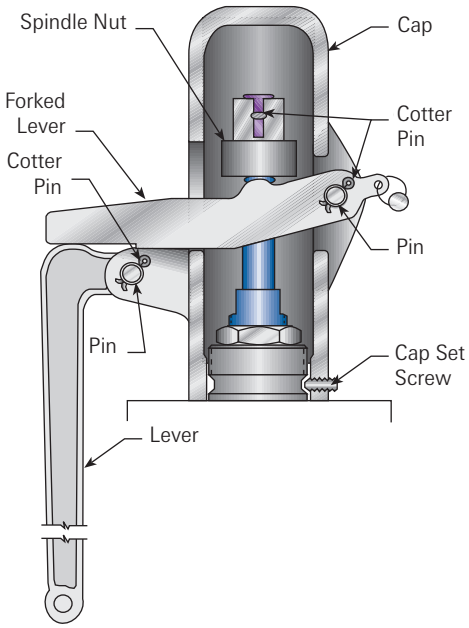
K – Q Orifice Construction

K thru Q Orifice

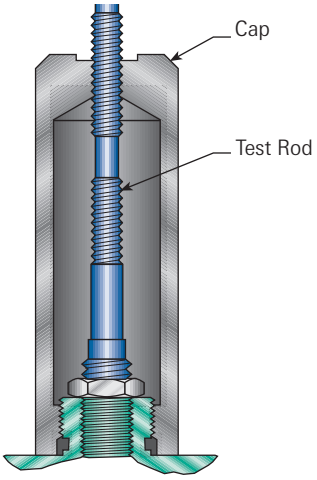


Caps and lifting levers

Regular Lifting Lever Type C (standard)

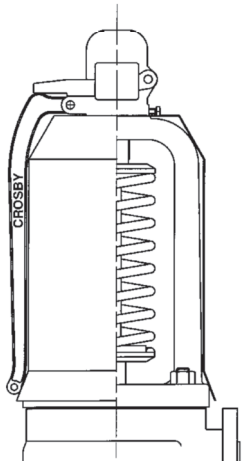


Optional Test Gag Type C



Additional cap furnished for gagging purposes only when requested and ordered by customer

Safety Valve with Optional Weatherhood for outdoor service



Optional drip pan elbows

For optimum safety valve performance, discharge piping should be supported independently of the valve. This can best be accomplished by installing a slip joint arrangement at the inlet to the riser pipe, using a drip pan elbow.

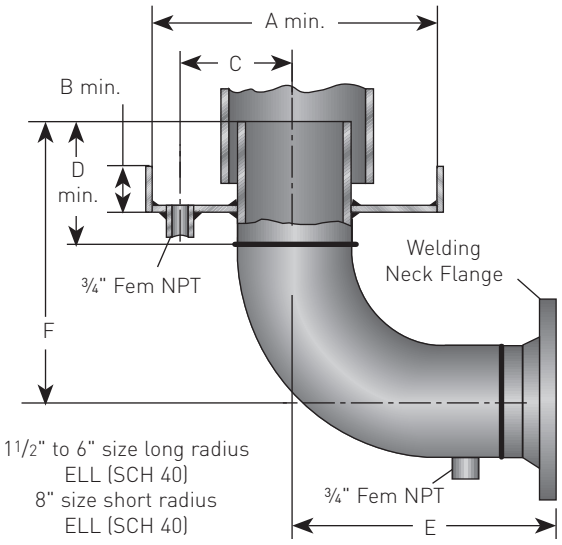
The riser should be sized sufficiently larger than the slip joint to provide clearance during expansion of the boiler, and should be located with enough clearance at the lower end to prevent "bottoming" on the drip pan.

Drain lines should be installed from the discharge elbow and the safety valve body, and piped separately from any other drain or vent line. The size of the drip pan elbow should be at least equal to that of the safety valve outlet size.

The flanged model EFS drip pan elbow should be used without any intermediary connection.

Specifications

Model:	EFS
Sizes:	1 1/2", 2 1/2", 3", 4", 6", 8"
Flange ANSI Class:	150 (1 1/2" to 8")
Material:	Carbon Steel



Dimensions – inches

Valve Outlet Size	A	B	C	D	E 150 ANSI Class	F
1 1/2	7	2 1/2	2 1/2	6	4 11/16	9
2 1/2	9	2 1/2	3	7	6 1/2	10 3/4
3	9	3	3	8	7 1/4	12 1/2
4	12	3	4	8	9	14
6	14	4	5	8	12 1/2	17
8	16	4	6 1/2	8	12	16

Pressure/Temperature Limits

CL 300 – ANSI raised face flange

Valve Size Inlet Orifice Outlet	Orifice Area square inch	Orifice Area square [mm]	Maximum Set Pressure at 900°F [482°C] or less psig	Maximum Set Pressure at 900°F [482°C] or less [barg]	Maximum Set Pressure at 950°F [510°C] psig	Maximum Set Pressure at 950°F [510°C] [barg]	Maximum Set Pressure at 1000°F [538°C] psig	Maximum Set Pressure at 1000°F [538°C] [barg]	Style Designation Standard Body Material and Maximum Temperature SA216 Gr. WCB 750°F [399°C]	Style Designation Standard Body Material and Maximum Temperature SA217 Gr. WC6 1000°F [538°C]	Standard Flanged Outlet Class
1¼ F 1½	0.339	[218.7]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150
1¼ G 1½	0.553	[356.8]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150
1½ H 2½	0.868	[600.0]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150
1½ J 2½	1.327	[856.1]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150
2 K 3	2.046	[1320.0]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150
2½ L 4	3.167	[2043.2]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150
3 M 4	3.955	[2551.6]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150
4 N 6	4.831	[3116.8]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150
4 P 6	7.031	[4536.1]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150
6 Q 8	12.174	[7854.2]	330	[22.76]	320	[22.07]	215	[14.83]	HSL-36	HSL-38	Class 150

CL 600 – ANSI raised face flange

Valve Size Inlet Orifice Outlet	Orifice Area square inch	Orifice Area square [mm]	Maximum Set Pressure at 900°F [482°C] or less psig	Maximum Set Pressure at 900°F [482°C] or less [barg]	Maximum Set Pressure at 950°F [510°C] psig	Maximum Set Pressure at 950°F [510°C] [barg]	Maximum Set Pressure at 1000°F [538°C] psig	Maximum Set Pressure at 1000°F [538°C] [barg]	Style Designation Standard Body Material and Maximum Temperature SA216 Gr. WCB 750°F [399°C]	Style Designation Standard Body Material and Maximum Temperature SA217 Gr. WC6 1000°F [538°C]	Standard Flanged Outlet Class
1¼ F 1½	0.339	[218.7]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150
1¼ G 1½	0.553	[356.8]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150
1½ H 2½	0.868	[600.0]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150
1½ J 2½	1.327	[856.1]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150
2 K 3	2.046	[1320.0]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150
2½ L 4	3.167	[2043.2]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150
3 M 4	3.955	[2551.6]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150
4 N 6	4.831	[3116.8]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150
4 P 6	7.031	[4536.1]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150
6 Q 8	12.174	[7854.2]	725	[50]	640	[44.14]	430	[29.66]	HSL-46	HSL-48	Class 150

Note: Set pressure is limited to either the inlet pressure limit per ASME B16.34 or the maximum set pressure listed in the tables above, whichever is lower.

Sizes, Connections, Dimensions and Weights

CL 300 - ANSI raised face flange

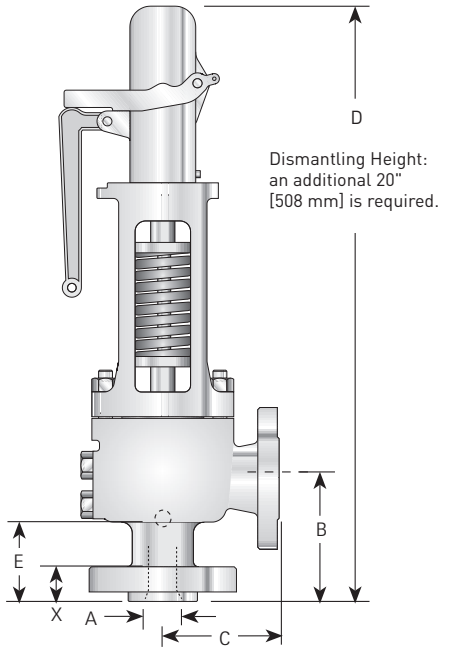
Valve Size Inlet Orifice Outlet	HSL Valve Style	Inlet ID "A"		Center-to-face Inlet "B"		Center-to-face Outlet "C"		Used to Find Bolt Length "X"[1]		Approx. Height "D"		Drain Height "E"		NPT Drain Size	Approx. Weight
		in	mm	in	mm	in	mm	in	mm	in	mm	in	mm		lb (kg)
1 1/4 F 1 1/2	3( )	1 1/4	31.8	4 13/32	111.9	4 3/16	106.4	1 3/16	30.2	21 1/2	546	2 11/16	68	1/4	41 (18.6)
1 1/4 G 1 1/2	3( )	1 1/4	31.8	4 13/32	111.9	4 3/16	106.4	1 3/16	30.2	21 1/2	546	2 11/16	68	1/4	41 (18.6)
1 1/2 H 2 1/2	3( )	1 1/2	38.1	4 3/4	120.7	4 7/8	123.8	1 1/4	31.75	22 1/4	565	2 5/8	66	3/8	56 (25.4)
1 1/2 J 2 1/2	3( )	1 1/2	38.1	4 3/4	120.7	4 7/8	123.8	1 1/4	31.75	26 3/4	679	2 5/8	66	3/8	71 (32.2)
2 K 3	3( )	2	50.8	5 1/4	133.4	5 9/16	141.3	1 1/2	38.1	30 1/8	765	3 1/8	80	3/8	90 (40.8)
2 1/2 L 4	3( )	2 1/2	63.5	6 1/8	155.6	6 5/16	160.3	1 13/16	46	32 7/8	835	3 7/8	98	1/2	138 (62.6)
3 M 4	3( )	3	76.2	6 1/2	165.1	6 7/16	163.5	1 7/8	47.6	33 9/16	852	4 3/16	107	1/2	156 (70.8)
4 N 6	3( )	4	101.6	7 1/4	184.2	7 7/16	188.9	2 1/8	54	40 3/4	1035	4 1/4	108	3/4	261 (118.4)
4 P 6	3( )	4	101.6	7 7/16	188.9	8 3/16	207.9	2 1/8	54	41 1/4	1048	4 7/16	113	3/4	281 (127.5)
6 Q 8	3( )	6	152.4	9 7/8	250.8	9 3/8	238.1	2 1/2	63.5	47 1/16	1195	4 13/16	122	3/4	494 (224.1)

CL 600 - ANSI raised face flange

Valve Size Inlet Orifice Outlet	HSL Valve Style	Inlet ID "A"		Center-to-face Inlet "B"		Center-to-face Outlet "C"		Used to Find Bolt Length "X"[1]		Approx. Height "D"		Drain Height "E"		NPT Drain Size	Approx. Weight
		in	mm	in	mm	in	mm	in	mm	in	mm	in	mm		lb (kg)
1 1/4 F 1 1/2	4( )	1 1/4	31.8	4 13/32	111.9	4 3/16	106.4	1 3/16	30.2	21 1/2	546	2 11/16	68	1/4	41 (18.6)
1 1/4 G 1 1/2	4( )	1 1/4	31.8	4 13/32	111.9	4 3/16	106.4	1 3/16	30.2	21 1/2	546	2 11/16	68	1/4	41 (18.6)
1 1/2 H 2 1/2	4( )	1 1/2	38.1	4 3/4	120.7	4 7/8	123.8	1 1/4	31.75	22 1/4	565	2 5/8	66	3/8	56 (25.4)
1 1/2 J 2 1/2	4( )	1 1/2	38.1	4 3/4	120.7	4 7/8	123.8	1 1/4	31.75	26 3/4	679	2 5/8	66	3/8	72 (32.7)
2 K 3	4( )	2	50.8	5 1/4	133.4	5 9/16	141.3	1 1/2	38.1	30 1/8	765	3 1/8	80	3/8	90 (40.8)
2 1/2 L 4	4( )	2 1/2	63.5	6 1/8	155.6	6 5/16	160.3	1 13/16	46	32 7/8	835	3 7/8	98	1/2	138 (62.6)
3 M 4	4( )	3	76.2	6 1/2	165.1	6 7/16	163.5	1 7/8	47.6	33 9/16	852	4 3/16	107	3/4	156 (70.8)
4 N 6	4( )	4	101.6	7 11/16	195.2	7 7/16	188.9	2 7/16	62	41 3/8	1051	4 3/4	121	3/4	261 (118.4)
4 P 6	4( )	4	101.6	7 11/16	195.2	8 3/16	207.9	2 7/16	62	41 1/2	1054	4 3/4	121	3/4	298 (135.2)
6 Q 8	4( )	6	152.4	10 5/16	261.9	9 3/8	238.1	2 7/8	73	47 1/2	1207	5 3/8	137	3/4	494 (224.1)

Note:

1. Bolt holes straddle centerline on flanged connections.



Saturated Steam Capacities **Pounds per hour at 3% overpressure, USCS* Units/Section I**

Set pressures 15 – 725 psig

Set Pressure (psig)	Orifice Area (sq in) F .339	G .553	H .868	J 1.327	K 2.046	L 3.167	M 3.955	N 4.831	P 7.031	Q 12.174
15	481	785	1231	1883	2903	4493	5611	6854	9975	17271
20	557	908	1426	2180	3360	5202	6496	7935	11548	19995
30	709	1156	1814	2773	4276	6619	8266	10097	14695	25444
40	860	1403	2203	3367	5192	8036	10036	12259	17841	30892
50	1012	1651	2591	3961	6107	9454	11806	14421	20988	36340
60	1164	1898	2979	4555	7023	10871	13576	16583	24135	41788
70	1317	2148	3372	5155	7948	12303	15364	18767	27313	47291
80	1473	2403	3772	5767	8891	13762	17187	20993	30554	52903
90	1629	2658	4172	6378	9834	15222	19010	23220	33795	58515
100	1786	2913	4572	6990	10777	16682	20833	25447	37036	64126
110	1942	3168	4972	7602	11720	18142	22656	27674	40277	69738
120	2098	3423	5372	8213	12664	19602	24479	29901	43518	75350
130	2254	3678	5773	8825	13607	21062	26302	32128	46759	80962
140	2411	3933	6173	9437	14550	22522	28125	34355	50000	86573
150	2567	4187	6573	10048	15493	23981	29948	36582	53241	92185
160	2723	4442	6973	10660	16436	25441	31772	38809	56482	97797
170	2880	4697	7373	11272	17379	26901	33595	41036	59723	103409
180	3036	4952	7773	11884	18322	28361	35418	43262	62964	109020
190	3192	5207	8173	12495	19265	29821	37241	45489	66205	114632
200	3348	5462	8573	13107	20209	31281	39064	47716	69446	120244
210	3505	5717	8973	13719	21152	32741	40887	49943	72687	125856
220	3661	5972	9374	14330	22095	34200	42710	52170	75928	131467
230	3817	6227	9774	14942	23038	35660	44533	54397	79169	137079
240	3973	6482	10174	15554	23981	37120	46356	56624	82410	142691
250	4130	6737	10574	16165	24924	38580	48179	58851	85651	148302
260	4286	6992	10974	16777	25867	40040	50003	61078	88892	153914
270	4442	7246	11374	17389	26810	41500	51826	63305	92133	159526
280	4598	7501	11774	18000	27754	42960	53649	65531	95374	165138
290	4755	7756	12174	18612	28697	44420	55472	67758	98615	170749
300	4911	8011	12574	19224	29640	45879	57295	69985	101856	176361
310	5067	8266	12975	19836	30583	47339	59118	72212	105097	181973
320	5224	8521	13375	20447	31526	48799	60941	74439	108338	187585
330	5380	8776	13775	21059	32469	50259	62764	76666	111579	193196
340	5536	9031	14175	21671	33412	51719	64587	78893	114820	198808
350	5692	9286	14575	22282	34355	53179	66410	81120	118061	204420
360	5849	9541	14975	22894	35299	54639	68234	83347	121302	210032
370	6005	9796	15375	23506	36242	56098	70057	85574	124543	215643
380	6161	10050	15775	24117	37185	57558	71880	87801	127784	221255
390	6317	10305	16175	24729	38128	59018	73703	90027	131025	226867

* United States Customary System

Capacity formula:
W = (51.5 x AP x K)

Where
W = Rated capacity, lbs/hr.
P = (1.03 x set pressure) + 14.7 = absolute pressure, psia
K = 0.869 = average coefficient of discharge
A = nozzle throat (orifice) area, sq. in.

Notes:

1. For steam capacities at 10% overpressure, multiply the capacity from the above table by the ratio

$$\frac{1.10p + 14.7}{1.03p + 14.7}$$

where "p" is set pressure (psig).

2. For superheated steam, multiply the saturated steam capacities by Superheat Correction Factor K_{sh} on page 12.

Saturated Steam Capacities - continued

Pounds per hour at 3% overpressure, USCS* Units/Section I

Set pressures 15 – 725 psig

Set Pressure (psig)	Orifice Area (sq in) F .339	G .553	H .868	J 1.327	K 2.046	L 3.167	M 3.955	N 4.831	P 7.031	Q 12.174
400	6474	10560	16576	25341	39071	60478	75526	92254	134266	232479
410	6630	10815	16976	25953	40014	61938	77349	94481	137507	238090
420	6786	11070	17376	26564	40957	63398	79172	96708	140748	243702
430	6942	11325	17776	27176	41900	64858	80995	98935	143989	249314
440	7099	11580	18176	27788	42844	66317	82818	101162	147230	254926
450	7255	11835	18576	28399	43787	67777	84641	103389	150471	260537
460	7411	12090	18976	29011	44730	69237	86465	105616	153712	266149
470	7568	12345	19376	29623	45673	70697	88288	107843	156953	271761
480	7724	12600	19777	30234	46616	72157	90111	110070	160194	277372
490	7880	12854	20177	30846	47559	73617	91934	112296	163435	282984
500	8036	13109	20577	31458	48502	75077	93757	114523	166676	288596
510	8193	13364	20977	32069	49445	76537	95580	116750	169917	294208
520	8349	13619	21377	32681	50389	77996	97403	118977	173158	299819
530	8505	13874	21777	33293	51332	79456	99226	121204	176399	305431
540	8661	14129	22177	33905	52275	80916	101049	123431	179640	311043
550	8818	14384	22577	34516	53218	82376	102872	125658	182881	316655
560	8974	14639	22977	35128	54161	83836	104696	127885	186122	322266
570	9130	14894	23378	35740	55104	85296	106519	130112	189364	327878
580	9286	15149	23778	36351	56047	86756	108342	132339	192605	333490
590	9443	15404	24178	36963	56990	88215	110165	134565	195846	339102
600	9599	15658	24578	37575	57934	89675	111988	136792	199087	344713
610	9755	15913	24978	38186	58877	91135	113811	139019	202328	350325
620	9911	16168	25378	38798	59820	92595	115634	141246	205569	355937
630	10068	16423	25778	39410	60763	94055	117457	143473	208810	361549
640	10224	16678	26178	40022	61706	95515	119280	145700	212051	367160
650	10380	16933	26578	40634	62649	96975	121103	147927	215292	372771
660	10536	17188	26978	41246	63592	98435	122926	150154	218533	378382
670	10692	17443	27378	41858	64535	99895	124749	152381	221774	383993
680	10848	17698	27778	42470	65478	101355	126572	154608	225015	389604
690	11004	17953	28178	43082	66421	102815	128395	156835	228256	395215
700	11160	18208	28578	43694	67364	104275	130218	159062	231497	400826
710	11316	18463	28978	44306	68307	105735	132041	161289	234738	406437
720	11472	18718	29378	44915	69250	107195	133864	163516	237979	412048
725	11550	18845	29578	45221	69721	107924	134775	164629	239599	414853

* United States Customary System

Capacity formula:
W = (51.5 x AP x K)

Where
W = Rated capacity, lbs/hr.
P = (1.03 x set pressure) + 14.7 = absolute pressure, psia
K = 0.869 = average coefficient of discharge
A = nozzle throat (orifice) area, sq. in.

Saturated Steam Capacities **Kilograms per hour at 3% overpressure**

Set pressures 1.034 – 50 barg

Set Pressure [barg]	Orifice Area [sq mm] F [218.7]	G [356.8]	H [560.0]	J [856.1]	K [1320.0]	L [2043.2]	M [2551.6]	N [3116.8]	P [4536.1]	Q [7854.2]
1.034	218	356	559	854	1317	2038	2545	3109	4524	7834
2	315	513	805	1231	1898	2938	3670	4482	6524	11295
3	414	676	1061	1622	2501	3871	4834	5905	8594	14879
4	514	839	1316	2013	3103	4803	5998	7327	10664	18464
5	615	1003	1575	2408	3713	5747	7177	8766	12759	22091
6	718	1171	1838	2810	4333	6707	8376	10231	14891	25783
7	821	1339	2102	3213	4954	7668	9575	11696	17023	29474
8	924	1507	2365	3615	5574	8628	10775	13161	19155	33166
9	1026	1674	2628	4018	6194	9588	11974	14626	21287	36858
10	1129	1842	2891	4420	6815	10549	13173	16091	23419	40549
11	1232	2010	3154	4822	7435	11509	14373	17556	25551	44241
12	1335	2177	3418	5225	8056	12469	15572	19021	27678	47933
13	1438	2345	3681	5627	8676	13430	16771	20486	29815	51624
14	1540	2513	3944	6030	9297	14390	17971	21951	31947	55316
15	1643	2680	4207	6432	9917	15351	19170	23416	34079	59008
16	1746	2848	4470	6834	10537	16311	20369	24881	36211	62699
17	1849	3016	4734	7237	11158	17271	21569	26346	38344	66391
18	1952	3183	4997	7639	11778	18232	22768	27811	40476	70083
19	2054	3351	5260	8042	12399	19192	23967	29276	42608	73774
20	2157	3519	5523	8444	13019	20152	25167	30741	44740	77466
21	2260	3687	5786	8846	13640	21113	26366	32206	46872	81158
22	2363	3854	6050	9249	14260	22073	27565	33671	49004	84849
23	2466	4022	6313	9651	14880	23033	28765	35136	51136	88541
24	2568	4190	6576	10054	15501	23994	29964	36601	53268	92233
25	2671	4357	6839	10456	16121	24954	31163	38066	55400	95924
26	2774	4525	7103	10858	16742	25915	32362	39530	57532	99616
27	2877	4693	7366	11261	17362	26875	33562	40995	59664	103308
28	2980	4860	7629	11663	17983	27835	34761	42460	61797	106999
29	3082	5028	7892	12066	18603	28796	35960	43925	63929	110691
30	3185	5196	8155	12468	19223	29756	37160	45390	66061	114382
31	3288	5363	8419	12870	19844	30716	38359	46855	68193	118074
32	3391	5531	8682	13273	20464	31677	39558	48320	70325	121766
33	3494	5699	8945	13675	21085	32637	40758	49785	72457	125457
34	3596	5867	9208	14078	21705	33597	41957	51250	74589	129149
35	3699	6034	9471	14480	22326	34558	43156	52715	76721	132841
36	3802	6202	9735	14882	22946	35518	44356	54180	78853	136532
37	3905	6370	9998	15285	23566	36479	45555	55645	80985	140224
38	4008	6537	10261	15687	24187	37439	46754	57110	83117	143916
39	4110	6705	10524	16090	24807	38399	47954	58575	85250	147607
40	4213	6873	10788	16492	25428	39360	49153	60040	87382	151299

Capacity formula:
Capacity is calculated by converting valve set pressure in barg to psig, calculating in pounds per hour by ASME Section I Capacity formula, and converting to kilograms per hour.

Notes:

1. For steam capacities at 10% overpressure, multiply the capacity from the above table by the ratio

$$\frac{1.10p + 14.7}{1.03p + 14.7}$$

where "p" is set pressure (psig).

2. For superheated steam, multiply the saturated steam capacities by Superheat Correction Factor K_{sh} on page 12.

Saturated Steam Capacities - continued **Kilograms per hour at 3% overpressure**

Set pressures 1.034 – 50 barg

Set Pressure [barg]	Orifice Area [sq mm] F [218.7]	G [356.8]	H [560.0]	J [856.1]	K [1320.0]	L [2043.2]	M [2551.6]	N [3116.8]	P [4536.1]	Q [7854.2]
41	4316	7040	11051	16894	26048	40320	50352	61505	89514	154991
42	4419	7208	11314	17297	26669	41280	51552	62970	91646	158682
43	4522	7376	11577	17699	27289	42241	52751	64435	93778	162374
44	4624	7543	11840	18102	27910	43201	53950	65900	95910	166066
45	4727	7711	12104	18504	28530	44161	55150	67365	98042	169757
46	4830	7879	12367	18907	29150	45121	56350	68830	100174	173448
47	4933	8047	12630	19310	29770	46081	57550	70295	102306	177139
48	5036	8215	12893	19713	30390	47041	58750	71760	104438	180830
49	5139	8383	13156	20116	31010	48001	59950	73225	106570	184521
50	5242	8551	13419	20519	31630	48961	61150	74690	108702	188212

Capacity formula:
Capacity is calculated by converting valve set pressure in barg to psig, calculating in pounds per hour by ASME Section I Capacity formula, and converting to kilograms per hour.

Notes:

1. For steam capacities at 10% overpressure, multiply the capacity from the above table by the ratio

$$\frac{1.10p + 1.0136}{1.03p + 1.0136}$$

where "p" is set pressure [barg].

2. For superheated steam, multiply the saturated steam capacities by Superheat Correction Factor K_{sh} shown below.

Superheat correction factor - K_{sh}

Flowing[1] Pressure psia	[bara]	Total Temperature Superheated Steam 400°F [204°C]	450°F [232°C]	500°F [260°C]	550°F [288°C]	600°F [316°C]	650°F [343°C]	700°F [371°C]	750°F [399°C]	800°F [427°C]	850°F [454°C]	900°F [482°C]	950°F [510°C]	1000°F [538°C]
50	3.4	.987	.957	.930	.905	.882	.861	.841	.823	.805	.789	.774	.759	.745
100	6.9	.998	.963	.935	.909	.885	.864	.843	.825	.807	.790	.775	.760	.746
150	10.3	.984	.970	.940	.913	.888	.866	.846	.826	.808	.792	.776	.761	.747
200	13.8	.979	.977	.945	.917	.892	.869	.848	.828	.810	.793	.777	.762	.748
250	17.2		.972	.951	.921	.895	.871	.850	.830	.812	.794	.778	.763	.749
300	20.7		.968	.957	.926	.898	.874	.852	.832	.813	.796	.780	.764	.750
350	24.1		.968	.963	.930	.902	.877	.854	.834	.815	.797	.781	.765	.750
400	27.6			.963	.935	.906	.880	.857	.836	.816	.798	.782	.766	.751
450	31.0			.961	.940	.909	.883	.859	.838	.818	.800	.783	.767	.752
500	34.5			.961	.946	.914	.886	.862	.840	.820	.801	.784	.768	.753
550	37.9			.962	.952	.918	.889	.864	.842	.822	.803	.785	.769	.754
600	41.4			.964	.958	.922	.892	.867	.844	.823	.804	.787	.770	.755
650	44.8			.968	.958	.927	.896	.869	.846	.825	.806	.788	.771	.756
700	48.3				.958	.931	.899	.872	.848	.827	.807	.789	.772	.757
750	51.7				.958	.936	.903	.875	.850	.828	.809	.790	.774	.758
800	55.2				.960	.942	.906	.878	.852	.830	.810	.792	.774	.759

Note:

1. Flowing pressure is the valve set pressure plus the overpressure plus the atmospheric pressure (14.7 psia) in psia or bara.

Reaction Forces

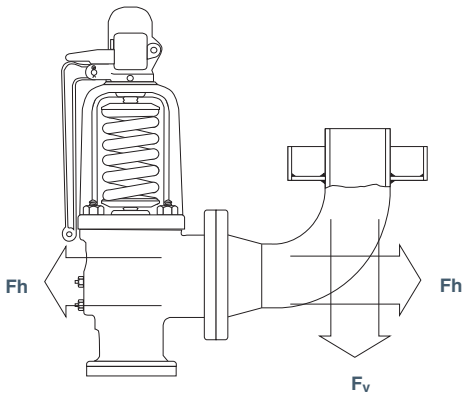
Orifice Designation	F		G		H		J		K		L		M		N		P		Q	
Outlet Dia.	1½"		1½"		2½"		2½"		3"		4"		4"		6"		6"		8"	
Flowing Press. psig [barg]	Total Outlet Reaction Force – lbs [N]																			
25 [1.72]	9.1	[40.5]	14.9	[66.3]	23.4	[104.1]	35.8	[159.2]	55.2	[245.5]	85.4	[379.9]	106.6	[474.2]	130.3	[579.6]	189.6	[843.4]	328.3	[1460.4]
50 [3.45]	14.8	[65.8]	24.2	[107.6]	37.9	[168.6]	58.0	[258.0]	89.4	[397.7]	138.5	[616.1]	172.9	[769.1]	211.2	[939.5]	307.4	[1367.4]	532.2	[2367.3]
75 [5.17]	20.6	[91.6]	33.6	[149.5]	52.7	[234.4]	80.6	[358.5]	124.3	[552.9]	192.4	[855.8]	240.3	[1068.9]	293.5	[1305.6]	427.2	[1900.3]	739.7	[3290.3]
100 [6.89]	26.5	[117.9]	46.6	[207.3]	67.9	[302.0]	113.4	[504.4]	174.6	[776.7]	251.4	[1118.3]	360.5	[1603.6]	378.1	[1681.9]	550.2	[2447.4]	952.7	[4237.8]
125 [8.62]	32.5	[144.6]	63.8	[283.8]	83.2	[370.1]	154.5	[687.3]	238.1	[1059.1]	349.6	[1555.1]	483.2	[2149.4]	462.8	[2058.6]	767.0	[3411.8]	1327.9	[5906.8]
150 [10.34]	38.4	[170.8]	81.0	[360.3]	103.8	[461.7]	195.9	[871.4]	301.8	[1342.5]	448.3	[1994.1]	606.3	[2697.0]	547.8	[2436.7]	985.9	[4385.5]	1707.0	[7593.1]
175 [12.07]	48.6	[216.2]	98.2	[436.8]	130.8	[581.8]	237.2	[1055.1]	365.5	[1625.8]	546.8	[2432.3]	729.5	[3245.0]	695.0	[3091.5]	1204.8	[5359.2]	2086.1	[9279.4]
200 [13.79]	59.2	[263.3]	115.5	[513.8]	157.9	[702.4]	278.6	[1239.3]	429.4	[1910.1]	645.7	[2872.2]	852.9	[3793.9]	845.8	[3762.3]	1424.3	[6335.6]	2466.1	[10969.8]
225 [15.51]	69.8	[310.5]	132.7	[590.3]	184.9	[822.5]	319.9	[1423.0]	493.1	[2193.4]	744.4	[3311.3]	976.1	[4341.9]	996.3	[4431.8]	1643.3	[7309.8]	2845.3	[12656.5]
250 [17.24]	80.4	[357.6]	150.0	[667.2]	212.0	[943.0]	361.4	[1607.6]	557.0	[2477.7]	843.2	[3750.7]	1099.6	[4891.3]	1147.1	[5102.6]	1862.8	[8286.1]	3225.4	[14347.3]
275 [18.96]	90.9	[404.3]	167.2	[743.7]	239.0	[1063.1]	402.7	[1791.3]	620.7	[2761.0]	941.8	[4189.3]	1222.7	[5438.8]	1297.5	[5771.6]	2081.7	[9259.9]	3604.3	[16032.7]
300 [20.68]	101.5	[451.5]	184.4	[820.3]	266.1	[1183.7]	444.0	[1975.0]	684.4	[3044.4]	1040.5	[4628.4]	1346.0	[5987.3]	1448.1	[6441.5]	2300.8	[10234.5]	3983.8	[17720.8]
325 [22.41]	112	[498.2]	201.6	[896.8]	293.0	[1303.3]	485.2	[2158.3]	748.0	[3327.3]	1138.9	[5066.1]	1468.8	[6533.5]	1598.1	[7108.7]	2519.1	[11205.5]	4361.8	[19402.3]
350 [24.13]	122.6	[545.4]	218.8	[973.3]	320.1	[1423.9]	526.5	[2342.0]	811.6	[3610.2]	1237.4	[5504.2]	1591.8	[7080.7]	1748.4	[7777.3]	2737.9	[12178.8]	4740.5	[21086.8]
375 [25.86]	133.1	[592.1]	235.9	[1049.3]	346.9	[1543.1]	567.6	[2524.8]	875.0	[3892.2]	1335.5	[5940.6]	1714.3	[7625.6]	1898.0	[8442.7]	2955.6	[13147.2]	5117.5	[22763.8]
400 [27.58]	143.6	[638.8]	253.1	[1125.8]	373.8	[1662.7]	608.7	[2707.6]	938.4	[4174.2]	1433.6	[6377.0]	1836.9	[8170.9]	2047.7	[9108.6]	3173.6	[14116.9]	5494.9	[24442.5]
425 [29.30]	154	[685.0]	270.1	[1201.5]	400.6	[1782.0]	649.7	[2890.0]	1001.5	[4454.9]	1531.4	[6812.0]	1958.9	[8713.6]	2196.8	[9771.9]	3390.5	[15081.7]	5870.5	[26113.3]
450 [31.03]	164.5	[731.7]	287.2	[1277.5]	427.4	[1901.2]	690.7	[3072.4]	1064.7	[4736.0]	1629.2	[7247.0]	2081.1	[9257.2]	2346.0	[10435.5]	3607.7	[16047.9]	6246.5	[27785.8]
475 [32.75]	174.9	[778.0]	304.2	[1353.1]	454.1	[2019.9]	731.4	[3253.4]	1127.6	[5015.8]	1726.5	[7679.9]	2202.6	[9797.7]	2494.4	[11095.6]	3823.7	[17008.7]	6620.6	[29449.9]
500 [34.47]	185.3	[824.3]	321.2	[1428.8]	480.8	[2138.7]	772.2	[3434.9]	1190.5	[5295.6]	1823.8	[8112.7]	2324.1	[10338.1]	2642.9	[11756.2]	4039.7	[17969.5]	6994.7	[31114.0]
525 [36.20]	195.7	[870.5]	338.1	[1503.9]	507.3	[2256.6]	812.8	[3615.5]	1253.1	[5574.1]	1920.7	[8543.7]	2445.1	[10876.3]	2790.7	[12413.7]	4254.8	[18926.3]	7367.1	[32770.5]
550 [37.92]	206.1	[916.8]	355.0	[1579.1]	533.9	[2374.9]	853.4	[3796.1]	1315.6	[5852.1]	2017.5	[8974.3]	2566.1	[11414.6]	2938.4	[13070.7]	4469.8	[19882.7]	7739.3	[34426.1]
575 [39.64]	216.4	[962.6]	371.9	[1654.3]	560.3	[2492.3]	893.8	[3975.8]	1377.9	[6129.2]	2113.9	[9403.1]	2686.4	[11949.7]	3085.4	[13724.5]	4683.8	[20834.6]	8109.8	[36074.2]
600 [41.37]	226.7	[1008.4]	388.7	[1729.0]	586.7	[2609.8]	934.1	[4155.1]	1440.1	[6405.9]	2210.2	[9831.5]	2806.6	[12484.4]	3232.2	[14377.5]	4897.5	[21785.2]	8479.8	[37720.0]
625 [43.09]	236.9	[1053.8]	405.4	[1803.3]	612.9	[2726.3]	974.3	[4333.9]	1502.0	[6681.2]	2306.0	[10257.6]	2926.4	[13017.3]	3378.5	[15028.3]	5110.4	[22732.2]	8848.4	[39359.6]
650 [44.82]	247.2	[1099.6]	422.1	[1877.6]	639.2	[2843.3]	1014.4	[4512.3]	1563.8	[6956.1]	2401.7	[10683.3]	3045.8	[13548.4]	3524.4	[15677.3]	5322.8	[23677.0]	9216.2	[40995.7]
675 [46.54]	257.4	[1145.0]	438.8	[1951.9]	665.3	[2959.4]	1054.3	[4689.8]	1625.4	[7230.1]	2497.0	[11107.2]	3164.8	[14077.7]	3669.8	[16324.1]	5534.3	[24617.8]	9582.5	[42625.1]
700 [48.26]	267.6	[1190.3]	455.4	[2025.7]	691.3	[3075.1]	1049.1	[4666.6]	1686.8	[7503.3]	2592.1	[11530.2]	3283.6	[14606.2]	3814.8	[16969.1]	5745.4	[25556.8]	9947.9	[44250.5]
725 [49.99]	277.7	[1235.3]	471.9	[2099.1]	717.3	[3190.7]	1133.8	[5043.4]	1748.0	[7775.5]	2686.8	[11951.5]	3401.9	[15132.4]	3959.3	[17611.8]	5955.7	[26492.3]	10312.0	[45870.1]

The basic equation for this is:

$$F_v = \frac{WV + (AP_e)}{g_c}$$

Where:

- F_v = Vertical force
- W = Flow in lbs/sec
- V = Velocity, ft/sec
- A = Area of outlet, sq. in.
- P_e = Static pressure in outlet elbow, psia
- g_c = Gravitational Constant



Total Resultant Force at Outlet Elbow[2]

The figure (left) shows a safety valve open and discharging at full capacity, with a 90° outlet elbow. The horizontal reaction force (Fh) is balanced by the force of discharging steam acting on the 90° elbow.

The vertical force (F_v) at the 90° elbow is unbalanced and exerts a bending moment on the valve. Vertical force (F_v) is the resultant of the reaction due to velocity and the static pressure of the steam acting on the area of the elbow when the valve is open and discharging.

Notes:

1. Flowing pressure is the valve set pressure plus the overpressure plus the atmospheric pressure (14.7 psia) in psia or bara.
2. Determination of outlet reaction forces is the responsibility of the designer of the vessel and/or piping.

Sizing ASME Section I Safety Valves

ASME Section I safety valves are devices designed to protect power boilers during an overpressure event. The proper sizing, selection, manufacturing, assembly, testing and maintenance are all critical to obtain optimum protection.

ASME Code Section I

1. Boilers-Safety Valve Requirements (PG-67)

Boilers having more than 500 sq ft of bare tube and boilers having combined bare tube and extended water heating surfaces exceeding 500 sq ft as well as a design steam generating capacity exceeding 4000 lb/hr. must have two or more safety valves. If only two safety valves are used, the relieving capacity of the smaller must not be less than 50% of that of the larger, so if only two valves are used, select valves so that each will relieve approximately half of the total boiler capacity.

2. Superheater Safety Valve Requirements (PG-68)

Boilers having attached superheaters must have at least one valve on the superheater. The valves on the drum must be large enough to relieve at 75% of the total boiler capacity. It is good practice to size the superheater valve to relieve approximately 20% of the total boiler capacity to protect the tubes against overheating.

3. Reheater Safety Valve Requirements (PG-68)

Boilers having reheaters must have at least one safety valve on the reheater outlet capable of relieving a minimum of 15% of the flow through the reheater. The remainder of the flow through the reheater may be discharged by safety valves on the reheater inlet.

4. Sample Calculations - Boiler Set Sizing

Boiler Specifications:

Total steam generation	170,000 lb/hr.
Design Pressure (MAWP)	500 psig
Drum Operating Pressure	450 psig
S. H. Outlet Temperature	550°F
S. H. Outlet Operating Pressure	425 psig

The superheater valve should relieve between 15% and 20% of the total generation capacity, or 25,500 lbs/hr. to 34,000 lbs/hr.

The superheater safety valve should be set to operate before the low set drum valve.

To determine superheater safety valve set pressure:

450 psig (Drum Operating Pressure)	–	425 psig (Superheater Outlet Operating Pressure)	=	25 psi (SH Pressure Drop)
500 psig (Design Pressure)	–	25 psi - 15 psig[1] (SH Pressure Drop)	=	460 psig (Set Pressure[2])

The Superheat Correction Factor K_{sh} is found on page 12. First convert Set Pressure Gage to Flowing Pressure Absolute by:

460 psig x 1.03 + 14.7 = 488.5 psia
At 488.5 psia and 550°F the K_{sh} = 0.945

To relieve 25,500 lbs/hr. superheated steam, the superheater valve must relieve 25,500/0.945 = 26,984 lb/hr. saturated steam.

From Capacity Table, page 10, a J orifice valve set at 460 psig will relieve 29,011 lbs/hr. saturated steam or 29,011 x 0.945 = 27,415 lbs/hr. superheated steam.

A **1½ J 2½ HSL-46** is required.

The balance of steam to be relieved by the drum valves; 170,000 - 27,415 = 142,585 lbs/hr. (Drum valves must relieve a minimum of 75% total boiler capacity).

Low set drum valve must set at 500 psig (MAWP-PG.67.3). High set drum valve 1.03 x 500 = 515 psig (PG-67.2).

From Capacity Tables, page 10, at 500 psig; two "L" orifice valves will discharge 75,077 x 2 - 150,154 lbs/hr.

Selection should be based on price comparison and also on using as many valves as practical of the same size. In this case, two "L" orifice valves should be used.

Industry practice would be to use two (2) valves on the drum.
Actual valve capacities from Capacity Table, page 10.

1st drum valve, **2½ L 4 HSL-46**	500 psig - 75,077 lbs/hr.
2nd drum valve, **2½ L 4 HSL-46**	515 psig - 77,266 lbs/hr.
Total capacity drum valves:	152,343 lbs/hr. (89.6%)
Capacity of superheater valve:	27,415 lbs/hr. (16.1%)

Total safety valve capacity: 179,758 lbs/hr. (105.7%)

Rechecking, the drum valves relieve 89.6% of total boiler capacity (complying with ASME Code requirement that drum valves relieve at least 75% of boiler capacity). Superheater valve relieves 16.1% of total boiler capacity – within the desirable range of 15% to 20% of total boiler capacity.

Notes:

1. The 15 psig subtracted from the superheater pressure drop is done to ensure that the superheater safety valve opens before the low set drum safety valve.
2. Can round set pressure up or down for even number.

Model Numbering

2½L 4 HSL -3 8 -C

Inlet x Orifice x Outlet
- 1¼ F 1½
- 1¼ G 1½
- 1½ H 2½
- 1½ J 2½
- 2 K 3
- 2½ L 4
- 3 M 4
- 4 N 6
- 4 P 6
- 6 Q 8

Valve series
- HSL – HSL High Capacity Flanged Steel Safety Valve

Inlet flange rating
- -3 – 300#
- -4 – 600#

Temperature limit/body material
- 6 – 750°F [399°C]/SA216 WCB/WCC
- 8 – 1000°F [538°C]/SA217 WC6

Cap and lifting lever type
- -C – (Standard) Regular lifting lever

Available Options

Accessories
- Test Gag
- Weatherhood
- CL 150# Drip Pan Elbow

Other
- Ring Type Joint (RTJ) Inlet

Model # Examples:

2½ L 4 HSL -38- C
6 Q 8 HSL -46- C

Order Information

Safety valves listed in this catalog are for steam service on steam generators, unfired pressure vessels and pipe lines. To assist customers in selecting proper safety valves, Crosby will recommend the most suitable safety valve, size and style. In order to do this, the following information is required:

Type of application

(a) Boiler Drum _____

(b) Superheater _____

(c) Reheater _____

(d) Other _____ (identify)

Applicable ASME Code

(a) Section I - Power Boilers

(b) Section VIII - Pressure Vessels

Single Valve System _____

Multiple Valve System _____

System requirements (for drum, superheater or reheater)

(a) Design Pressure _____ psig

(b) Design Temperature _____ °F

(c) Operating Pressure _____ psig

(d) Operating Temperature _____ °F

Valve specifications

For customers who wish to size their own safety valves, orders should include the following data:

Data	Example
Code Requirements	ASME Section I
Quantity of Valves	Two
Size - Inlet x Orifice x Outlet	1 1/4 G 1 1/2
Style	HSL-46
Set Pressure	350/355 psig
Required Capacity (Total)	
(or indicate actual valve capacity)	9286 lb/hr. - 9413 lb/hr.
Temperature - Saturated or °F	Saturated
Maximum Operating Pressure	
Drum	315
Superheater	None
Connections (Rating and Facing)	Flanged inlet/ANSI RFF CL 600

(a) Valve Set Pressure _____ psig

(b) Allowable Overpressure _____ %

(c) Relieving Capacity _____ lb/hr.

(d) Connections

Inlet Size and Flange Rating _____

Outlet Size and Flange Rating _____

Valve supplemental data

(a) Gag required _____

(b) Weatherhood required _____

(c) Export boxing _____

(d) Other _____ (specify)

PENTAIR VALVES & CONTROLS

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